

2 **The Standard Story of Scientific Method - Progress Based on Facts and Tests**

As explained in Chapter 1 we are here to dissuade you of a wonderful but misleading set of ideas--ideas which we would call myths about science, technology, society and progress. This subject is oriented around 4 ideas--four myths really--about science and technology as human, social and political institutions. The four stories can be abbreviated in four inter-linked statements:

- (1) - science discovers the truth about Nature (= scientific knowledge)**
- (2) - technology applies scientific knowledge toward practical ends;**
- (3) - society must adapt to technological innovations and**
- (4) - humanity (happily) benefits and social progress results.**

The purpose of the opening section of the subject is to deal with the first claim or story--'science discovers the truth about Nature'--the idea that science is some sort of simple machine for finding out verifiable, reliable, objective truths of nature, for technology to utilise. The first thing we have to do then is to unpack this seemingly simple and obvious expression: to articulate, to explicate this idea and to find out what ultimately lies behind it.

First of all we have to realise that statements (1) and (2) read together imply something remarkable about science, which may be formalised as follows:

**“What Science Proves True about Nature is the Sole Basis for
Technology and Social Progress”**

This is really the idea that cements the four statements together. Scientific knowledge is the basis, the only basis for technology, and from science based technological innovation we ultimately achieve social progress. After all, returning to the spirit of the four linked stories or myths, we don't want to build technology on incorrect knowledge, or found social 'progress' on error! When we say that there's a common idea or indeed a myth that 'science discovers the truth', what we really need to do is to open up the statement highlighted above to show what people in our society probably understand about the idea that 'science discovers' the truth.

What is it exactly that links the concept that 'Science discovers truths of nature' to 'Scientific knowledge is the sole basis of technology'? That is, how does science run, how does it come to produce this sound knowledge on which we ground technology and hence social progress? Here we get to the nub of the question, because the answer to how science discovers truths has a simple, widely accepted, believed, powerful, indeed beautiful answer.

There is a Scientific method, a method for doing science; where method is followed, science is being done; where method is not followed, nothing scientific is being done. In other words, when we question how science produces the goods, produces the truths that form the basis of technological and social progress, we have a ready made answer to insert, by means of using the scientific method.

Posing for the moment as firm believers in the commonly accepted stories about science, technology, society and progress, we see that if we ask:

"How does Science establish truths about nature?"

The answer is:

"By use of the scientific method".

And it is because scientific knowledge is produced through the use of the scientific method that,

"What Science Proves True about Nature is the Sole Basis for Technology and Social Progress"

Therefore, sticking with the commonly accepted tale, when people use the scientific method correctly, they produce genuine scientific knowledge. **So the traditional and commonsense answer to how does science do it, is that there is a proper way, a proper technique a proper method that produces the reliable, objective results.**

Now we come to a subtle point--and education is all about subtle points. During most of this chapter I am going to pretend that I fully believe in the reality and effectiveness of scientific method; that I fully accept the commonsense 2500 year old story that what makes science work is the proper

use of a thing called scientific method. This indeed is what most of you believe as well, as reinforced to you by the popular media; by the HSC examiners, by your science textbooks, and perhaps even by some of your lecturers in such social sciences as economics, psychology or even sociology. In the next chapter we will dismantle this simple, unexamined belief and show you why the story of scientific method is just a story, a myth in fact: A myth that misleads us about the actual nature of science and scientific work; a myth that gets in the way of our understanding the social dynamics of science. In subsequent chapters we shall then go on to see what recent work in history, philosophy and sociology of science has shown--that science is very real, very effective, very interesting, but that it just does not get "done" by people applying some simple methodology for finding the truth. The making and breaking of truth in science is a much more interesting human and social process than that.

The idea of scientific method actually goes back to the ancient Greek philosophers who started our Western scientific tradition about five or six hundred years before the birth of Christ. The idea or story of method then comes to us via the Medieval Universities of Europe where it was much discussed, and then takes on a new bold image in the so-called Scientific Revolution of the 17th Century--the time of Galileo and Newton, when modern science really got its start in Western Europe. From then it comes down to the present day. You can still take subjects on scientific method, and books are being written right this second expounding precisely what scientific method is (you'd think that we would have pinned it down by now--but that is part of the problem, as you shall soon see!).

Let's explore what scientific method is usually thought to consist of. Below is a list of assumptions that have always underpinned and guided Western thinking about scientific method:

- 1 - Nature is an objective system of facts.**
- 2 - Humans can objectively observe and report facts.**
- 3 - Scientific knowledge is based on facts alone.**
- 4 - Theories are generalisations of facts and are proven true or 'confirmed' by tests.**
- 5 - Science makes progress: Collecting more facts and successfully testing truer and more powerful theories.**

6 - Scientific knowledge is objective and proven, and therefore has no social, personal or political bias.

These are the key assumptions surrounding the belief in scientific method: I'll run through them, making some additional comments:

#1 There is a unique, objective Nature out there, and I am not questioning that belief. You will see, however that we can attack the simple idea of method and leave this one standing.

#2 Note this one well--this will be one of the main points of attack in the next chapter and throughout this section of the subject. We shall very soon see that we need a much more critical idea of what a fact is, and we need always to factor in human beliefs, goals, interests and aims in the shaping of what humans take to be facts. For the moment note that this belief has traditionally had an important role attached to it, first only humans who are unbiased, not 'subjective', rational, sane and sober can correctly observe true facts. If you suffer from one or more of the above 'limitations' you will not discover the truth, you will make errors and mistakes.

#3 This assumption states that scientific knowledge is based on facts--Well in this story or account, science must be based on fact, because if it is not, it will not be true, objective and reliable.

#4 Scientific knowledge is packaged in theories (generalisations of facts, proven true, "confirmed" is the technical word by tests) and we'll talk a lot about proving things by tests--trials by systematic observation or experiment, to test a proposed generalisation. If you pass the test--your theory is a confirmed, proven summary of the facts.

#5 Science makes progress--collecting facts, testing and proving truer and wider theories. Generally this idea of progress has been a key idea about science in Western culture since the 17th century. Science is the very model, the exemplar of what it means to make progress. Our knowledge of nature, over time, becomes more accurate, more compendious and more and more powerful.

#6 This point is obvious, because if science is based on facts only, facts observed generalised and tested by objective, rational people, then no social, personal or political bias can enter sound scientific knowledge. It is purely a mirror of objective nature, not a social or political product with messy human emotions, interests or biases polluting it.

Now it is that last point #6 which connects this whole set of assumptions about method to the bigger set of four basic beliefs that we are assessing in this subject. You will see here that we can take the 6 key assumptions about method and fit them within the framework of the 4 commonly accepted stories about science, technology, society and progress. So far we have seen that the notion “science discovers truths about nature” leads into the idea of scientific method and the assumptions that make it work. Those assumptions about method in turn lead to the key ideas that science is the sole basis for technology and thence for social progress. We therefore have:

“Science Discovers Truths About Nature”

How? By use of the Scientific Method

Which is based on the following assumptions:

- 1 - Nature is an objective system of facts.
- 2 - Humans can objectively observe and report facts.
- 3 - Scientific knowledge is based on facts alone.
- 4 - Theories are generalisations of facts and are proven true or ‘confirmed’ by tests.
- 5 - Science makes progress: Collecting more facts and successfully testing truer and more powerful theories.
- 6 - Scientific knowledge is objective and proven, and therefore has no social, personal or political bias.

So Therefore:

“What Science Proves True about Nature is the Sole Basis for Technology and Social Progress”

In other words, the whole commonsense Western story about how science, technology, society and progress interact hinges on believing this idea of scientific method.

Now let's look briefly at what method is supposed to consist of. Philosophers and scientists have been arguing for 350 years about these details--2500 years if you go back to the first person to theorise about scientific method--the Greek philosopher Aristotle. Here I am pretending everyone has already agreed about the details, that is, I am ignoring the unending disputes about what exactly is the correct story of scientific method in detail...I'll return to this problem a little bit later, because lack of any final agreement about method may indicate that we are dealing with a myth and not a hard, workable reality.

Consider (fig 1). We start with two fundamental things: Nature or the universe, which is a system of 'objective facts' is one of these, and the other thing you need in this story (for all stories need a sufficient number of characters, otherwise the story does not work structurally) is the unbiased observer. So, you have as it were, the subject, the unbiased observer; and the object, which is nature, a system of objective facts. It is a happy upbeat story, because the unbiased observer who by definition is 'unbiased' not insane, ill, not culturally biased; is not committed to, or conditioned by, any biographical, social, political, ideological, discursive, linguistic, anthropological or other set of influences.

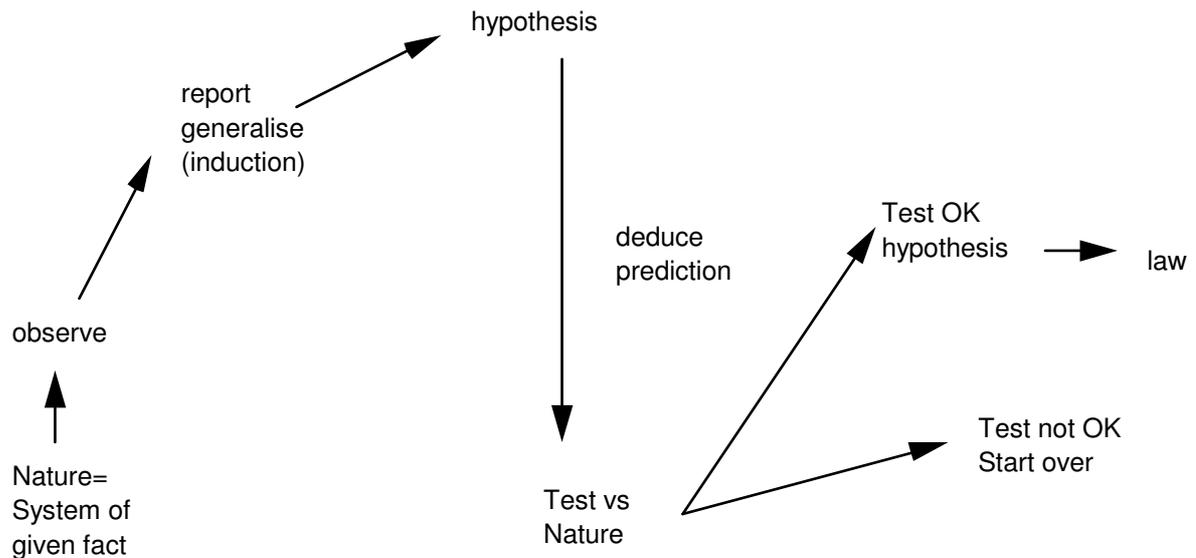
FIGURE 1



The subject (unbiased observer) gets in touch with the facts, which dance into his or her mind as little mirrors of reality. Now, once the unbiased observer is in contact with the facts, the method states that he/she forms generalisations about the relationships between the facts, this is called **Induction** (fig 2). A

generalisation that you form by unbiasedly observing the facts is a tentative generalisation, it's a potential candidate to become a law of nature, a scientific law, it's a draft law if you like; or what Aristotle would have called an Hypothesis (a tentative idea of a law). Since the hero of this story is extremely objective and rational, he/she will not jump to conclusions, but will put the tentative conclusions to the test.

FIGURE 2
THE METHOD STORY



What, then, is a Test? A test is not a test of bias or prejudice (pre-judgement). A test has to be objective and the only objective test is to test your hypothesis against nature. Strictly speaking, you do not always test your hypothesis against nature, but the prediction that has come from your hypothesis, or the explanation that is drawn on the basis of your hypothesis. You test the explanation or that prediction against the relevant facts.

Only two things can happen for the honest unbiased observer of the test: either your prediction or explanation is supported by the facts or it isn't supported by the facts. This is not a matter of opinion, but a matter of objective testing. If your prediction or explanation, based on your hypothesis, is supported by the facts, and if you then go through a few more tests successfully, you can say that your hypothesis is promoted to the status of a law. If your hypothesis fails, you get rid of the hypothesis and start again.

What is a Law? A law is a little hard brick of congealed fact. But remember where we got the law from: it is a generalisation about facts, tested and accepted and therefore becomes a law which is crystallised facts.

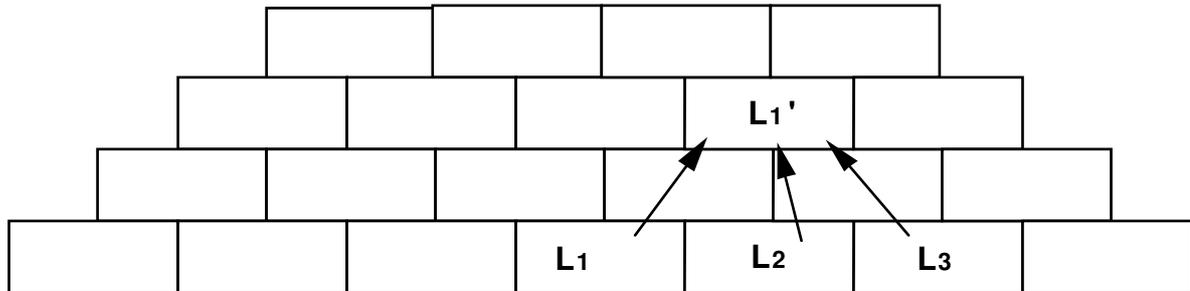
Several conclusions about the nature of science and the nature of the history of science follow from this story of method--they are **supposed** to follow from this story, for they are one of the prime **purposes** of this story:

First of all the history of science must consist in the discovery and extension of the scientific method, by heroic figures, starting with Aristotle and proceeding through Bacon, Galileo, and Newton. The scientific method has been perfected and then applied widely to different kinds of facts. For example, Aristotle for his own reasons did not stress the role of experiment in scientific method, or the role of mathematics in experimental method; but, in the 17th century the heroic scientific figures of the day corrected that oversight on the part of Aristotle. Bacon stressed experiment; Galileo and Newton stressed experiment and mathematization. So by the time of Newton (c1680) the scientific method as we know it to be was largely in place.

Given the discovery of the method, the history of science then consists of the slow, but steady, accumulation of systematic facts. The slow steady growth and progress of science is like the slow construction of a brick wall (fig 3). The wall grows longer, higher and firmer as time goes on and brick is laid upon brick--except in this case the bricks are little units of confirmed fact and theory. Using method over time we get a collection (a growing accumulation) of established facts in the form of laws, laws which are really little packages of summarised fact. And, every once in a while, whilst this collection is growing, somebody comes along and discovers how to generalise about the facts in Law 1, Law 2, Law 3, to produce a Law 1 Prime, which is on an upper level, another higher theory so to speak. But since these laws and theories are nothing but summarised facts, it is perfectly feasible that someone will come and generalise about these facts, producing yet a higher law. This is exactly what the great scientists do; they are the ones who add crucial bricks to this wall of facts so that the wall of facts grows throughout time progressively. It grows in length, width and height. **As time goes on we discover more and more truths and our knowledge collected in the brick wall comes to mirror, in a slightly different**

organisation, the system of objectives facts from whence it was all drawn, that is, it comes to mirror nature.

FIGURE 3
BRICK WALL METAPHOR OF PROGRESS



Bricks of fact and law grow wider and higher over time

The third conclusion we arrive at is that science makes **progress** slowly and surely from ignorance to truth, because with the piling up of the bricks ultimately comes a collection of systematised knowledge. The larger, wider and higher the wall, the more truths we learn and the less ignorant we become. **Progress towards the truth: we are closer to the truth than the people in the past; we can judge their scientific behaviour on the basis of the truths that we know. Perhaps they misused the method; perhaps they misjudged facts; perhaps they did not see certain facts because they were biased. We know more than they do, so we should judge them on that basis.**

This story is nice for historians of science like myself. If I believed this story (note I say if I believed it) my work would be a great deal easier. All I would have to do is look into historical records, books and archives and find out who were the good guys, the people who discovered and used scientific method to make progress, and who were the bad guys--maybe politicians and priests and poets who had biased reasons for opposing such noble work. The history of science would then be the history of (1) inventing and perfecting the method and (2) progressively applying the method--first to astronomy and physics, then to chemistry and biology and perhaps to society

and the human mind. Whilst (3) evil, biased people tried, unsuccessfully to obstruct the process.¹

That is the way the history of science has been written in the past, and you will find lots of books about the history of science that work that way. This form of history writing based on tracing how the 'good guys' developed and applied the method over and against the obstruction of religious, biased or ideological 'bad guys' has a special name in our field--**it is called Whig History**. But be careful--this is not the way historians of science have come to see things over the last 50 or 60 years--and we are going to introduce you to a view of science that is deeply sceptical of the idea that it is based on method and is therefore immune from human or social input.

NB: (In the Appendix to this chapter you will find a discussion of Whig History--both what it originally meant in writing political history, and how it came to be the main form of writing about the history of science. Read on for now, then read the Appendix, referring back to this section of the chapter when you do.)

Such, then, is the dominant Western commonsense story of scientific method. Clearly, the idea of Whig history, is closely related to the idea of method and to the image of scientific progress as a constantly enlarging wall of proven fact and theory. This is a seductive story, a beautiful story which people want to believe. It is powerfully convincing and that is why it is a fundamental belief of our scientific and technological culture. **It tells us what science is, how scientists work and why their work is reliable and how the history of science has unfolded in our society--what more could we ask of a key cultural story?**

The story of method is so wonderful that it is the subject of a huge, unending stream of literature: For example we know that in the 17th century Francis Bacon (1620) and Rene Descartes (1637) published influential accounts of scientific method which they each claimed was the key to the emerging new science of the period--and yet their accounts were quite different and incompatible. We also know that in 1687 the great Sir Isaac Newton

¹And notice that this story is also nice for scientists--they can define and defend themselves with the method story-- "we are the authorities; we must be independent and autonomous--just keep sending the cheques.... only we have the recipe for getting the truth out of nature", they can say--and have said since the 17th century.

published a version of method that had supposedly guided his work, but that account did not end the debate about method, which carried on through, for example, John Stuart Mill during the 19th century, and even down to the present, to Sir Karl Popper's great 1934 book on method. It is curious to see that there never really has been any final, complete consensus about scientific method, although virtually everyone in our culture believes in its existence as a real tool for performing scientific inquiry. For 2500 years thinkers have believed in scientific method, and yet have never come to any agreement about what, in detail, it is.

There exist, however, reasons to doubt the reality of the story of scientific method---reasons to doubt that it provides an accurate picture of the inside workings of science. First of all, no two great methodologists have ever agreed on what the exact story of scientific method is. Secondly, there is a reason to doubt the method story itself. The reason is that in the history of any science there have been points when major revolutions of theory have occurred. For example, the change in astronomy from the earth centred Medieval system to the sun centred system of Copernicus and Galileo; or around the beginning of this century, the shift from the classical physics of Isaac Newton to the relativity physics of Albert Einstein.

Theoretical revolutions in science are like political revolutions, whole theories and ways of seeing nature have been overthrown and replaced. So in a series of revolutions who had the true, real method? Each winner in turn claimed it in his time and was later overthrown. Each new dominant theory can be defended as finally sorting out the scientific method, and then it later gets thrown out itself. This might make you doubt that science gets done always according to one, simple set method. In chapters 4 and 5 of this book, we shall look at one of these 'revolutions', the so-called Chemical Revolution of the 18th century, centering on the discovery of oxygen. We shall certainly see that the story of method does not explain what was going on during that event in the history of chemistry.

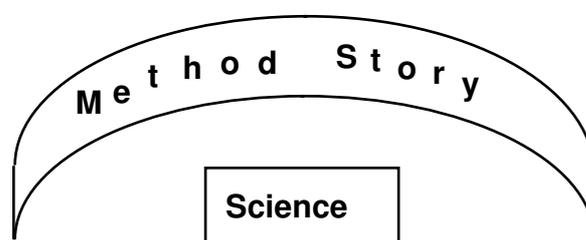
We are heading to the conclusion that all the rhetoric regarding scientific method is one vast cultural network of mythologies. Now, myths are important in understanding how a society or institution works. We should not use the term myth in a derogatory way, myths are not nonsense, they are socially very important. Within a given society, even our own, there are

myths that help explain the nature and purpose of important social institutions, or important social practices. Myths in this respect often take the form of very emotive and convincing stories about how a particular institution or practice originated, or indeed how it works.

In the West we pride ourselves on being scientific and 'rational' and so maybe we have less myths than other societies. This is what we have been taught in the West since the 18th century. We have science, so we don't need myths. I'm going to suggest that the story of scientific method may be one of the most important constitutive myths of the modern West. In fact it is the myth that **"there are no myths, because we have science instead"**. In other words, the scientific method may be a kind of mythic story that Westerners tell each other in order to explain why there is Western science and what Western science actually is.

Chapter 1 introduced you to the notion of science and technology as 'black boxes' in the engineering sense--social scientists and arts scholars have backed away from examining the inside workings of science and technology and have just looked at inputs and outputs. I'm going to suggest that the story of scientific method has helped to cause this--because it is like a shield or barrier around science hiding from us the real nature of what occurs inside the black box. Hiding from us that science is a messy, complex human historical institution, which has been shaped, and is shaped by cultural, political, economic and ideological forces. (fig 4). Science is, in Stewart Russell's immortal words "a seething mass of social-political contention".

FIGURE 4
ENQUIRY BLOCKED BY STORY



I'm suggesting that for too long we've been seduced by the barrier shield--the story of method, and avoided looking at the inside workings of science. Not only do we not open up the black box very often, but our whole attempt to study the social, political economic, and historical relations of science is

blocked by the story of method: "This is what science is--look no further than to this method of discovering and testing the truth".

We may ask how does the myth of method work; how did it start and whose interests does it serve? Once we have deconstructed this cover story, this camouflage, we can then begin to ask serious questions about the social and human reality of how science works and how scientific knowledge is constructed.

Our strategy in going forward is going to be determined by one very important point upon which we need to conclude: underneath the story of method, with its narrative allies, the ideas of scientific progress and Whig history there is something deeper, a belief that makes them all possible, which I shall call the *cult of facts*. This is the idea that the facts are just out there, waiting for the 'good guys' to invent scientific method and start making progress by applying the method to the discovery and testing of these facts.

In the next chapter we are going to try to persuade you that facts are curious things and are much more elusive and flexible perhaps than ordinary, everyday thinking presupposes. Facts are much more historical products and much more historically variable. They are far more socially and politically shaped than we usually give them credit for, especially in science.

The fundamental thing I think we're going to find out about facts is that they are very much a product of scientists' viewpoints, scientists' theories and scientists' choice of techniques; and that we need all kinds of social, political and historical analysis to explain scientists' choices of theory (and hence choices of the facts those theories entrain).

Once you see that facts are shaped by theories and viewpoints, then all of a sudden science has an interesting history, because instead of looking at the good guys picking up facts, you start looking at people struggling to construct, make out and sell certain facts over and against opponents, who want to make and sell different facts.

Appendix to Chapter 2

Understanding the Idea of Whig History:

This appendix is to demonstrate that there is a very special, and misguided, way of writing the history of science. A way of writing that depends upon old fashioned ideas about facts, method and progress. This misleading form of history writing is called Whig history, and we must disassemble it if we are to clear the ground for a critical history of science as a social institution and as a social product of our culture.

The Problem of 'Whig History' in the History of Science

In this Appendix we shall talk about a particular pathology of history writing which we call **Whig History**. Originally, Whig History was a way of writing British political history, but later it infected other types of historical writing, including, most importantly, the writing of the history of science and technology. In many ways it is still with us--especially when people who have not studied HPS try to deal with the history of science and technology.

In 19th Century Britain the term Whig denoted a member of a particular political party, the Whigs, someone who subscribed to the Whig philosophy and the Whig ideology. In the nineteenth and twentieth centuries it has meant people who write history in a certain way, reflecting the beliefs of that party, and that philosophical system.

The Whigs in the nineteenth century tended to be comfortable, liberal, open-minded English gentlemen, and their particular interest, point of focus, was that they were first of all very proud of English parliamentary constitutional democracy. English parliamentary constitutional democracy meant votes for a lot of people. It meant votes for people who were responsible enough to be allowed to vote (this excluded women and male workers of course). That is what they meant by constitutional monarchy; opposing their conception to the Continental European style of autocratic monarchy where the people had no rights--as in Prussia, Russia or the Austro-Hungarian Empire. The other thing the Whigs prided themselves upon was their religious tolerance. Yes, there was a Church of England, but you didn't have to be a member of the Church of England. You could be anything so long as you were Christian. Tolerance did not extend to atheists, Moslems, or very far to Jews.

The great Whig historians, starting with Macauley, evolved a way of writing English history that situated them in the position of the 'good guys' in British

history. The 'good guys' were the people who at any time favoured 'constitutional monarchy' and 'religious toleration' [as defined above]. The 'bad guys' were the people who at any time opposed one or both of those ideas.

English History, from the Whig perspective, was the story of the gradual, but inevitable triumph of the beliefs of the 'good guys' over the beliefs of the 'bad guys'. One example, 1215, the Magna Carta. In reality, the smelly, ignorant lice-infested feudal barons obtained from a weak and indecisive monarch, King John, a written statement enforcing certain aspects of their own privileges. In the Whig view of history, the feudal barons were harbingers, almost the 'discoverers' of the enlightened constitutional parliamentary viewpoint and they were speaking for the masses. They were virtually 'good guys', virtually liberal gentlemen of the 19th century! They were initiating the first steps of reform for us, and King John was a superstitious reactionary.

But consider this: The idea that the barons who forced King John to sign the Magna Carta had anything in common, philosophically, culturally, politically, with the men who in 1850 sat in the House of Commons on the Whig side of the House, is frankly absurd. The medieval barons who argued with King John were medieval barons who argued with King John - they were not 19th century Whigs. The barons wouldn't have wanted the Whigs to be there, to be able to vote, or to be able to say anything. The barons' viewpoint was 'Only barons should have a say about the running of things.'

From this example you can begin to see what the Whig style of history does--it reads the past to find good guys who supposedly agreed with or promoted ideas we now value in the present, and it sees the good guys being opposed by bad guys who, because of ignorance or bias supposedly opposed those ideas we now value in the present. What Whig history does is distort the reality of the issues, ideas, goals and viewpoints of people from the past. It refuses to take past people and events in their own social and cultural terms, and instead 'scores' them against a modern set of ideas and values.

Another example of Whig history at work comes from the period of the Protestant Reformation of the 16th and 17th centuries. The typical Whig historian says:

"There were Protestants and there were Catholics. England is a Protestant country. The Anglican church is virtually Catholic, but its historical origins are Protestant. It's tolerant. Protestants are tolerant. Protestantism is a step towards religious toleration. It's a step against the autocratic authoritarian, monolithic, superstitious, Catholic church. So the Protestants of the 16th century were 'good guys', and the Catholics of the 16th century, not to mention the Catholics of any other century, were bad guys. The Protestants stand on the ground of religious toleration and freedom and the Catholics don't."

I don't know whether you know anything about Martin Luther and John Calvin, but they were certainly not complacent, liberal, and easy going gents like the 19th century Whigs. Calvin was quite happy to burn people who didn't agree with him (as were some of the popes and inquisitors). Unfortunately for Calvin he only controlled Geneva, and the Pope and the Catholics controlled a lot more territory.

Martin Luther would not have approved of merchants and upstart artisans, or for that matter, working men sitting in Parliament. When there was a revolt of German peasants, Martin Luther said to the Princes and the rulers of Germany, you have every right to smash this peasant revolt, for people must listen to their local prince, and not to their local parliamentary monarchy. Martin Luther did not talk the language of 19th century politics. By the same token, these popes opposed to John Calvin, these Renaissance popes such as, Julius II or Leo XII, were cosmopolitan, lavish, materialistic, hedonistic, tolerant of cultural and intellectual variety and novelty. That's exactly what Calvin and Luther didn't like about the Popes; the Popes weren't strict or dogmatic enough. Now which side are we on? Do we need to be on either side? Was the debate in the 16th century a debate between good guys and bad guys, especially when good and bad are defined in the terms of a 19th century English whig gentleman?

The answer is, of course not, and, again, I think you see the point, Whig history is the evaluation and explanation of history from the standpoint of assigning merit and demerit based on some values and ideas accepted in the present. We impose present values upon the past, and miss the

specific, historical colourations of people in the past, their actual ideas, values, aims and viewpoints.

Whig history, in other words takes historical figures like Luther, Calvin, King John, the Barons the Popes out of their own historical contexts; it tears them out of the historical situations where their viewpoints, their actions, made sense; and it then recreates these figures in some kind of mythological way, in terms of what strikes a 19th century Whig historian as good or bad. Now, that is not the way to understand how history unfolds because it just distorts it from the start.

What makes all this interesting and pertinent to us is this: the very same thing happens in the history of science. There are Whiggish histories of science; indeed most histories of science are Whiggish histories of science. They judge the past by the standards of what currently is accepted as true and good in science. In the past there were good guys who foresaw the present truths and worked for them, and there were bad guys, biased, or ignorant guys who opposed the emergence of these truths.

Let me give you an example: Consider Nicholas Copernicus. If you were to take HPSC 2100, The Scientific Revolution, you would be hearing more about him, but for now let's settle for the fact that Nicholas Copernicus (died 1543) was the first modern European to state that the earth goes round the sun rather than the sun goes round the earth. Now, if we were going to study Nicolas Copernicus we'd find out that Copernicus thought only a very tiny number of things that we would agree with today. In fact there is virtually nothing that Nicolas Copernicus believed about astronomy, that strictly speaking we believe in today. **For example, he believed the sun was completely at rest in the centre of the universe, and that there are no other solar systems; that the earth rotates because it is natural for it to rotate, whatever that means.**

Viewing Copernicus in his own terms, in terms of what he actually believed, he's not some great good guy who's making a giant stride in our direction. By the same token, people who disagreed with Copernicus, were not fools. In fact, we would learn that even fifty or sixty years after Copernicus had died, they still had excellent rational reasons for rejecting his theory as scientifically inadequate. In fact, the wild man, the crazy man, the man who

was way out on a limb, was Copernicus, and at the time he was rightly criticised by his competitors. **So we distort history, by being Whiggish about it, when we say Copernicus was simply a good guy on the road to the truth, obstructed by bad guys who, ignorant or evil, did not want to take a step toward the truth.**

There's another reason why Whig history of science is suspect. If we judge Copernicus to be a good guy, we're judging him on the basis of present knowledge. The great historian of science, Thomas Kuhn (cf chapter 8), tells us that historians of science have discovered that every so often in the history of science there are major cataclysmic changes, discontinuous **revolutions** of concepts and theory. If theories change, sometimes radically, after a revolution, what people take as true scientific knowledge after a scientific revolution is different from what was true scientific knowledge before that scientific revolution. (Kuhn's examples of major revolutions in scientific theory include, the Newtonian revolution in physics in the 17th century; the Darwinian revolution in biology in the 19th century; and the Einstein and quantum mechanics revolutions in physics in our own century, and the Chemical Revolution of the 18th century, which we study in chapters 4 & 5 of this book.)

Now, suppose some of our own knowledge might be subject to a revolution somewhere down the track, then our Whig history, written before the revolution, will have to be recreated as a new whig history in favour of the new revolution or theory. So whig history makes history hostage to what we believe right now, even though it is obvious that what is taken to be true and good might change radically later, thus changing the whiggish pattern of 'good guys' and 'bad guys' in history.

When we write whig style history we don't bother to place the historical figures, the historical actors, in their own contexts of value, belief and behaviour, and we fail to understand what was 'reasonable' to them, and what 'made sense' to them, and hence we fail to understand why they were doing the things they were doing, in the context of their own time, their own society, their own belief systems. We make our present values and beliefs (which might change later in history) the measure and the explanation of what they did and why they did it. This tells us about our own beliefs, but not how history is made by the actions and beliefs of people in the past.

Let's look just a little more closely at this problem of whig history of science. Here we can make use of some of the material we have dealt with in the previous chapter. The key point about rather old fashioned--whiggish--thinking about the history of science is that it almost always depends upon underlying belief in the cult of facts and the two inter-linked stories which we have talked about--the myth of method and the myth of progress. Many books about the history of science will treat the material we cover in this subject according to just such a whiggish model:

(1) First, in any whiggish story about the history of science, there is the assumption that the truth, the facts, are out there for the heroes, the good guys to capture. [cult of facts] (2) The good guys, Copernicus, Galileo, Newton and the rest, go about this by inventing and applying 'the scientific method' that supposedly reliable and transferable tool for finding and assessing facts. [myth of method]. But (3) of course the good guys face opposition, from bias, religion and ideology so they can only prosper if they can win some autonomy and freedom for their endeavours. (4) Finally, of course, if all this happens, reliable knowledge of the facts of nature is built up, constituting **progress**.

When we study the work and struggles of people like Galileo, or Lavoisier (chapters 4, 5 and 6 of this book), we shall see that we do not want to stick with some sort of whiggish tale, and that modern perspectives on the history and philosophy of science suggest a rather different and more revealing type of historical analysis. **We are going to see that whiggish history of science depends upon and reinforces the key myths about science--method and progress. Hence we shall see that all these beliefs stand or fall together.** If they stand, we remain at the level of cultural myth and mystification in our understanding of Western Science; if they fall, the possibility of a demystified historical and social understanding of science and technology emerges, and that's where we are headed.