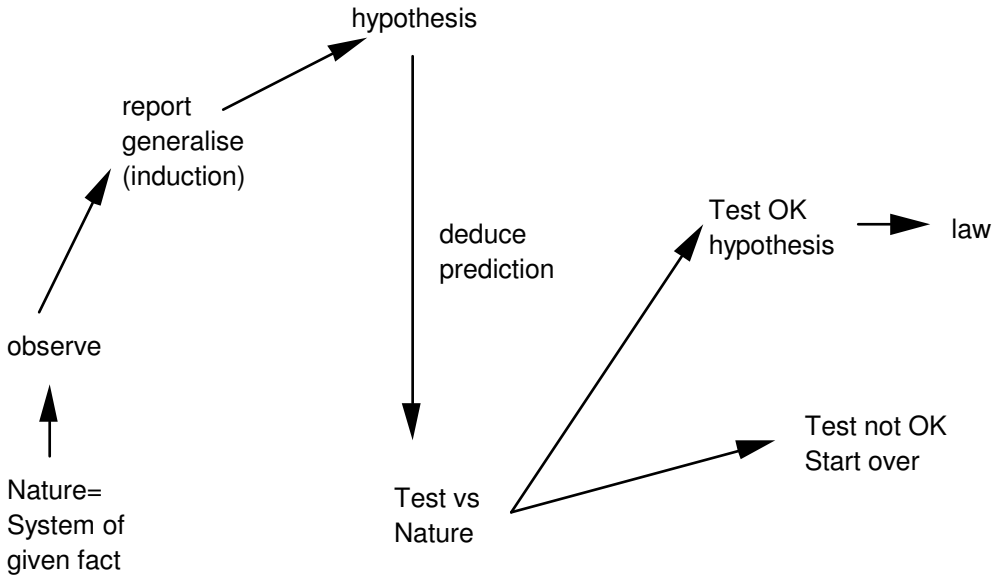
3 The Myth of Scientific Method - Facts and Tests Depend upon Theory and Prior Belief

This discussion focuses on the nature of 'facts' as portrayed in the method story **(fig 1 - method diagram)**. We shall attack the story of method at two weak points--the beginning where we supposedly observe the given facts of nature, and near the end where we test an hypothesis against the facts of nature. If facts are not so simple nor given as the story pretends, then we have to re-think whether the story of method is acceptable and ask again what really does occur in science.

FIGURE 1 STORY OF METHOD



Now, essentially the question we should ask ourselves is:

> **"What if these mythically pure facts are not really available? What if all our reports and observations depend critically on the state of the knowledge, belief, commitment, goals, values which we take with us into the observing/testing situation? What if 'facts' are partially constructed by us" through our observing and reporting procedures, and this cannot be otherwise?"**

Furthermore:

> **"What if facts are not just impressed upon us from the outside, with us as purely passive spectators--what if whatever we take as a fact is always conditioned, shaped, determined, by the beliefs, knowledge, goals and values that we bring to an observing/testing situation?"**

If there is always such a cultural loading of the facts available to humans, then this would necessarily entail problems for the standard story of method: Remember, if anything gets into science, into laws and theories, such as subjective belief, cultural baggage, human political, social concern, then we do not have what scientific knowledge is supposed to be, coagulated fact, which has been tested and confirmed.

That is, the standard story of method absolutely demands and requires that pure, 'nuggets' of fact are available from nature with no admixture of human subjectivity, culture, prior belief etc. But, if human facts are shaped or conditioned by human beliefs and aims, then science becomes a much more complex institutional activity--political, social, historical aspects need to be studied to understand how science makes facts, sustain facts, and sometimes changes facts.

In the standard story of method, there exists a very large assumption about how humans perceive and experience facts, a 'naive theory' of perception, if you will--sometimes explicit, sometimes implicit.

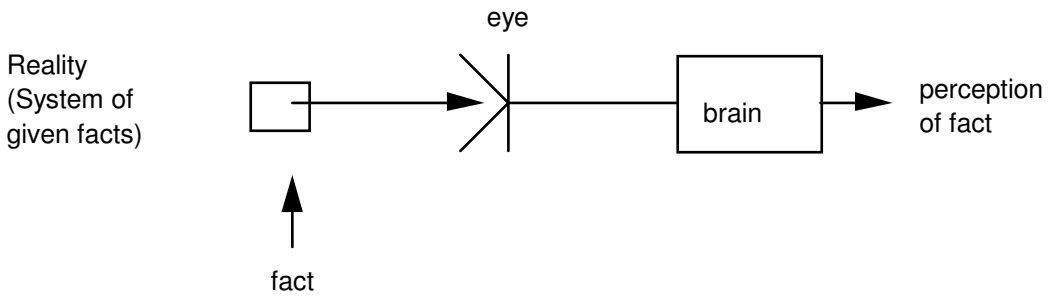
This naive theory of perception is a traditional story that has circulated amongst ordinary people, amongst western philosophers, and since the Ancient Greeks, amongst philosophers of science. It's a story that tries to tell us how we can get in touch with reality **through our perceptions**. This is the story (fig 2):

> "There is the world, the material world. It's a systematic collection of facts. Facts in the everyday use of the term facts. Over against the world, the object, is the perceiving subject with his or her visual and cognitive apparatus. Assuming the subject, the observer, is unbiased, free from social and cultural prejudices, he/she will receive true perceptions of reality--external facts."

The story in effect states that under good conditions of observation, facts in the world, or information about facts in the world will be conveyed to the sense organs, in this case by light. The information goes through the eye, registers on

the retina, (never mind that most facts are three dimensional but the retinal image is more two-dimensional and upside down). The information comes through your eye, it goes through the optic nerve into your brain and you have a perception. A perception of a fact. **This story 'Truth' therefore consists of the correspondence between perceptions and facts.**

FIGURE 2 NAIVE VIEW OF PERCEPTION



This is a story of a simple causal chain. **"World>Fact>Sense Organ>Nervous System>Brain>True Perception of Fact"**. This simple causal chain works, (this is still a story mind you), when everything is in good order, for example, when your eye is not damaged, the viewing conditions are adequate, you are not drunk, you are not insane, you are not stoned; and also when you are not politically religiously or socially biased. *Bias* would get in the way, for it would be an internal source of static or 'noise' which would interfere with the perception of facts; it would disrupt the causal chain. So, if everything is in *good order* and goes nicely, we can perceive the facts.

Facts of the matter on the outside get reproduced/represented on the inside. In the diagram 'Fact A' which is a part of that objective structure of facts which we call 'reality' is mirrored in the 'perception of Fact A'. A traditional metaphor of Western philosophy involved here is to assume that true knowledge would be a **perfect mirror image of external reality**.

The causal linkage, if everything is working correctly, would be that honest, healthy people have nice honest healthy perceptions. Yet how plausible is this suggestion? We can't disprove it. We can only provide evidence against it. You can't disprove a theory. You can only pile up a lot of evidence against it and hope that the evidence persuades your audience to accept a different conclusion.

Now it's time to look at some examples of so called *Gestalt figures*. (figs.3 & 4). Gestalt is a German word meaning form or shape. This type of diagram has been the subject of much investigation in cognitive and developmental psychology during this century.

FIGURE 3

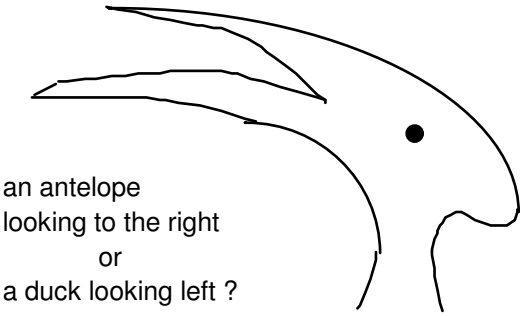
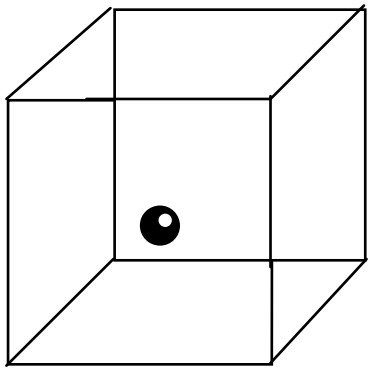


FIGURE 4



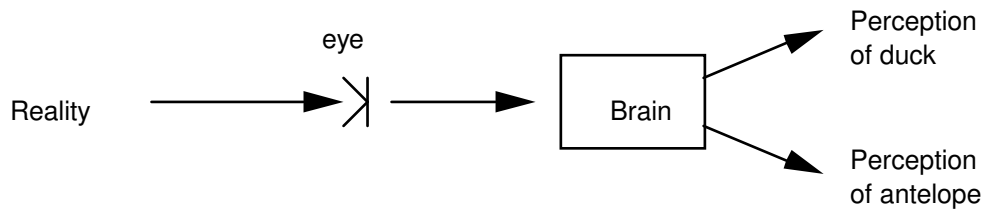
The Gestalt experience may be described as an experience in which you perceive something, then at the next moment you perceive something completely different. You oscillate or snap from one perception to the other. In fig 3. you will perhaps perceive either a duck or a rabbit. You may see a duck and a rabbit, you may see an antelope and a duck, you might see an 'alien' and a duck. This may occur because we've been treated to twenty-five or thirty years of the occasional science fiction movie, where it just so happens that the 'aliens' took some form that we, the viewers, somehow recognise. It doesn't matter which two you see as long as you have two different perceptions.

Some people have trouble seeing the two images in figure 3. If you can't see one or the other perhaps you can be 'taught' to see them. It's a very interesting idea that you can be taught to see something by members of a certain culture. (Maybe scientists as members of a sub-culture are taught to see things--the objects of scientific inquiry!)

Now a problem occurs, because you will admit that in figure 5 you perceive one image and then another different image. Presumably the paper is not

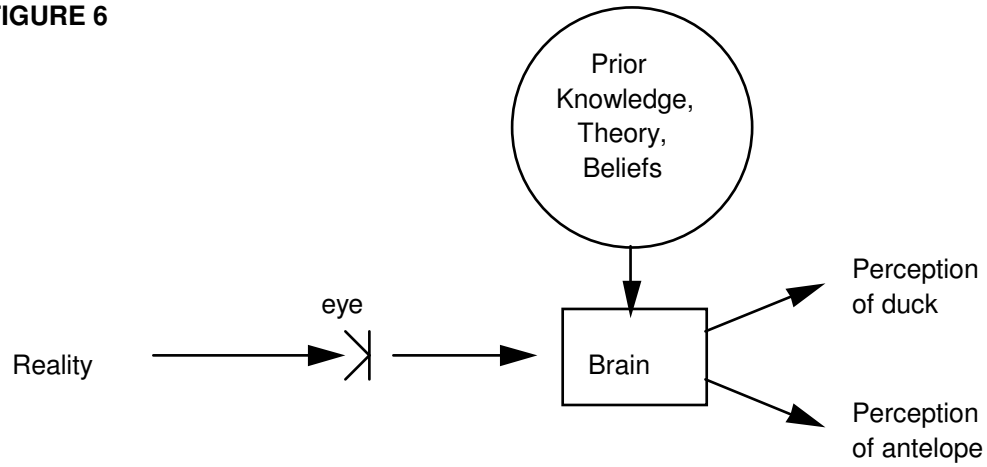
changing; the air and the light are not changing; your retinal images are not changing. However, when we talk about your optic nerve, I'm not sure, that we can say nothing is happening there, but let's for the sake of argument say nothing is changing there: **but it appears that something is changing because your brain is giving you two different perceptions**. You are receiving a perception of a fact which is a duck, and then you are receiving a perception of another fact which is an antelope.

FIGURE 5



How can this be? Obviously, we are going to have to fix up this naive man's theory regarding the perception of facts. There is a simple way to repair it, but the remedy has far-ranging consequences. (fig. 6) At the moment, we have one set of causes which is the incoming information. The same incoming information, however, gives two different perceptions. Behaving in a scientific manner (to save my theory) the easiest way is to add another set of causes. That will explain why we get two sets of perceptions under these circumstances. So I will call the incoming information from the world Cause 1. Let's introduce another set of factors (Cause 2) which we will call *prior belief* , which includes beliefs, aims, values, knowledge; in short, whatever you knew or believed before you looked at the Gestalt figures.

FIGURE 6



The final theory is that perceptions are caused or produced by the joint action of two different causes. One cause is the information in the world, and

obviously this information is not merely a small picture of a fact, let's suppose its just some pattern of electromagnetic disturbance. The other cause, which is conjointly necessary, is some form of prior knowledge, or prior belief, or prior theory.

This thesis suggests that you cannot have a perception, **without having both of those causes acting to shape and manufacture the perception.** You need an external input of electromagnetic disturbance and you need some prior knowledge to fuse it with. Depending on which bit of prior knowledge gets fused with the information, your brain **produces** one perception or another--perception of a duck/perception of an antelope. If you like, perceptions are manufactured products, perceptions are manufactured by your brain. Electromagnetic stimulation of the eye alone can't make a perception and neither can your prior stock of knowledge alone make a perception. It might make an imagination or a dream image, but not a perception. And yet, in this theory, it is quite obvious that what we perceive is not floating around in the outside world and wafting into our eyeballs--we literally make our perceptions inside our heads--using raw materials from outside and inside--otherwise no perception could occur!

What I'm suggesting in the duck/antelope case at hand is that in the vast array of your prior knowledge or prior belief, which is encoded in your brain [and God knows how that works because neurophysiologists don't quite know yet], those of you who alternately perceive 'duck' and 'antelope' certainly have two bits of theory which run as follows:

•***Bit of theory number 1:*** "In the world there are antelopey-like things". The theory probably goes on and asserts certain properties and characteristics about antelopes. You might say that you have a concept about antelopes or you have a **concept** of *antelopiness*. You obviously have a little space or node or bit of prior theory or prior belief or prior concept which concerns antelopes.

•***Bit of theory number 2:*** "In the world there are ducks", and you have a **concept** of *duckiness*.. You obviously have a little space or node or bit of prior theory, prior belief or prior concept which concerns ducks.

Now when you perceived the duck, your brain was processing the information through the 'duckiness' section of your knowledge framework, and so your brain produced the perception of a duck. Your brain didn't have a perception of a duck before you looked at the figure, it only had a conception of, prior

knowledge about, a theory of ducks in general; and it only **made a perception** of a duck when it received the incoming information, and molded it that way through your duck theory. But, in this Gestalt situation, the brain was having a little trouble knowing which bit of prior knowledge to apply, and in knowing which perception to construct. Your brain was unable to 'decide' which perception to make, so it alternated between one, and then the other. The two different perceptions coming from your brain squeeze, knead and mould the incoming information through two different pieces of your prior knowledge, which are your *antelopiness* concept/theory and your *duckiness* concept/theory.

I call this shaping of perceptions by prior knowledge, belief, values and aims

The Theory-Loading of Perception.

In other words: We can get two perceptions from the one Gestalt diagram in the outside world--because two operations need to occur in order to form a perception: (1) you need incoming information from the external world--electromagnetic disturbance and (2) you need to process it to form perceptions--processed by the brain using its pre-programmed stock of knowledge, belief, goals, values.

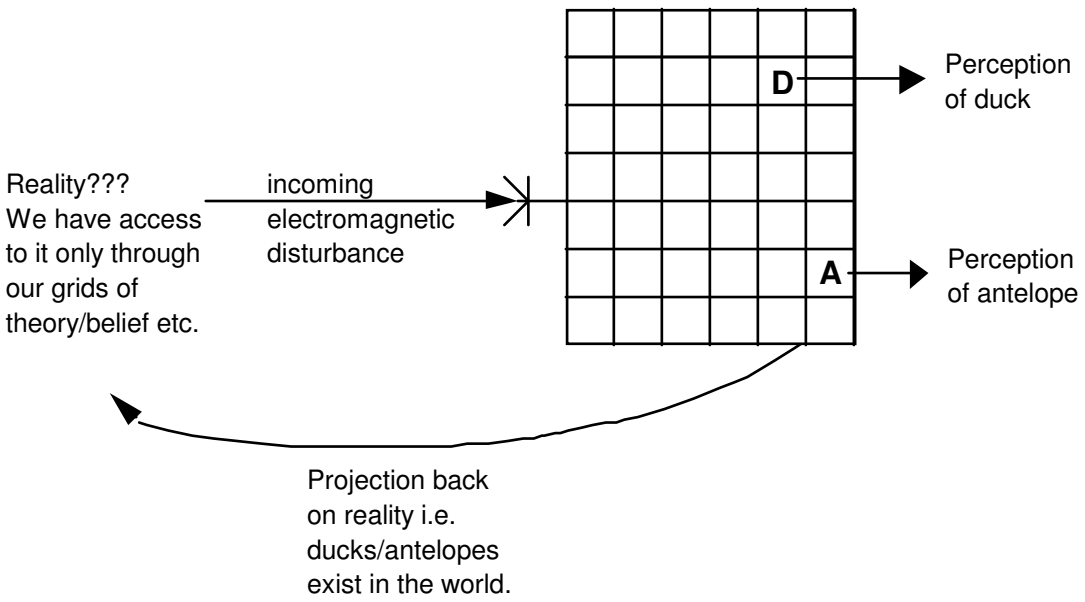
The incoming information is neither a duck, nor an antelope in the sense that your concepts define them--its just an electro-magnetic disturbance. So you have a duck or antelope perception, because the disturbance is alternatively molded and manufactured and shaped into a duck or antelope perception by the brain using its available duck and antelope concepts.

In this case your brain does not have enough of the usual cues--more electro-magnetic disturbance--to make a firm decision about processing your perception. So the brain flips its processing--what perception should it make...?

I have a metaphor that helps us make sense of this. Let's take the brain out of figure 6 and put in a gridwork - a network (fig. 7). These grids are a kind of a metaphor for the **network** of theories, beliefs and concepts that you hold. You have a grid of prior knowledge, prior belief, and I would say that along with knowledge and belief, come values and aims. We may say that one of the little nodes or spaces in the grid is probably your concept or theory of *antelopiness* , and one of the little nodes or spaces in the grid is your concept or theory of *duckiness.* Your brain is squeezing the "sausage meat" of externally derived

information through the antelope node and making a perception of an antelope in the one case; or, not being sure which perception to make, and squeezing the sausage meat of information through another little bit of the grid which is the duck concept and making a perception of a duck.

FIGURE 7



This is very interesting because what it really means is that the actual contents of the external world become a bit of a question mark. The world becomes a question mark because ultimately we do not directly know which objects it is divided into. **The world exists** but we don't know which facts it is divided into, because we only have access to facts which are constructed through our perceptions, and these perceptions are ultimately shaped by our conceptual grids.

Ever since we were children we have psychologically projected our grids back onto nature, and assumed that nature is divided into those facts defined by our evolving grids. As many philosophers, anthropologists, psychologists and linguists in this century have told us, people chop up the world according to their prior beliefs and theories. They view the world as being inhabited by various kinds of things depending on the categories set in their grids by belief, theory and language. It doesn't mean that there's no world out there. There is a world, but it only gets shaped for us, for our perceptions and our reports (facts), by our grids. And grids can vary from society to society, from one historical period to another, and with different groups within a society. The study of the history of human knowledge and belief is therefore the study of grids and of the factors--social, economic, political and cultural--that preserve or alter grids. In this respect the history of science is no different than the history of theology or myth!

Obviously grids are very complicated. We wouldn't begin to know how to map one completely or how to take one apart. We only have little intimations that they exist, partial maps of them perhaps, through the work of anthropologists, linguists, sociologists and historians. However, we can say certain things about grids:

First of all, its pretty clear that different species of animals certainly have different grids at the level of *hardware*. Some animals have grids that only allow them to perceive interesting prey, especially when the prey is in an interestingly vulnerable position. I suppose certain kinds of flies and spiders and frogs are wired up that way. The main purpose of their grids is to give them a perception of what's presumably good to eat, and what is in a position to be eaten. Well, we're all human beings and so we have the same hardware. It's the software that makes the difference, and the most important software program constituting our different grids is the particular language we speak. One can argue from history, anthropology and linguistics that different languages will, as it were, shape the world differently for the people who live within, and speak a particular language.

We can articulate the metaphor of hardware and software with the idea that presumably our *hardwares* are all the same, since we are all *homo sapiens*. But, culture, learning and development within a culture, learning a language, 'programs' us with slightly different softwares. Then, within a language community there may be different cultural/social categories to consider. For example, we all speak English, so we have largely the same broad language software; but, perhaps we're not all members of the same religion, political ideology, or social class. Presumably experience and participation in different cultural/social settings gives us, **at least at the margin**, slightly different grids. We could all be of the same social class and still have differences. There may be different special activities; for example, we might all be middle class academics of Catholic background, but, some of us may be professional economists while some of us might be professional HPS people. We, therefore, by virtue of these differences would have slightly different grids. We'd make out slightly different reports with slightly different facts. Of course, even if we were all middle class academic economists of a Catholic background we might have different theories within that specialty. I may be a right wing economist of the Milton Freedman type, and you might be a left wing economist. All these differences up and down the line can be registered as subtle differences

in the grid, therefore, differences in the types of facts that people perceive even under the same circumstances will occur.

In sumation I would like to say that the kinds of facts you are capable of perceiving/reporting depend upon the nature of your conceptual grid.
There are no little pictures of objective facts flying about and entering our eyes--those perceptions are manufactured in human minds, using prior cultural material and beliefs.

Change your grid slightly and the possibility of some facts disappears, and the possibility of other facts comes into being. Knowledge of the outside world does not lead us to this situation--our focus is on people and their perceptual/belief commitments--their grids.

Facts of nature do not determine grids--grids determine the ranges of possible facts within a given cultural group or sub-group.

You may think that this is not very important, because in everyday life these situations do not happen very often. I admit our concepts are well entrenched and our usual array of electro-magnetic cues are well established and so our brains, through education and socialisation, give us a fairly stable, unambiguous array of perceptions.

But what about at the frontiers of science--or anywhere facts and beliefs are contested and in conflict? At the frontier of scientific research, for example, new things are seen and proven to exist or not exist. Perhaps something a lot like a Gestalt switch goes on as facts are ruled right or wrong at the research front, as researchers argue about what is being seen and what is not being seen.

Yet we must ask ourselves where do these conceptual grids come from? From human socialisation and language as indicated certainly, but that does not explain the existance of new or changed ideas, and hence new or changed facts. Concepts don't change because nature imprints a new correct concept, but because we manipulate concepts in the grid by analogy, metaphor, associating, at the margin.

For example we may ask why 17th century scientists began to form a different picture of the cosmos from their Greek and Medieval predecessors; that is, the change from a finite, earth centred cosmos to an infinite universe of star and planet systems. If we follow the old story:

> **During the 17th century some dedicated objective scientists came along and invented scientific method and through using scientific method they discovered the right facts and theories.**

or, following the view just given:

> **The people who believed the earth stands still and the people who believed the earth moved are not bad guys vs good guys; or people without method and people with method; or people with (bad) cultural beliefs and people with no cultural beliefs. No, both groups had cultural beliefs; both groups constructed natural facts through those beliefs, so it must have been that social, economic, and cultural forces shaped changes in the grids, and those changes in the grids made nature appear different at the margin of contention.**

So, in general,

If you want to explain how and why scientists change their minds about facts and theories, do not tell me stories about discovering new objective facts--tell me how and why and under what conditions their conceptual grids changed--and to do that you need to explore the social, cultural, political and historical aspects of science.

Instead of making everything depend on poor old reality--the old world of given, objective facts, about which we do not have any real direct insight--only manufactured insight, structured insight, we should say that different scientists can perceive different facts--the kind of theory they are committed to determines the types of facts they can see.

We can go even further in exploring this fruitful idea of the theory loading of perceptions and facts if we concentrate for a moment on **language**. We shall see that languages shape 'facts' for their speakers and that languages contain implicit theories which do that shaping. The argument here would be that different languages shape the world of facts differently. It's not a question of some people making errors, because their language 'gets reality wrong' and someone else having a language that gets everything right; that is, reflects 'the world as it really is'. Languages do not get the facts of nature right or wrong--instead different languages shape the facts that are taken to exist in slightly different ways. I suppose that in the nineteenth century Europeans believed

that their languages reported the world correctly, but that the languages of native peoples reported the world incorrectly. This today becomes simply a question of different languages chopping up the world differently. Different languages embody different theories of what things exist and the things that exist interact.

Now, let me give you the verbal/symbolic report. -- "The chalk I am holding is white" -- a perfectly reasonable **fact**. My verbal/symbolic report, my stated fact, is a text in an Indo-European language - Standard English. Now I don't deny that is a fact, especially as this is a *widely accepted report* within a certain language community, and that it is a fact for that community; doing useful work in their everyday activities and communications. So, I do not deny that fact - "the chalk is white" - **but I do wonder whether there are any theories implied in that statement; I wonder whether my language pumps certain theories about the world and its organisation into this seemingly banal, and factual, statement.**

Are there any theories about the world involved in saying something as seemingly simple as the 'chalk is white'? -- 'It **is** white'. This statement seems to run along a line of theoretical cleavage in which 'whiteness', or 'being white' is a state that things have or they don't have. The same holds with any other colours when we discourse about them in English. For example, 'The tape recorder which I use to record my lectures **is black**'. This implies that it possesses blackness. Blackness is something it has in it. There is a very strong implication here that white, black and other colours are kinds of things or substances and that they are spread around the universe and that some things possess colours and other things do not. All of this seems to follow from the way in which an Indo-European language like English formulates the relation of subjects and predicate adjectives around the simple verb "to be". It is implied that subjects of sentences possess other things, particularly the qualities named in the predicate. The language implies the universe is stocked with things, subjects in sentences, which may or may not possess various other things--the different qualities and properties which can be predicated of them, using the verb 'to be'.

But, is this the only way to speak about chalk and its presumed colours? It is not. There is, for example, the language of physics as it has developed since the seventeenth century, since Newton really, but more especially the during the twentieth century. In this language colours are not properties in the world possessed or not possessed by objects. I'll give you an example of how this

other language works to divide up the world into things and their relations, but I'll give it to you in a very bad translation because I'll give it to you in English, whereas it should be stated mainly in mathematics. In English this other story goes like this: [Let's say, by the way that the chalk was red, because white is a very dodgy colour in this physics language--not a colour at all, but the presence of all colours at once!] Here then is the English translation of physics language on this issue:

> *Everything is made out of atoms and molecules; each type of atom or molecule has a characteristic way of absorbing and then re-emitting certain parts of the electromagnetic spectrum. The surface layer of this chalk is made of molecules which have the characteristic of absorbing certain bits of the spectrum, but re-emitting mainly electromagnetic radiation in that part of the spectrum which, when it strikes our nervous system, makes us apply the term 'red'. In other words there is no red, there are only interactions of electromagnetic radiation and molecules. And in a very real sense, the chalk isn't red, the chalk reds.*

This carries the implication, the theoretical cleavage, that the redness in our minds is the result of the interaction between us, the chalk, and whatever else there is in the universe. It is not that 'the grass is green', rather in physics we are closer to saying 'the grass *greens*'.

The world according to ordinary English and the world according to the language of modern physics are two different worlds really. In one world there are the colours that float around and attach themselves to things and in this other world there really are no colours, only relationships between atoms, molecules and energy. The two worlds are the creations of, and are expressed in, two different languages. The two different languages carry with them two different ways of giving reports, so that the two different languages divide up our reports and hence our worlds into two different sets of facts. Different languages-different facts; different theories--different facts. We call this **The Theory-Loading of Facts**--and it is very important for our understanding of how science really works and has developed.

Thus far we have been dissecting the key assumption in the myth--what we might call the cult of fact: The idea that there exists a world, a system, a set of given objective facts. They are just there and they are waiting for the good guys to arrive; the good guys who have the method in hand. If the good guys have the method and are unobstructed, they will be able to use the method to

uncover and test the facts and turn them into knowledge. What I suggested to you was that facts are not really so hard: They're not really that given; they're not just given out there ready to be uncovered (discovered), that facts are much more constructed than given.

After all, facts do not equal what strikes our eyes--electromagnetic disturbance; facts are not even as simple as our private perceptions--and we've seen that perceptions are the joint product of inside grids and outside information. We concluded that facts are communicable, discussible reports--verbal or symbolic reports which may relate back to our perceptions; but are also heavily shaped by the languages and theories or systems of communications in which we can utter or form the reports.

This means that facts are social constructs: contending groups and individuals struggle to construct and impose certain facts on others in science and in society at large. It means that facts are historically variable, the facts are different for different people at different points of time; and different for different individuals and groups at the same time. The facts are therefore negotiable and revisable rather than eternal. Most importantly, it means that when facts change and are altered--we don't look to see which good guys finally saw nature correctly and objectively--we ask which group won, why certain groups constructed their facts the way they did, and what political, social, intellectual and historical factors shaped and affected the way the facts were made and unmade by the contending parties. To explain scientific change we don't invoke a mythical method, we ask sociological, historical, political and economic questions about the players.

These findings about the theory-loading of facts are very corrosive of the traditional story of method discussed in the last chapter. Clearly, it remains true of humans that they observe things and generalise about them. But, now we can see that everything tends to depend upon the grids or theories or categories that humans take to the observing situation. You will observe, report and generalise about types of things and events which are allowed for and exist in your theoretical grid. **In other words, certainly humans observe and generalise, as the method story states, but that is only half the story, because the facts you generalise about are, to a very large extent prefabricated by your beliefs, aims and theories. This means that two contending parties backing different theories, can both say that they are obeying 'scientific method' because each will tend to observe and generalise about the sorts of facts shaped by their own theory.**

Similarly, the idea of theory-loading of facts is corrosive of the other side of the traditional method story--the point at which we test predictions against the facts revealed in experiments or controlled observations. Again, nobody is denying that humans perform tests and experiments and that they compare the results with their predictions. To that simple extent the traditional method story is correct. **But it's only half the story, because if observations are theory-laden, then of course the observations that humans make of the results of tests and experiments will be also. Again, people with differing theories or prior beliefs will tend to observe different facts in a test situation or experiment.** This undermines the idea that the facts are simply given to us from nature, and that objective method-obeying humans can simply compare THE FACTS to their predictions. The theory-loading of observation and facts infects the testing situation as well as we shall see later in chapters 6,7, and 9 of this book.

In the next two chapters I'm going to illustrate much of this for you with the first of my concrete case studies--I'm going to talk about some old and outdated chemistry, and some chemical debates in the 18th century; debates not between the good guys who discovered oxygen, and the bad guys who did not discover oxygen; but debates between two sets of people who held different theories, different aims, different languages, different vested interests, and who had different ideas about what the facts of chemistry were. It's a good case, historical cases often are--because both sides are dead, and so are their ideas--so we don't have a vested emotional interest ourselves in their debate. Hence we will be able to discuss whether oxygen is an objective fact of nature--or a social construct, a construct, moreover, created and modified over time through a chequered history of struggle, negotiation and modification.