26 Social Factors in the Scientific Revolution

We have been talking all through this book, about the internal social political complexion of any given scientific discipline. Any science is not just a scene for a repository of ideas but a scene of professionals struggling to establish their own claims about the facts and theories as the accepted ones (for the time being). Remember, we deconstructed a Kuhnian model which would have two block paradigms competing in the Astronomical Revolution, into a time series which would have people struggling with each other in the field of astronomy (fig. 1). This then was the field at the time--they were all in the same field--but they occupied different positions and made differing 'bids' within the field. We then looked at what was around the field -- the external factors. We have to look at those now in more detail.

What type and kind of factor can be in the larger environment to shape and effect a science? Let us remind ourselves about a few things concerning our discussion about Internalism and Externalism. One thing we decided was that it was extraordinarily silly of the Internalists to deny that no external forces could act on the sciences, for this is *prima facie* bimplausible, except to them, because they were so anxious to defeat the Marxist version of Externalism. On the other hand, one of the main points from the previous Chapter is that traditional Externalism was too simple in assuming that large social and economic factors simply imprint their shape and content on the sciences as though the sciences are simply wax in the hands of these external forces. It is because we see the inside of any science as a sub-culture that we know they must have some momentum, otherwise they would not qualify as 'institutions', so they are not immediately or totally shaped by the outside at any given moment. We used an analogy of the development of universitites as sub-cultures: How universities are obviously susceptible to and dependent upon external forces but were not at any given moment the imprinted results of whatever external forces there were at that particular time, because they have institutional momentum and inner social complexity.

Let us turn then to External factors in our new model: Firstly, consider the kinds of factors discussed in the classic Externalist literature. In the Marxist view, the factors of 'technological push'; that is, the expanding commercial capitalist economist creates technological bottlenecks (problems) and modern science is created on that story of solving those 'problems'. There is very little direct evidence (which means there is some but at this level we do not need to go into it) that 17th century physics, optics, mathematics, anatonomy (the sciences) were directed toward or even capable of solving these 'technological push' problems.

When we talked about J.D. Bernal, it was clear that he had recognised this and wound up saying that the 'big' result of the economic and social changes of the 16th and 17th century was not the solving of these technological problems but the invention of scientific method. Scientific method went on to solve these problems in the 18th and 19th centuries. If we are going to reinstitute external factors (which we need to) the answer does not reside here, although obviously there is something to be said for the emerging capitalist economy which we will discuss shortly.

So, let us think about some of the things that we have studied and now look at other external influences that we have stumbled across. What about religious belief and the institutions that support them? I believe that, quite independently of the economy of the time, one can look at the factor of religious belief and the institutional relations that support those beliefs, as a factor and shaper of scientific theory, and, in fact, a shaper of

the history of science in the period. This is one of the key external factors. I do not simply mean collections of religious ideas and religious beliefs--I mean beliefs and ideas grounded in how people lived and related to each other and found themselves in institutional relations to one another.

The best example of this breaking through and making a difference of religious factors is the Galileo affair. Just because we were sympathetic to the astronomical position of the Church does not mean that this affair was not a very good case of religious belief and religious institutions shaping the direction and content of science. It is a classic case of external cause. We only looked at the Catholic viewpoint. We did not look at the range or variety of Protestant responses to this affair, which is much too complicated to discuss in the amount of time allocated in this subject.

The Catholic Church as a constellation of institutions (ie: universities, schools, central workings of the Church as a body of belief which was decided upon and enforced), was saying it had a right to decide on the content and direction of natural philosophy and astronomy within its sphere of influence. They were serious about this, they had been doing it for centuries. They viewed Galileo as going too far, too fast in a direction that the Church was not ready to accept. Why? The reasons could be many. One: Not wanting to upset the structure of popular belief. Two: Not wanting to be embarassed in front of Protestants. Three: Not wanting to be pushed faster than the institution could move. For whatever reasons, the astronomical debate with Galileo and the repercussions around Galileo have to do with the Church, as an institution, claiming some power and legitimacy in the debate This debate is not about the 'bad' people versus the 'good' or superstitious people but simply the institution (the Church) claiming what it thought was its legitimate power.

Here is another more diffuse example of external factors. Science and natural philosophy are pursued and investigated and believed in by people for reasons. Some of the reasons are social values and beliefs they hold; the goals that they want to see pursued; the sentiments that they embrace. In other words, people select viewpoints in natural philosophy and the sciences because of their goals, values and interests.

We have seen that one of the big divides in this period is between Aristotelianism as it was practiced and taught in the universities on the one hand, and on the other hand magical neo-Platonism and mechanical philosophy. In other words those latter two schools of natural philosophy were on the same side of this particular divide that we are talking about. This divide involved the issue of what is the goal of a natural philosophy? What values are promoted or expressed in the pursuit of a given natural philosophy? What social interest is pursued in doing natural philosophy? The difference here was that the neo-Platonists and the mecahnical philosophers said their goals, values, aspirations were very much tied up with the desire to achieve systematic knowledge permitting the control and manipulation of nature--the exploitation and appropriation of nature. This was supposedly for everyone's benefit-- hat was the covering rhetoric but obviously it meant for the benefit of whoever could make the most progress in those ways.

By contrast, Aristotelianism in no way represented those values and sentiments. It had never been designed by Aristotle and his followers to represent those sentiments and as a scholastic, academic, university-based pursuit for educated members of the elite it did not preach or endorse those values, for it endorsed values of contemplation, passive observation and appreciation of knowledge and system of the knowledge, but certainly not knowledge for use.

Where did that contrast of social values and aspirations come from? We won't completely be able to answer this question here, but we will be heading in the right direction. The difference of social values and aspirations did not drop from the sky or grow up simply within some systems of ideas. Those differences, those cleavages must reflect different social locations or social groups or different social loci where aspirations and goals are being reformulated and being imposed on natural philosophy. So these differences point us in the direction of the larger society and socio-economic changes. Therefore, there are things happening in the society making some people demand a kind of practicality, utility, operation, power of exploitation out of natural philosophy and the sciences that had not been demanded before. That does not come from within the sciences and natural philosophy but can only come from outside.

Now I come to the toughest part of this argument, but perhaps the most important. If you were to ask me what the single most important external factor on the shaping and development of the sciences was in that period: I would say it was the existence of a sub-culture or institutional field of natural philosophizing (of doing natural philosophy). In other words the most important 'external' factor on the sciences was the cultural and social institution of doing, selling, learning and practicing natural philosophy. This is difficult to understand because there is no such thing as 'natural Philosophy' in modern science. Natural philosophy died in the 19th century because the sciences became so various and complex that nobody could persuade themselves that there was one big picture that embraced and controlled all the sciences.

What was natural philosophy for? This is the key question which educated men in this period, from the Middle Ages down through to the 18th century. Originally natural philosophy was a Greek attempt to get to the 'big picture': What is matter? How is it organised? Why are there changes? How do you know? It just so happens that Aristotle's natural philosophy was the most successful in the West and the one that was Christianised and institutionalised into the universities in the Middle Ages. This is only one kind of natural philosophy. We have also looked at neo-Platonism, mechanism and Newtonian natural philosophy. Generally speaking, what was natural philosophy for? It was used for two large functions which the people of the time thought were crucial.

The first function of natural philosophy was to provide a foundation, and a ground and a legitimation for theology and moral values. In other words, nobody was educated unless they had grounded and based their knowledge of religion and theology in a firm knowledge of natural philosophy. This was what the struggle of the Middle Ages was all about with Aristotelianism. Could you make it Christian enough so that it could adequately be put into the universities as preparation for theology? This was the battle that people like Thomas Aquinas fought. Students often ask why were these people so concerned with religion and this is the ultimate answer: natural philosophy was thought to be linked to religion. You had no firm religion without an appropriate natural philosophical base: you did not have an appropriate natural philosophy unless it is linked to religion. But, which natural philosophy, which religion? (fig. 2)

In our period there are Protestants and Catholics, and obviously if you live in a Protestant area you are taught natural philosophy as a basis for your own Protestant belief. If you live in a Catholic area you are taught natural philosophy as a basis for Catholicism. Everyone shares that Medieval assumption that natural philosophy is there as the basis for religion. Which natural philosophy is another question.

Basically, during the Middle Ages and throughout our period institutionally speaking it is Aristotelianism that is the appropriate basis. Anybody else who comes along to challenge Aristotelian natural philosophy has to face the problem of what are the religious implications of what he is saying. If you want to be a neo-Platonist or a magical neo-Platonist you have to show how to get a valid Protestant or Catholic position linked up to your natural philosophy. If you were to be a mechanist you would have to show how to achieve an appropriate religious linkage for the natural philosophy--Catholic (if you were Descartes) mechanism, or Protestant mechanism (for Boyle, who was a Puritan). This is what educated men had in mind when they studied natural philosophy: the religious question. How does this link to religion? Does it form a basis for my religion? Is my religion firmly grounded in it? Is your natural philosophy dangerous to my religion? Do I not like your natural philosophy because of its religious implications etc. are the terms of argument and aim..

The second function of natural philosophy was to provide the guidance and shaping -- the formative background -- to the sciences. Your natural philosophy provided the metaphysical background to any scientific work you might do or endorse. It provided the deep conceptual background and shaping to scientific work. (fig. 3) We have seen examples of this in astronomy. The Ptolemaic system of astronomy lived and breathed in relation to Aristotelianism. Copernicus and Kepler's version of astronomy were grounded in neo-Platonism which provided the stress on mathematical symmetry and simplicity as a criterion that was not allowable or present in Aristotelianism. In mechanism we've seen it as a shaper and a background to Copernicanism--its final triumph--and we know that the mechanical philosophy formed and shaped certain scientific directions which are still echoed today.

For example, the mechanical philosophy emphasised the mathematical study of physics. It also fostered the study of what was called Mechanistic Physiology (Descartes' *Man the Machine*) with his very bizarre theories of the workings of the body. Again you get mechanical philosophy shaping scientific work as the background metaphysics.

So, those are the functions of natural philosophy: up to ground theology and moral values; down to shape the sciences and that is why natural philosophy was the key intellectual **field of struggle**. Notice I say 'field of struggle' for there was an institutional centre where someone was 'in the driver's seat'. Who is it? University-based Aristotelians were in the driver's seat. Young men could be indoctrinated into Aristotelianism this way but there were people outside: Neo-Platonism was very much a creature of princely and royal courts and a creature of centres outside the universities: A creature of thinkers and intellectuals around the great printing houses where non-university based scholars and thinkers were gathered. (fig. 4)

So, for example, when Copernicus went to Italy he did not learn neo-Platonism at the University of Padua, which was a great Aristotelian centre, he picked up this neo-Platonism at the extra-University intellectual environment (and we know that he put his neo-Platonism to work in his astronomy). Another example: Magical neo-Platonists, such a Paracelsus, began to creep into social levels and parts of the social hierarchy that were not acceptable to the elite. This was a period of increased literacy, and when Paracelsianism as a radical neo-Platonism started to seep into the level of educated artisans and semi-literate people, this scared members of the elite. Natural philosophy had not been possessed by people of that kind of social background before. This means that natural philosophy was available to everyone (up for grabs) and we saw how the mechanical natural philosophers were rebelling against the such people gaining

possession of natural philosophy, and this was one determinating factor or a social outcome in a field of natural philosophical struggle.

In other words, just as I have argued that any given science--like Astronomy--is a field of struggle, natural philosophy, (which was more important than any one given field of science), **was itself a field of struggle over this entire period**: a struggle in print, in the universities, in the princely courts, a struggle (you might say) over the emerging literate public.

The long-term trend is the erosion of Aristotelianism as dominant; the upsurge of neo-Platonism, especially magical neo-Platonism which raises the stakes because it reaches down into the social hierarchy. Neo-Platonism starts to propose religious and social reforms around the turn of the seventeenth century--people like Giordano Bruno and the Roscicrucians--and that begets a backlash by people of a more establishment bent who want to be progressive in the sciences (they do not want to go back to Aristotelianism), who become mechanists.

This is not just a fight about ideas, but a fight of groups representing certain issues and places in society, so it is no different from the politics of knowledge in the modern world, except what they were arguing about is different because we no longer argue about natural philosophy. So, if you trace a science in this period, perhaps astronomy or some other science, you find it variously metaphysically shaped in various competing natural philosophies; and that the natural philosophies are are in conflict, reflecting various social locales and commitments of groups and individuals present in the field.

Let us come back to the issue of Capitalism because I think it has appeared to been omitted by the way I have criticised the Marxist Externalists. I think there is a great deal of fundamental truth in pinning some of the changing goals and attitudes in natural philosophy on these economic and social changes. Where I think the Marxist Externalists went wrong was in going from changing economy to technology bottlenecks to scientific answers. (fig. 5) That was not the pathway. I think it was more emergent commercial capitalism [and other big structural changes that accompanied that, such as consolidation of and conflict amongst states] that fostered the changing attitudes or aspirations about knowledge in the field of natural philosophy.

So, if you ask where did the change in aspiration come that favoured magic and neo-Platonism against Aristotelianism, or that favoured mechanism against Aristotelianism, I would say the ultimate motor of those changing attitudes was the emergence of the commercial capitalist economy in the early modern period. This is how educated men living in that society could turn around and say that what they learned in the universities was not particularly relevant to what they could have been getting out of natural philosophy in the present world. This is the common attitude of men whose actual systems were as different as Paracelseus, Descartes and Francis Bacon, who state that it is not that Aristotelianism is false, it is that it is irrelevant because it does not deal with action in the world and upon the world. If natural philosophy is to mean anything in this early modern world of increasing trade and commerce, state-building and welfare, it should be oriented towards practice, use, operation in control of nature--that is where the aspiration comes from, which is not to say that there were better guns or maps from these scientific aspirations, they gained these from craftsmanship. What they did get was magical neo-Platonic natural philosophy and mechanical philosophy, because those natural philosophies responded to those changing attitudes. (fig. 6)

Finally, the other two factors that interrelate with the changing economy in this period are:

(1) the centralisation and growth of the monarchies and their central governments; the growth in power of their bureaucracies

(2) religious changes and tensions of the period, which on the Catholic side meant organising against the Protestants and on the Protestant side vice versa.

Combined, all these huge factors which are what drives the attitudes, goals and aspirations that erode Medieval Aristotelianism. It cannot withstand them--although it takes a couple of centuries. (fig. 7)

A typical situation is something like this: René Descartes was a member of the middle-class in the sense that he was trained to be a lawyer. He was not a capitalist nor was he looking for technological fixes from science (he was not as Hessen and Bernal say he was). He was a member of the new administrative class which was supposed to run the French state, which was running bigger armies, bigger navies and a more extensive (as it were) commercial development.

What does René Descartes (who could stand for thousands here) want out of his education? He does not want to learn that man's knowledge of nature is limited to contemplation and that experiment, practice, technology, crafts have nothing to say to science and that science has nothing to say to them. That is not good enough because he lives a world where commerce, the growth of the states, the exercise of power -- all these kinds of things -- have new meanings or at least enhanced meanings. Descartes eventually becomes one of those people who sits down and says we must design a world view that is not magical (not like the Paracelsians) which will not appeal to the lower classes, which is religiously sound, but which says the world is the kind of thing that can be approached, manipulated, operated upon, exploited and appropriated.

This is what Descartes' natural philosophy says and they are the values it embodies. Within this, Descartes states that every single science must now be practiced within that framework: physics, optics, mathematics etc. So Descartes' viewpoint is a product of the society and economy of the time. His viewpoint and aspirations work out into a natural philosophy that has a consequence for the sciences. But, he isn't Hessen or Bernal's lackey of commercial capitalism, solving technological bottlenecks.

These are a difficult set of ideas but they are better than deluding ourselves in the Internalist/Externalist traditional point of view. Now if you take what I say and put it with my paper on the 'Scientific Revolution' in the *Companion to the History of Modern Science* and some readings of Easlea *Witchcraft, Magic and mechanical philosophy* you will begin to get an overall picture of the changes in science and natural philosophy in this period and their larger social attitudinal and external settings, which is the ultimate historical aim here. I commend that framework, and critical development of same, to your further study.

Figure 1

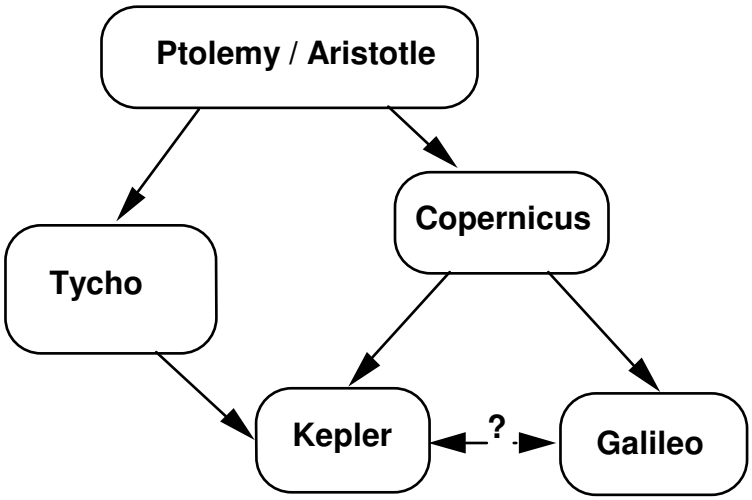


Figure 2

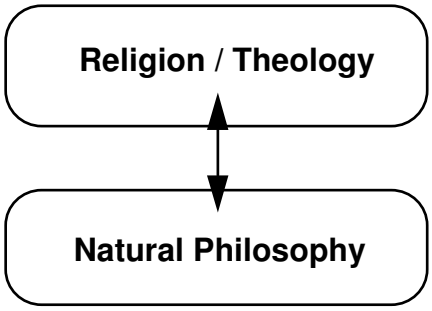
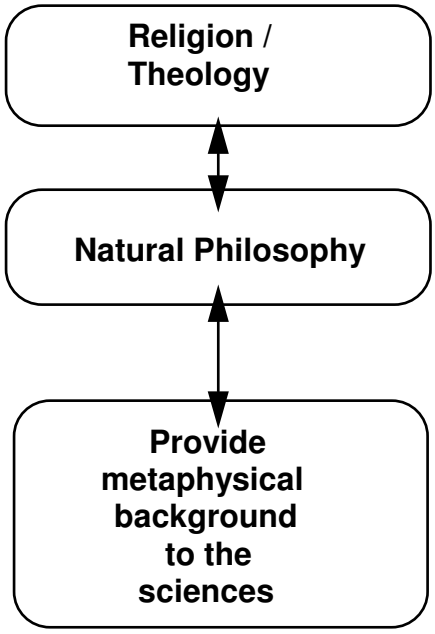


Figure 3



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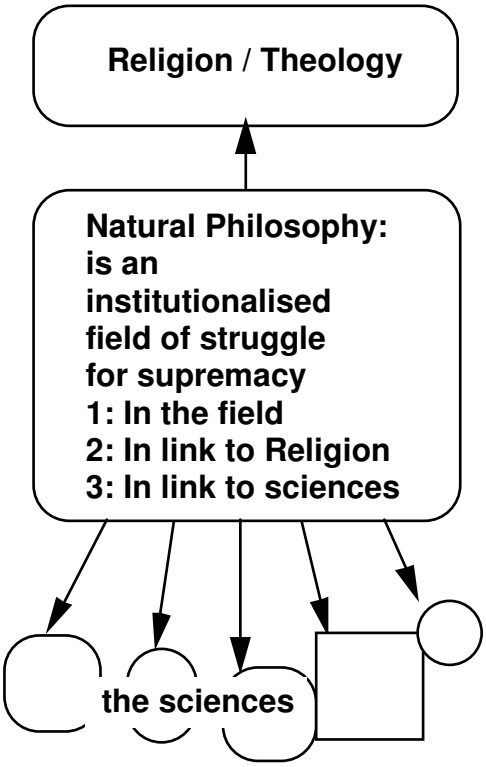


Figure 5

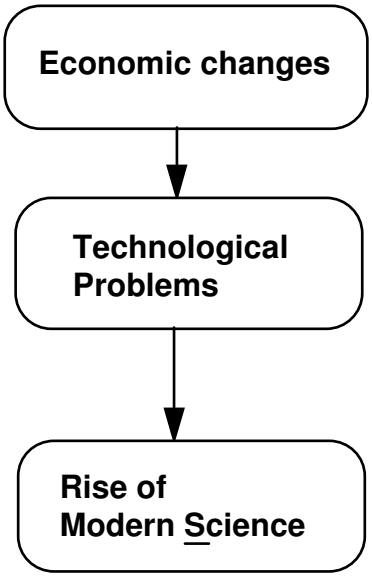


Figure 6

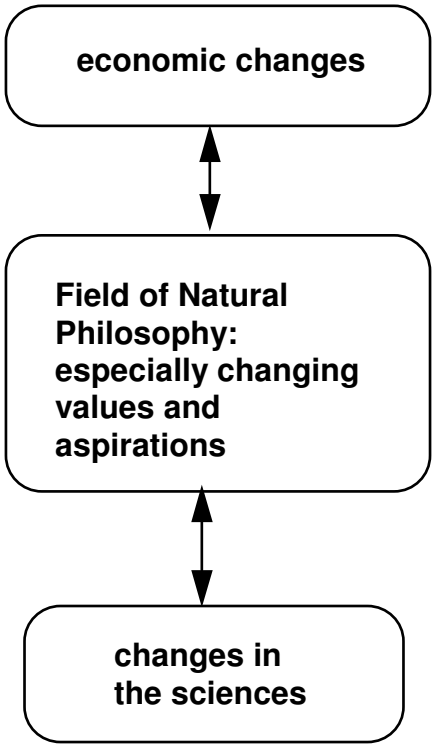
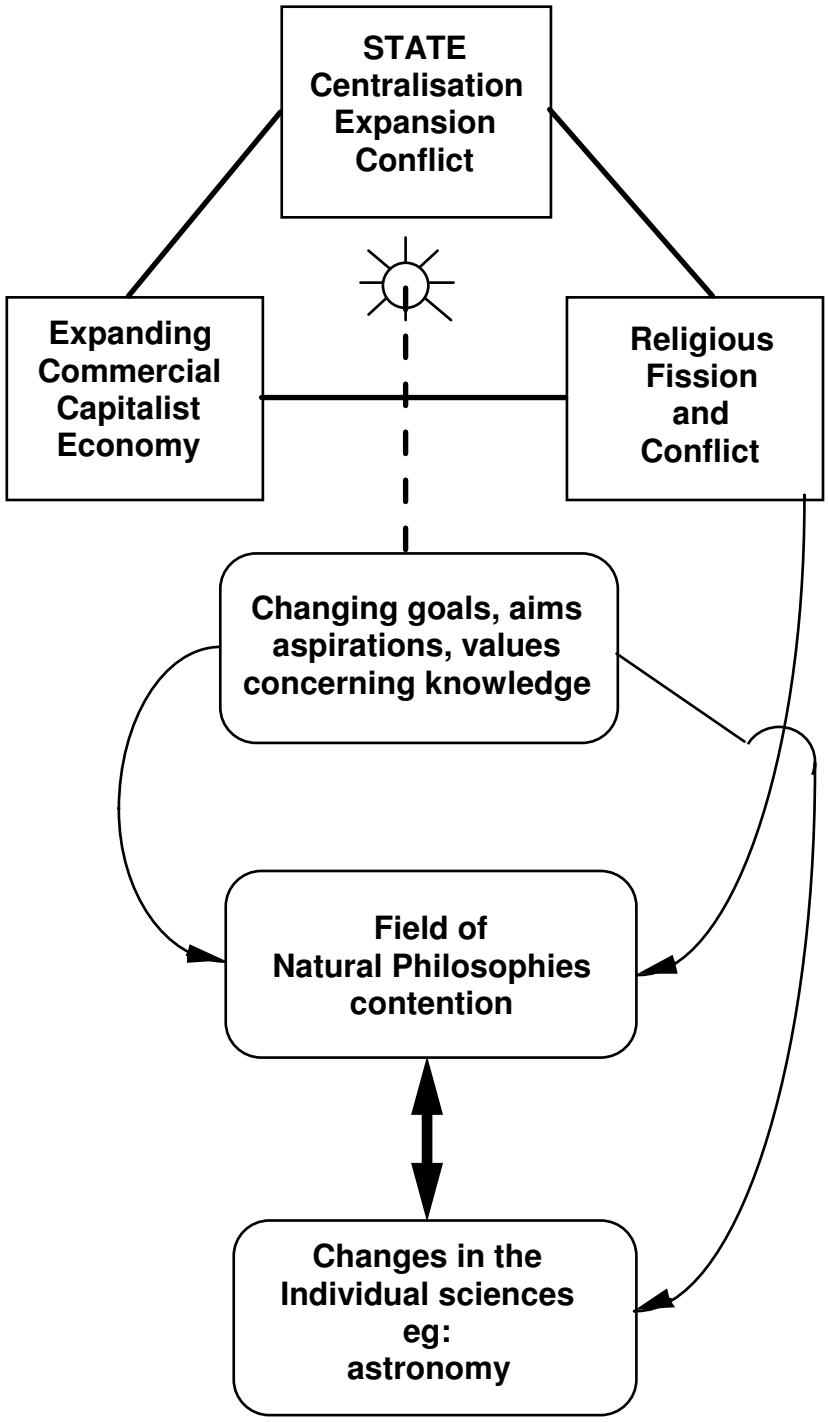

economic changes
Field of Natural Philosophy: especially changing values and aspirations
changes in the sciences

Figure 7


STATE
Centralisation
Expansion
Conflict
Expanding
Commercial
Capitalist
Economy
Religious
Fission
and
Conflict
Changing goals, aims
aspirations, values
concerning knowledge
Field of
Natural Philosophies
contention
Changes in the
Individual sciences
eg:
astronomy