# 19 Natural Philosophies at War in 17th Century I Defining Mechanical Philosophy

We discussed two Chapters ago (when we became involved with Galileo) that we were now moving into the area where we would look at the social context of science and scientific change. The Galileo affair illustrates that kind of larger contextual conditioning of the issues very well. Now we arrive at the heart of the matter, because we come to the issue of the conflict of philosophies of nature in the scientific revolution. This is important for it has to do with social context and social shaping. Natural Philosophies, these big pictures of reality -- the big systematic explanations of nature--were very socially and institutionally sensitive. They had to maintain proper relations to religion, to educational institutions, to the political climate, so they were social and cultural lightening rods. So when we look at the Natural Philosophical changes in the Scientific Revolution we are actually looking right at how larger social forces affected science. So Natural Philosophy is something social through and through.

Now before we talk about the Mechanical Philosophy lets remind ourselves of some general features of the field of Natural Philosophy. In Chapter 5 we saw that the Greeks had invented astronomy, anatomy, mathematics and other particular sciences, but that these were subordinated to a larger enterprise--a larger game -- which for them was the main game. It was called the Philosophy of Nature, where you had to supply a systematic, coherent answer to four questions that were basic to finding the defining the nature of physical reality: (1) What is matter? (2) How is matter organised into a cosmos? (3) How do changes and motions occur? (4) How do you know all that? (The answer to which was some version of scientific method.)

We also know that the Aristotelian version of Natural Philosophy became the dominant institutionalised system of Natural Philosophy in Europe in the Middle Ages and in the period we have been studying. It is the philosophy of nature against which all of the changes and initiatives we have been looking at were aimed. In fact, the Scientific Revolution didn't mark the end of Natural Philosophy as a field of contention and cultural import, it just meant a change in which natural philosophical system would be dominant. In other words, Aristotelianism was replaced but it wasn't replaced by 'no' system of Natural Philosophy but by Mechanism and a little bit later, Mechanism was overlaid with Newtonianism. But you may say, "How come we don't have this domain or field of Natural Philosophy any more?", for we don't, Natural Philosophy finally died and faded away in the early 19th century for the simple reason that the sciences became too numerous, too varied and too sub-divided into specialties. That made it impossible for anyone to sit on top of all sciences and say "I have the one answer -- the one system of Natural Philosophy that explains and controls all of the sciences." However, the idea of *method* survived. You may say that the idea of method is the last vanishing ghost of Natural Philosophy, the last hope that some genuine and operative unity can be given to all the sciences. But compare what we said about Kuhn in Chapters 15 and 16 on the issue of method and the sciences

Now, how does astronomy relate to the field of Natural Philosophy, in particular to that dominant system of natural philosophy, the Aristotelian. Astronomy is a technical subject where you have mathematical theories for setting up predictions of the motions of the planets. But, as soon as you ask within astronomy: -- what are the planets made out of? -- what causes them to move? -- what is the basic lay-out of the heavenly

bodies? -- as soon as you ask any of these questions you are asking about cosmology, about matter, about causation. So astronomy (Ptolemy for instance) took place under the guidance of Aristotelian natural philosophy -- and this supplies the deep answers for Ptolemiac astronomy. So therefore Ptolemaic astronomy is under the Aristotelian umbrella and, as we've seen, goes on to say things that are just too technical and too mathematical to be taken as real within the framework of that particular system of natural philosophy.

If you are going to substitute a new astronomical theory -- Copernican theory -- you are going to raise questions of a natural philosophical nature. Copernican theory raises questions like -- "What are the other planets made of, since our Earth is a planet as well?" What is the Earth made of that constitutes the Earth as a planet? Questions of matter. Copernican astronomy also raises questions such as, Why do the planets move around the Sun? Questions of causation. Copernican astronomy raises questions of cosmology -- What is the number of the planets? What is their order? Why is the matter set up that way? So if you are going to put in a new astronomy on a technical basis, you are going to raise natural philosophic questions.

What we have read so far has not concentrated on natural philosophy as a field of contending systems and approaches, but rather, followed along the line the astronomical innovators have had to scramble for scattered answers to fragmentary questions. Copernicus had almost no answers to those questions. He had no alternative system of natural philosophy to replace Aristotle and give him some of the framing answers to support his new astronomy.. Kepler did have an alternative system of natural philosophy. He said " Natural philosophy must become neo-Platonic for there are all these immaterial forces and these number harmonies, and the Sun forces these planets to go around and there are these basic laws controlling it all". So Kepler's was a whole alternative system of natural philosophy of a Platonic character. Galileo wasn't much for that kind system building in natural philosophy. He just as it were juggled bits and pieces -- telescope, law of inertia, theory of the tides-- for he didn't really have another alternative system of natural philosophy to replace Aristotle's.

What we are going to see is that the Mechanical Philosophy takes over Copernican astronomy. They fit hand and glove the mechanical natural philosophy is the vehicle through which Copernicanism triumphs. (And as I shall say at the end -- Copernicanism was the tail and Mechanical Philosophy the actual dog. Mechanical Philosophy didn't triumph because Copernicanism was acceptable, rather Copernicanism became acceptable because the Mechanical Philosophy was so acceptable in its own right as a full replacement system against Aristotle's. Therefore, I am also trying to say that the Copernican Revolution was also a revolution about natural philosophy.)

We have seen Tycho modifying Ptolemaic astronomy and partially modifying Aristotelian natural philosophy -- fluid heavens, bit of corruption up there, harmonies -- but it isn't a major alteration of Aristotelian natural philosophy, because Tycho tries to keep the broad thrust of traditional Aristotelian system of natural philosophy and get his own version of astronomy in there, as the astronomy appropriate to a revised Aristotelian natural philosophy. What this means, again, is that if you want to do astronomy, the fundamental premises of your astronomy will be controlled by the particular system or kind of natural philosophy that you subscribe to. Your natural philosophy is your 'metaphysical background' to your astronomical work. And that is perfectly obvious in the case of Ptolemy -- Aristotelian Natural Philosophy is the background in which Ptolemaic astronomy makes sense. What is the natural

philosophical background in which Copernicanism makes sense? So far none -- except perhaps for the excesses -- unacceptable excesses -- Kepler's vision of a neo-Platonic system of natural philosophy.

So it was inevitable that a conflict of astronomy had to be a battle of contending systems of natural philosophies because astronomy, like the other existing narrower sciences, was controlled by an overarching view of nature. As we say, philosophies of nature were meant to control and prioritise the other sciences as well. If you wanted to do optics you had to choose your natural philosophy. And the same applied to other areas like anatomy or physiology, were you had to choose your natural philosophy. These sciences only made sense within a system of natural philosophy, and of course the dominant institutionalised one was Aristotle's.

In the 1620s, 30s, and 40s, a relatively short period of time, the mechanical philosophy -- a new system or variety of natural philosophy -- was constructed and accepted. A handful of thinkers constructed this new philosophy -- three of them are listed in Figure 1 and notice that they were all born within a few years of each other -- they all came to maturity in the sixteens and 20s -- and this new species of natural philosophy won out fairly quickly within the field of struggle about natural philosophy, so that by 1660 or 1670 virtually all educated men thought that the mechanical philosophy was more or less correct. And with that virtually all educated men thought that Copernicanism was correct as well. I will return to that issue at the end of this Chapter.

Aristotelianism, however, continued to be taught in the universities down to about 1700 but by then it was just something that you learnt at university when you were a kid; it wasn't the real truth about nature for that was the mechanical approach to natural philosophy that Hobbes, Descartes and the others had taught. In the early 1700s mechanism was taught in the universities and was increasingly challenged by the natural philosophy of Newton, and we are going to see that Newton's approacha to natural philosophy was not entirely mechanistic and we are going to see why that was.

Now, the mechanical philosophy of nature has shaped modern common-sense in the West. For fifty or sixty years in the seventeenth century, mechanical philosophy was the dominant system of natural philosophy (from about 1650 to about 1700) and then Newtonianism came in. But even after 1700 and down to the present, the mechanical philosophy has shaped what we consider to be common-sense (and that is interesting because our common-sense is not obviously true but a residue of seventeen century mechanical philosophy in a way).

For example, all educated westerners believe that the universe is infinite. Now perhaps we don't all accept it is infinite in the way that Einstein views it as infinite, but that is what we think unreflectingly. And the first people in the west to teach consistently that the universe was infinite were the mechanical philosophers of the seventeen century. Here is another example: we, in the twentieth century, are apt to say, when asked to define science, 'well science is the application of mathematics and experiment to the study of nature'. That is pretty vague but that is what we say. (It won't get you very far in the study of the history of science but that is what we say). The first people to say that consistently were the mechanical philosophers of the seventeenth century. So, on these kinds of points, we are the heirs or descendants of the mechanical philosophers. We are not the descendants of Aristotelianism which taught the universe was finite and that experiment was of no use in science, for the very good reason that experiment places bodies in artificial and constrained situations where they do not behave naturally. (Aristotelian natural philosophy is about the natural behaviour of bodies therefore

experiments are not revealing about nature). So we are not the heirs of Aristotelianism -- we are the heirs of mechanical philosophy.

There is another key idea central to mechanical philosophy that we have inherited, at least until recently: Nature is there to be appropriated and exploited for the benefits of supposedly, everyone, but of course really for selected 'somebodies'. But, this is not an Aristotelian idea for his natural philosophy is one of contemplation of nature, you do not appropriate or exploit it. That idea is characteristic of the mechanical philosophy. Now those ideas: infinite universe, science is mathematics and experiment, nature is there for exploitation -- those were essentials of the mechanical philosophy and broadly speaking a lot of people still believe them. Of course, believing those ideas does not qualify you as a modern scientist. I cannot just walk into a physics lecture and say "Hi there! The universe is infinite -- do experiments using mathematics and exploit nature". Obviously I wouldn't be teaching physics would I, but just mouthing twentieth century common-sense. I wouldn't be saying anything technical. What was avant garde, novel and challenging in the seventeenth century and at the cutting edge of debate about which is the correct 'big' system of nature in 17th century is now just educated common-sense.

What I want to do is characterise the mechanical philosophy, and in the next Chapter ask why it was invented and accepted so quickly. You will see that there is a piece of the story that I am hiding from you. The conflict amongst systems of natural philosophy at the time was not just between two (Aristotelianism and mechanism solely) for there was a third challenger, neo-Platonism. Especially the kind of neo-Platonism attached to magic and ideas of social/political/religious reform. It turns out that the mechanical philosophers were not very big on reform, if that reform was coming from the bottom up or from people that they did not like. The mechanical philosophy was put together to make certain that the third challenger would be defeated. The main reasons for the concern were not to overthrow Aristotelianism. The mechanical philosophers, to a man, thought Aristotelianism irrelevant and false. The real issue was: are we going to give into neo-Platonism and magic and suffer the nasty social and political consequences of that? So the reasons for the choice of the mechanical philosophy, I will argue, were political, social and religious much more than scientific. In the end, I will suggest that **the mechanical philosophy was not accepted because it was true, but it was true because it was accepted**, and it was accepted on political, religious and social grounds. That's why it had such a sudden sweeping success.

Now let us consider some central aspects of the mechanical philosophy. Everything in the physical world is one of three types of things according to the mechanical philosophy. It is either God, or a Human Mind or Soul (immaterial) and everything else is an atom or an organisation of two or more atoms. Some of the mechanists didn't like to say 'atom' (for it is a Greek term for the smallest unbreakable, impenetrable piece of matter) because the ancient Greek Atomists were considered atheists (because they thought the Gods were made out of atoms). So if you were going to be a Christian Atomist/Mechanical philosopher in the seventeenth century, sometimes you did away with the term 'atom' and substituted the word '*corpuscle*' --little microscopic bodies--in other words 'atoms'.

Now what were these little bodies like, (after all, every physical thing is either an atom or a collection of atoms) well, they are very stripped down pieces of matter. They have very few properties or qualities, usually only three or four in number. They are all quantifiable in principle, if not always in practice: an atom has size and shape; it is moveable and it is impenetrable (which means that when atoms bump into each other

they bounce around and they don't get broken into further pieces). So it would be interesting to know the laws of collision according to which atoms bounce around for then you would really know how nature works!

Size, shape, mobility, and impenetrability. That is usually it--every physical body in the world is an atom or collection of atoms having only size, shape, mobility and impenetrability. This is pretty wild because there are a lot of properties and qualities that we believe are in the world that are not on this list. What about colours? Atoms don't have colours so no bodies have colours. What about taste? What about smell? Tones? Well atoms don't have taste or smell or tones so big bodies, macroscopic bodies don't have taste or tone or smells or colours. What about hot or cold, wet or dry? Atoms have none of these things. They are only **this** big, **this** shape, moving, or at rest, and impenetrable.

So macroscopic bodies don't really have heat or cold, or wetness or dryness. But we are inclined to say these things are in the world--to say chalk is white--but what do you mean there is no 'whiteness' in the world, there it is -- it is a white piece of chalk. You go to a Chinese restaurant and you order sweet and sour pork -- it had better be sweet and sour. What is the point of talking about all these qualities if it doesn't mean anything? All these properties are *not* on the list of properties that atoms have, and according to the mechanical philosophers, all these other properties and qualities don't deserve to be on the list because they are not properties or qualities that atoms have. Now according to these fellows (Descartes, Hobbes etc), these other properties exist in one place and one place only, inside **human minds**. (Possibly in animal minds, if animals have minds -- this was a point of contention for Descartes, who argued that animals don't have minds -- they are just machines, so that if a dog shows pain it is not really in pain it is just programmed by God to give a reaction like pain to a stimulus that would cause pain, as if it had a mind and could feel pain. Which is probably an invitation to exploit dogs and other animals.) (fig 2)

How do these properties and qualities appear in your mind? Depending upon how your nervous system and your sense organs and your brain are impacted by certain atoms and atomic motions. Light atoms bounce off the chalk and enter your eye-balls, jangle your nerves so that your mind or soul has a subjective perception of white. Has anyone got a lighter or match? Now, ouch! Hot, painful -- there is no painfulness here in my finger -- there is no heat from the flame for what is really happening is the atomic motion in the flame jangled my nerves and ultimately caused my soul or mind to have *subjective* sensations of hotness and pain. There is no such thing as 'hotness' out there. Atoms aren't hot -- maybe when they move fast and hit my nerves and that causes my perception of hotness, but there is no 'hotness' in the atoms. Everything is explained by the size, shape, arrangement, or motion of atoms and *everything else is reduced to a subjective registration of events*.

This is a nice trick because it turns Aristotelianism into a subjective fantasy. The language and terminology of Aristotelianism is nothing but a ghastly mistake, according to the mechanists, for it is a projection onto nature of our subjective experiences -- the heavy, the light, the wet, the dry etc. None of this exists in nature. Later, these objective qualities were called by John Locke the 'primary qualities' that are in and of the real world and the subjective ones were called 'secondary properties'. Since the seventeenth century, science has added to the list of primary qualities. Newton, for example, added mass and gravitational force. The nineteenth century added energy and electrical and magnetic fields. Twentieth century science has added various sub-atomic properties like 'charm' and 'spin'. So, gravitational force, mass, energy -- these really

exist, and we we have lengthened the original list of primary qualities of the 17th century mechanists, but it is still the same idea that there are 'real' properties of really existing bits and pieces and all the rest is just in your head man! So the mechanists were saying that Aristotelian natural philosophers didn't know the nature of reality which is size, shape, mobility, and impenetrability of atoms.

All natural philosophies are human constructs and they are usually based on some master idea -- leading metaphor or image -- the choice for the leading image or metaphor of a natural philosophy tells you a lot about the values and aims of the people who made up that natural philosophy, and a lot about the people who selected it. Well, the leading idea/metaphor for the mechanical philosophy was the machine: The pre-steam engine machine; the machine that had no internal sources of power (we are talking about the 17th century now). In those days, before anybody had built any engines like steam engines, machines meant things like levers or pulleys, or combinations thereof. Machines were basically geometrical arrangements of material parts so that when you put in some effort at one end by the use of wheel, water, human or animal powers, the movement and arrangement of parts delivered some useful versions of the power at the other end. Machines were arrangement of parts that moved in order to accomplish output, *but they always needed an external input of power*.

Well, according to these thinkers, nature is a machine. It is nothing but an arrangement of parts and their motion. Nature can be studied therefore, (in fact it must be studied), mathematically. You have to be able to describe the parts and their motions mathematically, so therefore, we are looking for some new mathematical physics that will describe the motions and behaviour of atoms. It also means that nature is to be studied experimentally. Take apart bits of nature, see what they are made of, how they are arranged and re-assemble them or make slightly better versions of them. There is no harm done in experimenting on nature. (Remember, this is different from the Aristotelian view of things where if you experiment you are ripping nature up and therefore preventing it from revealing what is natural). The big question is, who made the machine of nature, because in the seventeenth century no-one had seen a machine that had made or designed itself or another machine -- this machine of nature has a divine designer/engineer. And almost everything I said about the mechanical philosophy that I said before follows from this metaphor and from this idea.

'Nature the machine', means that you have to use mathematics in approaching and explaining it. Nature the machine means you can rip it apart and do experiments upon it. Thirdly, you can really rip it up for man's material benefit, after all its just a machine that God put there and he gave us souls to understand it; the only way to understand it is to rip it apart. As Descartes says in his *Discourse on Method* (1637) following this mechanical philosophy will make us the masters and possessors of nature. (Which is not the kind of thing that the Greek or Medieval natural philosophers would say). By the way, all of this means that human crafts and technology are immediately relevant to science and science relevant to them because they are the kinds of thing that God did to nature on a microscopic scale, practiced on a human macroscopic scale. Human technology and technics might teach us something about science, and science certainly will improve human technics and technology. (In Aristotelianism there was no connection between technology and science because technology was the artificial, the unnatural and nature was nature).

Now, two sets of final points about the mechanistic natural philosophy. The first is a theological point. According to these people (and recall Gassendi was a Catholic priest, Descartes was a practicing Catholic and Hobbes was a Protestant) the mechanical

philosophy is the most Christian and theologically orthodox natural philosophy you could hope to have. Aristotle and the neo-Platonists have got it wrong. Only the mechanical philosophy is acceptably Christian -- why? -- because it makes God to be everything and nature, the dead machine, virtually nothing -- and that is the Judeo-Christian 'doctrine of creation': An omnipotent creator made the universe and everything about the universe depends on the omnipotent creator, God. According to them, how better can you express this except by holding that an omnipotent creator, God, made a dead lifeless machine; and that that dead, lifeless machine depends entirely upon Him for **it can do nothing by itself**. So this is the perfect Christian natural philosophy according to them. Now everyone didn't agree with that, but this was their argument.

The second point has to do with the relationship of Mechanism to Copernican theory. **All the mechanical philosophers were Copernicans**. No Aristotelians were Copernicans. There were quite a few Platonists running around, and some of them were Copernicans, but not all Platonists were Copernicans. There is thus, an affinity between mechanical philosophy and Copernicanism. Here is one way of thinking about it. These guys believe in inertial motion; Descartes formulates the law of straight line inertial motion. If you are thinking about atoms moving around in a void of space, moving inertially until they bump into something, you will say (in a strict mathematical theoretical way) that it goes and goes and there is no end to where it could go if it didn't bump into anything. So you get the infinite universe. Also, in this infinite universe there are a lot of stars, but is the Sun special because its in the middle? There is no middle in an infinite universe. What are you going to say? There are a lot of stars and maybe planets go around the other stars but around here the planets and the Sun go around the Earth? You are not going to say any of that. You are going to say the Sun is a star -- there are an infinite number of stars, but around here the planets go around the Sun and over there probably there are planets going around those stars. That is what you are going to say. It is the only thing that will make sense. So they wind up being Copernicans of a peculiar kind -- **infinite universe Copernicans**. That is not the kind of Copernican that Copernicus was--he had a finite universe. Kepler and Galileo also had finite universes. They were all, so to speak 'Medieval/Greek Copernicans'. With the mechanical philosophy you get Copernicanism in its infinite-universe form.

Now as I said before, I believe that Copernicanism is the tail on the dog of this mechanical philosophy. There are lots of reasons to be a mechanical philosopher (as I will say in the next Chapter). Favouring Copernicanism was not the only reason for being a mechanical philosopher (there were social, political and religious reasons as well). So it is very likely that in most cases the mechanical philosophers chose to be mechanical philosophers and brought the Copernicanism along rather than choosing Copernicanism and then inventing mechanical philosophy for it. Mechanical philosophy had lots of attractions, not just that it harboured Copernicanism.

So if you like, the Copernican revolution ends with a whimper rather than a bang. It doesn't end with Newton, for although he does things that are important, the Copernican revolution is over before Newton comes on the scene. The Copernican revolution was over with the triumph of the mechanical philosophy when Newton was a boy.

Consider a typical pathway to mechanism and Copernicanism for someone like Descartes, for he is convinced as a young man (unjustifiably) by Galileo of the general truth of Copernicanism. The real struggle and work is to become a mechanical philosopher and develop mechanical philosophy for larger social, political and religious

reasons and that draws along the Copernicanism, so that and when he writes his system up, it is a mechanical philosophy embodying an infinite universe version of Copernicanism. So,why do people devise and accept mechanism? That is the **real** question and that is what we have to talk about in the next chapter.

**Figure 1**

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|---|---|
| **René Descartes** | **1596 - 1650** |
| **Thomas Hobbes** | **1588 - 1676** |
| **Pierre Gassendi** | **1592 - 1655** |
| **Marin Mersenne** | **1588 - 1648** |
| **Isaac Beekman** | **1588 - 1636** |

**Figure 2**

| **Primary Qualities** | **Secondary Qualities** |
|---|---|
| **Size** | **Tastes** |
| **Shape** | **Smells** |
| **Mass (quantity of matter)** | **Colours** |
| **Motion** | **Hot / Cold** |
| **Impenetrability** | **Wet / Dry** |
| | **Tones** |

**Later**

**Forces**
**Fields**
**Energy**
**Entropy**
**'Charm'**