Research Methodology
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Lecture - 19
Historical Perspective: The Advent of Scientific Materialism Part 01

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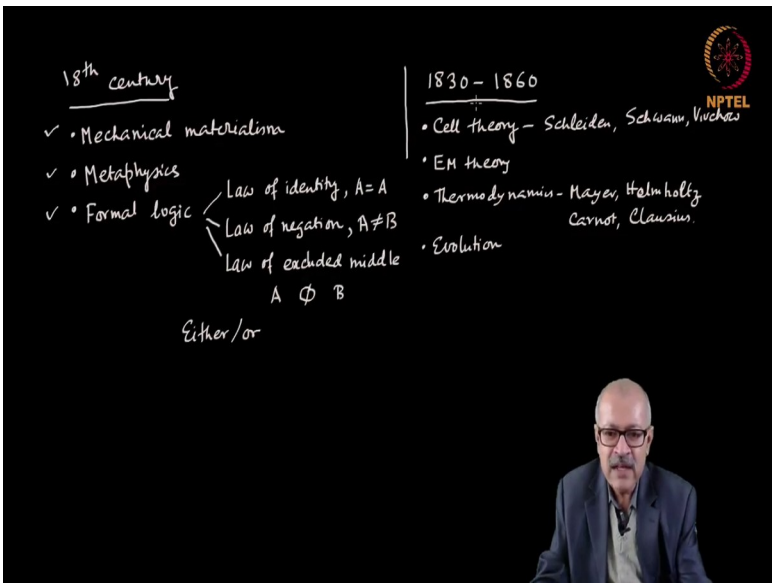

Through the 18th century, science was developing unabated and various old unscientific ideas were dispelled slowly through various experimental studies, experimental investigation, and checking whether these are true or not. Through that, science was steadily progressing. A glimpse of that we have heard in the last class. I am not going into the details.

But what I am trying to point out is that, in the 18th century, science was developing with a philosophical grounding and the philosophical grounding was provided by the idea of mechanical materialism that we have come across in the last class. Mechanical materialism: the main idea of mechanical materialism was that the world is sort of composed of matter (Refer Time: 01:39), but the whole picture was like a machine.

The world was viewed like a machine and each individual thing are viewed as part of a machine. The mechanical materialists tried to explain everything in terms of the properties and interaction of these parts. I will come to a bit more detail a little later.

The second philosophical grounding was provided by what is known as metaphysics. Metaphysics is a way of thinking that was developed in the antiquity. In that point of view, things are studied as they are. ‘As they are’ means it is assumed that each thing has a property which we have to study, but a fixed property. So, everything is fixed. They are not something that are changing. Everything has a fixed character and this is what we should study. And the logical grounding, since we have to argue by using logic, the logical grounding was provided by what is known as ‘formal logic’.

Now, this formal logic: again it was started by Socrates, but formalized by Aristotle. It is basically a way of logical argument, logical thinking, which seeks to eliminate any possibility of ambiguity. For that purpose, Aristotle made the point that everything is what it is and is not something else. A is A and not equal to B.

Formal logic had three laws: the law of identity, the law of negation, and the law of excluded middle.

The law of identity said that, if you are trying to describe something, to understand something whose property you are trying to understand, define that first, that entity. It is that and that only. If you are defining A, for example, if you are talking about a tree then a tree is a tree only. It is not a shrub, it is not a vine, it is not a sapling. Each of these are different things. Essentially, A is equal to A only.

The law of negation said that A is not equal to another thing B. So, if you have defined something, then it goes as a part of the logical structure, that thing is not at the same time something else.

And to further clarify, the third law was the ‘law of excluded middle’, which means that if there is an A and if there is something B, then there is nothing in between. That means, there is nothing that is at the same time A as well as B. There is nothing which is, at the same time, a tree as well as a shrub. There is nothing which is, at the same time, a mammal as well as a reptile; something like that. So, these laws together with the idea of metaphysics—allows one to study things as they are and that is what happened. People studied things, things means inanimate objects, the biological objects, as they are.

With that, you can probe the properties of, say, oxygen. You can probe the characters of certain animals and things like that. But metaphysics assumed that the character,

properties and whatever we study—these are fixed. These are not changing. And therefore, a metaphysical way of thinking, in common parlance, would identify a particular person as good, a particular person as bad and it goes out of the assumption that a good person may, at some point of time, turn into a bad one or a bad person may turn into a good one.

So, changing character was out of the purview of the philosophy of metaphysics. You can see that the formal logical structure uses an 'either/or' kind of logic. So, it is either this or that, but nothing can be something in between. So, with that kind of philosophical grounding—mechanical materialism, metaphysics and formal logic—science was progressing and through that various developments happened.

But over the period from about 1830 to about 1860, various great developments happened in science. First we learnt about cell theory. Cell theory that said that cell is the building block of biological matter, a cell can be born only out of a cell, so and so forth. Cells are born, cells develop, they go through evolution, and then at some point of time they die. Every animal body is composed of one or more cells; cell is the building block. We learnt about this is by the work of Schleiden, Schwann, Virchow and others.

The electromagnetic theory was developed in this period, by the work of Oersted, Henry, Ampere, Ohm, Gauss and others. And finally, it was crowned by the great experimentalist Michael Faraday who showed that the interaction between electricity and magnetism is dynamic, not static. Only a flowing charge can induce magnetism and only a changing magnetic field can induce a flow of charge. These ideas were put into a mathematical form by Maxwell. So, this is what happened in this period and Maxwells paper came around 1859.

Thermodynamics was also developing in this period through the work of Mayer, Helmholtz, Carnot, Sadi Carnot and finally, Clausius. Through their work we came to know that all forms of energy are inter-convertible. But when you are trying to convert a low quality energy, which is somewhat dispersed form of energy like heat, into a high quality energy, which is more organized and regular form of energy like the rotation of a shaft or electricity flowing through a wire, then you cannot convert it at a 100 percent efficiency. Some part of the energy goes into the environment. These ideas were formalized by Clausius into the first law and the second law of thermodynamics.

Most importantly, the evolution theory in biology was developed in this period by Darwin. Darwin's book also came out in 1859.

Through these, we first time came to a situation where the philosophical grounding started to prove inadequate to understand the property of matter that was being revealed. Why? Because in all these, the focus was 'change'. We are, for the first time, realizing that the matter that we are studying is continuously going through changes, evolving. Nothing is static, nothing has a fixed property. All these things are changing. Not only that, things are coming into being, evolving, and then going out of being.

Each cell comes into being, evolves, and goes out of being. Each organism comes into being, evolves, and goes out of being. Each species comes into being, evolves, and then becomes extinct, so on and so forth. In the view of this time that was revealed was that things are continuously changing, things do not have fixed properties. The view of metaphysics was that we should study things as they are. Now, if some thing continuously changes; obviously, you cannot talk about a fixed property, a fixed characteristic. So, we had a difficulty there.

Formal logic also ran into difficulty. For example, in the formal logic everything is viewed in terms of either/or, it is either A or B, and there is nothing that can be at the same time A as well as B. But in this period biologists came across an animal called platypus. You know that the reptiles lay eggs and mammals suckle their young and there is a hard division between them, so A and B are separate. But platypus lay eggs as well as suckle their young. So, where do you put them?

We started to find that there are certain things that are in both bins. It was necessary for biology to put everything in bins: bins like birds, bins like reptiles, bins like trees, bins like mammals. It was necessary in order to organize their knowledge, but it was slowly being revealed that the division between the bins were not so hard and fast. There is a possibility that something can have some properties of this bin and some properties of that bin. In that case, formal logic had a difficulty. ***

It was also found that, what was earlier A can in some situations behave as B. The same thing, water, in some situation can behave as ice—a different thing. So, something can change from one to the other. A seed can at some point of time germinate into a tree, and

the seed is not the same thing as the tree. So, something that was one thing can change into another.

It is not that people earlier did not come across changing things. We see night and day, we see calves are born and they grow into cows and they ultimately die. People saw that. But from a idealistic point of view, if one subscribes to the idea of idealism, then all changes happen with a purpose, according to them. But Darwin showed that the whole evolution is happening without any purpose, it was happening by very well defined laws of nature, the law of natural selection. And therefore, there is nothing like a purpose for which the evolution is happening.

So, evolution or change had to come to the center point of all studies. When the center point of all studies changed, then we had to change the notion, the way science was progressing assuming certain philosophical grounding. That needed to be changed.

So, as I told you, people did see changes, but in the idealist view, things change with an objective, with a purpose. While in the view of mechanical materialists, things change of course, but they tried to study all changes in terms of the ultimate building blocks of everything. They pictured everything as made of hard impenetrable particles, and they tried to understand all the various behaviors in nature in terms of the properties and the interaction between those hard impenetrable particles.

What does the universe comprise? The universe comprised an infinite number of such hard impenetrable particles. So, their view was that if you want to study something, look at what it is composed of. Mechanical materialism saw everything as a machine and every machine is composed of parts. Each part moves or behaves according to some fixed laws and the parts interact with each other to behave like something—that is the machine.

Therefore, if you look at anything like a machine, what would you do? You will basically find out what the component parts are, and how they interact with each other. Then you will try to understand everything in terms of the component parts and their interaction. That way, you will believe, that the understanding of that thing can be obtained. Effectively it was saying that the behavior of the parts, if you sum them together, the sum is essentially the behavior of the whole. So, sum of the parts is equal to the whole.

This picture was best expressed by a Newtonian scientist, Laplace, after whom you see the Laplace transform and various things that go after the name of Laplace. He was a great mathematician and physicist, basically worked on classical celestial mechanics. He wrote a book in which he said that, just give me the initial position and momenta of all the particles in this universe and give me enough computing power, and I can tell you what is going to happen to the universe ever in future.

What was the basis of his assertion? The basis of the assertion was the understanding that all that can happen is nothing but the sum-total of the behavior of the small particles, and if I can calculate the position and the trajectory of each particle then I can calculate the whole.

Now, in this period that I was talking about, as we were going through these developments, it was realized that, no, the whole is not just a sum of the parts.

A cell consists of millions of molecules, but if you simply go and study which molecules are there, what are their properties and how they react with each other, will you be able to infer the character of the cell? No. The cell has a definite action, property, behavior, and a cell interacts with other cells in a particular way that cannot be inferred just by looking at what it is composed of, their properties. So, the cell as a whole has an emergent property which cannot be inferred by looking at the parts.

So, the sum of the parts is not the same as the whole, this idea came during this time. Mechanical materialism was trying to understand everything in terms of breaking things into parts and understanding the behavior of the parts. But that may not really help. So, the picture that the world is composed of hard impenetrable particles and if you can somehow understand how they behave and how they interact, everything is done—this idea came into a problem.

Then, every part needs a motive force and every part moves with some fixed laws—that was the assertion of mechanical materialism. Therefore, they tried to find out what the forces are, what the fixed laws are, that each component, each individual part obeys.

There was another issue with mechanical materialism. If you look at a machine, it has the parts. Look at the wrist-watch. It has parts which go around, but they repeat the same

motion endlessly. You know, endless repetition of the same kind of motion—that is the character of a machine.

But in this period we are realizing that is not quite true because evolution happens. Evolution means something changes to another thing, and that cannot be understood in terms of endless repetition of the same process. So, we were starting to realize that mechanical materialism will not serve the purpose.

Metaphysics, on the other hand, as I said, it was talking about things in abstraction. Well, all thoughts are abstract thoughts. There cannot be any thought that is not abstract thought. I am not talking about just abstraction. I am talking about the property of something, the character of something, they were trying to understand as abstracted from the condition of existence. They would say iron is hard without referring to its condition: its temperature and things like that. A man is good, that boy is intelligent, irrespective of and without referring to the condition of existence.

This way of thinking was diverse from reality, and it was believed that everything has some kind of inherent property, and they tried to study that inherent property. While in reality, with these developments it was realized that, there are no inherent properties. Properties actually evolved. Through interaction with the environment, a human also evolves, in interaction with the human environment.

So, earlier everything was assumed to be given, fixed, stable, but we were slowly coming to realize that things are not given, things are not fixed, things are not stable, things are always changing and things are always coming into being, evolving, and going out of being. So, we have seen that all three philosophical groundings were challenged by the developments that happened during this period, and with that, a new kind of philosophy was taking birth.