The Marxist, XXVII 1–2, January–June 2011

Prabir Purkayastha

Science, History and Society

We have looked at how dialectical materialism provides the following:

a. A world view
b. A method to analyse nature and society
c. A philosophy of science

As a philosophy of science, dialectics does not stand outside science dictating to it through the laws of dialectics but shows how the method of dialectics helps in the process of discovery and how dialectical laws unfold in nature. As Engels put it, Marx did not deduce the laws of capital from dialectics but showed that laws of dialectics held within the domain of capital and its development.[1] It is the same way that Engels investigated nature in his Dialectics of Nature.[2]

Of course, the relation between dialectics and nature is not a static one: as we know more and more of nature, the philosophical apparatus – the structure of thought and its terms also change in order to incorporate the changes we encounter. Each of these disciplines – relativity, quantum mechanics, genetics – provides challenges to philosophy. In each case, philosophical framework has

also to undergo change and reconstitute itself with this new knowledge. Therefore, dialectics must also undergo similar changes and reconstitution as we delve deeper and deeper into nature.

In the Marxist framework, scientific laws 'reflect' the objective material reality outside us and also build relations between its various parts. Newtonian mechanics tells us about how the solar system and planets are bound together through the forces of gravity and their own momentum. This relationship is not just a subjective picture we have created but exists independently outside of us: it has a cognitive existence outside of us.

SCIENCE AS A PRODUCT OF HISTORY

While accepting science as reflecting *real relationships* in nature, Marx and most Marxists also hold that science and scientific knowledge is *historically* produced. The developments in science are not just the works of a few great men who, with the power of their intellect, laid bare the secrets of nature. Marx, and following Marx, Marxists hold that science is created historically – that the needs of society give rise to science.

Marx says, 'Feuerbach speaks in particular of the perception of natural science; he mentions secrets which are disclosed only to the eye of the physicist and chemist: but where would natural science be without industry and commerce? Even this 'pure' natural science is provided with an aim, as with its material, only through trade and industry, through the sensuous activity of men.'[3]

Engels stated, 'If, as you say, technique largely depends on the state of science, science depends far more still on the state and the requirements of technique. If society has a technical need, that helps science forward more than ten universities.'[4]

While pointing out how society's needs drive science, Engels was careful also to talk about levels in science – he discussed how science moved from astronomy to mechanics, then to chemical and finally to the biological sciences. The inner complexity of science in which chemistry and biology add extra dimensions of complexity was accepted by Bernal as well in his *Science in History*.[5] He was quite aware that the discoveries, for example, in genetics, would not take place without first developing physics and then chemistry. Therefore,

in the Marxist scheme, society and its needs drives science, but it does not drive discovery as it pleases. There is an inner logic of discovery as well, which determines what set of problems are solvable within the science and technology of that age.

It is hard today to understand the impact of Marxist thought on history of science, without going back to 1931, when a team of brilliant Soviet scholars lead by Bukharin presented this view to the Second International Congress of the History of Science and Technology in London. Boris Hessen's seminal work on Newton, 'The Social and Economic Roots of Newton's *Principia*', where he presented 'the method of dialectical materialism and the conception of this historical process which Marx created to an analysis of the genesis and development of Newton's work in connection with the period in which he lived and worked', had an enormous impact. For the first time, history of science was being presented not as an individual process but as a social process. To a band of young scientists, Bernal, Needham, J.B.S. Haldane, Lancelot Hogben, and many others, this was indeed a completely new way of looking at science.

Making science a historical process also brought in the question whether science could be bourgeois science or proletarian science? The clarity we have today on this question with hindsight did not exist then. The question was how did the social process of discovery in science govern the categories of thought in which the scientific laws were being cast? In other words, was not ideology inevitably a part of science and therefore class science?

Much of this debate came about with the theory of relativity, quantum mechanics and later with Lysenko and genetics. A very important section of scientists, particularly of the Copenhagen school, were using the results of theory of relativity and quantum mechanics to deny objectivity to the external world. For them, the laws of science were only laws of experiments and created by scientists. Whether these laws had an objective basis or not was for them a wrong question. Therefore, the issue of materialism and fight against idealism in science was very much a part of the ideological struggle being waged amongst scientists then. From this, the belief also grew that there were two ways of looking at science – the bourgeois way and the proletarian way.

What was missed here was that interpretation of scientific laws

according to the ideological choices of the scientists is different from arguing that scientific theories themselves need to be changed because of the ideological beliefs of the scientists.

Much of this debate came to a head with the Lysenko issue. There was a real debate in science (and even today) about the role of heredity and environment on the individual. The infant science of genetics seemed to predispose heredity far more than environment and was seen to be an ally in the ideological battle that argues that social hierarchy is due to inherited superiority. Further, the studies in genetics at that time were confined almost exclusively to the fruit fly and did not appear to have any immediate utility. It is in this context that Lysenko, an excellent plant breeder, supported finally by the Communist Party, attacked genetics, setting back Soviet science in this sphere by decades. The great advances in agriculture in the green revolution of the 1960s, could not have taken place without understanding genetics, showing the peril of dictating to science in the name of what is bourgeois science and proletarian science. This was one case where the urgent need of Soviet agriculture overrode good science causing lasting harm to both Soviet agriculture and science.

When we talk of social needs driving science, it may very well be the needs of the ruling classes. Therefore, 'societal' by no means implies society as a whole. It simply means that the impulse driving science is from outside science and within society, be it ruling class interest or larger social concerns.

If societal demands drive society and it certainly fulfils class needs as a part of the forces of production (as well as a part of forces of destruction for military dominance), why should we not call it class science? How do we then reconcile these two views – that science is a product of history and yet creates objective knowledge? Finally, is science also a part of the ideology of the ruling classes?

These are the questions we have to address. While the relationship between science and ideology is simpler to answer in the realm of physics and chemistry, it does become more complex in areas such as psychology, where the social and the biological intersect, giving far more play to ideology.

The first question, then, is: if science is historically produced, how does this historical process produce objective science? What we

need to recognize is that while the problems that need to be solved are posed by social needs, the knowledge that is created is cognitively independent of us. Thus, the need of ancient agriculture – Egyptian, Indian, or Babylonian – was to know when to sow and when to reap. This created the demand for a calendar. The demand for a calendar translated in turn to a study of the heavens and gave birth to astronomy. However, this astronomical knowledge that was created was based on the objective reality of the motions of the heavenly objects and was independent of the social need that gave rise to it.

In the natural sciences, despite the social needs that propel science, the science that is discovered is a relation between parts of nature. It is this relationship – the laws of science – that we discover. And even if we state them in terms of our thought processes, they are invariant relationships within nature that we capture in our thought process. These are the laws of science.

It might be argued that since of the laws of science are continuously changing – Newtonian science being replaced by Einsteinian framework, how do we therefore see these laws as invariant? The answer to that is that it is possible to derive Newtonian science from the Einsteinian one, imposing some conditions. Therefore, Newtonian science is not invalid because of Einstein's development. In fact, we still use Newtonian formulations in our everyday work as this is sufficient for the kind of calculations we need. Newtonian physics is not false science in this sense, but only an incomplete one. And for the purpose it was created, it was indeed sufficiently complete. A partial view of nature is inherent in any science, as science is never complete – nature is inexhaustible. This does not make this science wrong or invalid.

The second sets of issues arise out of the categories of thought through which science expresses itself. As these are also historically produced, is ideology not inherently a part of science? The categories of thought that we use to capture scientific phenomena of course owe their origin to human beings' social consciousness. However, these categories – when it is mass, momentum, or energy – have very little to do with ideology. This changes when we come to science of human beings – our categories of thought are deeply imprinted with our social consciousness.[6] That is why 'scientific' racism and eugenics both use science in a particular way. Neither is the science of, for

example, cognitive psychology free of ideological biases. But even in these areas, it is important to realise that science and ideology, even though mixed intimately, need to be fought *within* science. It is not feasible to reject the discipline because it has ideology even within the cognitive categories it uses in its formulations. The battle here is of course not just within science – it is also a battle in society. As long as the historical conditions exist for class rule, science, which is a part of this ideological battle, will also be a terrain of struggle.

How does the ruling class impose itself on science? It imposes in the following three ways. First, it 'selects' the class of problems that scientists should work on. This is by the way of funding or patronage – the funds determine which part of science will attract the largest number of working scientists. Therefore, the problems of science it chooses are those that are directly required for capital or for imperialist domination. The Manhattan project made clear that this is the era of big science and big science does provide results.

The second is that the kind of science practiced and its results are used directly in increased domination of capital over other classes and natural resources. Science as a factor of production helps in making capital even more powerful. Not only does it provide means to develop new technology, increasing the exploitation of labour, but also direct means of control of the working class or peasantry. Monsanto's Bt seeds is an example – control over the seeds gives Monsanto control over the farmers. Why the specific choice – choice of Bt to be implanted though genetic modifications into various seeds – as well as its results, both are governed by Monsanto's corporate needs and not that of the farmer or the consumer.

The third is that in a range of disciplines, science and ideology are intimately mixed, making any separation difficult. This is specifically in areas where science and truth directly endanger class rule. An example is of course, racism, where Darwin's theories were used to justify the supremacy of the white races, therefore European imperial rule. Later, IQ studies again were used for the same purpose. Social sciences, biological sciences and psychology are the ones far more affected by this.

The contradiction between science being governed by class needs and yet finding out real truths about the world cannot be resolved at the level of ideas. 'The resolution of the contradiction between science as the growth of human knowledge and science as ideology of

oppression comes only with political revolution'.[7] It is only by resolving the social contradictions within which science develops that we can hope to resolve the contradiction between ideology and science.

SCIENCE, TECHNOLOGY AND INDUSTRIAL PRODUCTION

When we look at production, we tend to look at science and technology as somewhat identical elements. It is important to separate here the artefacts (the tools/machines, etc.) which are physical parts of the means of production, and knowledge – the human knowledge that allows the creation of these tools. Here again, scientific knowledge – the laws of nature – is a part of the knowledge that is required to create artefacts/ machines/tools. However, it is important to understand that there is a component of knowledge that is technical; there is a part of technical knowledge that is not just laws of nature, but includes things like rules of thumb, empirical relationships, factor of safety, past experience of technologists, etc. In Marx, as in a lot of contemporary writings, this scientific and technological knowledge is loosely clubbed together. The need to differential these two forms of knowledge arises because scientific knowledge, once created, is neither local nor social. The law of gravitation works similarly, whichever the place and whatever the time. However, the technical knowledge that is also embedded in an artefact or a tool, is relatively much more local – geographically and also historically – and makes sense only as a part of a larger production system. Technical knowledge therefore reflects not only scientific knowledge but also social relations.

A simple example is that we do not make electrical cables out of gold but use copper and lead even though gold is a better conductor. The cost of gold is a part of technological knowledge and a part of the larger system of production, which technology must capture.

The second reason why scientific and technological knowledge is not identical is that any artefact produced is always done with a purpose. The purpose for which a tool is created is embodied in the tool. The function that is being incorporated in the tool is meaningless without considering existing social relations. Without this social knowledge being embedded into the tool/artefact, the tool would have no purpose.

The relation between science and production is mediated

through technology. Marx's analysis of capital demonstrates the deep knowledge that he had acquired of the history of technology, particularly in the development of capitalism. Marx looked upon technology as the major force in capitalist production.[8] But he was also clear that capitalism first created the manufacturing stage before moving into machinofacture. It is when labour processes have been first broken down by capital into their component processes that technology can create machines that take over the functions that skilled craftsmen earlier performed. Marx went a step further to clarify that capital not only creates machines to speed up and intensify the labour process, but also creates machines that can in turn manufacture machines. And it is technology and machines that brings about the fundamental change in capitalism – its continuous dynamism.

It is this dynamism that Marx and Engels refer to in *The Communist Manifesto*:

> The bourgeoisie, during its rule of scarce one hundred years, has created more massive and more colossal productive forces than have all preceding generations together. Subjection of Nature's forces to man, machinery, application of chemistry to industry and agriculture, steam-navigation, railways, electric telegraphs, clearing of whole continents for cultivation, canalisation of rivers, whole populations conjured out of the ground – what earlier century had even a presentiment that such productive forces slumbered in the lap of social labour?

In creating this technology of building machines, Marx also clarified that such a change could not have arisen by experience and rule of knowledge alone. Scientific knowledge was indispensable in this process. Marx says, 'The implements of labour, in the form of machinery, necessitate the substitution of natural forces for human force, and the conscious application of science, instead of rule of thumb'.[9] He further says that 'Intelligence in production expands in one direction because it vanishes in many others. What is lost by the detail labourers, is concentrated in the capital that employs them . . . modern industry makes science a productive force and presses it into the service of capital'.[10]

Marx also talked of science as universal labour. In his scheme, capital converts scientists to wage labour, just as it does all others – physicians, artists, poets, etc.[11]

As we have said earlier, unlike all other products of labour, science is one product that does not change based on either local or social conditions. In this sense, the labour that produces it – scientific labour – is closest to universal labour that Marx uses in his labour theory of value. He also distinguished this scientific, universal labour from cooperative labour in volume 3 of *Capital*:

> Universal labour is scientific labour, such as discoveries and inventions. This labour is conditioned on the cooperation of living fellow beings and on the labours of those who have gone before. Cooperative labour, on the other hand, is a direct co-operation of living individuals.

In Marx's formulation, scientific and technical knowledge were both a part of intellectual labour and therefore a part of this universal labour. Without going into a detailed relation between scientific and technical knowledge, let us club both forms of knowledge in this historical account of development of productive forces. One can argue that Marx overemphasised the scientific aspects of building the technology of machines and it was still largely craft-based knowledge that created the first set of machines that Marx talks about. However, this is a matter of detail.

One of the major points in Marx's treatment of science and technology is that he recognizes that capital, in its search for profits, continuously revolutionizes the means of production – change in the means of production is built into the capitalist system. This is unlike any other ruling class, where the stability of the production system was the goal of the ruling classes.[12] The Indian caste system is particular example of this stability, where no new technology could be admitted. The only way to introduce new technology into the system was to change one's religion. It is not an accident that the new technologies that came with Islam to India saw large-scale conversion to Islam by the artisans in order to practice those crafts.

The development of machinofacure particularly in textiles in England meant that there was an enormous development in the science of mechanics. Not only did the scientists have more things to study, the technology that was developing also provided new instruments of discovery. Chemical industry in France followed. Chemical and the dye industry again provided an impetus to scientific and technological research.

The Scientific Revolution of the 16-17th century was the product of the Renaissance. It brought together a number of elements – for instance, a combination of craft or artisanal knowledge with the development of mathematics. New instruments were developed such as the telescope and the magnifying glass, bringing new phenomena into view. Finally the access to knowledge increased enormously with the printing press. All this resulted in the renaissance where art/culture and science both flowered.

The technological revolution followed the scientific revolution. If the scientific revolution was coterminus with development of capitalist relations in production, the technological revolution – machinofacture as Marx put it – was really located in the 18th century.

The 20th century is the *first time* we see scientific and technological revolution happening simultaneously. Bernal, in his *Science in History* talks about a new scientific and technological revolution happening simultaneously from the beginning of the century. The combination of science with technology entering production was institutionalised through a variety of instruments – publicly funded science and technical institutions, to R&D laboratories that were a part of the industry. Science began to be increasingly perceived as providing competitive advantage to nations. France and Germany had set up their educational systems consciously with this purpose.

Science was perceived to be of direct importance to industrial production and had not only to be *produced* but also *reproduced*. It is this system of reproduction of science – to create continuously new scientists (or scientific workers) – that produced the complex of universities, institutions and research laboratories of the 20th century.

Bernal's key contribution in his seminal book, *The Social Function of Science*[13] was to recognize that the production of science and its reproduction required planning – science had now to be planned and funded. He also quantified the amount of scientific research (R&D) being done in UK and was the first to measure the research intensity of each industry. Finally, taking the example of Soviet Union, he proposed an at least 10-fold increase in R&D expenditure for science in order to meet the demand of industrial production and larger social needs.

In *Social Function of Science,* Bernal also brought out how science, instead of being used for public good, was being misused for war and

private appropriation. The enormous potential of science and technology was harnessed not for the benefit of the people, but to increase profits for capitalists and the needs of war. Bernal felt that capitalism, with its intrinsic anarchy, was incapable of planning and utilizing science for increasing production – capitalism was a fetter to the growth of science as a productive force. He also felt that the Soviet system of planning science would give it a long-term competitive edge, not only in fulfilling the aspirations of the people but also in out-producing the capitalist mode of production.

In hindsight, we can say that Bernal, like most other Marxists of his times, underestimated the resilience of the capitalist system. With the success of 'big' science – the Manhattan Project – capitalism re-organised science very much on the lines that Bernal was suggesting. What was missing was of course public good. Also, Soviet science became bureaucratized and incapable of change – something Bernal had warned of as a danger in his planning model of science.

Bernal's ideas on planning of science were opposed by an influential group of scientists. They argued that planning of science was not possible as no one can predict the direction that science would take.[14] They argued for freedom in science as opposed to planning, which they felt was very much a part of socialist thought.

The post-War period saw the victory of Bernal's proposals for planning science, even in capitalist societies. So did his argument that countries need to expand scientific research by a factor of 10 as a percentage of GDP. Within two decades, this had become the norm in most advanced economies.[15] The irony is that how quickly capitalism adopted the planning model in science, in spite of the Cold War.

Bernal had shown that Soviet Union, starting as a backward economy, was able to develop due to planning science, building scientific institutions and the resources it had put into it. The impact of the example of Soviet Union and Bernal's writings on developing countries, particularly India, was significant. Most developing countries saw the state as an instrument of development and in this, building scientific and technological infrastructure was seen as one of the key tasks of the state. In India, there was an enormous influence of Bernal in setting up of CSIR and various other scientific institutions as part of the Nehruvian policies towards science and technology. In

fact J.B.S. Haldane and Bernal both played very important roles in setting up of Indian scientific infrastructure.

Bernal's *Social Function of Science* is also interesting for the way he looks at technology. He talks about how technology has to have a certain scale for it to make a difference to industrial production. We have already talked about how science and technology knowledge is universal labour. If labour produces capital, it also produces knowledge as a force for production. In this sense, this knowledge is 'dead' labour, in the same way as is capital. Bernal's concept of what constitutes meaningful technology is very similar to Marx's understanding of capital. Marx says that money has to have a certain size before it can become capital. Similarly, Bernal held that technology has to have a certain scale before it is meaningful. Obviously, both money and technology share this common characteristic of capital.

However, there is one specific character of science and technology knowledge that distinguishes itself from other forms of capital – money as capital or tangible capital as plant and machinery – depreciate with use. Knowledge as capital does not – it can be used again and again without any loss. We will return later to the contradiction between the possibility of repeated use of knowledge without loss and the legal monopoly that capital enjoys through Patents and Copyright.

It is important to realize that the retreat from science and technology towards anti-modernity received a major impetus due to the First World War. Poison gas – directly a product of 'modern' science – had a similar impact to that of Hiroshima/Nagasaki. For the first time, science and technology were not seen as only forces of progress but also as forces of destruction. In ideological terms, this period also saw the propagation of irrational ideas in science in some of the leading practitioners.

However, there is one element which makes the current epoch different for all preceding period. While earlier, humanity could endanger its immediate environment, it could not destroy civilization and much of the existing biosphere. Today, the destructive potential of runaway technology – nuclear weapons, climate change, biological weapons – can impact or even destroy our civilization as we know it. This has added a new dimension to the issue of social control over technology and democratization in decision making on how major

scientific and technological decision should be made. It is difficult to accept that only scientists and technologists, who understand their subject well, should be left fully in charge of all the developments in science and technology.

INTELLECTUAL PROPERTY, KNOWLEDGE MONOPOLY AND THE RENT ECONOMY

The 20th century saw the emergence of public funded university and technical institutions, while technology development was more concentrated in R&D laboratories of large corporations. The age of the lone inventors – Edison, Siemens, Westinghouse, Graham Bell – was over by 19th Century. The 20th century saw industry-based R&D laboratories, where the corporations gathered together leading scientists and technologists to create the technologies of the future. In this phase, capital was still expanding production. Even though finance capital was already dominant over productive capital, all major capitalist countries still had a strong manufacturing base.

In this phase of development, science was regarded as public goods and its development largely concentrated in the university system or publicly funded research institutions. Technology development was largely regarded as a private enterprise. Science was supposed to produce new knowledge, which could then be mined by technology to produce artefacts. The role of innovation was to convert ideas into artefacts.

The system of intellectual property rights – the system of patents arose – to provide protection to useful ideas that were embodied in artefacts. However, from the beginning, patents also had a public purpose – the state-granted monopoly for a certain period was to ensure the public disclosure of the invention.

The transformation of this system that existed for several centuries came about as a result of two kinds of transformations. The first relates to the way in which the university system of knowledge production has been transformed, under the neo-liberal order, into profit making commercial enterprises.[16] Second, the distinction between science and technology has blurred considerably and the two are far more closely integrated. For example, an advance in genetics can – almost seamlessly – lead to an artefact that is both patentable and marketable.

Similar is the case of innovations in the field of electronics and communications. Many disciplines of science, as a consequence, are being driven closer to the systems of production.

The end of 20th century has also shown the rupture of finance capital and productive capital. Today, global capital operates far more as disembodied finance capital, controlling production at one end with its control over technology and at the other control over markets. It is this phase of capital, where capital increasingly is living off speculation and rent that also sees the separation of knowledge as capital from physical capital as productive capital.

The conversion of the university system as a system for producing knowledge directly for commercial purposes has happened simultaneously with the destruction of the R&D laboratories that was very much a part of the industrial landscape of the 20th century. Finance capital directly controls university science, not through investments but buying 'knowledge' – the monopoly is exercised through buying of patents that university research produces. It is this monopoly, in turn that allows it to dominate over industrial capital.

It is this transformation capital to 'pure' finance capital and rent seeking using its monopoly over knowledge – patents, copyrights, industrial designs, etc., – that characterises the current phase of capital. It has been accompanied by the advanced capitalist countries becoming more and more 'service' economies. In essence, they dominate the world by virtue of control over the global financial structure, the new knowledge required for production and control over distribution through retail and global brands.

It is in this structure that the universities are increasingly being captured by capital – what is being termed as 'University Inc'. The major source of funding for creating new knowledge is still publicly funded, but increasingly, their output is privatized. The Bayh Dole Act and similar other laws[17] in different parts of the world are being enacted for this purpose. This is the second enclosure movement in which the knowledge created as public goods is sought to be privatized.

The transformation of publicly funded science to private science is not taking place through science being privately funded. Science institutions are still publicly funded, both in the advanced capitalist countries and in countries like India. It is the *orientation* of scientific

research that is increasingly being dictated by private capital. In such a system of knowledge production, a deeper analysis of nature that has no immediate commercial application is of much lower priority than what the industry considers as lucrative research. Thus long-term knowledge production is devalued in favour of immediate and short-term gains. Thereby, science is explicitly seen as a means of generating profits – patenting of university research is seen by both the scientists and the university administrators as the major driver of research.

The impact of such a shift is visible. In India, for example, a major thrust in agricultural production in the decade of 1970s and 80s (termed as the 'green revolution') arose out of public domain science. Today, the gene revolution is controlled by a few private corporations – and they are seen as the possible drivers of a second 'green revolution'. IARI, ICAR and agricultural universities are increasingly getting tied to corporations like Monsanto and their corporate goals, instead of taking advances in science to the farmers as was their original goal.

The trajectory towards private appropriation of knowledge is typified by the Bayh Dole Act in the US. The Act, enforced in 1980, reversed the almost universal assumption that public funded research should not be protected by private rights in the form of intellectual property protection. The Act allowed Universities and other non-profit entities to patent research that was funded from public sources. *Fortune* magazine held the Bayh Dole Act responsible for pushing up the cost of medicine in the US: 'Americans spent $179 billion on prescription drugs in 2003, up from $12 billion in 1980.'[18] The article states that the Bayh Dole Act had actually retarded the progress in science instead of helping it. The discovery of new molecules, a measure of innovation in the pharmaceutical industry, has actually come down.[19] It helped a few companies, universities and scientists to become fabulously rich, at the expense of scientific development and the common people.

Salk, the creator of the oral polio vaccine, was once asked who owned the patent for his polio vaccine. He is believed to have said, 'the people'. This is an answer that one would expect from few scientists today. The last two decades have seen the creation of a new category of private property rights called Intellectual Property Rights, bringing

under one umbrella what were earlier disparate rights. Thus different kinds of private property rights — creative rights of authors under copyright and industrial property rights such as patents, trademark, trade secrets and industrial designs – has been brought under the common rubric of Intellectual Property Rights (IPR). The objective of this exercise was twofold. First, it sought to give a cover of individual creativity to legitimise essentially corporate rights. The second was to expand enormously the scope of these rights.

The impact of this new IPR regime, coupled with the global trading regime under WTO, has led to the private appropriation on a grand scale of commonly held biological and knowledge resources of society. The patents regime today has expanded to patenting of life forms, genetic resources, genetic information in life sciences, patenting methods and algorithms in computational sciences and even patenting of how business is done. Not only are methods and algorithms being patented, copyrights has been extended to include software and all forms of electronically held information. Traditional knowledge and biological resources, held and nurtured by different communities, are being pirated by global corporations. Increasingly, the enterprise of science as a collaborative and open activity for creating knowledge is being subverted into a corporate exercise of creating monopolies and making super profits from the consumers.

The impact of such appropriation is now visible. The HIV/AIDS epidemic has shown it is impossible for the vast majority of the people in the globe today to pay the costs of new life saving drugs which are patent protected. If the IPR regime has been damaging to the life of those suffering from disease, what lies in store for agriculture is even worse. Using advances in biotechnology and bioinformatics, corporate seed companies and corporate plant breeders will control global agriculture and food production. With food prices already sky-rocketing, the impact of such a monopoly on the vast sections of the people can well be imagined.

Software, a specifically 20th century creation, used an 18th century legal form – copyright – to create a monopoly. The problem of this restrictive access is that it does not address the specificity of software – its generally short lifespan, the nature of the work, etc. With changing interpretations of patenting, software is now also being patented in many countries. As information technology encompasses almost every

sphere of human activity, all such activities will be controlled by patents or copyrights. The knowledge economy is about rent economy – rent by virtue of legal monopoly over knowledge.

The intellectual property rights regime is a blatant attempt to exclude people from the domain of knowledge by enclosing it, similar to the enclosing of commons carried out over the last 500 years. It uses a legal artifice called IPR to privatise knowledge which is publicly held. Any enclosure of knowledge is doubly pernicious – it not only reduces access by others, it also puts a price on access to something which is infinitely duplicable. The enclosure therefore of knowledge using the IPR regime is even more iniquitous than the earlier forms of enclosure movements. The struggle against intellectual property rights of various kinds becomes a battle for preserving the global commons, specifically knowledge in its various forms.

The impact of privatisation of knowledge and science is also changing the way science is being done. Science is no longer the collaborative and open activity aimed at creating new knowledge about nature. It has become a secretive exercise where a patent is filed before a paper is published. Ideas are not shared as they now have a commercial value. Paradoxically, this is happening in a situation where the possibility of open, collaborative work has multiplied enormously.

It is the understanding that science needs to be put back as an open and collaborative exercise[20] that has given birth to the commons movement. While the environmental and ecological movements have looked at commons and fought against their privatisation, the kind of commons that they have looked at are finite resources such as grazing lands, forests, fisheries, oceans and atmosphere, etc. These commons are still natural resources, which appeared to have been infinite in an earlier era and are now realised to be finite and capable of over-exploitation and degradation. The knowledge commons are intrinsically different in that they do not degrade with use. A law of nature or the knowledge of a genetic code does not have any subtractive aspect: their repeated use does not subtract from them in any way.[21]

It is interesting that capitalism sees the finite commons as infinite and demands the right to dump waste material in these commons. Yet it regards the infinite commons as finite and demands monopoly rights over it!

Never before has society had the ability to bring together different

communities and resources, like it has today, in order to produce new knowledge. It is social, universal labour and its private appropriation as IPR under capitalism that today stands in the way of liberating this enormous power of the collective for production of new knowledge for the benefit of the people.

SOCIAL CONSTRUCTIVISM AND TECHNOLOGICAL DETERMINISM

There are certain debates that have gained ground in what are called science, technology and society studies, or social studies of science or science policy. They deal with how society shapes technology and how technology shapes society. One particular that has gained ground is social constructivism.

Social constructivism is an influential school of scholars arguing that technology does not unfold in a unilinear fashion from some inner logic, but is the result of a series of social choices. If this is only what they were stating, we would little to quarrel about. The key problem in their account is that the social here is devoid of class and industrial production, but merely sociological. The success in advancing production is treated merely as one factor on par with other sociological factors, e.g., a preference for young men to prefer speedier bicycles, etc. In this view, technological effectiveness in solving a given problem is only one driver along with various others. The second problem with social constructivism is that it assumes that technology is infinitely plastic – it can offer a range of solutions all almost equally effective technologically. What is chosen finally – in this view – is what fits best into the social preferences of the various actors and groups.

Social constructivists use the principle of neutrality between social options, for example, cultural preferences and economic needs. Class and class interests in promoting a certain kind of technology disappear in such a paradigm. Russell makes this point in his criticism of social constructivism, 'If we accept that arguments over technological options are socially constructed, then it follows that a relativist approach with respect to them leads us into relativism with respect to social interests – in other words, political neutrality'.[22] It says nothing about the impact of such choices being made and makes no distinction between an emancipatory technology and an oppressive one.[23] That there are social choices being made in the development of technology

does not tell us anything about the choices that should be made from an emancipatory viewpoint: it provides no instrument of intellectual struggle. The second problem with the social constructivists' account is the belief that technology is infinitely plastic and that the design space is therefore infinite. Social constructivism seems to believe that there are infinite choices possible and the final choice is dependent on largely sociological factors. Instead the feasible design space for most technologies is strictly limited and the social shaping drives artefacts only within a narrow range of choices.[24] When social constructivism looks at technology, only those few options that are technologically effective are left. Social choice amongst a few technology options that have already been sieved through as technologically effective, is quite different from what social constructivism perceives is the 'construction' of technology.

The mirror image of social constructivism is technological determinism. It is interesting that depending on the context, Marx, Engels and Marxists such as Bernal have been accused of both a completely externalist view of science and technology as well as technological determinism. In Bernal's case, his *Science in History* is treated as a crude externalist account of history of science, while his *Social Function of Science* is treated as technological determinism or scientism. What does technological determinism mean? It means that technology creates society – it is relatively autonomous of society and it creates a society consistent with the level of technology.

Let us take the first part of technological determinism – that technology development creates social change. Here again, there is no doubt the underlying belief in Marxism that as technology and science develop, it leads to the development of productive forces and their conflict with existing relations of production. However, all serious Marxists have also shown how the system of production of science and technology are themselves products of the existing production relations. Though it is a closed loop, it is not a static one. Even if social monopoly of certain classes tries to keep technology static, it will change albeit slowly over time and this will introduce changes in the system. But technology is as much determined by society as society is determined by technology. We come back to the relationship of technology and society being a dialectical one.

The argument that the kind of technology that arises is imprinted with the class relations of society is different from the same argument

vis-à-vis science. The products of technology have social functions and therefore do encode societal relationships in some way. Marx says, 'The hand-mill gives you society with the feudal lord; the steam-mill society with the industrial capitalist'.[2525] Karl Marx, The Poverty of Philosophy in Chapter 2, The Metaphysics of Political Economy

Let us take one example. A labour shortage economy may have a high cost of labour and need to automate for improving quality and reducing labour costs. A labour surplus economy may have low labour costs and find such automation not competitive. Here, a selective automation that ensures quality in the production process – a form of semi-automation may be the preferred technology choice. Therefore, technologies are far more located within the social context.

Let us take another example. One of the reasons that hybrid seeds were favoured during the green revolution was because hybrids were consciously created in order to enable the monopoly of seed companies. The decision to create hybrid seeds and not seeds that bred true was the result of this class choice. It is for this same reason that Bt cotton in India is promoted through hybrids so that Monsanto can retain control over the seed market.

In this sense, technology does reflect social relationships, just as society reflects the level of technology. Given a technology, we can see the kind of society that created it. Technological determinism makes this a one-way process, while Marxists look upon this process of technology creating society and society creating technology as a dialectical, two-way process.

CONCLUSIONS

The issue of what science can do and what science actually does is a terrain of struggle within science and also in the larger social arena. It is a battle for the future direction of science. It is part of the larger battle of allocation of resources for the betterment of humanity. It is a battle against irrationalism in science and in society. Socially conscious scientists and scientifically conscious progressive sections must wage this battle together. It also means democratisation of scientific decision making; a handful of scientists cannot sit and decide what society needs. Bernal and other scientists' struggle for social responsibility of the scientists came from this basic perspective, as did the bodies of scientists for peace and against nuclear weapons. This is also why

popularisation of science was and continues to be a major thrust of progressive science movements.

Today, there is an alternate view of science (and technology) that we also need to contest. This is that science and technology – most of these views collapse science and technology as one common entity – have an ideological underpinning of domination over nature.[26] In this view, knowing nature and domination over nature is identical and this is the ideology of science. It is the ideology of domination of nature that is endangering the planet. If this view is to be followed through, one should retreat from science as the only way of saving the world. Much of the anti-science and anti-technology views have this viewpoint, even if it is couched in different forms. For them, the 'enemy' is science, technology and development and not capital. It is divorced from the class issue of who owns the means of production and uses it for what end.

The problem of retreat from science and implicitly development is that the world does not stand still. At any point of time, society is in a state of dynamic equilibrium with nature. It has no option to opt out of this equilibrium and seek a stasis – it can either go forward or it will inevitably go backward. This is apart from keeping in a stasis the current capitalist system and keeping major sections of the world's population at subsistence levels. The argument that we should now retreat from science is not only to retreat from the hope of building a better society, it is also the refusal to understand that without developing knowledge and our tools of production, we cannot even stay at our current levels of development.

Let us take two examples. One is medicine. It is a simple evolutionary fact that bacteria get immune to specific antibiotics over time. What will happen if we stop developing new medicine? Increasingly, our armoury of medicines will become ineffective over time. We will still be able to use them by cycling different antibiotics, but their effectiveness will be nowhere as it is today. Apart from this, we also have new diseases that arise – HIV/AIDS is one example. New medicines are just not the fancy of global corporations and their scientists but a vital requirement.

It is possible for us to also evolve our defence mechanisms and become relatively immune to diseases. This is what humanity did earlier. The problem is that this takes a long time and can devastate societies. Plague and Black Death are not too far in the past for us to

think that this is a simple process!

The other example is food production. It is estimated that human population was about 300 million 2000 years ago[27] and took about 1600 years to double. The next doubling took only 250 years – by 1850, the population had reached 1.2 billion. By 1950, another 100 years, we have crossed 2.5 billion and reached more than 6 billion in only 50 more years.

Malthus had predicted that humanity would run out of food as population increases geometrically and food production increases linearly. Obviously, science and technology change has kept pace and therefore so has food production, defeating the Malthusian paradigm. But what happens if we freeze science and technology? It is simply that food production would no longer keep pace with increased population, even if that population stabilised as it is predicted to be doing over the next 50 years.

Nor is it possible to freeze the boundaries of knowledge, even in certain areas. We may artificially create boundaries in terms of disciplines – in nature all knowledge is dialectically interconnected. One cannot unravel nature at one end without unravelling it at other ends as well.

We are not arguing for a simple use/misuse model of science – that science is value neutral and it is either used or misused by social groups/classes/nations. The scientist or the scientific worker is not just creating neutral knowledge – s/he is developing knowledge which can be used for human or environmental destruction and to favour the few. One cannot divorce the two – creating this scientific knowledge and fighting at the level of society. Both of these must go together in a struggle to reshape science to serve the needs of larger humanity. The choice of problems, the kind of solutions offered, the direction that science takes are all a part of this larger struggle.

I will end with a quote from Helena Sheehan, who encapsulates the position that I would take on science, technology and society:

> In the tradition of Bernal, the left took its stand with science. I do not believe that the debunking of science in terms of its cognitive capacity or its social potential is an appropriate activity for the left. It is neither epistemologically sound nor politically progressive. The left should take its stand with science, a critically reconstructed, socially responsible science, but with all the higher possibilities of science. It should engage in a radical

critique of the incorporation of science to global capital. It should open a path to the progressive potentialities of science.[28]

This is the challenge we face today.

REFERENCES

Frederick Engels, *Anti-Dühring*, 1877. Available at http://www.marxists.org/archive/marx/works/1877/anti-duhring/ch10.htm

Frederick Engels, *Dialectics of Nature*.

J.D. Bernal, *Social Function of Science*, George Routledge and Sons, London, 1939.

J.D. Bernal, *Science in History* Vols. 1-4, London: Watts, 1954, reprinted by KSSP.

Reader in Marxist Philosophy, ed. Howrad Selsam & Henry Martel, International Publishers, 1963.

Articles from *Science and Nature* in http://www.autodidactproject.org

NOTES

[1] Marx observes: 'Here, as in natural science, *is shown* the correctness of the law discovered by Hegel in his *Logic*, that merely quantitative changes beyond a certain point pass into qualitative differences.', *Anti-Dühring* by Frederick Engels 1877, http://www.marxists.org/archive/marx/works/1877/anti-duhring/ch10.htm

2 Frederick Engels, *Dialectics of Nature*.

3 Karl Marx and Frederick Engels, *The German Ideology*

4 Letter from Engels to Borgius, January 25, 1894, wrongly identified as Engels to H. Starkenburg. http://www.marxists.org/archive/marx/works/1894/letters/94_01_25.htm

[5] J.D. Bernal, *Science in History*, Vols. 1-4 (London: Watts, 1954), reprinted by KSSP.

[6] Marx wrote to Friedrich Engels in 1862, 'It is remarkable how Darwin rediscovers, among the beasts and plants, the society of England with its division of labour, competition, opening up of new markets, "inventions" and Malthusian "struggle for existence". It is Hobbes' *bellum omnium contra omnes* and is reminiscent of Hegel's *Phenomenology*, in which civil society figures as an "intellectual animal kingdom", whereas, in Darwin, the animal kingdom figures as civil society.' http://www.marxists.org/archive/marx/works/1862/letters/62_06_18.htm

[7] Richard Levins, 'Class Science and Scientific Truth', http://www.mail-archive.com/pen-l@galaxy.csuchico.edu/msg07185.html

[8] Nathan Rosenberg, 'Karl Marx on the Economic Role of Science', *The Journal of Political Economy*, Volume 82, Issue 4, July-Aug. 1974. Rosenberg's account of Marx's understanding of science, technology and society is quite a Marxian one, even though he would not identify himself as a Marxist.

[9] Karl Marx, *Capital* Vol. I, Ch 15, New Delhi: LeftWord, 2010. The online reference is here: http://www.marxists.org/archive/marx/works/1867-c1/ch15.htm.

[10] Karl Marx. *Capital* Vol. I, Ch 14, online reference available at http://www.marxists.org/archive/marx/works/1867-c1/ch14.htm. This, and the previous quote, is also available in Robert S. Cohen, Karl Marx on Science and Nature (Excerpts), Science as Social Process, http://www.autodidactproject.org/other/sn-cohenrs1.html.

[11] 'The bourgeoisie has stripped of its halo every occupation hitherto honoured and looked up to with reverent awe. It has converted the physician, the lawyer, the priest, the poet and

the scientist into wage labourers.' Marx and Engels, *The Communist Manifesto*.

12 'The bourgeoisie cannot exist without constantly revolutionising the instruments of production, and thereby the relations of production, and with them the whole relations of society. Conservation of the old modes of production in unaltered form, was, on the contrary, the first condition of existence for all earlier industrial classes', Marx and Engels Communist Manifesto.

13 J.D. Bernal, *Social Function of Science*, George Routledge and Sons, London, 1939.

14 Michael Polanyi, 'Rights and Duties of Science', in *Contempt of Freedom: The Russian Experiment and After* (London 1940) quoted by Robert E. Filner, 'Science and Marxism in England, 1930 1945', *Science and Nature*, no. 3 (1980), pp. 60-69.

15 Christopher Freeman, 'The Social Functions of Science' in Swann, Brenda and Francis Aprahamian, *J D Bernal: A Life in Science and Politics*. Verso, 1999.

16 'Academic administrators increasingly refer to students as consumers and to education and research as products. They talk about branding and marketing and now spend more on lobbying in Washington than defense contractors do.' Jennifer Washburn, *University, Inc.: The Corporate Corruption of Higher Education*, Basic Books, 2005.

17 In India also, there was an attempt to introduce a law, which was even worse than the Bayh Dole Act, The Protection and Utilisation of Publicly-Funded Intellectual Property Bill. While some major provisions were modified to prevent wholesale privatization of publicly funded research, the country would have been better off without even this modified Bill.

18 The Law of Unintended Consequences, Fortune, September 19, 2005.

19 Arti K. Rai, Jerome H. Reichman, Paul F. Uhlir, and Colin Crossman, 'Pathways Across the Valley of Death: Novel Intellectual Property Strategies for Accelerated Drug Discovery', VIII *Yale Journal of Health Law, Policy & Ethics* 53-89, 2008.

20 Prabir Purkayastha, Amit Sengupta, 'The Struggle to Bring Back the "Public" into Science', in a forthcoming book on knowledge commons to be published in French. A part of this section is from this contribution.

21 David Bollier, *Silent Theft: The Private Plunder of Our Common Wealth*, Routledge, 2002 and also in James Boyle, 'The Second Enclosure Movement and the Construction of the Public Domain', 2003, http://www.law.duke.edu/pd/papers/boyle.pdf

22 Stewart Russell, 'The Social Construction of Artefacts: A Response to Pinch and Bijker', *Social Studies of Science*, Vol. 16, 1986, pp. 331-46.

23 Langdon Winner, 'Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology', *Science, Technology, & Human Values*, Vol. 18, No. 3, 1993.

24 Walter G. Vincenti, 'The Technical Shaping of Technology: Real-World Constraints and Technical Logic in Edison's Electrical Lighting System', *Social Studies of Science*, Vol. 25, No. 3, Aug., 1995.

25 Karl Marx, The Poverty of Philosophy in Chapter 2, The Metaphysics of Political Economy http://www.marxists.org/archive/marx/works/1847/poverty-philosophy/ch02.htm#s2

26 Marx also talked of science as allowing humanity to 'control nature'. In this, he was contrasting how earlier nature dominated over humanity and only science and technology liberated humanity from blind obedience to nature.

27 See http://www.un.org/esa/population/publications/sixbillion/sixbilpart1.pdf.

28 Helena M Sheehan, 'J.D. Bernal: Philosophy, Politics and the Science of Science', *Journal of Physics*: Conference Series 57, 2007, Conference on John Desmond Bernal: Science and Society.