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J.D.Bernal : A Centenary Tribute

Arjun Patil

[The author is an experimental scientist, who specialises in instrument building. He is also involved in science teaching and popularisation]

The twentieth century is rightly called the century of scientific revolutions and the twenty-first century began with a bang : with the report that the first draft of the human genome map had been completed. This was achieved by astounding investments - with the monopoly business having a big stake in it. And there is no denying that they will reap the profits. But the results of this genome mapping experiment also meant a victory for the working class ideology for it showed that "life is beginning to cease to be a mystery" and could now be pictured and would become "practically a cryptogram, a puzzle, a code that can be broken". This working model of life "while removing most of the mysteries of life will not reduce in the minds of the scientific biologists of today any of the appreciation of its complexity and beauty

These were the words of J.D. Bernal, whose hundredth birthday we celebrate this year. According to Dorothy Hodgkin (the 1964 Nobel prize winner, in chemistry and Bernal's student and colleague in science and public activity) many of Bernal's pioneering ideas were the foundations of "our understanding of the structure and functions in physics, chemistry and biology." This interrelation between structure and function remained Bernal's recurrent themes . On social questions he tried to explore the relations between the functions of science and the structure of the society in which it operates. This brought forth the scientists' role as a citizen. Bernal considered that a scientist's duty did not end with exploration of nature and its interpretations and applications but also lay in changing the social functions of science to a just and equitable. Science, to him was to satisfy mankind's eternal dream of "a life of plenty of food and no work to do" (not only for the rich and princes) so that all citizens of the globe will have the liberty "to see the world and enjoy it at leisure"; and also have "the possibility of really finding out what one would like to do and doing it". This essay is an account of the life and works of Bernal. Some emphasis is given here

on his exploits in natural science - area which the readers of this journal will find interesting and useful - also giving a flavour of the way a scientist and a common citizen may cooperate in addressing the problems of science and of the society.

Childhood and student days:

John Desmond Bernal was born on 10.5.1901 in an Irish catholic family, who were formerly Spanish shepherdic Jews and his mother was an American. John Desmond was a precocious child . He even tried writing an autobiography at the age of nine!. He tried building things. Bernal's ideas in instrument building were very innovative but he was clumsy with his hands. He once nearly electrocuted himself and a colleague, while setting up an x-ray tube. Bernal, in later life would show great foresight as one who could give ideas about new instruments, which his collaborators would build - often with most inexpensive objects, like broken clocks, cycle tubes, etc. No these were not toys, these were the scientific instruments with which research data were taken and published before the international community.

At the age of ten Desmond left Ireland for England to join a school. He had witnessed the Irish independence movement and had sympathies for it. He had also seen the ruination of several English families because of the World War I. Bernal found his first intellectual satisfaction when he came to study in Cambridge for here he could meet many kinds of people,- broken soldiers, workers, students of several disciplines, intellectuals and so on,- whose stories and experiences stimulated his intellectual process. Mere interpretation of the world did not satisfy him but the path of change appeared uncertain. It was in one meeting on 7th November 1919 that he heard from a friend about the October revolution in Russia and about the experiments in socialism with power to the soviets. That opened up a new world for him. Bernal now noted how narrow his Irish patriotism was. It indeed impressed him that to change the world one need not wait for a messiah to appear but that "It was the people that would sweep away all things that I hated..... It would bring the scientific world state."

This hope led Bernal to study the ideology on which the new soviet society was based i.e. Marxism-Leninism. He renounced catholicism and declared himself a communist. His family despatched a priest to bring Bernal back to the catholic fold. They argued at length but finally it was the priest who left the church! The second one involved a different kind of encounter. Some students thought that this young communist must be taught a lesson. They attacked Bernal one night in his room This combat group (which had links with a future admiral, Lord Mountbatten) got a severe beating from Bernal. They fled, though they outnumbered him. This was because of one tactical error they had made. They came in smoking cigarettes. Bernal

simply switched off the light. They could not see him but he could see where they were and gave a huge punch on the face of everyone. By 1923, Bernal and his wife became members of the communist party. They actively mobilised workers for the 1926 general strike. After a decade or so he left the membership of the party but remained a communist. Informal yet deep links with the party still continued.

Scientific contributions

Having thus gained a framework and a world view Bernal tried to gain a wider vision of science by studying different courses that Cambridge offered. For his Tripos he read such diverse areas like mathematics, chemistry, biology, physics, mineralogy etc. When Dorothy Hodgkin met him for the first time, she found Bernal to be well informed in archaeology (an archaeologist's daughter she was!) and his encyclopedic knowledge earned him the nickname: SAGE. In accepting Marxism, however, Bernal was not alone. The Cambridge group now consisted of other brilliant scientists. Joseph Needham, J.B.S.Haldane were in this group. Like Oparin in the USSR, Haldane had made pioneering work on the theory of chemical evolution of life i.e. life consisted of inanimate molecules. To this Bernal added another dimension and an extremely important one at that,-and said that it was not merely the chemistry of molecules but also the arrangement of the molecules that needed to be seen. The question thus was: how does the structure determine the function? The first landmark in this was attained by Watson and Crick's determination of the DNA structure in 1953 i.e. in twenty years, Bernal's pioneering ideas had become the accepted methods in biology.

As a young student Bernal had gained reputation as a versatile and brilliant personality, who excelled in physics and mathematics and could have taken any of these areas as his research field. Though physics under Rutherford was making news, Bernal displeased Rutherford to no small extent by not doing nuclear physics but by choosing crystallography (still a fairly unfashionable area at that time) as his area of research and worked out some very involved mathematics for that. He finally chose the area of biology as the field of his work. Perhaps he thought that the deepest problems of science were there in biology and that the mystery of life was the one, which could unshackle the human mind, as Darwinism (in spite of its limitations) had done in the last century. Bernal chose this field also because biology was too complex to be solved by biologists themselves and needed inputs from other areas like physics and chemistry. It was he who established x-ray crystallography as an important tool for the study of biology and later developments in biology owe a great deal to this and many other contributions from Bernal, which may be difficult to enumerate.

These include formulation of the Bernal tables, which helped early

crystallographers (there were no computers in those days) to approximately calculate the structures of crystals, pioneering works on sex hormones, proteins, viruses, structure of different solid phases of water (for example, ice, snow etc). Later he gave the first model of the liquid state (called the Bernal hard sphere model) and is also considered a pioneer in the physics of composites. Many famous biologists, including Nobel Laureates have acknowledged their success to the insight that Bernal provided in the decisive phases of their work. Dorothy Hodgkin expressed that she should have shared her Nobel Prize with Bernal instead of winning it alone. Max Perutz's and John Kendrew's work on the structures of hemoglobin and myoglobin and Aaron Klug's on electron microscopy of viruses owe a lot to their association with Bernal and led them to their Nobel Prizes. In many of the areas Bernal said the first word and left it to the community to say the last. Bernal never got the Nobel - perhaps for his politics - though many feel that he could have wiped away a dozen of them!

A Universalists' View of science:

As a student of science four aspects of Bernal's scientific work do stand out and deserve analyses by sociologists. First is his role as a great catalyst, a universalist who could see the gaps and interconnections between disciplines and hence succeeded in bringing together men of complementary skills from different branches. The second is his ability to devise simple yet sharply focused methods for tackling scientific problems. The third was the absence of bureaucratic control over his juniors. And lastly he showed that science can be done at all levels. Some illustrations will be provided in support of these.

Bernal was indeed a pioneer in cross-disciplinary science. Modern biology was apt for that and yet Bernal's scientific work never had the support of large funds. After his Cambridge days, he moved to the Birbeck College. This college where he taught did not belong to the aristocrats but was meant for industrial workers, who wanted to update their knowledge. Bernal considered himself happy and privileged for he interacted with the members of the class, which according to him, would liberate the whole mankind. His experimental set up was always modest but the output was deep in insight.. His lab was popularly called 'The Institute for the study of Things'. It was to this physically modest and intellectually stimulating environment of the working class college, that internationally reputed scientists would come. The problems that this lab dealt with, were the problems of life, of which biology formed a part.

Science and society interactions:

It was indeed not biology alone but LIFE that Bernal and his

collaborators were interested in. What interrupted their total attention to the lab were the events outside the laboratory. It was in response to these global issues that Bernal in his Cambridge days formed the Cambridge Scientists' Anti War Group. It focused on many social issues like the economic depression of the 30's, the Nazi horror in Hitler's Germany, the Spanish civil war, Japanese invasion of China, freedom movements in the British empire and so on. In this gloomy environment, the Soviet Union was the beacon of hope and Bernal made his contact with the Soviet scientists when Bukharin led the first team to England in 1931.

An important offshoot of these debates was that one recognized the need for a strong movement for popularization of science. A leading role in these activities was taken up by Haldane (who wrote regularly for the Daily Worker), the journalist Crowther and fellow biologist Lancelot Hogben. This was accompanied by theoretical studies on scientific developments world over - in which Bernal took the lead.

Bernal's analysis of these social issues are found in his work, "The Social Function of Science" which created a stir when it appeared in 1939. It was here that Bernal analyzed the liberating effect of the socialist revolution in the Soviet Union and considered the exploitative nature of the capitalist system to be a hindrance to the growth of science. This book also analyzed briefly the science in colonial India and commented on the occasional brilliance and extreme unreliability of Indian science. Perhaps the most incisive statement was that he considered that the main social forces behind the development of science in India were not the scientists themselves but the political agitators behind the struggle for independence from colonial rule.

A large part of the above book contains an analysis of science in Nazi Germany. The book appeared after the Dimitrov thesis. Bernal saw in fascism "an attempt to maintain an unstable and discredited system of private or monopoly production by a combination of physical force and mystical demagoguery". Historically Germany had a late beginning in science but matured exactly at a time when German industrialization was gaining its maturity. In fact, German industry-university link was what made both flourish. It was this nexus again that helped fascist ideas to penetrate in academic circles, after the demise of the Weimar republic. By that time the German war industry had been solidly entrenched in German chemical enterprise, which began with Haber's (famous for industrial synthesis of ammonia) production of poison gas during the first world war. Bernal noted that one of the reasons why Hitler could subvert academic life was the complacency (even collaboration by) of the non Jewish intelligentsia who easily accepted the fascist view of patriotism. They considered that the expulsion of the Jewish members of the academic faculty gave them an opportunity. The

dangerous features in Fascist science was that science under fascism became an instrument to redefine certain reactionary human values like purity of race, national pride, and to spread the message : that peace was to be treated as a preparation for war. Under fascism science ceased to become a discipline for the discovery of truth but was to be an agency to popularise the ideas of national socialism. The message of hope was, however, given by the French intelligentsia. They gave solid resistance to French fascism and mobilized popular opinion for the anti fascist Popular Front. The great intellectuals like Frederich and Irene Joliot Curie, Langevin, Picasso, Sartre became the rallying figures behind this front, of which the French communists formed the backbone. Bernal concluded that the Third Reich under Hitler would unleash a World War. He rallied the British scientists in war preparations and with Solly Zuckerman studied the effects of aerial bombing on civilian population.

A Scientist in the Field:

It is here that Bernal's role as a communist, a scientist (as much a practical one as a theorist) and a catalyst come to the fore. The threat of German aerial bombing had created panic in London (those were the pre radar days) and even trained scientists (including his friend J.B.S. Haldane) could not predict the damage potential of bombs of different sizes. It was clear that the working class would be the most vulnerable section in the event of bombings. Bernal considered it his duty to educate the citizens about the possible damages, and in constructing damage proof shelters. He sought the help of his friend Solly Zuckerman - a doctor, turned anatomist, turned curator of zoo - to conduct practical experiments. Some abandoned shelters were selected in the countryside . Zuckermann and Bernal brought apes and pigeons and left them in these shelters. They contacted the police department for incendiary bombs of different sizes. With the official sanction the bombs were exploded at different distances from these shelters and then they examined the damages to these captive animals. In a later experiment the two friends acted as their own "guinea pigs", sitting in the shelters while the bombs were exploded nearby! These simple experiments showed that the believed damage potentials of most of the bombs were highly exaggerated. Their results proved invaluable for civil defence, particularly in working class areas and also generated more confidence amongst the citizens.

This involvement helped Bernal and his friends in gaining acceptance from the governmental defence establishments, even though Bernal was a communist, i.e. "as red as the fire of hell". His one time enemy Lord Mountbatten now became his supporter, for the most committed anti fascists were the Reds. Bernal was one of the

pioneers in applying operations research ideas in these war years and was directly involved in the D-Day landing of the Allied forces in Normandy. His special attention was in devising aerial photography methods to photograph the shapes of waves on the Normandy beaches under different conditions of wind. From the patterns of these waves he devised methods to determine the inclinations of the beaches and conclude whether they could withstand the landing of tanks and armoured vehicles.

Before the Normandy plan had matured the allied plan was to assault from the frozen arctics. It was here that Bernal put his own research work into use. It was in the mid 1930's, while stranded in Moscow airport that Bernal watched the surrounding mist and decided to work on water. He discovered later that water is not so simple as people thought it to be and that ice had several structural phases. It struck him during the war years that if icebergs be packed with jute fibres, they could become hard and strong enough to carry tanks and allow landing of planes. This led him to the pioneering work on composites. Experiments proved Bernal to be right. This plan was, however, abandoned because the Normandy operations proved to be more viable than those from the arctics.

Cold War and Scientists' Response:

At the end of the second world war this anti fascist alliance was broken and cold war took over. Bernal, like his friend Joliot in France was out of favour with the establishment. Moreover, the bombing of Hiroshima and Nagasaki placed a special responsibility on scientists to see that the results of their scientific work were not put to use for destructive purposes. It was at this stage that Bernal involved himself in organising several fora to contain the damages of the cold war. These were the Scientific Workers' Association, The Pugwash Conference, the World Peace Council etc. It is necessary to note the commendable support that Indian scientists (e.g. M.N.Saha, D.D.Kosambi, S.S.Sokhe)gave to these efforts. Bernal was also pivotal in mobilising the support of British scientists in helping the newly independent colonies in their scientific planning and in mobilising support for the UNESCO, the brain child of the UNESCO being his fellow Marxist, Joseph Needham.

Science in History:

Bernal's important work: Science in History appeared in the 1950's and one entire session of the Soviet Academy of Science was devoted to the study of this single work - an honour never given to any other scientist. We will here quote only one of his many significant observations. The book is not a mere chronological history of science. It gives a method to analyse the role that science has played in history. Science, according to Bernal, "will not fail for lack of human capacity; where it fails will be for lack of social organisation

to make use of that capacity". This has happened because the imperialist system perpetuates underdevelopment and has stopped the entire humanity from involving itself with scientific progress. The situation was deeply accentuated in the cold war days - particularly with the escalation of threats of nuclear war. This huge manpower, according to Bernal could be released for human progress and also for that of science only with the demise of imperialism and the capitalist system.

The hope according to Bernal lay with the socialist system, whose scientific progress he analyzed in great detail. The collapse of socialism in Eastern Europe, to some, may signify the demise of ideology. Yet any serious student of history, would agree that no society in the past could achieve such rapid scientific progress as these socialist societies did and never before was science put at the service of such huge mass of humanity - a process that began even in the "dark days of 1918". What baffled the world was that science in these societies was planned, and the philosophy of dialectical materialism - though no substitute for scientific exploration - acted as guidance "to integrate and organize different branches of scientific research in relation to one another and to the social processes of which they form a part". What was equally impressive was the way the scientific manpower was created and harnessed e.g. by reorganising the erstwhile ceremonial body like the Russian Academy of Science to the new Soviet Academy,- giving it powers and making it accountable to the society. With the abolition of classes every citizen felt a stake in the system and that accounted for their massive participation as in the Stakhanovist movement. Bernal noted that equally commendable was the Peoples' Republic of China's success in wiping out illiteracy from sixty million children in mere five years. Their experiences in control of floods showed that success of science is best guaranteed when it is backed by supportive participation by the masses. Bernal had concluded that the future of science in these societies depended as much on their internal stability as also on cessation of hostilities in the socialist camp and in these societies' ability to ward off external threats of war, including nuclear war.

Bernal died on 15.09.1971, i.e. twenty years before the collapse of Soviet Union. He was a regular visitor there, since the 1950s and must have noticed the imperfections, both in the Stalin and post Stalin eras. Since he never denounced either Stalin or the post Stalin leadership of the USSR it is not clear as to what his evaluations were. It is also not known whether he had warned the soviet leadership about the distortions in soviet science , in the Lyshenko era. Bernal maintained good relations with many heads of state like Zhou en lai, Krushchov, Mao, Nkrumah and Nehru. He closely interacted with many anti imperialist intellectuals like, Picasso, Nazim Hikmet, Paul Robeson and Pablo Neruda. The main thrust of

these actions suggests that his priority was to develop an anti imperialist front.

Links with India :

Bernal's close links with India deserve a special mention and paid several visits here. His friend Blackett came to India many times as a scientific adviser, while his student Dorothy Hodgkin had many students from India as her collaborator. Bernal's friend J.B.S.Haldane settled in India in the fifties and became an Indian citizen. Bernal himself commended the Nehru-Mahalanabis plan. Indian scientists owe gratitude to Bernal on account of two other things. Bernal was responsible in no small measure in drawing G.N. Ramachandran's (unquestionably the greatest Indian scientist in the postwar era) attention to some outstanding problems in protein structure . They met in a conference in Madras and Bernal told Ramachandran about some intriguing features in the protein called collagen found in tendons in skin. For GNR(he died on 07.04.01), the problem was : where would he get the samples of collagen from? Bernal suggested that it could be looked for at the Central Leather Research Institute i.e. not far away from the university campus and it so happened that collagen could be procured from there with no great effort. That turned out to be the beginning of GNR's path breaking work on the structure of collagen- conducted in a small university department. The lesson here for Indian science is clear. The breakthroughs can come even in modest environments and modest investments. Bernal's own pioneering work on the structure of liquids and amorphous solids was done at the Birbeck College, only with steel balls procured from ball bearings! Bernal thus showed that there was a space for doing science at all levels. The other episode relates to Kosambi. Bernal introduced A.R. Vasudev Murthy (a chemist and sanskritist) of Indian Institute of Science to D.D.Kosambi (Bernal uses Kosambi's characterization of science as the 'cognition of necessity' in Science in History) during the Indian Science Congress in Poona in 1950. Kosambi told Vasudev Murthy that he intended to make a study of Indian history on the lines given in Engels' "Origin of the family, private property and the state". It was in this way that Kosambi's collaborations with the scientific community in Bangalore began and stimulated them in lively debates on the social functions of science and the culture and civilization of ancient India, the outcome being Kosambi's widely read monographs on the subject.

Science for international cooperation and for a world without war:

Bernal, the catalyst believed that scientific cooperation between nations would help to mitigate the difficulties caused by the cold war and lead to better understanding between countries. His attention was directed in two different angles. On the one hand he sought cooperation between the soviet bloc and the west on scientific projects. This had only limited success. On the other Bernal gave

special attention to the problem of building science in newly liberated nations . It is maintained by some scholars that his understanding of the scientific needs of the former colonies had an incompleteness because of limited study. However, what he argued goes as follows . It is not difficult to list out at least some of the most urgent needs like, food ,health and education and see in what way science can be geared to remove some of the most urgent ones. Here too his faith in the new governments of the former colonies appear to be misplaced, e.g. Bernal considered India's industrialisation to be in the socialist path. However, what is undisputed is the fact that the scientific revolution of the twentieth century, in an egalitarian society can satisfy most of the basic needs of the people. Bernal, for example dreamt of a situation where protein deficiency in poorer societies could be solved by cheap industrial production of amino acids ! and other food requirements could be satisfied by cheaply growing algae and fungi in factories under artificial lighting rather than under weak sunlight! The scientific revolution in the twentieth century, which was triggered by a crisis in the realm of knowledge (in physics, which later became all pervading) has expanded the boundaries of knowledge to such a prodigious expanse that the pre war concept of a romantic science is "irretrievably lost" and that science has become an enterprise, deeply established now in the affairs of the state and a scientist is to be truly referred to as a scientific worker. Bernal advocated that science in the backward countries has to be sponsored by the state . This will be backed by an initial process of learning from the rest of the world while building their own self reliant path. . This will be a short phase, since scientists mature fast, as was in the Soviet Union, to be followed by a social process which can produce "scientists who can appreciate the particular needs and particular genius of their own country and do there with and for their own people what no foreign scientist could do". The social structure that will facilitate this, is what concerns us most.