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The National Education Policy 2016: A Critical Appraisal

THE MINISTRY of Human Resources Development (MHRD) has come out with a 43-page document called "Some Inputs for Draft New Education Policy" (NEP-2016), available in the website http://mhrd.gov.in/nep-new. This is the third education policy to be formulated since India's independence, the first one was in 1968 and the second was in 1986 (revised in 1992). Naturally it has raised hopes in the education-loving people that the new policy will address the real issues confronting education in our country and will take positive steps in realizing the long-cherished dream of a universal, secular, democratic and scientific education system.

So, in this appraisal, we will first take a look at what the real issues are, and then will evaluate how the policy takes note of them and proposes to address them.

The problems that need to be addressed

The first problem is that, in spite of repeated declarations and lofty pronouncements, education has not reached a vast section of the Indian populace. According to the government's statistics, "the absolute number of out-of-school children remains high and "India currently has the largest non-literate population in the world with the absolute number of non-literates among population aged 7 and above being 282.6 million in 2011. India also hosts the largest number of youth and adult illiterates in the world with the youth literacy rate (15-24 years) and adult literacy rate (15 years and above) in India in 2011 being 86.1 percent and 69.3 percent respectively" (page 7).

The NEP-2016 document acknowledges "In the last 40 years, a number of programmes have been started, such as, Rural Functional Literacy Programme (RFLP), National Literacy Mission (NLM), Saakshar Bharat Abhiyan, etc. Despite all these efforts, India still has over 280 million adult illiterates which is about one-third of the total number of adult illiterates in the world" (clause 4.7).

This is the bleak situation almost seven decades after India's independence, where a large fraction of the population is sieved out without any scope of being intellectually productive. Moreover, it seems literacy has been equated to 'functional literacy' which is taken as the ability to sign one's name.

The children, who are fortunate enough to get into a school, face a challenging situation that causes high drop-out rates. Most school buildings are unfit to be called 'buildings', many do not have a roof over their heads, most schools do not have toilets (especially for girls), and if they exist are in a unusable state. Many primary and lower secondary schools have just one teacher for four classes. Naturally the standard of education imparted is abysmally low. The NEP-2016 admits that "In 2014-15, the retention rate at primary level was 83.7 per cent and it was as low as 67.4 percent at the elementary level. This

indicates that roughly, four in every 10 children enrolled in grade I leave the school before completing grade VIII" (page 12).

In addition to that, the deliberate degradation of the examination system, the abolition of the pass-fail system, and the abolition of English learning at the primary and lower-secondary levels have created a condition where the standard of education at the government-run schools has hit rock bottom. High-charging private English medium schools have mushroomed to fill the void. It is felt that the void has been deliberately created so that these schools can do a roaring business peddling education. Even poorer people prefer their children to go to the so-called English medium kindergartens. Parents do not want to admit their children in government-run schools; but many cannot afford to admit their children in private schools.

This has created two classes of students: those who are educated in the government-run schools and receive a low quality of education, and those who are educated in private schools and have the advantage of having examinations and English education. Naturally the 'haves' have an advantage over the 'have-nots' when it comes to entry into higher education. Thus a large number of students are deliberately deprived of the scope of furthering their education.

The school curriculum has been made heavy with jargon and superfluous material that do not give the students any conceptual understanding. Just take a look at any school textbook, and you will wonder about 20-30% of the material "why do students have to learn this?"

One of the most damaging developments in recent years is the degradation of language teaching. With the emphasis on multiple choice questions, a condition has been created where students can score high marks without learning to express clearly their thoughts verbally or in written language. Since language is the vehicle of thought, this weakening of language learning has in turn weakened the ability of the students to grasp higher ideas. And without adequate exposure to the treasure house of literature, students lack exposure to the high standard of ethics, morality, and culture that are reflected in great literature.

The course content of the higher secondary level has been made so heavy that most schools cannot complete the course within the allotted teaching time. Things that should normally be taught in college or university are now included in the school curriculum. Most students have to rely on private tuition to learn what is supposed to be taught in school. Those who cannot afford it, fall to the bottom or out of the class. Those who somehow can complete the syllabus get only superficial knowledge. There is emphasis on learning by rote, not concept building, logical thinking, and solving the problems of life and society with the help of science.

Add to this the fact that practically no government school has any facility for experimentation. The students have to confine their learning to textbooks, the quality of which is often sub-standard. Naturally their understanding becomes truncated. The science textbooks are crammed with facts, figures, and theories, but nowhere do we see any mention of how we learnt these to be true. We teach students what science has found, but do not teach how science has found them. The method of science and the life-struggle of great scientists are not included in the curriculum. Naturally, students learn science just as any other subject, without understanding that it is a guide to thinking. That is why we see so many persons who are science literates subscribing to all sorts of unscientific be-

liefs and superstitions.

Most of those who are fortunate enough to get some sort of schooling cannot advance to the next ladder: "the Gross Enrolment Ratio in higher education remains low at 23.6 percent in 2014-15." This is not because students do not want to go into higher education. The actual reason is that the number of colleges and universities is hopelessly insufficient to provide higher education to all those who aspire for it. The NEP-2016 declares as its target "to increase GER to 25.2 per cent in 2017-18 and further to 30 per cent in 2020-21" (page 7). If the target itself is set so low, the chance of any real increase in higher education is marginal. It also contradicts its pronouncement in a later section on ensuring that all secondary students have "equitable access to higher education".

Why this reluctance to increase the reach of higher education? The fact is that the Indian industry is unable to put this vast number of educated individuals to productive use, and most will remain unemployed. Even in a job-oriented discipline like engineering, there is a big mismatch between the number of engineers being currently produced and the number finding gainful employment. This is a curse of the capitalist production system: the more it advances the less it employs. Thus, in this society, a large section of the population is doomed to remain outside the ambit of money and commodity circulation, in perpetual misery. And the system is better off if it manages to keep these people uneducated, so that they believe they are 'unemployable'.

Still, a large number of students get education in colleges and universities—a number that is larger than the employment capacity of Indian industries. That is why we see a shrewd design in the Indian higher education scenario. The standard of the universities have been gradually eroded by depriving them of the flow of funds required to sustain a healthy environment of teaching and research, and through political intervention in the day-to-day functioning. On the other hand, systems of "favoured" institutions have been created—the IITs, NITs, IISERs, etc.—which receive the lion's share of educational funding and are projected as "centres of excellence". Only a handful students receive education in these centres of excellence, and the vast majority is left to flounder in the sea of mediocre education. They are then branded as "unemployable".

Thus we see that the dream of universal, secular, democratic and scientific education system is far from being met. Instead, the Indian education system is in a state of rot and needs an urgent and drastic overhaul—which clearly shows the failure of NPE-1968 and NPE-1986.

But if we read through these two documents we find no dearth of high-sounding verbiage. For example, the National Policy on Education (1968) laid stress on "the need for a radical reconstruction of the education system, to improve its quality at all stages, and the development of science and technology, the cultivation of moral and social values, and a closer relation between education and the life of the people. The Resolution stressed the role of education in promoting national progress, a sense of common citizenship and culture, and in strengthening national integration."

Similarly, the National Policy on Education 1986 envisaged a "national system of education which implies that up to a given level, all students, irrespective of caste, creed, location or sex, have access to education of a comparative quality". We clearly see that none of these objectives have been met. We do not even see a semblance of attempt by the people in power to meet these objectives. The lesson to be learnt is

that we should not take such statements at their face value, and should check the actual actions taken by the MHRD under its current leadership to verify its earnestness in actually implementing the declared aims and objectives.

Now let us see how much realization about the real state of the education system is reflected in the proposed NEP-2016. We will see that most of the real problems discussed above do not find mention in the document. So we confine ourselves to the ones that are mentioned, and will check how the government proposes to address the problems.

The content of NEP-2016

Like the earlier NEPs, the NEP-2016 declares a lofty objective: "The National Education Policy, 2016 envisions a credible education system capable of ensuring inclusive quality education and lifelong learning opportunities for all and producing students/graduates equipped with the knowledge, skills, attitudes and values that are required to lead a productive life, participate in the country's development process, respond to the requirements of the fastchanging, everglobalising, knowledge-based societies, and developing responsible citizens who respect the Indian tradition of acceptance of diversity of India's heritage, culture and history and promote social cohesion and religious amity" (page 14).

Such pronouncements are not much different from those in NEP-68 and NEP-86, and, are slickly phrased in such a way that there is no measurable yardstick of commitment or success in any of these directions, and so one cannot accuse the government of failure in meeting the objectives.

Then the document goes on to invoke Mahatma Gandhi's teaching: "The real difficulty is that people have no idea of what education truly is. We assess the value of education in the same manner as we assess the value of land or of shares in the stock exchange market. We want to provide only such education as would enable the student to earn more. We hardly give any thought to the improvement of the character of the educated" (page 5).

Wonderful! Upon seeing this quotation in the NEP-2016 document one would tend to believe that finally the education policy makers have realized that earning is not the sole objective of education and appropriate emphasis would be placed on "improvement of the character of the educated."

Job-oriented education: But as we read on, we realize that is not the Government's agenda at all. In fact, one of the main objections of the educationists to the NEP-86 was its undue stress on job-oriented education. Most prominent educationists feel that the primary purpose of education should be man-making and character-building, that education should enable the educated to think clearly, rationally, and with proper scientific and historical perspective. They feel that the slogan of job-oriented education without first fulfilling the above objective goes exactly in the opposite direction.

We find that the primary agenda of the NEP-2016 is again to promote job-oriented education, but cloaked under a different expression. "The need for the development of human skills, including life skills, that meet the demands of the emerging knowledge economy and society highlights the need to promote the acquisition by learners of knowledge and skills on a life-long basis to enhance their capacity to adapt to changing skill requirements" (page 4).

And then it goes on to say "India is one of the youngest nations in the world with more than 54 percent of its total population below 25 years of age. It is estimated

that there will be 104.62 million fresh entrants to the workforce by 2022 who will need to be skilled. However, institutional arrangements to support technical and vocational education programmes remain quite inadequate. Formally linking the development of skills in vocational fields, and bringing an academic equivalence to vocational accomplishments with avenues for horizontal and vertical mobility of students has been attempted only recently. To enhance employability, a blend of education and skills is essential for individual growth and economic development" (page 8).

"There is a growing realisation that there exist serious disconnects between the existing school and higher education curricula and the curricular thrusts that are needed for promoting the acquisition by students of relevant skills required for decent work and a better life in a rapidly changing world" (page 9).

At another place it says "Expanding opportunities for skill development and ensuring acquisition by young people and adults of the skills and competencies for life and work, including technical and vocational skills that are required for employability, work and entrepreneurship and for adapting to an ever-changing world of work" (page 9).

Thus, according to the education policymakers, the acquisition of "skill" is the focus. Our organization feels that the development of personality, thinking capacity and quality of mind should be the primary focus of education, and skill may be imparted only after meeting these primary objectives. According to Albert Einstein, "The school should always have as its aim that the young person leaves it as a harmonious personality, not as a specialist. Otherwise, he — with his specialized knowledge — more closely resembles a well-trained dog than a harmoniously developed person."

Expansion of the school system: The document does recognize some of the limitations of our school education mentioned earlier. "The biggest challenge facing school education relates to the unsatisfactory level of student learning. The findings of the National Achievement Surveys (NAS) covering Grades III, V, VIII and X suggest that learning levels of a significant proportion of students do not measure up to the expected learning levels". "The perceived failure of the schools in the government system to provide education of good quality has triggered entry of a large number of private schools, many of which lack required infrastructure, learning environment, and competent teachers" (page 8).

Thus, the document recognizes the need for expanding the reach of the education system. But as a means it proposes to rely on non-formal channels. "Significant changes have taken place in the education sector. The educational activities and learning process are no longer confined to the classroom and, therefore, the domain of education is no longer limited to formal schooling or higher education. The educational process is not only mediated by classroom-based curriculum transaction but also by media, both electronic and print, information and communication technologies, books and journals etc. Learners today have access to more current knowledge through non-institutionalized means" (page 4). This implies that the government does not really intend to increase, augment, and improve the school education system, and that is why it eulogizes "out of classroom" learning. The entire focus of NEP-2016 is to produce a large number of half-educated people to satisfy the needs of the job market rather than to improve the quality of education and to make it accessible to larger number of students.

Commercialization of education: The document recognizes the problem of commercialization of education: "Commercialisation is rampant both in school and higher education sub-sectors as reflected in the charges levied for admissions in private educational institutions. The proliferation of sub-standard educational institutions has contributed to the diminished credibility of the education system" (page 12).

But does it recommend substituting it by well-funded government school and college system? No. They are only mentioning the problem in passing, and the document does not propose stoppage of commercialization of education. As we will see later, the government actually proposes to strengthen private investment in the education sector.

No detention policy: The document recognizes the problem created by no-detention policy. It says: "The present provisions of no-detention policy will be amended, as it has seriously affected the academic performance of students." But then, it seeks to continue the policy in the primary stage: "The no detention policy will be limited up to class V and the system of detention will be restored at the upper primary stage" (clause 4.3-3). If the policy has seriously affected the academic performance of students, will it not continue to have detrimental effects on primary education—the foundation of the whole education system? We demand that proper examination system should be brought back from the primary level.

Examination reform: Similarly, the document acknowledges the problems of the examination system in the higher levels also. "The overall assessment practices at the school and college/university level remain unsatisfactory. In most cases the assessment of learning achievement continues to focus on rote learning and testing the students' ability to reproduce content knowledge. The whole assessment system needs to be revamped to ensure comprehensive assessment of the students, including learning outcomes relating to both scholastic and co-scholastic domains" (clause 4.5).

That is good thinking. But in what direction do they seek to bring in changes? That is not spelt out clearly, retaining the scope of retrograde steps that might jeopardize the education system further.

The only concrete recommendation we find is this: "High failure rate in class-X examination is attributed to a large extent to poor performance in three subjects: Mathematics, Science and English. In order to reduce the failure rates, class X examination in Mathematics, Science and English will be at two levels: Part-A at a higher level and Part-B at a lower level. Students who intend to join courses/ programmes for which science, mathematics or English is not a prerequisite or wish to shift to vocational stream after class-X will be able to opt for Part-B level examination" (clause 4.5-8). This recommendation is highly debatable and has no relation to the problems of the present examination system pointed out in the same document.

English: One welcome aspect of NEP-2016 is that it proposes to introduce English as second language from the primary level: "Knowledge of English plays an important role in the national and international mobility of students and provides an access to global knowledge. Hence, it is important to make children proficient in reading and writing English. Therefore, if the medium of instruction upto primary level is the mother tongue or local or regional language, the second language will be English and the choice of the third language (at the upper primary and secondary levels) will be with the individual states and local authorities,

in keeping with the Constitutional provisions" (clause 4.11-2).

While the increased emphasis on English is welcome, they clearly state that they are proposing a three-language formula (clause 4.11)—which many eminent educationists have opposed.

Sanskrit: In 'Language and Culture in Education' (clause 4.11-5) it mentions that, "Keeping in view special importance of Sanskrit to the growth and development of Indian languages and its unique contribution to the cultural unity of the country, facilities for teaching Sanskrit at the school and university stages will be offered on a more liberal scale." In this context it is worthwhile to recall that, in May 2016, the MHRD has issued an advisory to the IITs and other institutes of national importance instructing them to initiate "Sanskrit Cells" for introducing courses in Sanskrit. The MHRD Committee headed by Shri N Gopalaswamy, a former Chief Election Commissioner, recommends this step "in order to facilitate study of Science and Technology in Sanskrit literature and inter disciplinary study of various modern subjects and its corresponding subjects in Sanskrit literature." The MHRD document (http:// mhrd.gov.in/ sites/ upload_files/ mhrd/files/Report-CVRM.pdf) titled 'Vision and Road Map for the Development of Sanskrit Ten Year Perspective Plan' further claims, "There are hundreds of works like Siddhanta Shiromani, Vriksha Ayurveda, Upavana Vinoda, Mayamatam, etc., to name a few, which are of great relevance in the context of research and innovation."

Actually the government is trying to impose Sanskrit at various levels of the education system as a part of their indoctrination agenda, where the Vedic age will be painted in a picture of imaginary glory—Pushpak vimanas flying to other planets, surgeons planting elephant heads on human torsos, missiles flying with nuclear warheads (what else is Brahmastra?), and doctors routinely giving birth to test-tube babies—all these supposedly occurring ten thousand years back!

The objective of the education system is to equip students with the latest and the most refined knowledge about the working of nature, obtained through the rigorous scientific method of observation, experimentation, theory-building, and objective testing of theories. Teaching a mixture of old and new texts in the name of a so-called 'inter-disciplinary' study might lead to a truncated, confused and erroneous understanding.

Curricular reforms: Regarding curriculum renewal and examination reforms, the document just gives a quotation from Swami Vivekananda, "Education is not the amount of information that we put into your brain and runs riot there, undigested, all your life. We must have life-building, man-making, character-making assimilation of ideas. If you have assimilated five ideas and made them your life and character, you have more education than any man who has got by heart a whole library.. . If education is identical with information, the libraries are the greatest sages of the world and encyclopedia are the greatest Rishis" (clause 4.5).

Surprisingly, the rest of the document is completely silent about what steps will be taken to change the information-centric curricula into ones whose objectives are life-building, man-making, character-making. There is no emphasis on inculcation of scientific bent of mind and logical thinking.

The anti-science attitide: It is noticeable that the NEP-2016 document consciously avoids spelling out the anti-science approach the current NDA government has

been pursuing in all fields of education. The history textbooks are being modified by mixing mythology with history and by projecting a distorted image of India's past. Subjects like Vedic mathematics are being introduced in the school curricula. Many other steps are being surreptitiously taken to propagate unscientific bents of mind and various shades of superstitions. But these find no mention in the policy statement.

Only in two places we find hints of what are to come. "The Education System which was evolved first in ancient India is known as the Vedic system. The ultimate aim of education in ancient India was not knowledge, as preparation for life in this world or for life beyond, but for complete realization of the self." This is the way they are trying to define the objective of modern education! And then they propose that "Ways of building synergies and linkages, providing mentoring and advice between Ashram shalas and nearby secondary schools/ higher secondary schools/ Kendriya Vidyalayas/ Navodaya Vidyalayas will be worked out." (clause 4.6-4). That is it, then. The schools and colleges will be guided by what they call the "Ashram shalas", in reality the religious fanatics!

It is historically a fact that the Vedic education included a varna (caste) system, in which lower castes were denied scope of education. By citing this as an 'ideal' education system, does the government plan to do something similar today?

Governance of education: The policy document states that (clause 4.14-4) "The State will endeavour to implement the recommendations of earlier policies of 1968 and 1986/92 for the creation of an Indian Education Service (IES), which is reiterated herein too. The IES will be an all India service with HRD as the cadre controlling authority." The move seems to be aimed at formalising the shifting of control of educational institutions from the hands of educationists to the hands of bureaucrats. We demand that education should be governed by the collective wisdom of the academic community through a democratic process.

Financing of education

One remarkable (and welcome) aspect of the policy statement is that it envisages a universal elementary and secondary education and seeks to ensure 100% enrolment of eligible students in higher education. "Achieving universal elementary and secondary education and ensuring that all secondary education graduates have access to higher secondary education and all higher secondary education graduates have equitable access to higher education and that all enrolled students are supported to successfully complete their education with all of them achieving expected learning outcomes" (Goals and objectives, point 2).

Yet, as we have seen earlier, the NEP-2016 declares as its target to increase gross enrolment ratio to 25.2 per cent in 2017-18 and further to 30 per cent in 2020-21!!

The policy statement even says that "Education, in Indian context, should be considered a public good and there is a need for greater public investment in the sector. There are evidences to show that countries which have heavily privatized education systems could not economically and socially progress and hence there is a value loss rather than gain. On the other hand, countries which consider education a public good reap greater social benefits on a sustained basis" (clause 4.21)

It goes without saying that fulfilling this objective will require many-fold increase in the educational facilities at all levels, and it costs money. Therefore the success crucially depends on the flow of adequate funds. The document even acknowledges

that the prime reason for the failure of education policies so far was inadequate financial commitment of the respective governments. "Insufficient financing of education continues to constrain efforts to expand access to education and foster quality education. Several studies have reported the challenges in education governance exemplified by the delayed fund flows to schools/ colleges/ universities. The earlier education policies had endorsed a norm of 6 percent of GDP as the minimum expenditure on education. However, this target has never been met" (page 12, Budgetary Constraints).

The policy statement then declares "The earlier National Policies of 1968 and 1986/92 had recommended 6% of GDP as the norm for the national outlay on education. However, the actual expenditure on education has remained consistently below this level and in recent years it has hovered around 3.5%. ... The government will take steps for reaching the long pending goal of raising the investment in education sector to at least 6% of GDP as a priority" (clause 4.21). This is a very welcome wish, indeed. However, we would like to point out that it has been demanded by educationists for a long time that 10% of the union and state budgets should be allotted to education and research.

We need to note that the earlier education policies had no dearth of such wishful pronouncements which were never planned to be met. Will the current policy meet the same fate?

There are already a few indicators. Ever since the current NDA government came to power, the financial outlay in education and scientific research has been drastically reduced. The science funding agencies like the DST have experienced slashing of their budget. The IITs, IISERs, and NITs have also experienced reduction of their funds. In fact, the former Minister of Human Resource Development, Smt Smriti Irani asked the IITs to raise the running expenditure entirely from students' fees, and as a result the fees of the IITs have gone up from Rs. 90,000 per semester to Rs. 2 lakhs per semester in one go. The IISERs and the NITs have also been ordered to increase the students' fees. If this is the status of the 'favoured' institutions, it is anybody's guess how much financial support the mainstream less-endowed institutions and universities receive from the government. Do these moves reflect any intention of increasing the governmental support for education?

In fact, the NEP-2016 document amply betrays the government's real intentions. "Over the next decade, at least 100 new centres/ departments of excellence, in the field of higher education, both in the public and the private sector, will be established to promote excellence in research and encourage innovations."

But who will fund these ventures? "Private trusts, philanthropists and foundations will be given freedom to establish such Centres of Excellence" (clause 4.20). Ha! The cat is out of the bag.

Their policy is in fact spelt out quite clearly: "In order to supplement the Government efforts, investment in education by private providers through philanthropy and corporate sector responsibility will be encouraged. The Government will take steps for incentivizing private sector investment in education, such as, tax benefits and inclusion of education within the definition of infrastructure. In general, public funding will continue for core activities, whereas other functions can be through private funding. Private funding and FDI for R&D and other quality enhancement activities in education institutions will be pursued as an important strategy for mobilising financial

resources" (clause 4.21-2).

"HEIs (Higher Education Institutions) funded by governments need to find ways of increasing their revenues through other sources, such as, alumni funding, endowment funding, tuition fee enhancement along with fee waiver for disadvantaged sections, and private investment" (clause 4.21-4).

The infusion of foreign direct investment (FDI) is now welcome: "Selected foreign universities, from the top 200 in the world, will be encouraged to establish their presence in India through collaboration with Indian universities. If required, steps will be taken to put in place an enabling legislation. Rules/ Regulations will be framed so that it is possible for a foreign university to offer its own degree to the Indian students studying in India, such that these degrees will be valid also in the country of origin" (clause 4.18-1).

Thus it is clear that the government is not really committing any increased public fund inflow into the education and research sector. It is washing its hand of the financial responsibility of education in stages, and inviting private capital (even FDI) to be invested in the educational sector. The crocodile tears about commercialization of education mentioned earlier should be seen in this light.

The process followed in formulating the policy

While the government claims that it has held "hundreds and thousands" of consultations with people at different levels, the fact is the most people directly concerned with education have no idea about the existence of such a consultative process. It has never been publicized in any form, and unless one accesses the webpage of the MHRD, there is no way to know about it. How many people would visit the MHRD website for no reason, and would chance upon the related documents?

It is clear that the government does not intend to follow a democratic process in formulating NEP-2016. Just a five-member committee headed by a retired bureaucrat Mr T S R Subramaniam was constituted to formulate the policy. This committee submitted its 230-page report and recommendations to the HRD Ministry on 27th May, 2016. No debates/discussions have been held involving teachers, scientists, and educationists. It is also to be noted that the MHRD released only a 43-page abridged version of the report, and has not subjected the whole policy statement to public scrutiny. Why this secrecy? Why should the education loving people not know the content of the whole policy?

The document, now available only in English, should also be made available in all the state languages so that all people can be made aware of the NEP 2016 and what it portends for the future of education, and can meaningfully take part in as wide a debate as possible so as to evolve a education policy that will truly address the education needs of the masses.

The Breakthrough Science Society urges all education loving people to protest against the attempt to formulate such a crucial policy statement without adequate consultative process. We also urge all people to use not only whatever means of registering public opinion that have been offered—by sending emails to nep.edu@gov.in—but also to start their own campaigns using whatever platforms, including online petitions, to publicise the issue. □

A Brief History of Science
Part 14: Genetics Becomes a Science

Soumitro Banerjee*

AS WE HAVE seen earlier, two *different* theories of evolution were proposed by Lamarck and Darwin. Lamarck's theory saw evolution as the consequence of direct influence of environment on each individual organism's anatomy and physiology, and the theory rested on the hypothesis that the characteristics acquired within an organism's lifetime are inheritable. Darwin's position, in contrast, was that the main driving force of evolution was natural selection. There is variation within every population, and individual organisms with certain anatomical and physiological features are better adapted to a specific natural environment. These organisms are preferentially selected by nature: they have a larger probability of surviving to maturity and of producing the next generation. Thus certain characteristic traits are selected by nature and certain other traits are eliminated. This is the way the environment actsat the species levelto lead to the evolution of species.

For a long time following the proposition of these two theories it was not clear which theory was correct. There were questions faced by both theories that could not be answered at that time. For example, Lamarck's use-disuse theory could not explain how entirely new organs could evolve, and Darwin's theory could not explain why variation always exists in every population in spite of elimination of variations by natural selection. Initially the main struggle was to defend the theory of evolution in face of the severe opposition by the religious authorities, and only at the beginning of the 20th century did scientists start the serious attempt to subject each theory to strict experimental tests.

Mendel unravels the laws of heredity

For a long time it went unnoticed that Gregor Mendel (1822-1884) had done a series of experiments in the 1860s that provided the clue to understanding the laws of heredity. He did systematic experiments with plants like garden peas. In one experiment, he took the tall and dwarf varieties of garden peas, and first made sure that in successive generations pure-bred plants of the tall variety never produced any dwarf plant and vice versa, and that each variety was easily distinguishable from the other one even when raised in unfavourable environmental conditions. He then obtained hybrid seeds by fertilizing the flowers of one variety with the pollen of the other, and found that the resulting plants were all tall. The dwarf character had disappeared in the first (F_1) generation. Then he obtained the second generation by allowing the flowers to be fertilized by their own pollen, and found to his surprise that the dwarf character has again appeared in a few plants. Careful

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counting revealed that on an average tall and dwarf plants appeared in 3:1 ratio in the second (F_2) generation.

Mendel assumed that there is a 'factor' responsible for tall and dwarf varieties which is inherited through breeding and after hybridization, one of them remains suppressed by the other in the F_1 generation but reappears in the F_2 generation. In explaining the observation, Mendel hypothesized that living organisms transmit the characteristic traits through the reproductive mechanism in form of 'units of heredity' — things that are either there or not there, but do not mix. Some of these are dominant (like the tall character) and some are recessive (like the dwarf character), so that an F_1 hybrid plant carrying both units of heredity would invariably be tall. But in the next generation some of the plants would inherit dwarf-dwarf units of heredity and would exhibit dwarf character, while the plants inheriting tall-dwarf, dwarf-tall, and tall-tall units would all exhibit tall character. If the segregation occurs with equal probability, the F_2 generation will produce dwarf and tall plants in 1:3 ratios. This is Mendel's First Law, i.e., the Law of Segregation. Mendel confirmed the law by experimenting with plants with similarly distinguishable characteristic features (for example, those producing green and yellow seeds).

When he crossed organisms that differ with regard to two traits (say, seed colour: green/yellow and seed surface: smooth/wrinkled), he found that all the plants in the F_1 generation produce smooth yellow seeds, but in the F_2 progeny the characters were appearing in the proportion 9 (yellow-smooth) : 3 (yellow-wrinkled) : 3 (green-smooth) : 1 (green-wrinkled). On careful examination he found that these can be explained if he assumed that these physical features are determined by two

Gregor Johann Mendel (1822-1884)

such units of heredity that were independent with respect to each other. This led to his second law, i.e., the Law of Independent Assortment.

He read out his article 'Experiments in plant hybridization' at the Brunn Natural History Society in 1865, which was published in the Proceeding of the Society next year. But unfortunately scientists of that period failed to realize the importance of Mendel's experiments. Darwin did not come to know about it in his lifetime.

In the year 1900, about 30 years after the publication of Mendel's work, three scientists (Carl Correns, Erich Tschermak von Seysenegg, and Hugo de Vries) each independently chanced upon this work, conducted the experiments themselves, and confirmed that the results were indeed correct.

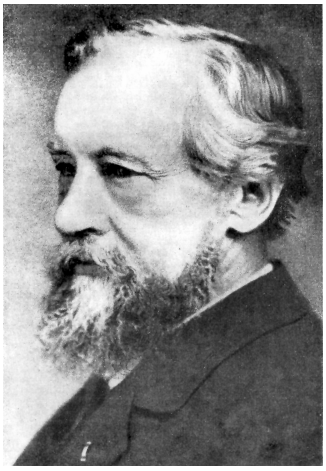
The Dutch botanist Hugo de Vries (1848-1935) did a detailed field study of a species called evening primrose that grew wild in the areas near Amsterdam, and noticed that once in a while plants with new physical traits (for example, a giant variety and a dwarf variety) appeared. He collected their seeds, cultivated them, and found that they bred true, i.e., produced plants with the same characteristics. Yet, in the place where he first noticed these plants, there were no other plant with the same charac-

ter. How did these new characters suddenly appear? De Vries hypothesized that the "units of heredity" can sometimes undergo sudden change on their own, which he called mutation.

The Swiss scientist Albrecht Koelliker (1817-1905) had earlier proposed that evolution proceeds not by slow incremental changes mediated by natural selection as theorized by Darwin, but by sudden changes. De Vries' mutation theory apparently supported this claim. This attracted sharp criticism from scientists of the time because mutation theory appeared to contradict Darwin. However, it was soon demonstrated that mutations do not necessarily lead to large changes in the physical structure of an organism; small variations can also result from mutations. Thus, this theory was not really at odds with Darwin's theory of natural selection. Not only that, it was realized that the occurrence of mutations can plug the big hole in Darwin's theory: It explains how new variations may appear in a species.

The discovery of Mendel's work created quite a stir among the biologists of that time, because it answered some of the questions that had been bugging them for quite some time. But were the Mendelian laws universally applicable? William Bateson (1861-1926), an experimental biologist of Cambridge University, conducted similar experiments on poultry, rabbits, and other animals that breed quickly, and confirmed that these laws apply to the animal world as well. He became instrumental in popularizing Mendel's work through his books "Mendel's principles of heredity — A defense" (1902), "Mendel's principles of heredity" (1909), etc. In 1906, Bateson gave the name "genetics" to the new discipline emerging out of the study of heredity.

Lucian Cuenot (1866-1951) did a very detailed study of inheritance in mice, and



Hugo de Vries (1848-1935)

established that coat patterns and colours can be treated as traits through which the Mendelian laws of inheritance can be tested. W E Castle (1867-1962) in the United States studied the heredity of other mammals in detail (including albinism in rats) and established that the Mendelian laws were valid. The Danish biologist Wilhelm L Johannsen (1857-1927) showed that ordinarily cross-fertilizing plants were more amenable to improvement by natural selection than the plants that normally self-fertilize. He also coined the terms 'gene', 'genotype' and 'phenotype' that are in common use today. Thus, within a few years of the rediscovery of Mendel's paper, the area of genetics was born and was making rapid strides.

But, were the Mendelian laws of inheritance always applicable? We have seen earlier that Mendel carefully selected the traits for study that were clearly segregated — like the tall and dwarf varieties — where there can be nothing in between. But there are many other traits that allow continuous variation. Plants bearing flowers of different colours may sometimes yield flowers of intermediate or 'mixed' colours when crossed.

Human parents of different heights may produce progeny of an intermediate height. How are these cases to be accounted?

Sir Francis Galton, Carl Pearson, and W F R Weldon favoured a statistical approach in biometry to settle the issue. But that was in apparent contradiction with the genetics school led by Bateson. Was inheritance really 'particulate', or was it a continuous variable? Controversy, scientific debates, and heated exchanges ensued. Finally when the dust settled, it became clear that continuous variations can also be explained in Mendelian terms if one assumed that these traits are determined by a large number of genes acting in a cumulative manner. The Swedish plant breeder H Nilsson-Ehle demonstrated evidence of such inheritance through experiments on cereal crops. Though Yule (1873-1949) was the first to propose this hypothesis, R A fisher (1890-1962) was instrumental in uniting the two schools of thought to produce a coherent picture of genetic inheritance.

It became recognized that there is a physical unit of inheritance, called gene. These units are 'particulate', in the sense that a gene is either there or not there in an organism, and cannot be further divided or mixed with each other. The physical characteristics of an organism are determined by the existence or non-existence of specific genes in its body. There can be two or more alternative forms of a gene, called alleles, which can determine a characteristic trait of an organism. Each organism carries a pair of alleles coming from the mother and the father, and its physical characteristics will depend on which of these is dominant and which is recessive. This was the initial hypothesis which was supported by experiments. But later more complex forms of inheritance were found. For example, in some cases neither of the alleles is dominant, resulting in physical expression

William Bateson (1861-1926)

of both the characteristics and intermediate forms. Sometimes multiple genes working together determine the physical characteristics of an organism, resulting in complicated expressions of the Mendelian laws of heredity that can be understood only through statistical analysis of the measured physical features.

Where do genes reside?

Even though Mendel formulated the correct mathematical pattern governing transmission of genes from the observed expressions of their characteristics, he had no idea about the biological mechanisms of their transmission. After the concept of gene was established, scientists directed their attention to this issue. It was clear that the genes responsible for heredity must reside in the sex cells because they are transmitted through sexual reproduction. But by what mechanism does the daughter cell receive the genes from the parent cells and become a complete cell?

Way back in 1879, Walter Flemming (1843-1915) of Germany had shown that the nucleus of every cell contains a thread-like substance that readily absorbed dye and could be studied under the microscope.

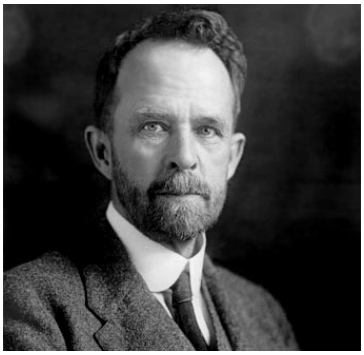
These were called chromosomes. Flemming (and another scientist Edouard van Beneden) observed that, when a cell divided, the chromosomes were duplicated and were shared between the two daughter cells.

In the last decade of the 19th century August Weismann (1834-1914) proposed that inheritance only takes place by means of the germ cells, such as egg cells and sperm cells. Other cells of the body, the somatic cells, do not function as agents of heredity. His idea was that changes in the somatic cells do not affect the germ cells, and genetic information cannot pass from somatic cells to germ cells, and on to the next generation.

Wilhelm Roux (1850-1924) formulated several models of the mechanism of transmission of genetic information and concluded that the observed behaviour is possible only if the genes were lined up in a row like beads on a string, and were duplicated exactly. Where can one find such bead-like structure inside a cell? T Bovari and W Sutton made careful study of the components of a cell and realized that the chromosomes fit the bill, and so the bead-like arrangement of genetic information must be residing in the chromosomes in each cell.

Thomas Hunt Morgan (1866-1945), the American geneticist, adopted the fruit fly Drosophila melanogaster for his experimental studies because these organisms reproduce very fast and so successive generations can be studied in a short span of time. Moreover, the individuals carrying a gene and those not carrying a gene can be easily distinguished. His studies established that there is direct association of a particular chromosome and particular features of the organism. In 1920, Morgan conclusively demonstrated that the chromosomes in the nucleus of a cell carry the genes.

He and his students did detailed mapping



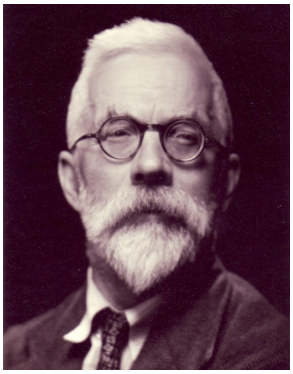
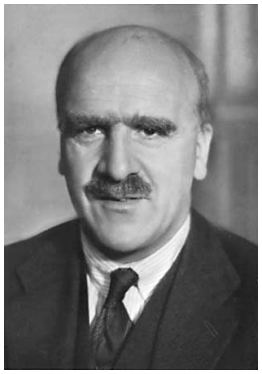
Thomas Hunt Morgan (1866-1945)

of the four chromosomes of the drosophila using techniques available in his time, and showed that genes are discrete units lined up in the chromosome.

In 1910, Morgan and his associates observed the first spontaneous gene mutation in the drosophila in his lab that resulted in the change in colour of the eye. He also discovered a mechanism of genetic inheritance, including linkages and crossovers in chromosomes. In 1915, he and his associates Sturtevant, Bridges, and Muller wrote a very influential book "The mechanism of Mendelian heredity" which summarized all the progress that had been made in genetics till that time.

These developments strongly supported the Darwinian theory of evolution by natural selection and removed its weaknesses. In the 1920s, R A Fisher and J B S Haldane combined Mendelian inheritance with Darwinian natural selection through application of mathematical analysis to population genetics. Through this rigorous approach, they put the genetic theory of heredity and evolution (called modern evolutionary synthesis or Neo-Darwinism) on a firm footing. On the other hand, the developments in genetics were used to refute the Lamarckian mechanism.

What light did genetics throw on the process of evolution? In a population of a

Ronald Aylmer Fisher (1890-1962) and John Burdon Sanderson Haldane (1892-1964)

certain species, the DNA molecule of every individual is not the same. Though grossly similar, there are some finer differences in the DNA molecules in the members of a species. This is what gives them the variation that Darwin talked about. New variations come about when, in the process of copying the DNA in reproductive cells, some errors or mutations occur.

All the animals of a given species are in contradiction with the environment, and the variation caused by minute differences in their genetic code give them unequal survival probability. The ones that survive to reach maturity can transmit their genetic code to their offspring. Thus natural selection favours certain genes while it weeds out the genes that are unfavourable for survival of the animals. This is what causes gradual and quantitative changes in the population. In modern terms, the relative frequency of competing genes changes with time.

Qualitative changes may occur when a new gene that has significant impact on an organism's physiological organization enters the species. In the beginning the mutation happens in one individual. If the result of the mutation is favourable for the survival of the individual, it survives to maturity and transmits the mutated new gene to its progeny. If those with the gene have better survival probability than those without it, the new gene spreads fast through the population, and within a few generations it is found that all the individuals of the population have the new gene. If one looks at the species as a whole, one sees that the characteristics of the population have changed, and it is now a qualitatively new species.

However, such single-line evolution is rarely observed. Branching is a characteristic feature of evolution. How does is come about? When some organisms of a species get isolated from the main population due to some reason and find themselves in a different environment, evolution progresses in different directions in the two populations. As a result, the two populations may become significantly different in their physical characteristics and habits, so that even if they come in contact with each other at a later time, they do not mate. They are then identified as different species. The different lines of evolution can continue after that, due to the reproductive isolation.

This is how quantitative change in the relative gene frequency can lead to a qualitative change in the species.

What are genes made of?

Now that the theory of genes based on their behaviour in determining heredity was firmly established, people turned their attention on the chemistry of genes. Earlier in 1909, A F Garrod had shown that a gene produces an enzyme. Following the lead, many scientists conducted directed experiments and demonstrated that each gene is responsible for the production of a specific protein molecule.

But what kind of chemical structure carries the genetic information? The first conceptual break was produced by the eminent

physicist Erwin Schrödinger. In 1944 he wrote a book titled 'What is life?' in which he argued, citing the stability of genetic information in spite of continuous jostling and collisions among the components of a cell, that the carrier of hereditary information must be a molecule. But what type of molecule? Schroedinger guessed that it would have to be some kind of 'an aperiodic crystal' in order to carry information.

Earlier in 1869 the Swiss biochemist Friedrich Meischer (1844-1895) had shown that chromosomes contain two kinds of molecules: proteins, and nucleic acids. Since proteins, comprising large amino acid chains, can be of immense complexity, people at that time assumed that the protein component of chromosomes is the carrier of genetic information. There was another factor contributing to this belief. The American scientist, Phoebus Levene (1869-1940), chemically analyzed a large amount of RNA obtained from yeast, and found that it contains almost equal amounts of the bases guanine, adenine, uracil and cytosine. He concluded, erroneously, that the RNA was a repetitive arrangement of these bases, and hence cannot contain much information.

But one experiment by the British microbiologist Fred Griffith (1881-1941) indicated otherwise. In this experiment, he took pneumococci bacteria (that causes pneumonia) which has two strains: a virulent one, and another that does not produce much ill effect. He killed the virulent bacteria by heat and injected it into mice. The mice did not develop any disease. But when he mixed the dead bacteria with living bacteria of the non-lethal variety, the progeny developed virulence.

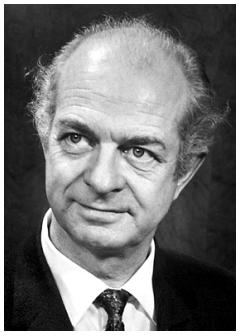
The American microbiologist Oswald Avery (1877-1955) carried this line of work further. He extracted nucleic acid from the chromosome of the virulent bacteria, purified it, and kept it in contact with the non-lethal strain of living bacteria. It was found that the progeny of the living bacteria developed some of the features of the dead bacteria from which the nucleic acid was taken. These transferred traits perpetuated generation after generation, indicating that some genetic change has occurred in the recipient bacteria. Thus, genetic information was transmitted from the killed bacteria into the living ones through the medium of nucleic acid. This showed that nucleic acid and not the proteins in a chromosome contain genetic information. This was further substantiated by A Hershey and M Chase using radioactive tracers. The experiments of Zinder and Lederberg (1952) showed that when a bacterium enters a host cell, it leaves the protein part behind. Only the nucleic acid part enters, multiplies, and takes up a new protein envelope.

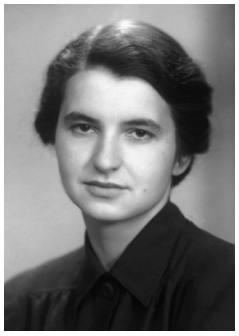
Out of the two types of nucleic acid molecules, it was found that deoxyribonucleic acid (DNA) was the genetic material in most organisms. Erwin Chargaff (1905-2002) then showed that the DNA molecule allows great variability — there are as many different DNA molecules as there are species. The bases found in DNA molecules come in two varieties: guanine (G) and adenine (A) belong to the family of purines, and cytosine (C) and thymine (T) are pyrimidines. Different DNA molecules can have different sequences of these bases. Chargaff additionally showed that the amount of adenine is always equal to thymine, and the amount of guanine is always the same as cytosine.

This was the primary clue when people tried to work out the structure of the DNA molecule. The second clue came from the group led by Linus Pauling who showed in 1951 that some of the complicated protein molecules have a helical structure — the so-called alpha-helix. The third clue came

from crystallographic studies of the DNA molecule (some of the clearest x-ray diffraction pictures were obtained by Rosalind Franklin at King's College, London). A Ph.D student named Francis Crick and a postdoctoral student named James Watson at Cambridge University took a shot at the problem outside of their official assignment. They pieced together the leads provided by the earlier researchers and in March 1953 came up with the double-helix structure of the DNA molecule.

This was the crowning glory of the half-a-century long quest to understand the material basis for heredity. After this discovery, pieces of the jigsaw puzzle came together to form a unified picture. Genetics became a mature science, and progressed in leaps and bounds.





Linus Carl Pauling (1901-1994) and Rosalind Elsie Franklin (1920-1958)

The Philosophical Confusions

All these developments were happening at a time when scientific materialism had developed significantly, and was slowly finding acceptance in the scientific community, but the older modes of thinking — including metaphysics and mechanical determinism — were still prevalent. During the early days of the development of genetics, a lot of things were unclear and confusion prevailed among scientists. In such situations the philosophical position of individual scientists becomes the predominant factor dictating their interpretation of theories. As a result, we see various sorts of confusions in different stages of the development of the theory of genetics.

For example, many scientists viewed the carrier of heredity—the gene—as static and unchangeable. Some viewed an individual organism's physical structure as being fatalistically given by its genetic makeup, with practically no role being played by the environment. Some scientists negated the causal link between the environment and the evolutionary process and opined that the changes are random. We see evidence of such confusion in books, even textbooks, written in that period.

But the most important confusions came from a different angle.

We have earlier seen that in the early phase, capitalism opposed religious bigotry, promoted rationality, and encouraged the development of science and technology. But in the late 19th century, capitalism was approaching old age and was developing signs of chronic diseases. In this system of production, the capitalists own the means of production and employ wage labourers to produce goods. The value created by the labour of a wage-worker is more than the wage paid by the owner to the worker. This is called surplus value and is appropriated by the capitalist owner. The process invariably leads to pauperization of the masses and accumulation of wealth in the hands of a few. Now, the success of the system crucially depends on the market. But since most of the population has very little purchasing power, the market cannot expand in step with production capacity. This results in periodic market crisis and surplus production. From their zeal to gain maximum profit, the European powers had colonized the rest of the world to exploit

James Dewey Watson (born 1928), Francis Harry Compton Crick (1916-2004)

their cheap labour and natural resources of the colonies. But that could not stem the crisis. The early half of the 20th century saw two world wars between imperialist powers over the control of the restricted markets and natural resources.

People do not like war, and in order to get them to support war and the subjugation of one people by another, some theoretical justification needs to be provided. Initially the concentration of wealth in the hands of a few was justified by citing "survival of the fittest"[1]. But the fact is, ever since humankind transcended the phase of purely biological evolution and entered the phase of bio-cultural evolution, natural selection is no longer effective. The survival of individual humans is no longer subject to the vagaries of nature: we wear clothes and build houses so that weather extremities do not affect us; predators no longer pose much threat to us; we are no longer dependent on specific niche diets — we cook and prepare food from a variety of materials available in nature. That is why nature can no longer 'select' specific genetic makeups. Yet it was argued that since man is also an animal, in human society also the fittest should survive. The same "law of nature" was cited to justify the subjugation of the Indian people by the British.

But with the development of genetics, things took a new turn. Now some people started claiming that the white race was genetically superior to the others. In Germany, Hitler took it a step further, to claim that the "Aryan race" was genetically superior to all other races on Earth (including non-Aryan whites like the East Europeans), and so it had the right to rule over the whole planet.

Not only that. An idea was floated that it is possible to improve the human race by selective breeding and by exterminating the people who are perceived to be genetically inferior. Even many common Germans started seeing the Nazi concentration camps as a necessary evil, aimed at creating a better world in future. Thus support of a majority of Germans was obtained by citing a wrong science.

The idea of improving the human race by selective breeding was not confined to the German fascists. The idea was caught by many people, even scientists, of different countries, and a movement, called the Eugenics movement was born out of it!

Yet, at base of such notions was the idea that human qualities like intelligence, compassion, mental abilities, etc., were genetically governed. It has been shown by many scientists that this is a false idea, not supported by evidence. Our physical features — the colour of the skin and eyes, curliness of hair, etc. are genetically governed. Height, weight, physical build, etc., are determined by a combination of genetic factors and our life-style. But intelligence and other mental faculties are completely the product of an individual's interaction with the environment, especially social interactions, through his or her life-time. We obtain the ingredients of our thought from

[1]Darwin did not use this phrase. It was in fact coined by the biologist Herbert Spencer and was promptly caught hold of by the media.

the surrounding society. Through social interactions we come in contact with the thoughts of others, with the cross-currents of various lines of thought. Our minds form through these interactions. And a person who grows up in an intellecually challenging environment has a higher probability of being more intelligent than one whose surroundings do not pose such challenges. Yet, the idea that mental faculties are genetically determined floated in the air, and in spite of being debunked by many scientists, still remains current in modern society.

It is also to be noted that genetics has made spectacular progress by taking a reductionist approach like other natural sciences. Any organism is broken up unto constituent parts, and each part is studied in details. We studied cells, then its nucleus, then its chromosome, then the nucleic acid, and finally the properties of individual genes. But, it has been shown in many areas of science that the whole may be more than the sum of the parts. At some point we'll need to put the pieces together to study the emergent property of the whole.

(*To be continued.*)

* Past installments of this article are available in our homepage www.breakthrough-india.org in the link → Breakthrough magazine → Archive.

References:

1. John Gribbin, "History of Western Science", Penguin Press, UK, 2002.
2. Richard Levins and Richard C. Lewontin, "The dialectical biologist", Harvard University Press, 1985.
3. Isaac Asimov, "A short history of biology", Natural History Press, USA, 1964.

The birth and growth of a Scientific Idea — Science of Motion

K. Sampath *

Introduction

Knocking down Aristotle's philosophy of science of motion, Galileo proved that:

1. The effect of force was not to produce motion, but to change motion—to produce acceleration. A constant force does not lead to constant speed but to constant acceleration. The speed increases by equal increments within equal time periods, and the distances covered in equal time periods are not equal.

2. Gravity causes all objects to increase their speed of fall at the same rate

3. Bodies do not require a cause to continue their motion; a body in motion will continue in its motion so long as no factor disturbs that motion. This principle is called the principle of inertia. A body on which no force acts would either be at rest or would move at a constant speed. It moves equal distances in equal intervals of time.

In this article we discuss how he established these ideas.

Ideas prevailing before Galileo

According to Aristotle's idea, force produces motion; it implies that bodies cannot move unless acted on by a force. Motion is accompanied by resistance of the medium. Therefore speed is proportional to force and is inversely proportional to resistance.

This notion appears reasonable when one considers pulling or pushing a cart: the cart moves only when it is pulled or pushed, and stops when pulling or pushing ceases. Aristotle asserted that motion was primarily determined by the intrinsic nature of the substance that is moving. He believed that all motion needed a force to maintain it; motion continues as long as force is exerted on the moving body. He felt all motion is the internal urge of bodies trying to seek their due place on earth or in space, on the basis of reason and purpose. Why does a stone fall down and smoke move up? According to Aristotle, they act this way because the natural place of stone is on the earth and that of fire is in the air, and the stone's and the fire's nature is to move to their natural place. He asserted that nature of the thing and reason for the fact are identical.

Aristotle believed that a stone fell to the ground because the stone and the ground were similar in substance. Likewise, smoke rose away from the Earth because of the similarity primarily with air. For falling bodies, the force is the weight pulling down a body and the resistance is that of the medium, air or water. Aristotle's law of falling bodies states that the speed of fall of a body is proportional to its weight and inversely proportional to the density of the medium; the heavier the body the faster it falls. It is not unreasonable to think

*The author is a retired scientist, DRDO

that bodies which are heavy come down and light ones go up—as stones and water come down while fire and gases go up. Aristotle also said that the shape of the body determines whether it would sink or float in water; a needle or a leaf floats whereas a stone or a sphere sinks.

One can stand up now to test—drop a coin and a feather side by side simultaneously; the feather takes much longer to hit the ground. That is why Aristotle thought that heavy objects fell faster. The Aristotelian mode of thinking ruled for two thousand years.

Lacunae in Aristotle's thought

Aristotle was one of the greatest observers of all time but unfortunately not an experimentalist. He had an acute power of observation but this power of observation alone is not sufficient to uncover the inherent complexities of sciences—in our present case Physics. He failed to consider the fact that air friction act differently on different falling bodies. Science of physics demands planned experiments which was alien to Aristotle and his contemporaries. And their method of dealing with science was based on qualitative and not quantitative, i.e., contemplation, not experimentation.

Justification of the prevailing ideas

Consider the following situation. A stone weighing fifty kilograms is laid upon an open vessel containing mercury; the stone floats on the surface of mercury; on the other hand if a gold coin is placed on the surface of the mercury, it will sink to the bottom. Therefore, scientists of that era reasoned: gravity depends on the nature of the substance. Their idea was also that a vacuum could not exist and Aristotle declared that 'nature abhors vacuum'.

The methods of scientific investigation was yet to be invented and introduced. One of the main differences between the science of the ancient Greeks and science today is that, today we use experimentation to test our observations and ideas. Yet the march of scientific investigation was steadily progressing but slowly.

The growth of idea after Aristotle

Now, let us come back to the issue of falling bodies. The following accounts show that even in Greek times not everybody believed in Aristotle's theory on motion of bodies. Democritus (470-400 B.C.) asserted and also taught that a moving body continued in its motion until something intervened/ disturbed, the motion. Plutarch was a Greek historian, biographer, and essayist (A.D. 100), who wrote that 'everything is carried along by the motion natural to it, if not deflected by something else'.

And at the onset of Renaissance, many scientists conducted experiments even before Galileo's theoretical work on motion of falling bodies which disproved Aristotle's claim that heavier bodies fall faster than lighter ones.

In mechanics, Leonardo Da Vinci (1452-1519) said that 'every body has weight in the direction in which it is moving', and asserted that the falling body increases its speed as the fall progresses. Being an experimenter by habit, he must have done some experiments to arrive at this conclusion. Then in 1544, the historian Benedetto Varchi referred to actual tests which refuted Aristotle's claim.

In 1576, Giuseppe Moletti reported that bodies made of the same material but varying in weight and bodies of the same volume but of different materials, dropped from a height had arrived the Earth at the same time.

In the year 1586, Simon Stevinus and Jan Cornetts de Groot conducted an experiment in Delft on falling bodies; and

found that spheres of different weights, when dropped thirty feet from the church tower, reached the ground at the same time. They concluded from the sound of the impacts, that the spheres fell with the same speed, not as stated by Aristotle. Stevinus is regarded by many as the first one to perform experiments on falling bodies. He failed to do experiments scientifically and also missed to use mathematics to establish the theory of falling bodies.

In 1597 Jacopo Mazzoni, of the University of Pisa, reported that he had observed objects falling at the same speed regardless of weight and pieces of an object descending at the same rate as the whole.

Now it is a known fact that from a given height any two objects, when released in vacuum will reach the ground simultaneously (the Apollo astronauts verified this fact on the Moon, using a feather and a wrench).

Entry of Galileo Galilei

Galileo Galilei, (born Feb 15, 1564, died Jan 8, 1642), initially showed a distaste for science. His father reluctantly sent him to University of Pisa, to study medicine. Galileo, accidentally heard a lecture on geometry and felt that mathematics is more interesting than medicine; and his interest drove him towards the mathematics classroom. When his deep interest was brought to the notice of University authorities, they transferred him to mathematics and science. After completion of his study, he was offered the post of lecturer at the University of Pisa at the age of 25. After two years he was elevated to professor of Mathematics at Padua and he remained in that post for 18 years.

Galileo Galilei was an experimentalist who for the first time had the insight and talent to connect theory with experiment. At Pisa he started to work on discovering principles of mechanics. His mathematical acumen helped him to investigate mechanical problems. The seed of the idea of motion of bodies had already sprouted on the scientific field. Now it was to be nurtured. Galileo Galilei—was the right person for the job as he had better tools of scientific investigation than his predecessors. He departed from the classical methods then reigning and dealt with the problem of motion of bodies under the action of natural forces in a different way. He thought that it is worthwhile first to investigate how they behave than to speculate why they do so in a particular manner. This was a paradigm shift.

Ground work

Galileo at first confirmed that the speed of a freely falling body increases as the fall progresses; that the rate of fall does not depend on weight, color, shape, size or material; and that the rate of fall depends on the distance traversed during the fall.

Galileo proved, for example, that the composition of a body does not determine the character of its fall by conducting an experiment with a ball of wax. He dropped a ball of wax in water, naturally it went to the bottom and then he added salt in the water to increase the density of water; he found at a certain level of density, the wax ball started floating up to the surface of water. He understood that every event occurred in accordance with some universal law.

Galileo's Analysis

At the outset Galileo wanted to find the law which governed the increase in speed of a falling body. He understood that the increase in speed is connected with distance and time. There are two variables connected with increase in speed of falling bodies—time and distance (third variable, medium — neglecting air resis-

tance). Hence he speculated that the increase in speed of the freely falling body could be proportional either to the distance travelled or to the time that had elapsed since the start of the fall.

Galileo reasoned that if the increase in speed at each point is proportional to the distance of the fall, then at the very start, the distance is zero—as it had not moved at all, and then, the speed should be zero, and the body should stand suspended in the air. Thus he came to the conclusion — 'to think further on this line is useless.'

He focused his attention to consider the time elapsed during the fall. He felt it is not advisable to measure the speed or distance directly as the fall is too fast. It was clear that a freely falling body is subject to an increase in speed during the course of fall. The force acting on the body is also the same (uniform) during the fall at every point. The increase in speed cannot be haphazard, because in general, there exists uniformity and simplicity in nature—Galileo felt. Speed is related to distance and duration. Since the increase in speed is spread over the entire duration; on combining these facts, Galileo guessed that the speed at any point would be just double the average speed up to that point.

But a scientist needs experimental facts to support the theory. Experiments could have been done by dropping an object from different heights and noting the durations of fall. But how to measure the duration of a speedy fall? The methods of measuring time known at that time were the sun-dial, burning candles and water-clocks which were too crude for his purpose. Galileo chose the water clock and improved its design in a very ingenious way. Still it could not meet the desired degree of accuracy to measure the speed of fall.

Now the only way for Galileo was to slow down the speed of the fall. How to do so was a million lira question to our great Galileo.

Galileo's observations

In Pisa, a lamp hanging from the ceiling of the Cathedral swinging in breeze caught his attention. He noticed that the time taken to complete a swing does not depend on whether the swing was big or small. A swing always took the same time. He timed the oscillations by counting his pulse (notice how a scientist can overcome an apparently insurmountable hurdle). Galileo confirmed this primitive observation by exact experiment using a pendulum in his laboratory. And he also found that the air resistance was too small to introduce any complications on the swinging motion. A ball made of lead, cork or any other material would swing to and fro in the same time. This experiment made him declare that gravity caused all bodies to increase in speed of fall at the same rate.

Galileo experimented on objects falling in water (only medium of fall changed); where the motion of the objects was slow enough so that he could record the duration of fall with a pendulum clock. This technique, established that all heavy bodies (for example a steel ball) reach the bottom of the tank in about the same amount of time, which is a bit longer than the time they would take to fall the same distance in air. He also found that bodies that are lighter take a longer time to reach the bottom. Also on examining the free fall of substances of different materials, he found that there was an upward force exerted by the medium. Thus, Galileo established that gravity is same for falling object whatever the media may be.

Analogy

The above experiments in water suggested that experiments with slowly moving bodies are possible and such motion are akin to

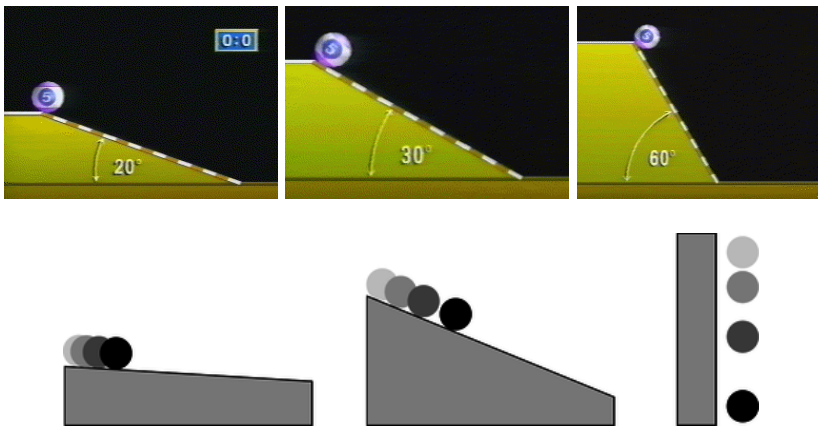


Figure 1: Speed increases gradually on a smooth slope, and the motion is similar to the motion of a falling object.

the motion of falling body in air. The measurement of time could be done with great accuracy if the motion is slow. Thus he established a fine line of reasoning for his next experiment.

Experimentation of the rolling body on an inclined plane

Having established that the experiment can be done keeping the main phenomena intact and by slowing down the fall, Galileo went ahead to arrive at quantitative measurements of how the speed of a falling object increased as the fall progressed. He let a ball roll down on a smooth slope (to avoid opposing frictional force) instead of dropping it vertically; and recorded the distance and the time of rolling down. If s_1, s_2, and s_3 represent the distances measured from the same starting point on an inclined plane, and t_1, t_2, and t_3 the corresponding times taken to roll down these distances, then $s_1/t_1^2 = s_2/t_2^2 = s_3/t_3^2 = a$. Then he increased the slope step by step and recorded the distances and times of motion. Whenever the angle changed, the ratio s/t^2 took on a new value say $a_1, a_2, a_3 \cdots$; although for any one angle it remained constant regardless of distance of roll. In general, for each angle of incline, the value of s/t^2 was constant. This verified his conjecture that speed of fall increased uniformly.

As the ball rolled down the inclined plane, Galileo used a klepsydra, a version of the ancient water clock, to measure the relative distances covered in terms of amounts of water collected in a jar; also equal intervals of time were measured by musical intervals.

On the analysis of data collected, Galileo found that steeper the incline, the more rapidly the ball would gain speed, but the increase in speed was uniform irrespective of inclination.

Finally, when the angle of inclination became 90°, the ball would move straight down, and then it becomes a freely falling object. By his reasoning, s/t^2 would still be some constant. Thus Galileo had arrived at a constant value a of s/t^2 that was characteristic of uniform acceleration and he could conclude that free fall was a uniformly accelerated motion.

Now it was clear that constant force causes *change of motion*, i.e., produces acceleration.

A Summary of Galilean Equations

Below is a summary of the relationships among distance s, velocity v, acceleration, and time t:

Condition	Proportionality constant	Basic Equation
Assuming continuous uniform motion: $s \propto vt$	1	$s = vt$
After uniform acceleration from rest: $s \propto vt$	$\frac{1}{2}$	$s = \frac{1}{2}vt$
After uniform acceleration from rest: $v \propto t$	a	$v = at$
After uniform acceleration from rest: $s \propto t^2$	$\frac{1}{2}a$	$s = \frac{1}{2}at^2$

Uniform motion: Motion of a rolling body on a horizontal plane

He then explored motion without gravity (Fif.2). On experimenting with a rolling ball, as the ball begins to roll down the smooth plane, the force of gravity acts on it, and the ball moves faster and faster, until it reaches the bottom. Then it rolls on the smooth horizontal plane.

Now, as the ball rolled on the smooth horizontal plane, gravity was no longer pulling the ball to accelerate its motion. The effect of gravity is now acting perpendicular to the direction of motion. He observed that the ball now continued to move horizontally, in a straight line, with a constant uniform motion until checked by friction and the resistance of air. This implied that the horizontal and vertical forces are completely independent! This fact led Galileo to postulate the law of inertia — 'Bodies do not require a cause to continue their motion; a body in motion will continue in its motion so long as no factor disturbs that motion'.

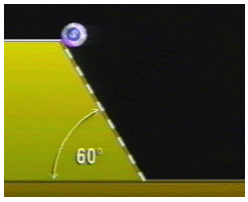


Figure 2: Experiment with a rolling ball: it gained speed by rolling down an inclined plane, and then rolled on a horizontal surface.

Even though Galileo was the first to experimentally obtain the above equations of motion, René Descartes was the first to state the principle of motion with perfect clarity. Descartes wrote in 1644 that 'when a body is at rest, it has the power of remaining at rest and of resisting everything which could change. Similarly when it is in motion, it has the power of continuing in motion with the same velocity and in the same direction.' After thirty years Huygens restated the same in his own words and then in 1687, Newton restated in his Principia Mathematica (p.190) and made it the footing of his whole system of dynamics.

References:

1. 'The growth of scientific ideas' by W.P.D. Wightman.
2. 'The Growth of Physical Science' by Sir James Jeans
3. Various webpages

"Knowledge comes from noticing the resemblances and recurrences in the events that happen around us."

— Wilfred Trotter

News & Views

Is Climate Change Responsible for Decline of Harappan Civilisation?

A group of scientists, led by Prof. Anindya Sarkar of IIT Kharagpur, has made a detailed study on Oxygen isotope (^{18}O) records of animal teeth and bone phosphates (apatite) from an excavated archaeological trench in the Harrapan site located at Bhiranna in the State of Haryana. The study was published in the journal named *Scientific Reports* by Nature publishers.

Recent excavations and carbon dating studies have revealed that Bhiranna settlement at the bank of presently defunct extension of Ghaggar river, is the oldest of all sites in the Indian subcontinent dating back to more than 7000 BC. Bhiranna is also one of the most thickly populated settlements among the Harappan sites.

The Harappan civilisation, which lasted almost for 5500 years, starting from 7500 BC to 1800 BC, has developed through different cultural levels. Based on the spatio-temporal distribution of archaeological remains spread through-out the subcontinent, the cultural levels of Harappan period are named as Pre-Harappan Hakra culture (7500-6000 BC), Early Harappan (6000-4500 BC), Early Mature Harappan (4500-3000 BC) and Mature Harappan (3000-1800 BC). While the first two phases were represented by pastoral and early village farming communities, the mature Harappan settlements were highly urbanized with several organized cities, developed material and craft culture, having trans-Asiatic trading links to regions as distant as Arabia and Mesopotamia.

The signatures of different cultural levels of Harappan period in the form of artefacts have been discovered at the Bhiranna site during excavation in 2005 by Archaeological Survey of India. The authors have made carbon dating of charcoal samples and used a method known as Optically Stimulated Luminescence (OSL) to date the pottery samples excavated at successive levels to show that the Bhiranna site has preserved remains from all the four Harappan cultural phases.

The excavations also yielded large quantities of faunal remains comprising bones, teeth, horn cores, etc. from all the four periods at Bhirrana and were identified at species levels. Preliminary faunal investigations suggested presence of domestic cattle e.g., cow/ox (Bos indicus), buffalo (Bubalus bubalis), goat (Capra hircus) and sheep (Ovis aries) from the earliest levels. Besides the dietary use of cattle and goats, wild fauna such as nilgai (Boselaphas tragocamelus), Indian spotted deer (Axis axis) and antelope (Antilope cervicapra) were also a part of the diet.

Taking due advantage of the situation the authors studied the Oxygen isotope (^{18}O) records of animal teeth and bone phosphates (bio-apatite) from the successive cultural levels starting from Hakra to mature Harappan culture. The ^{18}O record is based on ^{18}O to ^{16}O ratio in fossil bone or tooth enamel bioapatite is a robust tool for estimating the past meteoric water composition or drinking water for land animals.

Period	Cultural levels	Year BP (based on radiocarbon ages in different trenches)	Attributes
I A	Hakra ware culture	7500-6000 BCE	Earliest cultural phase at Bhirrana, primarily identified from the ceramics quite similar to those identified from sites in Cholistan. The ceramics comprise mud appliqué ware, incised ware, Bi-chrome ware, tan slipped ware, blackburnished ware, brown on buff ware, simple red ware of medium fabric with common shapes like vase, bowl and cup. Also characterized by its subterranean dwelling pits, antiquities from the dwelling pits included beads of semiprecious stones like carnelian, agate, terracotta bangles, unbaked triangular clay cakes, querns, crucible, chert blade, crucible fragments with molten copper.
IB	Early Harappan culture	6000-4500 BCE	Settlement expanded and the entire site came under occupation. The houses were built of mud bricks in the ratio of 3:2:1 and measured 45×30×15cm; 42×28×14cm and 39×36×13cm. Yielded terracotta figurines, arrow heads, rings and bangles of copper, beads of carnelian, jasper, shell, bull figurines, chert blades, terracotta bangle.
II A	Early Mature Harappan culture	4500-3000 BCE	Beginning of fortification wall, house-complexes, streets and lanes
II B	Mature Harappan culture	3000-1800 BCE	Fully developed house complexes contain painted ceramics which included geometric, floral and faunal motifs. Incised figure of a dancing girl closely resembling the famous bronze dancing girl from Mohenjo-daro. Antiquities typical of the Mature Harappan period were recovered such as steatite seals, beads of semi-precious stone, shell and terracotta, animal figurines, bangles of faience, shell, copper bangles, chisels, rings, rods, stylised terracotta horns with symbolic head painted in black.

Under a constant body temperature of approximately 37°C, the ^{18}O in mammalian phosphate essentially depends on the ^{18}O value of water ingested by the organism.

The results when correlated with the climate records of the region revealed that the pre-Harappans started inhabiting this area along the mighty Ghaggar-Hakra rivers fed by intensified monsoon from 7500 to 6000 BC. The monsoon monotonically declined after 6000 BC yet the settlements continued to survive from early to mature Harappan time (up to around 1800 BC).

The authors write "not only the Harappan civilization originated during the 8th to 7th millennium BC, it continued and flourished in the face of overall declining rainfall throughout the middle to late Holocene period. It is difficult to point to one single cause that drove the Harappan decline although diverse suggestions from Aryan invasion, to catastrophic flood or droughts, change in monsoon and river dynamics, sea-levels, trade decline to increased societal violence and spread of infectious diseases have been proposed. The continued survival of Harappans at Bhirrana suggests adaptation to at least one detrimental factor that is monsoon change."

The authors have further suggested that to adjust to the arid conditions in mature Harappan period, Harappan people shifted to low yield drought resistant summer crops, which forced them to abandon organised large storage system, giving rise to smaller household based crop processing

and storage. The authors have suggested that this might have been the reason behind de-urbanisation of Harappan civilisation rather than abrupt collapse as suggested previously.

Going back to antiquity, this study showed that Harappan civilisation passed through different cultural levels gradually from simple to advanced societies. This ancient civilisation in the Indian subcontinent survived through continuing low monsoon arid conditions, which may overrule climate change as one of the possible reasons for the collapse of Harappan civilisation. However, as a matter of fact, the lost brick making technology and complete disappearance of Harappan script in the post-Harappan period, favours the theory of sudden collapse of the civilisation rather than continuous dispersion. More studies in different perspectives will further unveil the mystery of Indus-Valley civilisation. □

Article reference: Sarkar, A., Mukherjee, A.D., Bera, M.K., Das, B., Juyal, N., Morthekai, P., Deshpande, R.D., Shinde, V.S. and Rao, L.S., "Oxygen isotope in archaeological bioapatites from India: Implications to climate change and decline of Bronze Age Harappan civilization," *Scientific reports*, **6**, 2016.

Discovery of a new human ancestor

Scientists at the Institute of Evolutionary Biology (IBE), a joint center of the University Pompeu Fabra (UPF) and the Consejo Superior de Investigaciones Cientficas (CSIC), have discovered a new extinct hominid that lived in South-East Asia. This species, not described until now, is an ancestor of humans like the Neanderthals or Denisovans and crossed with modern humans tens of thousands of years ago. The results were published in the journal

Aborigine people of the Andaman Islands

Nature Genetics on 25th of July 2016. The first two authors of the paper were Mayukh Mondal of the IBE and Ferran Casals of the UPF, and the work was done in collaboration with Prof. Partha Pratim Majumdar of the National Institute of Biomedical Genomics India.

Genetic analysis of a group of individuals from the Andaman Islands in the Indian Ocean has revealed that their DNA contains fragments that do not correspond to modern humans who left Africa about 80,000 years ago. When comparing these sequences with those of Neanderthal and Denisovan (two other extinct hominids), scientists have found that they are also distinctly different. IBE researchers have concluded that the DNA fragments belongs to an extinct hominid that shares a common ancestor with the other two but has a different story.

According to Jaume Bertranpetit, group leader of the IBE and Professor at the UPF,

"We have found fragments of DNA from the extinct hominid which is part of the genome of modern humans. In the near future we hope to obtain the complete genome from fossils." In fact, different groups of scientists are now analyzing bones that could correspond to this hominid, perhaps known as Homo erectus.

The archaic Homo sapiens evolved into modern humans in Africa about 200,000 years ago. A small part left the continent around 80,000 years ago and gave rise to all human populations outside Africa. However, there were doubts whether pygmies like those in the Andaman islands came from an initial migration which happened 80,000 years ago. Thanks to DNA sequences obtained in this study, it was found that it is not the case and the 'Out of Africa' event for modern humans happened in a single migration wave, from which all non African modern humans descended.

The theory of a first wave of immigrants came from naturalists and anthropologists of the nineteenth century, who noticed that the Andamanese and other ethnic groups in isolated parts of Southeast Asia were physically similar to African pygmies. In fact, these people are called 'Negritos' because they have a short stature, black frizzy hair and dark skin. This study, however, denies this possibility. "The genome of these populations contain pieces of DNA from an extinct hominid but we have all just come from the same Out of Africa event" concludes Bertranpetit.

The small stature of Andamanese therefore is not explained by the founder effect, i.e., that the first inhabitants were short and thus their descendants were also. The scientific team found genetic evidence that this is the result of an evolutionary process of adaptation and natural selection.

Being smaller gives a selective advantage when living in an island where there is scarcity of food as well as lack of big predators. This study provides conclusive genetic evidence of this phenomenon, also observed in many animals: a 40 cm tall goat that inhabited the Balearic Islands, or one-meter-tall elephants who lived in Sicily. The current findings also could be used to explain the small stature of hominid fossils found in the island of Flores in Indonesia.

Article reference: Mondal M, Casals F, Xu T, Dall'Olio GM, Pybus M, Netea MG, Comas D, Laayouni H, Li Q, Majumder PP, Bertranpetit J, "Genomic analysis of Andamanese provides insights into ancient human migration into Asia and adaptation," *Nature Genetics*, **48**, 1066-1070, (2016)

BSS submits memorandum to the Central Environment Minister regarding the approval of GM Mustard

To:
Sri Anil Madhab Dave,
The Hon'ble Minister of State,
Ministry of Environment, Forest and
Climate Change, Government of India.

Sub: Memorandum in connection with the approval of GM Mustard (DMH-11 and its parental lines)

Dear Sir,

We express our grave concern and strong opposition to the initiatives of the Genetic Engineering Appraisal Committee for according approval to the environmental release of a GM hybrid Mustard (DMH-11) and its parental lines developed by Delhi University, about 14 years after a similar move by ProAgro, a Bayer subsidiary, was rejected by the regulatory authority.

India is a centre of diversity and secondary centre of origin for Indian Mustard (Brassica juncea) and mustard is widely

used essentially as edible and cooking vegetable oil in this country. Its seed and fresh leaves are also used as food and mustard oilseed cake is used as cattle feed. It is also used in many ways in the ayurvedic system of medicine.

As the regulatory authorities are on the verge of giving approval to the commercial cultivation of GM Mustard, we, as concerned and conscious citizens, firmly believe that introduction of this GM hybrid mustard (DMH-11) is not going to increase mustard production and reduce oil import bill to any appreciable extent. On the other hand it is going to destroy our mustard biodiversity, food security, safety and sovereignty and natural resource base for sound agricultural production system, which are to be protected to meet the demands of present and future generations for sustenance.

We strongly submit that this GM hybrid mustard (DMH-11) should not be accorded permission for environment release due to following reasons.

1. Agriculture being in the State list, the opinions of the State Governments are to be taken into account before talking any such decision. It may be mentioned that Rajasthan, Haryana, Bihar, West Bengal, Odisha, Madhya Pradesh, Gujarat and Kerala have refused to allow GM crop trial and/or cultivation in their states.

2. The claimed increase in yield of DMH-11 mustard was not verified by any independent agency.

3. After commercial release, the concerned GM crop (conferring sterility and herbicide resistance) will surely be transferred to other thousands of indigenous mustard varieties and its wild relatives in its centre of diversity through mechanical mixture, cross pollination and horizontal gene transfer. Hence there will be an irreparable loss of biodiversity that will be impossible to be rectified in due course. This also contravenes the Cartagena Protocol on Biosafety, of which India is a signatory, and provisions of Protection of Plant Varieties & Farmers Rights Act, 2001. The Cartagena Protocol requires that no GM crop shall be introduced in its centre of origin/diversity. PPV&FRA, 2001 requires that, varieties containing sterility trait (GURT) and producing toxins that are injurious to life (toxins that kill cells) shall not be registered. Indeed, transgenic technology is imprecise, unsafe, uncontrollable, irreversible, unstable and unpredictable technology. This DU GM Mustard variety has GURT trait and produces toxin.

4. As GM mustard variety is F1 hybrid in nature, farmers will not be able to keep seed for use in subsequent years. And thus, the farmers will lose the age-old right to save and share seeds. They will be made dependent on market for supply of seeds likely to be controlled by multinational seed companies.

5. From the experience of Round Up ready Soybean, HT and Bt Maize, and Bt Cotton elsewhere and in India, it is conclusively documented that within a few years of introduction of these crops, the use of chemical herbicides and pesticides have increased considerably, leading to various detrimental environmental consequences and development of super weeds, new pest complexes etc. Similar development will also occur in case of this herbicide tolerant (HT) GM mustard. Adverse impacts of GM crops on non-target organisms and also on soil health are well-documented. The GM crops, that may appear to be conducive

for large farm holdings of developed countries, has very little relevance to the resource-poor marginal and small farmers of India. It will not at all reduce the use of agricultural inputs like water, fertilizers and other agrochemicals and will not contribute to the achievement of food security in our country.

6. The real beneficiaries from the introduction of GM crops will be the seed-producing companies who will make profit from the patented seeds/technology in the forms of high seed costs, technology fees, royalties, increased sales of agri-chemicals, etc., pauperizing poor small and marginal farmers of India.

7. HT crops also mean greater chemical residues in consumer food that will create health hazards in due course.

8. Once the herbicide tolerant GM mustard is introduced, many other HT GM varieties of other crops which are in pipeline will likely get smooth entry in Indian agriculture. So, this GM mustard will act as a trojan horse for other GMOs.

9. Organic Farming will be directly impacted. It is reported that in Canada where similar GM canola are being grown for years, organic canola production is not possible.

10. Once, the GM crop is released for commercial cultivation and the contamination of local varieties occurs, the farmers and consumers will have no choice but to use GM contaminated mustard. Governments should not force their citizens to cultivate and eat GM food.

11. GM mustard will adversely impact honey bees and other beneficial insect populations that are major pollinators and this will eventually result in reduced yields—of not just mustard but many other open pollinated crops too. Honey production and its quality will also be affected thereby reducing its internal and export market.

12. The biosafety and other related data regarding this DU GM mustard are shrouded in secrecy. The ways the various tests of this GM mustard are conducted are deliberately misleading, unscientific, inadequate and unreliable. The full dossier with primary testing data has not yet been put on public domain for independent review.

13. The Supreme Court constituted Technical Expert Committee report said NO to GM crops for which we are the Centre of Origin/Diversity and also NO to the introduction of HT-GM crops in India. Further, a Task Force set up by the Ministry of Agriculture had earlier recommended the same.

14. There is no liability regime in place now as to who will be responsible and pay compensation for any detrimental consequences that will arise after release of the GM mustard—the crop developer, the regulators or the government.

15. On the technical front, the production of mustard and other oil seeds crop may be increased by area expansion (for which ample scopes are there), agronomically managing the crops in a better way, giving farmers adequate input and price support and adoption of SMI (System of Mustard Intensification) as well as relay sowing of the crop in rice fallows of India and strengthening farm extension support system. Similarly, provision of emergency/protective irrigation systems coupled with participatory water management at the community level will improve and stabilize production of oil

seed crops like groundnut and soybean.

16. It is not clear to the public as to who owns the technology used by DU scientists. Terms of conditions for the use of third party technology have not yet been revealed.

Lately, many other International Organizations like International Assessment of Agricultural Science and Technology for Development (IAASTD), Research and Information System for Developing Countries (RISDC), IFOAM expressed views that GM crops are not compatible with organic or sustainable agriculture and will not play any role in addressing climate change, hunger, poverty and food insecurity widely prevalent in developing countries. Many countries and regions of the world like France, Italy, UK, Norway, Spain, Saudi Arabia, Japan, Philippines, Thailand, Sri Lanka, Australia, New Zealand, Fiji, Algeria, Egypt. etc., have either banned or imposed moratoriums on the use and cultivation of GM crops.

This attempt by the regulatory authorities to force HT-GM mustard is a move towards establishing corporate control over our seed sovereignty and agriculture. We demand the approval shall not be accorded hastily and in a non-transparent way and farmers, consumers, biodiversity, and natural resource base of the country must be protected from the menace of GM crops. Government of India should also take initiatives and steps in favour of resource-poor farmers and consumers and also for promoting environment friendly sustainable technologies for crop production.

Thanking you
Yours faithfully

Place: Kolkata
Date: 5.10.2016

D Mukhopadhyay
President
S Banerjee
General Secretary

Petition on the formulation of the New Education Policy–2016

The *Breakthrough Science Society* initiated a petition to urge the Ministry of Human Resource Development (MHRD) to adopt a transparent and democratic process in formulating the New Education Policy. The petition, signed by 245 scientists and educationists, has been submitted to the MHRD.

Text of the petition

The MHRD has released a 43-page document titled "Some Inputs for Draft National Education Policy 2016" in the month of July as a step towards formulating an education policy with the avowed aim of remedying the ills plaguing the Indian education system. It has sought feedback from the people, the deadline being 15 September 2016. We strongly feel that formulation of such a policy statement needs threadbare discussion involving the key stakeholders—educationists, scientists, the teaching community, education-loving people, as well as the student community.

We note with deep concern that the document has not been publicized in any form, and most people directly concerned with education have no idea that such a consultative process is supposed to be taking place. Further, it has been published only in English, and not in any of the state languages thus excluding the majority of the people from the process. On top of that, the deadline set for sending suggestions is too short a time period for wide and meaningful deliberations. Moreover, the 230-page report of the 5-member T S R Subramaniam Committee, constituted by the Ministry for the purpose of drafting the Policy statement, has not been made public. All these show the government's reluctance to draw upon the collective wis-

dom of the key stakeholders in formulating the NEP-2016.

We are asking that the full draft of the proposed NEP-2016—not an abridged version—should be released. It should be properly publicized in the print and electronic media, and should be subjected to scrutiny and discussions by the stakeholders. It should be made available in all the state languages so that people can come to know the contents of the policy and what it portends for the future of education. Only then can meaningful and widest possible exchanges of opinions take place which will help to evolve an education policy that will truly address the education needs of the masses. Appropriate time, at least six months, should be allowed for this process. The policy may be tabled in the Parliament only after it is redrafted on the basis of the feedback received. □

Organizational News

Tribute to Mr. Yogesh Dhaked

Mr. Yogesh Dhaked, State Convenor of *Breakthrough Science Society* in Madhya Pradesh, breathed his last on 17 Aug 2016 at 10:20 AM at his home in the town of Guna. He was only 34 years of age. He was suffering from cancer for the past one and half years.

Yogesh was one of the prominent figures in the state in the fight against superstitions, and for the spread of scientific outlook in the society. He took an active role in the relief works in case of natural disasters, like the Gujrat earthquake, Uttrakhand Flood, etc.

He was one of the members of the Editorial Board of the Hindi Magzine Breakthrough. Even during his last days when his condition was deteriorating, he took responsibility of publishing an issue of the magazine. He was mentally alert in his struggle to discharge his responsibility till his last breath.

He had requested his family members not to perform any ritual following his death. His family honoured his last wish. When his mortal remains were taken to his native village, hundreds of admirers, family members and villagers paid floral tribute and joined his last journey.

The BSS Guna district organizing committee organized a memorial meeting on 4th September 2016. Dr. Soumitro Benerjee, the General Secretary of *Breakthrough Science Society* , addressed the gathering with an appeal to learn from the struggle of Mr. Yogesh Dhaked and to strengthen the science movement.

Kerala

Madam Curie Day: Madam Curie Day was observed extensively in different districts during July-August. Exhibitions, talks and documentary shows were arranged. Programs were organized in the following places: *Thiruvanathapuram district* – NSS Higher Secondary School, Nalanchira, Vocational Higher secondary School, Vattiyoorkavu, Vilappilsala and Mar Gregarious High School, Pravachambalam; *Alappuzha district* – Govt. Girls Higher secondary school, Cherthala, Government Arts and Science College Ambalapuzha, SDV Higher secondary school, Alappuzha, T K M College Nangiarkulangara and Tagore central school, Haripad; *Kottayam district* – St.Mary's college Manarkad, D B College Thalayolaparamabu, Astronomy

The Hiroshima-Nagasaki Day observation in Ernakulum, Kerala

Club Kottayam and Vivekananda School, Panachikad.

Hiroshima-Nagasaki Day Observations: A week long program of poster exhibitions, talks and documentary shows were organized in several districts on the occasion of the Hiroshima-Nagasaki Day. In Ernakulum city at Marine drive a poster exhibition and meeting was organised. Dr Godfrey Louis, Former Pro VC Cochin University, Shri.C.Ramachandran, Retd Scientist, ISRO and Shri Francis Kalathungal addressed the meeting.

In Ernakulam district programmes were organised in St. Mary's HS Chellanam, St.Xaviers Public School Kandakadavu and K R Gouri Amma College of Engg. Thuravoor. In Kottayam district programmes were organised in BCM College, Kottayam, Alphonsa College Pala, CMS School Kottayam, Astronomy Club Kottayam and Saraswathi Vidhya Mandir, Velloor.

Andhra Pradesh and Telangana

Second Hyderabad Science Conference: The Second Hyderabad Science Conference was held on 7 Sept, 2016 at Stanley College of Engineering and Technology for Women, Hyderabad. Prof Ravindharan Ethiraj, Retired professor of Osmania University was the main speaker. Addressing the students he explained the developments of science and technology and its importance in the society for the development of various fields. Sri S Janibhasha, Asst Professor, GITAM university made a presentation on the Evolution of human race. Dr Rajitha, Asst. Professor, GITAM University explained the scientific methodology and urged the students to apply it in daily life. A 14 member Hyderabad district committee was elected with D Gangaji as President, L Sarath as Secretary, Poojith Raj as Joint Secretary and 11 members. Nearly 350 students attended as delegates.

125th Death Anniversary of Iswar Chandra Vidyasagar: BSS, Hyderabad chapter observed Ishwar Chandra Vidyasagar's 125th death anniversary on 26 Sept, 2016 at Vanita Degree College for women. Smt Ch. Prameela was the main speaker. She spoke about the life struggle of Vidyasagar, and explained the need to free people from blind beliefs and superstitions and the role of scientific approach in fighting them. At the end of the program, Madam Curie Science Club was formed with 21 members.

Bihar

Discussion on "Science in Ancient India: Reality Vs Myth": Einstein Science Club, Jamalpur organized a Discussion on "Science in Ancient India: Reality Vs Myth" on 21 August, 2016 at Uma Complex, Jamalpur. The main speaker was Dr Radhakanta Koner (Member, All India Committee, BSS). At the end of the discussion, an anti-superstition show was conducted by the Club members Rahul, Ankan, Roushan, Amit, Durgesh and Ravi. Students and teachers of various institutions participated in the programme.

Left: Speakers at the open session of the Karnataka State Science Conference. Right: A section of the audience.

Karnataka

State Science Conference: The First Karnataka State Conference of Breakthrough Science Society was organised on 30-31 July 2016, at Gulbarga. The programme began with a science march with participation of more than 1000 school students and 500 common people. The march was flagged off by Prof. Challageri (Retd Physics professor and science populariser). The march culminated at the Rang Mandir – the venue of the open session. Prof. S.R.Niranjana (Vice-Chancellor of Gulbarga University), inaugurated the open session. In his inaugural speech he spoke on the advancements that science and technology has made in all fields and the need for science to become a way of life much more than it being subjects in the educational syllabus meant for career building. Prof. Dhrubajyothi Mukherjee, All India President, BSS was the Chief Guest. He said, "We must love the downtrodden and poor people in the country. Our science and technology should reach them and benefit them. We must take science to the common people and make it a way of life". Mr.G.Satish Kumar (State Convener, BSS) presided over the event. There was a cultural evening on 30th July 2016, the science drama 'Vignana Purana' and a miracle busting show attracted the audience. The delegate session covered three approach papers: water crisis and probable solutions, recent trends in science and technology, and science, culture and ethics. Three resolutions were passed in the conference: (1) Resolution pressing for Anti-superstition Bill, (2) Responsible role of media in promoting science and (3) the Main resolution on the problems faced by science and technology in the state. A 24-member state executive committee and 33 member council were elected and at the end of the conference with Mr.G.Satish Kumar as the State President and Smt.Rajani.K.S as the State Secretary.

Gujrat

155th Birth Anniversary of Acharya P C Ray: Discussions and documentary film shows on life struggle and research work of Acharya P C Ray were organized on 2 August, 2016 by Universe Science Forum (USF) at various places in Ahmedabad and Baroda. Discussions and film shows were held at Pragati Higher Secondary School, Bhavans Science College, L. M. Pharmacy College Hostel, M. G. Science College and Gujarat University in Ahmedabad. A sim-

The All Bengal Science Conference.
Left: A section of the audience; Right: The open session in progress

ilar programme was also held at the Department of Chemistry, M. S. University, Baroda.

Uttar Pradesh

Seminar on "Science in Ancient India: Myth vs. Reality": On 5 September, 2016, BSS, Allahabad Chapter organized a seminar on "Science in Ancient India: Myth vs. Reality" at CAV Inter College hall, Allahabad. Dr Soumitro Banerjee, Professor at IISER and General Secretary, BSS, was the main speaker. A large gathering of teachers and students from different colleges and the University participated in the seminar. Dr Pramod Pandey, Director of Planetarium, Allahabad, Dr R P Singh, Professor at ECC College, Dept of Mathematics, Dr Surendra Srivastava, Former HOD, Botany Department, CMP Degree College and Dr Ram Das Yadav, Principal, CAV inter College spoke.

Bengal

6th All Bengal Science Conference: The 6th All Bengal science conference was organized by Breakthrough Science Society, West Bengal State Committee in association with Acharya P. C. Ray Science Society, Durgapur on 22-23 October at DAV Model School at Durgapur. About 650 delegates from all over the state comprising students, teachers, professors and science loving peoples attended the conference.

On 22nd October the Conference was inaugurated by Mrs Papiya Mukherjee, Principal of DAV Model School and chairperson of the organizing committee. Discussions on different educational social and scientific issues were held in four sessions. 'Science Education and Education Policy' was discussed by Prof. Soumitro Banerjee (IISER Kolkata, General Secretary, BSS) and Prof. Anish Roy (Retired Prof., Presidency College and General Secretary, AISEC); 'Indian Renaissance and contribution of Vidyasagar in propagation of science education' was discussed by Sri Asish Lahiri (Popular Science Writer); Prof. Dhrubajyoti Mukherjee (Retired Prof., Calcutta University and President, BSS) and Prof. Amitabha Dutta (INSA Prof., C.U) discussed on 'Science and ethics'; 'Depletion of underground water, crisis of drinking water and arsenic pollution' was discussed by Prof. Anjali paul (IIT Kharagpur) and Dr. Mridul Das (Agriculture scientist). The local city students participated in the science model exhibition. In the evening there were a slide show on snakes, a drama and sky watching.

On 23rd October the delegate session started after flag hosting and garlanding in memory of science martyrs. Eight resolutions were moved and unanimously

Dr. Arun Speaking at the felicitation programme at Loyola College, Chennai

passed: (1) on the draft education policy, (2) against the moves to distort the Indian history by mixing with mythology, (3) demanding introduction of an anti-black-magic Act, (4) demanding scientific measures against arsenic pollution of drinking water, (5) demanding action against food adulteration, (6) urging the government not to introduce genetically modified mustard, (7) against installation of nuclear power plants, and (8) demanding effective steps to introduce scientific agricultural practice. The organizational report was placed by the state secretary Dr. Nilesh Maity. A new state committee with Prof. Amitabha Datta and Dr. Nilesh Maity as President and Secretary respectively was elected. Prof. Soumitro Banerjee, Sri Debasish Roy and Prof. Dhrubajyoti Mukherjee spoke on the future directions of the science activities and urged the delegates to build up a mighty science movement.

Tamilnadu

Discussion on the Discovery of Gravitational waves: A felicitation program honouring Dr K G Arun of Chennai Mathematical Institute and Member, LIGO Scientific Collaboration, was organised on August 23, 2016 at

Loyola College, Chennai. This was jointly organised by the BSS Tamilnadu Chapter and the Loyola Physics Association. Dr Uma Ramachandran presided. Dr Jerome Das, Dept of Physics, Loyola College welcomed the gathering of students and teachers from 10 city colleges. Shri Joseph Prabagar, Dept of Physics, Loyola College gave an introduction about the gravitational waves. Felicitations were offered by Dr R Venkatesan, Member, Advisory Committee, BSS Tamilnadu and Shri George Joseph, Secretary, BSS Tamilnadu. Dr K G Arun delivered an insightful lecture entitled "Listening to the Cosmic Whispers – The Dawn of Gravitational Wave Astronomy". He presented an overview of the LIGO experiment, its historical background, the salient features and the challenges faced. Prof Ramu Manivannan, Member, Advisory Committee, BSS Tamilnadu presented a memento to Dr Arun.

Madam Curie Day: As part of observance of Madam Curie Day, a half day discussion program was conducted on 14 July, 2016 at Gandhi Museum hall, Madurai. Students from different colleges in Madurai participated. Dr S Krishnasamy, inaugurating the discussion spoke about the different facets of the life of Marie Curie. Students actively participated in the discussion and spoke on selected topics. Mr M J Voltaire summarised the discussions.