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Discovery of the Higgs Boson — Standard Model Finds Its Missing Piece

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Introduction

The particle physics or high energy physics aims to describe how the elementary constituents of matter interact through the known fundamental forces like electromagnetic, weak and strong interaction. This in turn explains various sub-atomic phenomena and predicts previously unknown events, including existence of new particles or laws of physics at sub-microscopic world. The Standard Model (SM) of particle physics does exactly this in an amazingly successful fashion all the way to the length scale of about 10^{-18} meter by probing particle interactions at that proximity. The SM is expected to be valid up to a few hundred GeV in energy scale ($\sim 10^{-18}$ meter) and all the high energy experiments performed till this date below this energy has confirmed SM to an extremely high degree of accuracy. However, there is, or perhaps was, a problem—one unconfirmed part of SM. An important ingredient of SM is the famous Higgs boson and that remained elusive in all the previous experiments done over the last three decades. The Higgs boson or Higgs particle (also called simply as "Higgs") is important because the associated Higgs field drives a mechanism known as *spontaneous symmetry breaking* by which some of the elementary particles like electrons acquire mass.

The importance of finding Higgs can be understood from the context that a $10 billion LHC (Large Hadron Collider), which is one of the most expensive scientific instruments ever built, involving thousands of scientists and engineers of 50 different countries, is there to find the Higgs boson and investigate its properties along with looking for hints of new laws of physics! So when in December of 2011 two independent experimental teams working at two different detectors, CMS and ATLAS, in LHC reported possible evidence of a particle consistent with Higgs boson the excitement and expectation in scientific community became high and the announcement drew a fair amount of media attention. Finally on July 04, 2012, both the experimental teams at CMS and ATLAS announced the discovery of a new boson with mass of about 125 GeV (roughly that many times heavier than proton) which is compatible with the theoretical predictions about the properties of Higgs boson. The discovery turned the Higgs boson, the Standard Model, the LHC and all the participating scientists to instant celebrities.

Addressed as *God particle* in the mainstream media, the episode of Higgs discovery and the significance of the discovery is blown out of all proportion. To the common people it appears as if a *creator* of some kind has been glimpsed, The Higgs particle gained sort of supernatural aura despite the fact that it cannot create anything. Stories about Higgs boson and various fragments of SM, very rich in sensation and reciprocally low in scientific content, went viral in electronic and print media and overwhelmed almost everybody. Appreciating

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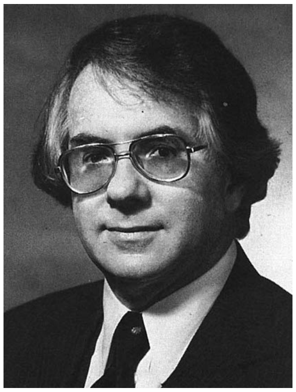
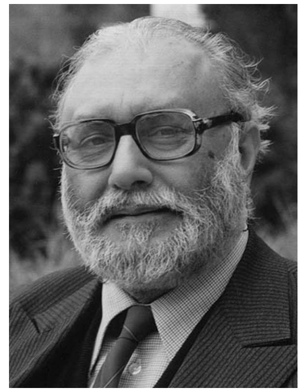




The founders of the standard model. Left: Sheldon Lee Glashow (born Dec. 5, 1932), middle: Steven Weinberg (born May 3, 1933), right: Mohammad Abdus Salam (29 Jan. 1926–21 Nov. 1996)

the event in proper spirit, even at the level of a pedestrian, has become difficult because of this. A true appraisal of the Higgs and its discovery actually requires a little more knowledge of SM of particle physics than what was catered to us so sensationally in media.

The Standard Model of Particle Physics

The Standard Model of particle physics in its present form originated from the works of Glashow in 1961 and Weinberg-Salam in 1967, when they proposed a quantum theory that unified electromagnetic and weak (*electroweak*) interactions. But before that in 1930's, Fermi first discussed a quantum theory of weak interactions to explain the beta decay of radioactive nuclei. It was about the same time when Dirac, Pauli and others attempted to quantize electromagnetism. Though these theories came close to explaining experimental results at low energies, it was realized that they will fail at high energies. Interestingly, right after Fermi's theory of β-decay the weakness of weak interaction was speculated by Klein to be due to a heavy mediator. A proper quantum theory of electromagnetism, called *quantum electrodynamics* (QED), was formulated in 1949 by Dyson, Feynman, Schwinger and Tomonaga. QED is considered to be the most accurate theory to date! In QED, the photons carry the electromagnetic force between electrically charged particles like electrons. Here photons are massless quanta of electromagnetic field and are (*vector*) bosons. The masslessness of photons is not only an observed fact but also an essential requirement of the theory. In the language of field theory, the electromagnetic field is a *gauge field*, the photons are gauge bosons that are the quanta of the gauge field and the reason photons are massless is because of something called *gauge symmetry* or *gauge invariance* of the theory (see Box-1). In the world of quantum physics, any sensible field theory must be a gauge invariant theory!

In 1962 the neutrinos, postulated way back in 1930s to describe the beta-decay, were discovered and in 1964 the *up, down, strange quarks* were hypothesized as fundamental constituents of proton, neutron and similar such particles, all of which are collectively called *hadrons* in particle physics parlance. The interesting fact about quarks is they interact among each other through

Box 1: Symmetry in physics

In common perlance, the word "symmetry" means a quality that makes something look good. But, why does a square look symmetrical? The underlying reason is that, if there is a square piece of paper lying on a table, and while I am not looking, if someone rotates it by 90°, I won't be able to make out any difference. In that sense a circle has a higher degree of symmetry, because I won't be able to see any difference if a circle is turned by any angle. Thus, in physics, symmetry means "invariance" to some operation.

Now, that "operation" may be of various kinds. For example, if, due to some reason the Earth becomes positively charged, we would notice no difference, because we always measure potential *differences*. It does not matter what is the potential of the ground with respect to which it is measured. Thus, electromagnetic forces are *symmetrical* against the "operation" of change in potential.

It has been found that the particles which are mediators of forces (such as the photon, which is the mediator of electromagnetic force) obey a kind of symmetry, called gauge symmetry. It simply means that their properties would remain unaltered when certain operations are performed. They also obey the statistics proposed by Satyendra Nath Bose, and so they are also called bosons. Hence the name "gauge boson".

the strong force to remain perpetually confined within the hadrons and can never be observed free. The quarks in addition to carrying fractional electric charges also carry strong or *color* charges. The field that is responsible for strong interaction among quarks is *color field* and the corresponding massless quanta are *gluons*, hence the name of the theory of strong interaction is *quantum chromodynamics* or QCD. The color field can also be treated as gauge field with gluons being the gauge bosons, which are massless for the same reason of gauge invariance. Even though the gluon-quark coupling is very different from photon-electron coupling, the strength of the former being about hundred times greater than the later for instance, still these two interactions can be described by the common framework of gauge theory.

In this backdrop Glashow in 1961 came up with a bold proposition of unifying weak and electromagnetic interactions and tried constructing a gauge theory for weak interaction. Later Salam and Weinberg completed the construction of electroweak theory based on which the Standard Model of particle physics as we know today grew up. It is in this context of electroweak unification, the Higgs mechanism and Higgs boson gained its present popularity.

The present picture of Standard Model tells us that the fundamental constituents of matter are quarks and leptons. Depending on how closely i.e., at what length scale the matter is observed, it is useful to describe matter in terms of the specific set of constituents that can be treated as *fundamental*. For instance, when we are looking at a building or a bridge we just consider bricks, mortar and steel as fundamental building block for engineering necessity without having to worry about the atoms and molecules they are made up of. Again, if someone is trying to explain chemical reactions up close that person can safely explain the relevant mechanism in terms of atoms and molecules considering them as fundamental without bothering about quarks or gluons or any of the particle physics stuff. The leptons and quarks become important when the matter is observed very closely at a scale of 10^{-15} to 10^{-20} meter. At this energy scale, the fundamental building blocks are the quarks and leptons which are treated as point-like objects without any structure.

However, getting so close to matter to make *observation* is not a trivial job. In our everyday world, we observe things of normal size by shining light on them and collecting the scattered light by our naked eyes. To observe tiny details of bigger objects like cell or tissue of our body, we take help of microscope, optical or electron, to collect the scattered photon or electrons. But further down is the atomic world which simply cannot be probed using microscopes. The atom itself or rather its nucleus was probed using a very different technique invented by Rutherford in 1911. The technique was to collide atoms with charged particles and, after collision, the details of scattering of these particles would tell the kind of interaction they underwent which in turn carry information about the structure of the atom itself and may reveal new kind of interaction. This was how atomic nucleus was discovered and gave one of the first glimpses of non-Coulombic interaction. Clearly, the charged particles need to be energetic enough to overcome Coulomb *i.e.* electromagnetic repulsion sufficiently to get closer to the nucleus. Rutherford used α-particles of few MeV that managed to get only within 27 fm (27×10^{-15} meter) of gold nucleus whose radius is about 7 fm. Obviously, more energetic particles would have taken Rutherford even closer to nucleus for observation. This exactly the reason why the experiments in particle physics demand more and more energetic particles to explore not only structure of matter but also to search new forces, new physics. So to put things in context, the observation in the length scale of 10^{-18} meter achievable at LHC requires particles of energy $\sim$ 100 GeV. An additional thing

Table 1: The particles that constitute the material world, as per the Standard Model.

Force carriers: Bosons			
Force	Quanta	Mass	
Strong	gluon	0	
E-M	photon	0	
Weak	$W^{\pm}$	80.4 GeV	
	Z^{o}	91.2 GeV	
Point like particles: Fermions			
Leptons			
1st gen	2nd gen	3rd gen	charge
e	μ	τ	± 1
ν_e	ν_μ	ν_τ	0
Quarks			
1st gen	2nd gen	3rd gen	charge
u	c	t	+2/3
d	s	b	-1/3
Higgs(?) $\sim$ 125 GeV: Boson			

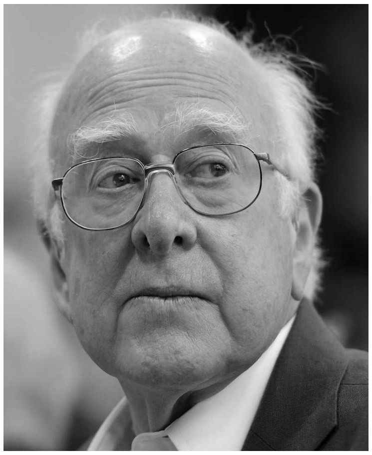
that happens at such high energy is the creation of newer heavier particles from the debris of collision by converting energy of collision into mass. So if any heavier particle is suspected to be in some energy range, the colliding particles must have sufficient energy to create it.

This is how high energy experiments were carried out at various colliders at CERN and Fermilab, which together with theoretical studies, lead to the foundation of Standard Model on a firm footing. The fundamental ingredients of Standard Model that we know of has thus emerged out of three decades of intense theoretical research and experiments in higher and higher energies, as shown in Table-1.

The quarks and leptons are often referred to as quanta of matter fields and they are collectively called fermions since each of them carry a property exclusively of quantum world, called *spin*, whose value is always 1/2. But the force carriers and Higgs, on the other hand, are bosons since the spin for them is always 1. As shown in Table-1, the leptons are arranged in three *generations* each in family of two. The electron and electron-neutrino are in the first generation of the leptons. Very similarly, the quarks are arranged in three generations each with a family of two quarks. The up and down quarks that make proton and neutron are in the first generation. Besides, we have the force carriers gauge bosons—the photon γ for the electromagnetic force, W^+, W^- and Z for the weak force, and gluons for the strong force. And finally there is the Higgs boson that belongs to neither of these families or generations. Among many others, one of the big success of Standard Model is the prediction and subsequent discovery of the charm quark and other *third generation* of quarks, which was honored with Nobel prize in 2008.

In all of this, the proposition of Higgs mechanism and its role in Standard Model is rather technical. Though it is popularly expressed that Higgs field gives mass to matter field quanta, electrons and quarks, it is difficult to see how this come about. Originally, Glashow's aim was to unify electromagnetic and weak interaction into a single integrated system where these two are not unrelated but different manifestations of one fundamental electroweak interaction. This is despite the fact that enormous difference exists between the two coupling strengths, the electromagnetic force being approximately 10^{11} times stronger than the weak. Glashow and others, however, realized that this could be accounted for if weak interaction is mediated by extremely massive bosonic quanta but they could not provide an appropriate mechanism for generation of such massive bosonic carrier(s). It is interesting to note that if the weak mediators are massless instead of massive then the strength of weak interaction turns out to be about five times more than electromagnetic interaction! Besides, if there is really one basic electroweak interaction then how come photon is massless, and the mediators of the weak interaction are heavy? Then there is the issue that electrons, the muons and the tauons (μ's and τ's) have masses while their neutrinos don't (or almost so) even though they are in the same family.

The masslessness of gauge bosons, like photons, and devising special mechanism to give mass, like the one done for $W^\pm$ and Z, are linked to the properties of gauge fields that has been mentioned before. It has already been mentioned that electroweak interaction, like strong and electromagnetic interactions, can be treated in gauge theory and is based on a very fundamental requirement called *gauge symmetry* or *invariance*. For any field theory to make sense it has to be a gauge invariant theory. The gauge symmetry or invariance, however, demands that the quanta of the gauge fields must be massless. This is the reason why any sensible particle physics theory can have only massless carriers of relevant interactions, as is the case with strong and electromagnetic interactions. Therefore, theory of particle physics *i.e.* electroweak theory is also a gauge invariant theory. In addition to this, the theory of particle physics must have one more important symmetry, known as *chiral symmetry* or *handedness*, which prevents giving masses to the fundamental fermions in the theory, i.e., the quarks and leptons. Clearly, this demand for gauge invariance is not a problem for photon, which is massless anyway, and similarly chiral symmetry is no threat to the neutrinos. The central question is therefore how to give masses to the weak force carriers, $W^\pm$ and Z as they would be called later, without breaking the gauge symmetry or invariance. Also the electrons and quarks have to have mass because that is what we see in experiments.



Peter Ware Higgs (born 29 May 1929)

We have a universe around us filled with matters like galaxies, stars, planets and life forms which do have mass.

In 1964, such a symmetry breaking proposal came from independent groups of scientists namely Englert, Brout, Higgs, Guralnik, Hagen and Kibble. It was Higgs who actually developed and refined the initial proposals further. The essential idea of the proposal was that the introduction of an extra *scalar* (bosonic) field in Standard Model gives finite mass to the W and Z gauge bosons without explicitly breaking the gauge symmetry. In 1967, Salam and Weinberg applied this *Higgs mechanism* to the electroweak theory of Glashow to break the bigger electroweak symmetry down to only a reduced electromagnetic symmetry. This breaking generates masses for $W^{\pm}$, Z but not for photons. The prediction of masses of $W^{\pm}$ and Z and subsequent discovery of them in 1983 at CERN right at the predicted mass established Standard Model as the correct theory of electroweak interaction. This Higgs field also gives mass to the quarks and electrons through *Yukawa coupling*, but not to the neutrinos, but the mechanism involved is somewhat different than what it is for W and Z.

Even though masses of W and Z can be predicted, Standard Model does not predict the masses of electrons, quarks and that of the Higgs boson. Instead, they have to be determined experimentally. The Standard Model, however, does predict that the Higgs boson lasts for only a very short time $\sim 10^{-21}$ second before it breaks up or decays into other well-known particles. According to the theoretical calculations, some of the important products of Higgs decay worth looking at (particularly at CMS) are pairs photon-photon, WW, ZZ, bottom-bottom quarks and $\tau\tau$-leptons.

Therefore, simply speaking, if these so-called *decay channels* are recorded at energy levels close to expected Higgs mass, then that might give a possible hint of the existence of the Higgs boson. In order for Higgs to decay, it has to be created and the condition conducive to its generation has to be obtained through proton-proton collision at extremely high speed. That was the objective of the LHC.

The LHC experiment

The way experiments in high energy particle physics are done in order to create *i.e.* to discover the particles like $W^{\pm}$, Z, quarks or Higgs, is basically the same—accelerate sub-atomic particles like proton-antiproton at Fermilab Tevatron or proton-proton at LHC, to high velocity and make them collide head-on with each other thus subjecting matter to extreme temperatures and densities. At LHC the highest energy of the protons in the colliding beams is 4 TeV (terra electron volts) each. It might not sound impressive to say that 1 TeV is approximately the kinetic energy of a flying house-fly, but then a house-fly consists of billions of protons and that basically makes energy of each proton miniscule in amount. But imparting 1 TeV of energy to a single proton sends it flying at a speed 99.999% of the speed of light or, put differently, raising it to a temperature of 12×10^{15} Kelvin!! Such high energetic beam of oppositely moving protons are set on collision course in the 27 km LHC tunnel, which upon colliding produce a deluge of elementary particles by converting kinetic energy of the particles into their masses. To produce heavier particles like Higgs and in enough numbers, the colliding protons at LHC needs to have very high energy. Since the mass of Higgs is not known, the search for Higgs progressed by excluding mass ranges where it cannot be found and eventually narrow down to a small range where a thorough search can be performed. Hence began the *Higgs hunting*.

The electrons are known to the scientists since 1890's but Higgs is relatively new in the fray. Various theoretical considerations, such as corrections it gives to the masses of $W^{\pm}$ and Z bosons, say that the mass of the Higgs cannot be below a certain value, and cannot be above a certain value. The generally accepted lower and upper bounds being roughly 115 GeV and 185 GeV respectively. In July 2011, two experiments at Fermilab Tevatron, namely CDF and D0, excluded Higgs boson in the range 156-177 GeV. By the same time, the CMS and ATLAS experiments at LHC excluded Higgs boson in the range 149-206 GeV. Around December 2011, these two experiments at LHC narrowed the search range to 115-130 Gev, focused specifically at 125 GeV because it was here where both CMS and ATLAS found "above average" events. However, discovery of a new boson was not claimed right away since the statistical criteria were not met. The excess events that was observed had *statistical significance* of $2.9\,\sigma$ meaning that the excess could also be due to some random phenomena (or some freak statistical fluctuation), and its probability was about 1 in 500. To call it a "discovery", this chance has to be 1 in one million (1/1,000,000). That criteria was eventually met at both the CMS and ATLAS experiments and the discovery of a new boson at 125 GeV was announced on July 04, 2012. However, the new boson is not called Higgs right away. The official statement said that *"a new particle observed at about 125 GeV is compatible, within the limited statistical accuracy, with being the SM Higgs boson. However, more data are required to measure its properties such as decay rates in various channels ($\gamma\,\gamma$, ZZ, WW, bb and $\tau\,\tau$) and ultimately its spin and parity, and hence ascertain whether it is indeed the SM Higgs boson or the result of new physics beyond the standard model"* (CMS presentation).

The discovery of a new boson, a likely candidate for Higgs, is just the end of the beginning of Higgs search. By the end of 2012 LHC is expected to increase its data set by more than three times, thereby gaining more access to this new particle and greater opportunity to study it in details. The search for new laws of physics will also go in parallel. It is generally accepted that SM is valid up to a few GeV. The LHC, in its search for Higgs, has explored till 550 GeV. But what lies beyond that energy range, particularly when LHC will reach its peak functionality at energy of 7 TeV per proton? Is it possible to get glimpses of physics beyond the standard model? A physical theory called Supersymmetry was developed some while ago to address some of the problems in SM and has interesting features like high energy unification of weak, electromagnetic and strong interactions, provide candidate for dark matter and contains mechanism for electroweak symmetry breaking. The *minimal supersymmetric SM* (MSSM) is one of the best candidates for physics beyond SM. This theory has well-defined predicted particle spectrum at TeV scale, therefore accessible to LHC. It is, therefore, well worth waiting to see what LHC churns out next. □

Hazards of nanoparticles and nanotechnology: Need for a general awareness

Madhusudan Jana*

Introduction

Electronic and optoelectronic devices are used in many areas of the society, from simple household appliances and multimedia systems to communications, computing, and medical instruments. Given the demand for ever more compact and powerful systems, there is growing interest in the development of nanoscale devices that could enable new functions and/or greatly enhanced performance. Semiconductor nanomaterials, quantum dots and nano-tubes are emerging as a powerful class of materials that, through controlled growth and organization, are opening up substantial opportunities for novel nanoscale photonic and electronic devices.

The term nanotechnology describes a range of technologies performed on a nanometer scale with widespread applications as an enabling technology in various industries. Nanotechnology encompasses the production and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to around 100 nanometers, as well as the integration of the resulting nanostructures into larger systems. When a new technology is developed, most discussion is focused on innovation and the possible uses it can be put to. Risk assessment in the beginning of this process is primarily focused on economic risks—will the new technology be economically viable? The impacts of the technology on the environment, i.e., environmental risks, are only discussed at the end of the development cycle, not in the beginning. This is because in the beginning of technology development, environmental risk is usually uncertain or unknown, and there has been little discussion of how to deal with this.

Risk is based on knowledge of harm and the probabilities that a harmful event may happen. Uncertainty means we may know what the possible harmful effects are but we dont know what the probabilities of a harmful event occurring are. It is, however, possible for science to assess the maturity of the original scientific innovation and to promote responsible technology development, i.e. reduce risks. Risk assessments methods for rapidly developing new technologies need to be developed that take these problems into account. Currently, international funding of research on the risks of nanotechnology is very small compared to the funding of its development. Some nanomaterials are hazardous to health and the environment but it is not possible to generalize for all nanomaterials. It is also not possible to extrapolate the effects produced by a substance of larger size to its possible effects when present in nanosize. In this review article some harmful effects of nanomaterials in human body as well as in environment have been summarized on the basis of a few reported studies.

Identified Hazards

In spite of having several beneficial aspects of using nanomaterials, the hazards and/or

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harmful effects cannot be ignored:

a) Nano-silver, which is widely used, is reported to be toxic to beneficial bacteria that break down wastes and recycle nutrients in the soil.

b) Fullerenes, which are used in electronics, electro-optics, cosmetics and cancer therapy, have been found to cause oxidative brain damage (through lipid peroxidation) in a kind of fish (juvenile largemouth bass) via the olfactory nerve that carries the sense of smell.

c) Carbon nanotubes cause inflammation and granulomas in the lungs of mice even at the lowest concentration when the animals inhaled aerosols of multi-wall carbon nanotubes.

d) Quantum dots are widely used in light emitting diodes, transistors, solar cells, drug delivery, cancer therapy and cell imaging. But most quantum dots contain highly toxic metals such as cadmium, which tends to be released when they enter the cells or organisms.

e) Many kinds of nanoparticles enhance the formation of insoluble fibrous protein aggregates (amyloids), which are associated with human diseases including Alzheimers, Parkinsons and Creutzfeld-Jacob disease.

It is possible that nanoparticles may be inhaled, ingested or taken in through the contact of nano-products with the skin. Through inhalation of nanoparticles the possible diseases include asthma, bronchitis, emphysema, lung cancer and neurodegenerative diseases. Nanoparticles in the gastrointestinal tract have been linked to Crohns disease and colon cancer. Nanoparticles that enter the circulatory system can cause arteriosclerosis, blood clots, arrhythmia, heart diseases, and ultimately death from heart disease. Nanoparticles entering other organs, such as liver, spleen, etc., may lead to diseases of these organs. Some nanoparticles are associated with autoimmune diseases, such as systemic lupus erythematosus, scleroderma, and rheumatoid arthritis.

How nanoparticles interact with living organisms

Nanoparticles can have the same dimensions as some biological molecules and can interact with these. In humans and in other living organisms, they may move inside the body, reach the blood and organs such as the liver or the heart, and may also cross cell membranes. Insoluble nanoparticles are a greater health concern because they can persist in the body for long periods of time.

a) The Surface Effects

All nanoparticles, on exposure to tissues and fluids of the body, will immediately adsorb onto their surface of the macromolecules that they encounter at their portal of entry. The specific features of this adsorption process will depend on the surface characteristics of the particles, including surface chemistry and surface energy, and may be modulated by intentional modification or functionalisation of the surfaces. The major emerging issue to be discussed in the context of the biological interactions of nanoparticles is related to those particles with little or no solubility, or being non-degradable at the locality where accumulation is observed.

b) The Size Effects

Reduction in size to the nanoscale level results in an enormous increase of the surface to volume ratio, so relatively more molecules of the chemical are present on the surface, thus enhancing the intrinsic toxicity. This may be one of the reasons why nanoparticles are generally more toxic than larger particles of the same insoluble material when compared on a mass dose base. In studies of low toxicity particles, TiO_2 induced a more severe lung inflammation and particle lymph node burden compared to $BaSO_4$ when dosed at mass burden in milligrams. Surface area was therefore a driver for inflammation for these materials; the differences in severity of the response disappeared when the dose was expressed as surface area. These examples emphasize the importance of particle size, and by implication, the amount of surface area presented to the biological system for particle toxicity.

c) The Chemical Composition

The chemical composition and the intrinsic toxicological properties of the chemical are of importance for the toxicity of particles. The effect of carbon black has been shown to be more severe than that of titanium dioxide, while for both compounds the nanoparticles induced lung inflammation and epithelial damage in rats at greater extent than their larger counterparts. The particles in ambient air as part of pollution of combustion origin are coated with all kinds of reactive chemicals including biological compounds such as endotoxin. Thus the information obtained from ambient air particles for nanoparticle toxicity should take into account the possible influence of particle composition and contamination.

d) The Shape Effects

Shape is also likely to be an important factor although there is little definitive evidence. Fibres provide a significant example of the debate about shape, especially in relation to inhalation, where the physical parameters of thinness and length appear to determine respirability and inflammatory potential. A special category of fibres are nanotubes, which may be of a few nanometres in diameter but with a length that could be several micrometers. Risks should be assessed bearing in mind the well known carcinogenic effects of certain asbestos fibres. In two recently published studies, single-wall carbon nanotubes were demonstrated to induce lung granulomas after intratracheal administration, indicating that these nanotubes cannot be classified as a new form of graphite on material safety data sheets. On a dose per mass basis the nanotubes were more toxic than quartz particles, well known for their lung toxicity, although the mass dose was very high and mechanical blockage of some airways was noted.

Effect of inhaled nanoparticles

a) The Epidemiological Evidence

Ambient particulate air pollution was found to be statistically associated with cardiovascular morbidity and mortality. However, very little is known on the relationship between the specific exposure to nanoparticles and health effects, in contrast with the large number of epidemiological studies on larger particles. The exposure-dose relationships depend on time and location, and epidemiological studies are hampered by the lack of appropriate measurement. There is some evidence that combustion-derived particles emanating from traffic are a key driver for adverse health effects.

b) The Dosimetry

Estimating the dose of inhaled particles requires the knowledge of several mechanisms including regional deposition, retention, solubility, redistribution, translocation into the circulation, metabolism, accumulation in certain organs and the excretion pathways via urine and faeces. The factors that control or affect particle deposition include the particle characteristics themselves, the respiratory tract geometry and individual features of ventilation such as the mode of breathing. Inhaled particulate matter can be deposited throughout the human respiratory system including pharyngeal, nasal, tracheobronchial and alveolar regions, depending on particle size. The fractional deposition efficiency of particles with a size below 100 nm is between 30 and 70 % in pulmonary regions, although the predictability becomes less accurate at the nanoscale.

c) The Systemic Toxicity

As mentioned above, nanoparticles may be able to translocate from the lung into the blood resulting in systemic exposure of internal organs, although the extent of this may vary. Another route of translocation from the airways may be by neuronal uptake. It is unknown whether this leads to potentially adverse consequences, but certainly warrants further studies. In view of the induction of inflammatory cytokines, a relation with a variety of neurological diseases might be considered.

The effects of nanoparticles on the Human body: some hypotheses

Several hypotheses were proposed for the adverse health effects of nanoparticles as part of ambient air pollution. These hypotheses for adverse health effects of nanoparticles include:

Particle characteristics:

- Formation of increased level of radical species compared to larger particles
- Increased induction of oxidative stress
- Importance of large surface area for interactions with cells and tissues
- Complex formation with biomolecules
- Induction of cellular DNA damage
- Induction of oxidative stress by lipid peroxidation

Distribution:

- Increased access to interstitial spaces
- Access to systemic circulation
- Deposition characteristics dependent on size
- Uptake by cells of respiratory epithelium

Organ system effects:

- Reduced function of macrophages, reduced phagocytosis of particles themselves, reduced macrophage mobility and cytoskeletal dysfunction
- Increased pro-inflammatory activity and induction of cytokines and other mediators
- Adverse effects on cardiac functions and vascular homeostasis

Some hypotheses raised for ambient air nanoparticles may be of limited or no relevance for engineered nanoparticles, such as adsorbance of toxic substances. Although such adsorbance cannot be ruled out, it is probably of less importance for production and handling facilities of large volumes of engineered nanoparticles compared to the particles in ambient air.

Four major routes to affect human body

1. Inhalation: Inhaled particles induce inflammation in respiratory tract causing tissue damage. e.g., inhaled silica particles create 'silicosis'

2. Dermal exposure: Particle may enter body through the skin.

3. Ingestion: Nanoparticles may cause liver damage with excessive inflammatory responses.

4. Injection: Nanoparticles are injected in medicine based on nanotechnology

The effects of nanoparticles on the environment

The potential problems associated with persistent insoluble nanoparticles in the environment may be considerably greater than with human health assessment. The protection goals and endpoints (i.e., protection of individuals vs. protection of populations) of an environmental effect assessment are clearly different from those used of the human health evaluation.

Scope of Nanoparticle Risk Assessment

Depending on the conditions of manufacture, formulation, use and final disposal, a risk assessment of nanoparticles may need to address:

- Safety of consumers using products that contain nanoparticles.
- Safety of local human populations due to chronic or acute release of nanoparticles from manufacturing and/or processing facilities.
- Worker safety during the manufacture of nanoparticles. It is noted that typically workers are exposed to higher levels of chemicals and for more prolonged periods of time compared to the general population and this will probably be the case for nanoparticles production.
- The impact on the environment per se resulting from production, formulation and use, and on the potential for human re-exposure through the environment. Particular attention is required for products that are deliberately used in nanoparticle form in the environment, e.g., biocides, environment improving agents.
- The environmental and human health risks involved in the disposal or recycling of nanoparticle dependant products. This includes the potential for nanoparticles to escape from 'contained' waste disposal sites as well as their impact on sewage treatment plants.

The traditional risk assessment procedure is an appropriate tool for assessing the risks from exposure to nanoparticles under specified exposure conditions. However, failure to meet the peoples' expectations may result in public fear or even rejection of nanotechnology based products. The flowchart in Fig. 1 may be followed for characterization of risks and their management.

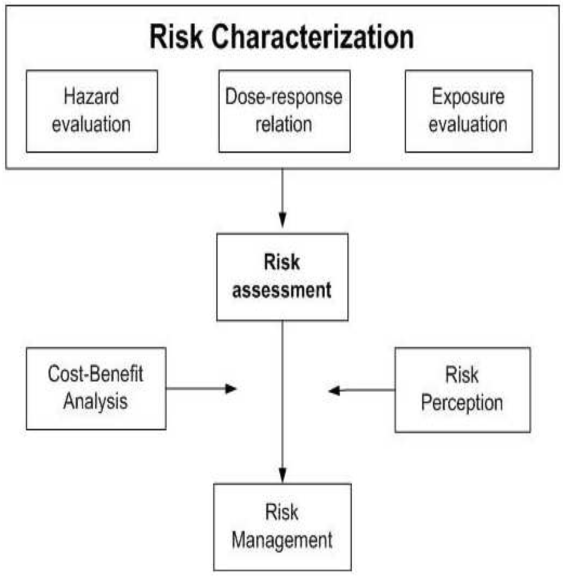

Figure 1: Flow chart for risk assessment and management.

It is important for risk assessment purposes to specify clearly at the outset the following factors.

1)Product specification (physical chemical properties)

The amount that is expected to be produced along with the anticipated uses and proposed routes for disposal/recycling of the product(s) at the end of its useful life. It is probable that different manufacturers will produce nanoparticles of rather similar chemical composition that are not identical in all their properties. It is therefore vital that the specification of the nanoparticle form is thorough and comprehensive. The description should include:

- The chemical composition of the nanoparticle including formulation components and impurities, surface chemistry, acidity/basicity, redox potential, reactivity (redox, photoreactivity etc.) and the nature of any surface coating or adsorbed species.
- The particle size range (and distribution) to which humans and/or the environment will be exposed, along with information on other physical characteristics, e.g. shape, density, surface area and charge, solubility, porosity, roughness morphology, crystallinity and magnetic properties.
- The extent to which the released particles are soluble in aqueous media, and/or are biodegradable.
- Their chemical and physical stability under relevant environmental conditions including potential for coalescence and/or degradation (along with the identification of the degradation products).

2) Examination of human exposure

- Identification and quantification of relevant exposure.
- Determination of the absorption of the nanoparticle by the appropriate route(s) of exposure at relevant doses and dose rates, including all possible translocation routes.
- Identification of the metabolic fate. This includes the characterisation and quantification of nanoparticles in body tissues.
- Examination of the potential for bioaccumulation following repeated exposure to the nanoparticles.

If there is good data on the uptake, metabolism, distribution and excretion of the substance in other physical forms it may be sufficient to demonstrate that uptake and clearance is comparable for the nanoparticle form using the appropriate route of exposure. If this is demonstrated, then only limited hazard identification and characterisation may be needed.

3) Examination of environmental exposure

- Identification and quantification of relevant exposure
- Determination of the environmental release pattern (and quantities), the distribution and fate of the nanoparticle in the various environmental compartments. For metal and metal oxide nanoparticles assessment of the dissolution rates and speciation in the environmental compartment will be key to understanding the fate and ultimately the bioavailability of the substance.
- Attention should be given to those nanoparticles that are designed to be deliberately released into the environment (for example agents used to clean up chemical spillages) and the waste products of nanotechnology.
- Establishment of concentrations (calculated and/or measured), in terms of particle surface and or number, in the different environmental compartments.
- Examination of the potential for bioaccumulation in different aquatic and terrestrial species and possibly the potential for biomagnification in the different environmental compartments.

Data demonstrating that the above processes and characteristics of the nanoparticle are similar to that of the conventional substance may lead to a reduction of data needs for the risk assessment.

What can we do now?

Hazard reduction of nanomaterials is necessary for students, engineers, and health professionals working on their production, processing, and analysis, as well as workers and consumers in contact with commercial products.

Control of Methods/Process, Equipment, and Tasks

The processing, equipment, and job tasks associated with the control methods are as follows:

1. Elimination: Change design to eliminate or minimize hazardous materials.
2. Substitution: Replace high-hazard material with a low one.
3. Engineering: Use isolation/enclosure, ventilation, filtration, and collection.
4. Administration: Adhere to procedures, policies, shift design, and new rules and regulations.
5. Personal Protective Equipment: Use respirators, clothing, gloves, goggles, and ear plugs.

Some methods of protection that should be used during the production and use of nanomaterials are outlined below:

a) Students, workers, engineers, doctors, and scientist who are working with nanomaterials and devices are recommended to wear a disposable, typically plastic, body covering over their work clothes during high-exposure activities and to wear long gloves pulled over their sleeves to minimize wrist exposure and other contamination.

b) The hazardous effects of nanomaterials need to be reduced during their production and processing. The waste of nanomaterials should be limited. Outputs are sometimes more hazardous than the products or wastes from such activities.

c) Workers who inhale nanomaterials are advised to consume milk and unrefined sugar to reduce the toxicity level of nanomaterials.

d) Wrist-length disposable nitrile gloves with extended sleeves must be worn during the handling of nanomaterials.

e) For eye protection, safety glasses with side shields must be on the face during the use of nanomaterials in the form of solids, liquids, and aerosols.

f) Volumes of liquid-based nanomaterials must be limited to the milliliter range (< 200 ml) in a sealed container when not in use.

g) Total particle masses must be limited to the milligram range (< 200 mg) and must be manipulated within a high efficient particulate air-filtered laboratory exhaust hood over water-soaked absorbent paper to capture any spilled materials.

h) Containers of nanomaterials must be labeled with a sign indicating "NANOMATERIALS".

i) Nanomaterials are considered to be hazardous materials, so workers should follow all the safety rules necessary in the field and laboratory.

j) Nano-ingredients in food, cosmetics and baby products such as silver, titanium oxide, fullerenes etc., for which toxicity data already exist should not be allowed to be used.

k) Nano-products should not be commercialized until they are demonstrated safe and obey regulations.

l) Consumer products containing nanotechnology should be clearly labeled about the amount of nanomaterial content.

m) Manufacturers of nano-products should properly register their products to the appropriate authorities and make it public without keeping secret.

n) Nanotechnology research activities must be made comprehensible to the public performed in a transparent manner, accountable, safe and sustainable, and not pose a threat to the environment.

o) Intensive research into the hazards of nanotechnology should also be carried out in equal proportion to the new commodity development.

p) The use of nanomaterials increasing worldwide brings with it several concerns for worker and user safety. Thus, new measurement devices should be developed and used in the specified areas where nanomaterials and devices are produced and utilized.

These steps will potentially reduce the risk of exposing nanomaterials to personnel and consumers.

Conclusion

In considering the potential of adverse health risks associated with nanotechnology products, two separate types of nanostructure may be identified, those where the structure itself is a free particle, and those where the nanostructure is an integral feature of a larger object. The situation with free nanoparticles, including agglomerates, is quite different. It is the generation, application, distribution, persistence and toxicological characteristics of free nanoparticles that give rise to concerns over possible human health and environmental risks. These concerns include the physical, chemical or biological degradation of nanocomposites, which potentially releases nanoparticles.

Free nanoparticles may occur naturally, or may be the unintentional products of an industrial or domestic process, or they may be specifically engineered for applications which depend on their unique properties. These properties will primarily be influenced by the high surface to volume ratio associated with nanoparticles and the quantum effects that occur in the nanometre range. Careful characterisation of the physico-chemical properties is essential, for which appropriate methodologies must become available for routine use.

In considering the hazards associated with nanoparticles, the size, shape and composition, including surface charge and adsorbed species, of the nanoparticles are important. The phenomena of surface modification, aggregation and dissolution or degradation are also significant. Since nanoparticles that are readily soluble in the physiological environment lose their particle specific effects, they only remain of concern if they dissolve into harmful molecules. For particles that are essentially insoluble, there is the possibility of biopersistence, resulting in long term exposure and associated nanoparticle-specific effects. So the characterisation of nanoparticles used in biological evaluations is essential.

The safety evaluation of nanoparticles and nanostructures cannot rely solely on the toxicological profile of the equivalent bulk material. Nanomaterials need to be evaluated for their risk on a case by case basis for each preparation including the intended use of the material. In carrying out the risk assessment for products of nanotechnology, new testing strategies will be required that will address the product specification, the intended use and the identification of potential exposure scenarios, both human and environmental. Conventional toxicity and ecotoxicity tests have already been shown to be useful in evaluating the hazards of nanoparticles. However, some methods may require modification and some new testing methods may also be needed. It appears that nanoparticles can exacerbate certain pre-existing medical conditions and may increase susceptibility to some diseases, which may require modification of testing strategies. However, apart from the scientific methodology and enrichment of knowledge, there should be Government policies to control and/or monitor over the unauthenticated use of nanomaterials and nanotechnologies. □

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A Brief History of Science
Part-1: The Advent of Agriculture

Soumitro Banerjee*

Introduction

In my class I often ask my students "What was the first major scientific invention of mankind?" Some say "fire", some say "wheel". None of these is actually true. Fire was tamed long before the species Homo Sapiens appeared on the face of the Earth. It was achieved by some pre-human ancestor species. In fact, it was the use of fire and the consequent shift in diet from raw meat to roasted meat that caused the change in the shape of the mouth. This, in turn, enabled the development of articulated speech—a prime characteristics of the human species. Hence taming of fire cannot be said to be a "human" invention. The invention of the wheel, in contrast, happened much later—when the requirement for bulk transport arose in the society following the development of agriculture.

The invention of agriculture is, in fact, the first major scientific invention that caused a great change in the structure of the society. In the following pages we shall delve into the details of that scientific revolution.

The structure of society before the advent of agriculture

Scientists believe that the "anatomically modern" man evolved around 2,00,000 years ago and the "behaviourally modern" man (capable of articulated speech and tool-making) evolved towards the end of the last ice age, around 40,000 years ago. Since then, until the advent of agriculture some 10,000 years ago—that is, for the most part of human history—the main means of subsistence were hunting and gathering. What was the society like, in those times?

Firstly, the resources in the forests were limited. When the food sources in one area got depleted, people had to move to another in search of food. So, the people in those times had to be constantly on move, leading a nomadic life. There was no "settled" life (houses, villages, towns) in those times.

Secondly, the food items they hunted and gathered are all perishable. If you don't eat it now, it will rot. So there was no question of storing food. Consequently, there was no question of somebody amassing wealth depriving the others. True, the savages fought with each other for food. But once the issue is settled—somebody having a bigger chunk of food and somebody smaller—there was no difference between one individual and another. Nobody could keep the food for eating later. They were all equal. There were no haves and have-nots. There were no kings and queens. There was no upper class and lower class.[1]

A peculiar characteristics of a society without class division is that there is no private property. Whatever meagre resources

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[1]A detailed account of this period is found in "Man makes himself" by V. Gordon Childe [1].

they had: the bow, the arrow, the spear—belonged to everybody. This is a feature noticed by the famous anthropologist Morgan in the 19th century while studying the aborigine groups who were still in the "hunting-gathering" stage. In our country the writings of the famous Bengali litterateur Bibhuti Bhusan bear testimony to this fact when he describes the life of the tribals in Chhotanagpur (now in Jharkhand). When these tribals passed by somebody's house, if some article like a spade or a stool was found lying outside, they would simply take it. People thought they are habitual thieves. But Bibhuti Bhusan shows that these tribals did not have the idea of something "belonging to" somebody. If something useful is found lying somewhere, they found it natural to use it. They did not the sense of private property. This is the second important character of a society in hunting-gathering stage.

The life in this hunting-gathering stage was largely dependent on the vagaries of nature. A stone falls from a hill and kills somebody. So they tried to please the stone so that it does not kill anymore. Fierce storms killed people; so they tried to please the wind. The sun gave light; and so they tried to please the sun. The way of pleasing was to dance, to chant, and to offer things that they perceived as pleasant. In this stage there was no idea of god. What they tried to please were all natural forces. In that primitive state of knowledge they had no idea how to tame these natural forces. So they performed rituals to please these natural forces. In anthropological literature, this is called the "magic" phase in the development of culture[2]. This is the third important feature of the savage society.

In the hunting-gathering stage, their tools and implements were all made of stone. From the angle of material use, this period is called the "paleolithic" or the old stone age.

As the human population increased, the available resources in the forests proved to be insufficient to sustain the society. The society faced a crisis. The escape from the crisis was provided by the advent of agriculture.

The invention of agriculture

The exact circumstances of the invention of agriculture and the who-did-it are not known. But one can easily realise the course of events unfolding as the society faced the shortage of food. People must have noticed that seeds fall on the ground, germinate, grow into plants, and then bear fruit. So if you put many seeds of a fruit-bearing plant in a convenient place they will produce fruits after some time. Some grassy plants produce small and hard grains. These are particularly convenient as food because these can be stored for use later. For us, the logic behind agriculture seems to be obvious. But for the people 20,000 years ago, this small step involved a lot of trial-and-error, wrong and right guesses, and pangs of hunger. "Somewhere in the Mediterranean region, wheat grew wild" wrote H. G. Wells, "and man may have learned to pound and then grind up its seeds for food long before he learned to sow. He reaped before he sowed." [3]

Thus started the cultivation of food-grains like wheat and barley in the forest clearings and open grasslands. It was still the stone age (the stone age after the invention of agriculture is called the neolithic or the new stone age), and so the cultivation with stone implements was very primitive. It was a small beginning, but it ushered a sea-change in the society.

[2]For details, read "The Golden Bough" by Sir James Frazer [2].

Socio-cultural changes brought in by agriculture

Firstly, wherever agriculture was practised, people had to stay rooted there at least until the harvest time. Mostly agriculture demanded a settled life in one place. So settlements developed. People started building houses fit for long periods of accupation. Slowly these started taking the shape of villages and towns. The human race moved away from nomadic life and took step towards settled life. Such settlements began to grow in Nile valley, in Mesopotemia, in the Tigris-Euphrates plains.

Secondly, for the first time a condition was created where the product of agriculture—the foodgrains—could be stored for later use. In those early days agriculture was not very productive, and so there was scarcity of food. But people could not move away in search of food, because agriculture demanded that they have to remain there. The the dearth of the stored items to fulfil the needs of the whole clan caused fights within the clans over the meagre amount of food available. But unlike the hunting-gathering times, the ones who won and could forcibly occupy the foodgrains, could keep it. Thus, by sheer muscle power, some people could own the foodgrains, depriving the others. This was not possible in the hunting-gathering time.

After the start of agriculture, the available cultivable land was very small, because forests cannot be cleared with stone implements. For the first time occupation of this meagre land was of value. By the same process of intra-clan fights, some people occupied the available land, depriving the others. These people slowly became the rulers of clans. Some of these clans, and the land they dominated, increased when they fought with and defeated other clans. Thus, kings and kingdoms appeared (for a detailed account, see [1]).

In the hunting-gathering society also, skirmishes and fights between tribes and clans were common. Since food was in short supply, the victor clan did not want to increase the number of hungry mouths, and the vanquished clan was simply killed off. But when agriculture started, it became advantagous to keep the prisoners alive, to force them to work in the fields of the victor clan. Thus started slavery—a phase of society where some people owned the land, and the slaves worked on the land.

Another important change was taking place in the cultural picture. As we have seen, culturally the hunting-gathering society was in the “magic” phase—where the music, the dance, and other cultural aspects were aimed towards pleasing the natural forces. Now, with the advent of agriculture, and the consequent creation of the rulers and the ruled, people saw that some men were bestowed with power and privilege. In logical extension, they pictured the natural forces also to have similar powers. Thus started a cultural phase in which gods appeared [2].

Note that as yet there was no concept of an omnipotent god. The gods (plural) of that time essentially represented the natural forces, but imagined in the character of powerful humans. Each god was specialized in a particular aspect—a god for rain, a god for sun, a god for wind, a god for love, etc.—and each had very human character. They could get angry, they could be pleased with offerings, they had family relations with other gods. The Greek gods, for example, reflect the nature of this period. But this character is found in the culture of all the societies of that time, in different parts of the globe.

Slowly the clan chiefs and local kings increased their power and the land they control, and around 5000 years ago, large empires began to develop—in Assyria, Sumeria, Egypt and other places in the middle East—mainly centred around the fertile Tigris-Euphratis and Nile river basins. Around 2750 BC, a large kingdom developed in Sumeria in the land spanning from the Persian Gulf to the Mediterranean sea, with Sargon as the king. The first Babylonian empire was consolidated by the king Hammurabi around 2100 BC. Around the same time there was a semitic invasion of Egypt which set up the rule of the Pharaohs. Thus the condition was created for another development in the cultural landscape.

The advent of large empires brought some order and stability in the society, with laws and rules created by the powerful emperors that everybody had to obey. People saw that there is a similar order and stability in nature too: the sun rises in the East and sets in the West everyday, the seasons change from winter to summer and back, high and low tides come in clock-like regularity. From analogy, they argued that, the way the harmony and stability in society is created by the existence of a powerful king at the helm, guiding and creating the rules for the society, in a similar manner the harmony and order in nature is created by an all-powerful Lord, who guides the universe and creates the laws that nature follows. Thus was born the idea of an omnipotent God. From written records it seems that this idea first appeared in the literature of the Jewish people—the Hebrew Bible—which was later adopted by the Christian and Islam religions [3].

In the hunting-gathering society there was practically no exchange between the clans. Every clan had to hunt, gather, and thereby arrange the food independently. When agriculture developed, this was no longer possible, because every area is not suitable for the production of all types of food. So exchanges became necessary. Initially the exchanges were in the form of barter: some amount of one product being exchanged with some amount of another. But the problem was that the two types of produce may not be available at the same time. So the need arose of some kind of guarantee that if one gives up some amount of rice he produced, at a later time he can get an equivalent amount of meat. When kings and empires emerged, they began to play the role of intermediary by producing objects bearing the seal of the king (in the form of terracotta disks and, later, coins)—which acted as this guarantee. Thus, money appeared in the society as the means of exchange.

In the hunting-gathering society, everybody had to do everything; the whole clan had to participate in hunting. There was very little specialization of activities. As agriculture developed, people had to perform specific tasks: some producing implements needed for agriculture, some tilling the land, some exchanging the produce, etc. Thus, specialization of activities developed, specific people devoting time and energy to specific type of work.

It was in the backdrop of these social and cultural developments that we have to understand the scientific developments resulting from the development of agriculture.

The developments in science resulting from the advent of agriculture

The advent of agriculture was a scientific development, and we have seen that it caused a tumultuous change in the structure of society and its cultural edifice. These societal changes, in turn, created the conditions for further developments in science.

Wheel: Large volume of exchange over relatively large distances demanded modes of transport other than being carried physically by the slaves. This societal necessity prompted the next major technological breakthrough: the invention of the wheel. There is evidence of the use of wheel in Sumeria around 3500 BC. The Indus Valley civilization had the use of wheel around 3000 BC. Slowly its use spread to other societies, and carts on wheels, carried by oxen or horses became the prime mode of transport.

Pottery: In the hunting-gethering society, people ate fruits and roasted meat. But when agriculture developed, the diet shifted towards foodgrains—which had to be cooked. Moreover, wheat and barley are reaped once a year, and had to be consumed all round the year. Thus storage became necessary. Earthen pottery developed in almost all neolithic societies as the means of storing and cooking food.

Pottery involves a number of complex processes: choice of the right kind of clay, application of water in the right measure, use of a rotating wheel in which the soft and moist clay is given shape, and the use of a kiln in which the dried pot is burnt to make it hard. Thus, this development demanded some knowledge of the motion of a rotating body, and the controlled production of heat by burning of a fuel like charcoal, etc. In the opinion of Gordon Childe, "pottery involved an appreciation of a number of distinct processes, the application of a whole constellation of discoveries." Various societies developed distinctive techniques of shaping and burning clay. This enables the archeologists of today to identify ancient people and their period when they find characteristic pieces of pottery at the excavation sites.

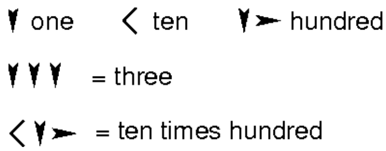
Metallurgy: Agricultural implements made of stone were not very effective in ploughing the land, and so the agriculture in the neolothic age was primitive. As the demand grew, there was need to improve agricultural production. This drove the development in metallurgy.

Metallic copper is often found in nature, and so the initial use came from collecting the metal and beating it into various shapes. But as the demand grew other sources were found. The pottery furnaces used fire-wood and charcoal, which are reducing agents. If the clay from which the pottery was being made contained the minerals of copper and tin, some part of it would have reacted with the carbon to produce metallic copper, or more probably, a mixture of copper, tin, and other metals. Probably some people accidentally found this alloy, bronze, in the hearths, and found it useful. Slowly the knowledge spread through trade routes, ushering the "Bronze Age".

For this, people had to develop methods of producing a reducing atmosphere by restricting the flow of air. Even though the reduction of the ore can be achieved at 800°C, melting of metallic copper requires a temperature of 1085°C, for which blowers had to be developed. Fashioning useful objects out of bronze required die-casting. Archeological evidence in Egypt and Mesopotemia shows that all this had been achieved by about 3000 BC.

Thus, bronze came into use for making agricultural implements, weapons, and coins. A group of metal-workers developed in every society. When some clan developed particular useful ways of fashioning bronze, it spread quickly to the other societies related by commodity exchange. The "bronze age" lasted for a long time, about two millennia, before the production and use of iron was mastered around 1200 BC.

The course of events in the discovery was probably similar: Some community may have accidentally reduced iron ore when they tried to use it as clay for making pottery or the furnace itself. Some confusion, groping in the dark, wrong and right



Box-1:
Cuneiform numbers of Babylon

Thousands of burnt clay disks with cuneiform script have been discovered in the library of the Babylonian king Ashurbanipal. These are now kept in the British Museum. These show that the babylonians had three arrowhead-shaped symbols for one, ten, and hundred, as shown above, and they could write the big numbers using these. In those terracotta tablets there is mention of numbers like 14 being square numbers. This confused the archaeologists for a long time. The problem was cracked when they realized that the Babylonians wrote numbers to the base of 60 (which means 14 is $1 \times 60 + 4 = 64$, a perfect square). This base-60 number system has found its way into modern times in various ways—60 minutes in an hour, 360 degrees in a circle, etc.

guesses, and trial and error must have gone in before they could figure out where this black hard substance came from. There is evidence that iron-extraction first started in the iron-ore rich areas of Asia Minor. Slowly the technique was developed, and the knowledge quickly spread along the trade routes.

Numbers: In the hunting-gathering society, numbers were required only for counting animals and fruits, and so people had use for only whole numbers of small denominations. Most clans of that time knew how to count up to 3, and anything more than 3 were "many". Society had not placed any greater demand on human intellect.

But when agriculture developed, people needed to count bigger numbers. For this purpose the "positional system" was developed. In the modern "decimal" system when we write 354, we actually construct the number as

$$3 \times 10^2 + 5 \times 10^1 + 4 \times 10^0.$$

Here 10 is the radix. But similar number systems could be constructed with other numbers as radix. The Maya civilization of South America used 20 as radix, in Babylon people wrote numbers with 60 as radix (see Box-1). The Arabs used 10 as radix. But these systems would be rather restricted without the use of the number zero. This was discovered in India in the early Buddhist period. Thus started the decimal number system in the modern form.

After the onset of private property, when people started to "own" land, the dimensions of the land had to be measured. It is easy to see that land does not always come in "whole number" dimensions, like 2 miles by 3 miles. Moreover, the quantity of foodgrain had to be measured (especially when trade was involved), and this also does not come in whole number units. So, the practical necessities made it imperative to conceive fractional numbers. Soon the method of writing fractions was invented.

Writing: With the advent of private property, keeping a record of the possession became a necessity. The heads of cattle and the baskets of foodgrain had to be counted, and for that purpose the number systems evolved, as shown above. Initially the numbers were recorded by cuts in sticks, knots in ropes, and by strokes in terracotta tablets. But slowly symbols for the numbers evolved, and these were written down in clay which were burnt for preservation.

The logical extension followed, where not only the numbers, but also the objects and actions started to be represented by symbols. The cuneiform of Mesopotemia and the hieroglyphics of Egypt are scripts of that time. The development of true alphabets—where the symbols represent sounds and not whole words—developed much later, after the onset of the iron age. It is noteworthy that writing actually developed out of accountancy.

Astronomy: Soon after agriculture was initiated, people noticed that each type of foodgrain has to be sown at a particular time, and has to be reaped at another particular time. Thus, the need arose to develop a method of timekeeping. This can be done using any event that occurs in equal intervals of time. Initially nature provided the clue: the appearance of certain birds and insects indicate the arrival of specific seasons. But in many cases it was necessary to prepare before the arrival of an event (for example, the annual flood of the Nile basin). So more accurate indicators were necessary. People noticed that the motion of the sun and the moon follows such periodic cycles. Thus, in order to develop a calendar, people started keeping record of the apparent motion of the sun and the moon. Thus started the first phase of astronomy.

Arithmatic: Trade and exchange demanded one to perform the basic arithmatic operations of addition, subtraction, multiplication, and division. Actually addition and subtraction started even before people started to write the number-symbols. But when the signs were invented to represent numbers, it became possible to do these operations in an abstract way, by manipulating the numbers, without counting the actual objects.

The demand of repeated addition and subtraction (multiplication and division) also came from trade, but more so from land measurement and building (you have to calculate how many stones you need in order to build a pyramid).

Geometry: The measurement of land demanded the ability to measure the area of rectangles, triangles, polygons and circles. The Egyptians developed the ability to calculate these (see Box-2).

The advent of agriculture also demanded that the quantity of foodgrains stored in granaries had to be measured. Now, it so happened that the Bablylonians made the granaries in the shape of pyramid without the pointed top, which was replaced by the roof. Thus mathematically the problem was to find the volume of a truncated pyramid. In the terracotta tablets we find verbal instructions to calculate it, which when translated to the language of algebra, looks like

$$\text{Volume} = h\left[\frac{(a+b)^2}{2} + \frac{(a-b)^2}{2}\right]$$

where a is the length of the side of the base, b is the length of the side of the top, and h is the height. This is reasonably good, but not accurate enough. The Egyptians improved upon it (because they had much to do with pyramids), which we find in a papyrus now kept in the Pushkin State Museum of Moscow (called the Moscow papyrus). In it we find the question and answer: "If you are told: a truncated pyramid of 6 for the vertical height by 4 on the base by 2 on the top: You are to square the 4; result 16. You are to double 4; result 8. You are to square this 2; result 4. You are to add the 16 and the 8 and the 4; result 28. You are to take 1/3 of 6; result 2. You are to take 28 twice; result 56. See, it is of 56. You will find [it] right" In modern language the prescription translates to the formula

$$\text{Volume} = \frac{h}{3}\left(a^2 + ab + b^2\right)$$

Box-2:
The Ahmes papyrus

A piece of papyrus was found by the Scottish explorer Alexander Henry Rhind (now kept in the British Museum) in 1858 which contains probably the best examples of Egyptian mathematics. It was written by a scribe named Ahmes (hence the name) around 1650 BC. It shows that the Egyptians had progressed considerably in geometry. For example, it poses the question "How to find the area of a circle of diameter 9 "khet"? It proceeds to answer as follows: "First subtract 1/9th of the diameter, that is 1, from 9. We get 8. Now find 8 times 8. We get 64. This is the area." In modern language the method translates to area=$(d - d/9)^2$. Now we know that the area is $\pi(d/2)^2$, which gives a value of 63.6164. This is not very far from what they got.

This turns out to be the correct formula for the volume of a truncated pyramid.

Thus we see that the practical requirements of the time drove a significant development in geometry, and paved the way for the fantastic growth of the subject in the later times.

Conclusion

The neolithic revolution that occurred with the advent of agriculture has all the characteristic features of a true scientific revolution. Firstly, the discovery itself was prompted by social necessity; secondly, the discovery resulted in far-reaching change in the structure of the society; and thirdly, the discovery and the resulting change in the society fuelled further development in science and technology.

But there are certain features in the nature of science of that time, which changed in the later phases of human history. One can notice that all the developments in this period started from some *observation*, which was followed by trial and error. Often, through many trials and many errors, and manipulation of the things at hand, one reached a desirable result. When that was achieved, it was propagated, practised, and improved upon—again by trial and error. At that stage technology preceded theory.

Another noticeable feature is that the ideas of that time were basically materialistic. People concerned themselves with the immediate necessities of the society. In that

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primitive stage of human knowledge, they did not have the answers to many questions that concerned them. In the absence of the right answers, they resorted to speculations. But the questions concerned the immediate problems of survival. Even the imagination of the gods of that time were reflection of their material necessities and the problems of survival.

It was in the later phase, in the first major iron age civilization that took root in Greece, when slavery was entrenched strongly to create a class who had enough free time to engage in thinking alone, that we find speculation taking flight away from physical reality. The flight of imagination resulted in theoretical developments, but brought in subjective thoughts and idealism—which were to block the advance of science in the subsequent periods. That great upheaval of human intellect, its positives, negatives, and achievements, will be the subject matter of the next part of this essay. □

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Organizational News

Kolkata scientists participating in the LHC experiment felicitated

The researchers at the European Organization for Nuclear Research (CERN), Geneva, announced on 4th July that the Large Hadron Collider (LHC) experiment has yielded the observation of a new particle of mass about 126 times the mass of a proton. The Breakthrough Science Society of India joins the scientific community of the whole world in rejoicing the discovery.

It is a matter of great pride for us that three teams from Kolkata participated in the CERN project. One team from the Saha Institute of Nuclear Physics participated in the Compact Muon Solenoid (CMS) detector. Two teams participated in “A Large Ion Collider Experiment” (ALICE)—one from the Saha Institute of Nuclear Physics and the other from the Variable Energy Cyclotron Centre. These three teams were felicitated in a programme held at the Triguna Sen Auditorium, Jadavpur University, Kolkata, on 28 July Saturday. Prof. Palash Baran Pal explained the theory of Higgs boson, and the leaders of the three teams spoke on the experiment, the method of detection, and the Indian groups’ contribution in it.

All the members of the three teams were honoured by presenting them a felicitation certificate, and two books published by the *Breakthrough Science Society* . Those who were felicitated were Sunanda Banerjee, Subir Sarkar, Suchandra Datta, Sukalyan Chattopadhyay, Tinku Sinha, Sandip Sarkar, Pradip Roy, Abhee K. Dutt-Mazumder, Debasish Das, Swapan Sen, Suvendu Bose, Gobinda Majumdar, Satyaki Bhattacharya, Y.P. Viyogi, Tapan Nayak, Subhasish Chattopadhyay, Premomoy Ghosh, G.S.N. Murthy, Susanta Pal, R.N. Singaraju, Shuaib Ahammed Khan, Jogender Saini, Bedangadas Mohanty, Zubayer Ahammed, Anand Dubey, Tapas Samanta, M.R. Dutta Majumdar, Tushar K. Das, and Nilima Mondal. Prof. Narayan Banerjee, Dean of Faculty Affairs at IISER Kolkata presided over the programme.

Transit of Venus, 6 June 2012: Once in a life time event organised in grandeur across the country

“Look up to the sky”, “Our last chance to see the transit”, “Don’t miss the rare celestial spectacle”—such were the posters and banners displayed in research institutes, educational institutions, public playgrounds, parks, market places across the country. The Breakthrough Science Society had geared up much in advance to ensure that every citizen—be it a student, professional, employee, worker, or peasant—catches a glimpse of the rare celestial event.

Accordingly more than a lakh sun filters were made, thousands of booklets in English, Hindi, Bengali, Tamil, Malayalam, Kannada, Telugu, Oriya and many other state languages were published, a documentary film with commentary in English, Hindi, Bengali, Oriya, Gujarati was

The speakers at the felicitation of the Kolkata scientists involved in the LHC: (from left): Prof. Palash Baran Pal, Prof. Sunanda Banerjee, Prof. Tapan Nayak, Prof. Sukalyan Chattopadhyay, Prof. Narayan Banerjee (President), and Prof. Soumitro Banerjee.

brought out, lakhs of pamphlets were printed in almost all state languages, thousands of awareness lectures and seminars in schools, colleges, tuition centres, Universities, Research Institutes, and localities were conducted. Press conferences, press briefings and announcements in both print and visual media about the venues of public observation centres were organised across the country.

As a result, on the day of the transit around 500 observation centres were established and nearly 50,000 people observed the event under our direct supervision. Observation centres witnessed people assembling at the venue by 5.00 am, much before we could set up the telescopes! Such was the enthusiasm. Many observation centres had science models, chart exhibitions, lectures, binoculars, telescopes, sun filters, quiz questions on astronomy to keep the atmosphere lively, to celebrate the few hours that would never repeat in our life times.

Here is a brief report of the programmes organised across the country. But first, we report what happened in our neighbouring country.

Bangladesh

The "Vigyan Andolan Mancha" of the neighbouring country Bangladesh organized many observations camps using the sun-filters supplied by *Breakthrough Science Society* . Such camps were organized at Dhaka University, Jahangirnagar University, Bangladesh Agricultural University, Kaunia High School of Maimansingh, Begum Rokeya University of Rangpur, Brajamohan College of Barisal, Khokan Park of Bagura, Nasirabad Boys' School and St. Placid School of Chattogram. In the Dhaka University camp, an astronomy quiz contest was held, and Prof. M. A. Aziz Mian distributed the prizes. Vigyan Andola Mancha organizers Md. Abu Nayeem, Kalyan Dutta, and Sadat hasan Niloy were present at the Dhaka University camp, and Imran Habib Ruman was present in the Barisal camp.

KARNATAKA

Programmes were organised in 13 districts of the state, covering many taluqs, villages, schools, colleges, universities, research institutes, and general public. Charts, sci-

Mass observation camp at Barisal in Bangladesh, using the filters made by *Breakthrough Science Society* of India.

ence models, telescopes, binoculars, ball mirror projections were organised at various venues.

As a preparatory measure, BSS oragnised a 2-day state-level workshop on Transit of Venus at the Raman Research Institute (RRI), Bangalore. Nearly 70 BSS activists and supporters from 10 districts of Karnataka and Hyderabad district of AP participated in the workshop. BSS brought out 1000 Kannada booklets on the event apart from 1500 English booklets procured from the central office. All the books were sold out. Nearly 10,000 sun filters were sold to the general public for safe viewing of the transit, which were made by 15 BSS voluneteers in two workshops.

Here is a brief report on the scenario in various districts.

Bangalore: The Bangalore Unit of BSS organised a press conference on 2 June at Press Club on the event. Mr G. Satish Kumar, State Convener, BSS, Ms. Rajani K.S, district-in-charge and H B Niranajan Murthy briefed the Press about various aspects of the event. It was covered well by the leading dailies both in Kannada and English.

June 6, 2012 the day when the sky was expected to be bright to help science enthusiasts and general public relish one of the rare celestial events, Bangalore sky was disappointingly cloudy. Sun peeped between clouds now and then for a few minutes. But Bangaloreans had resolved to catch the shadow of venus on the sun. People waited in the ground from 6.30am to 9.30am to witness the event. Students were present at many venues much before 6.30am. Such was the enthusiasm!

Mass observation centres were set up at 10 different locations spread across the city. The locations are Malleswaram ground, Sankey park, JP Park-Mattikere, Lal bagh, RPA school grounds, National College grounds, HMT ground-RT Nagar, Kengeri– opposite library, Nandini layout ground, and Bannerghatta ground.

Viewing with BSS-prepared solar filters independently happened in around 14 educational institutions: Deeksha PU College-Mahalakshmipuram, Amar Jyothi PU College-KR puram, Saneguruvanahalli government high school-Basaveshwarnagar, Kempapura government primary and secondary school, Ammanni College for women, Raman Research Institute, IISc, Adarsha school-RT Nagar, Ganapati Raman Tuitions, Devaraj Urs Internatinal Residential School, RL Jalappa Institute of Technology, Brilliant Tuitions, Sri Vani educational institution-Machohalli, St Theresa's PU College-Mallasandra, Apartments like Janapriya heights-Bagalkunte, SLS Symphony-Bhuvaneshwarinagar.

More than 8000 people watched the transit at various locations. Both print and visual media carried good reports of the programme. Some of the TV channels like Udaya TV, ETV, News9 covered BSS programmes.

Mysore: Students from Marimallappa P.U. College, Sadvidya PU College, Vidyashrama P U College, Cauveri school, and Urs Boarding School participated in the Transit of Venus viewing programme organised by Breakthrough Science Society, Mysore Unit at Urs Boarding School campus. Around 500 people gathered at the venue between 6.30 am and 9.30am. Despite thick cloud cover people were anxiously waiting to get a glimpse of the life time event. Constant interaction with the crowd kept the interest alive and people's enthusiasm was fuelled when clouds cleared from the face of the sun for a couple of minutes by around 9am. Mr. B.Ravi, state unit member of BSS was also invited for a briefing of the event on one of the Kannada TV Channels–Suvarna TV.

Tumkur: At tumkur, public event was organised at MG Stadium grounds. Students from different schools and taluks came in

Mass observation of ToV in Bangalore.

hundreds to view the event. All BSS books were sold out.

Davangere: Lectures on Transit of venus were organised by the Davangere Unit of Breakthrough Science Society at Bapuji College, Magnur Basappa College, AVK Women's College and Quest tutorial. A public viewing event was organised at Govt High school ground. Around 1500 people including students from Jain Vidyalaya, Kiran Education tutorial, Government High School, Government First Grade College, and general public participated. Mr. Manjunath, the Davangere Unit in-charge, built a handy telescope the previous night to aid public viewing. The image of the transit projected through the telescope generated a lot of exitement in the gathering at the Government High School Grounds and received appreciation from people.

Dharwad: Despite a cloud cover in the sky around 500 people gathered at Kalabhavan maidan at Dharwad under the guidance of Mr. Gangadhar, Dharwad Unit in-charge. Students from KNK Girls High School, Karnataka High School, RLS High school and general public participated.

Bellary: A public Transit of venus viewing was organised at SG PU College grounds, Bellary. Around 500 interested people gathered at the venue. Institution level programmes were simultaneously organised at VIMS medical college and Government D.Ed college. A total of around 1000 people participated in the programme.

Raichur: Students of Govt ITI, Govt Polytechnic, LVD College, AME's PU College, Agriculture University and Govt PU College observed the Transit of Venus independently at their respective institutions. Public programme was organised at Mavinkere Park and Bhagath Singh Circle. Around 500 people participated. At Devadurga, it was a rare sight to see Lingasur and Sindanur villagers taking active part in the event.

Hassan: Public sky gazing was organised at Hasanamba indoor stadium, football ground. Around 300 students and general public participated in the programme. Students of Malnad Engineering College, Government Science College, 3 BCM hostels, Hassan PU College simultaneously witnessed the event. Visual media covered the entire event. Kannada channels TV9 and Kasturi took interview of the general public and the organisers at the Hasanamba Indoor Stadium.

Kolar: Public viewing was organised at Vivekananda Vidya Kendra, Parandahalli, KGF taluq. Around 300 students, from schools around the area, teachers and general public were present at the venue.

Bijapur: Around 200 people participated in the event held on the terrace of the BD society PU college. 4 science clubs were subsequently formed in different educational institutions.

Gulbarga: The Gulbarga Unit of BSS organised a press conference on 2 June which was well covered by the local press. Subsequently, the event was organised in various taluqs and villages apart from the Gubarga city, including the PDA Engineering College which has an active BSS college unit. Around 250 people gathered at Shahbad Hobli ground, around 600 at Jevargi taluq, around 150 villagers at Halkatti village and at Wadi hobli RPF Railway ground around 300 people gathered to witness the rare celestial event. A Quotation exhibition was organised at the Railway ground. At the Gulbarga University Boys and Girls hostels, and the Mehta School, the students observed the transit using sun filters of BSS.

Yadgiri: Transit viewing was organised at RV English medium high school, and the Govt junior college grounds. Large number of students and general public participated.

Chitradurga: Hosadurga taluq: Public viewing of the ToV was organised at Kannada Model Higher Primary School, Hosadurga, St. Antony Public School, Govt. Boys Junior College, Chitraduga, Madakari Nayaka High School, SJMIT Engineering College, Government Science Degree College, Govt High School, NG Halli, Govt Jr College, Hosadurga, Sri Gangambika Girls High School, and around 12 Government primary and middle schools in the Hiriyur taluq.

Children observing the ToV in a Karnataka camp.

TAMIL NADU

BSS Tamilnadu started the preparations for the ToV from April 2012. A booklet on ToV in Tamil was prepared. A Workshop aimed at mobilising a batch of volunteers was held at Anna University, Chennai on 6th May 2012. In the workshop Dr.Venkatesan explained the science and history of the phenomenon. It was attended by about 50 participants. A few banners on ToV for publicity purpose were made and displayed in Chennai.

6th May, Marina beach, Chennai: Awareness program on ToV and telescope viewing of Venus and Moon was conducted. Making of an inclinometer and using it for dis-

Mass observation of ToV at the Elliots Beach, Chennai.

tance measurements was taught to students. Books and filters were sold to the public.

During the campaign in Chennai, volunteers came into contact with Mr. Vijayakumar and Mr. Dhinakar of Tamilnadu Astronomical Society (TAS) who are amateur astronomers and astro-photographers. A meeting of BSS and TAS was held at Springfield School, KK Nagar, Chennai on 13-5-2012, and it was decided that the two organizations would conduct the mass obvervation of the ToV together at the Elliots beach, Besant Nagar, Chennai.

A central awareness program was conducted at Marina beach, Chennai on 27-5-2012. This program was addressed by Dr. Venkatesan from the BSS and Mr.Vijayakumar from the Tamilnadu Astronomical Society. Mr. Dhinakar of TAS demonstrated a simple method of projecting the sun using plain front coated mirror and a lens. Newspapers gave good coverage of the program.

Kalpakkam Community FM radio arranged for broadcasting two narrations about ToV 2012 rendered by Dr.Venkatesan, and a group discussion, which were well received by the people. On June 3rd, an interview was given to Shalini TV (Cable) about ToV 2012 by Mr.V.Sudhakar and Mr.George Joseph. On June 5, an announcement about the 6th program at Elliots beach was given in Kalaignar TV from BSS by Mr. Sai Kumar.

BSS volunteers organised awareness programs and discussions at several places in Tamilnadu, namely Neyveli, Salem, Villupram, Madurai, Thiruthangal, Theni, Ambattur and in a few localities in Chennai.

Awareness Programmes :

Chennai: Over a period of a month before the 6th of June, mass awareness programmes were conducted in Ambattur, Annannur, Vyasarpadi, Korukkupet, Otteri, Pallikaranai, SOS Village, and Tambaram.

Neyveli: Widespread campaign was organized by Mr. Narayanasamy in and around Neyveli township. More than 500 sun filters were distributed.

Villupuram: A discussion on the science and history of ToV was conducted by Dr.Venkatesan on 20th May. Campaigns among students and general public were conducted by Mr.Guru, Pandian and Elumalai.

Madurai: A talk was organized on 13-5-2012 by Ms.Mary in the KV school, Madurai that was addressed by Prof.Yogarajan.

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Theni: Mr.Govindarajan organized group discussions in 5 villages near Theni.

Thiruthnagal: Expository discussions on TOV were conducted at Kalaimagal Higher Secondary School (25 May), VSKD Matriculation Girls Higher Secondary School, Sivakasi (2 June), SHNV Boys Higher Secondary School (4 June), SHNV Matriculation Higher Secindary School, Sivakasi (4 June), SNG Girls Higher Secondary School, Sundaravel Matric HSS, Glory Matric HSS, Muthumari Matric HSS, KMKA Matric HSS and Lions Matric HSS school (5 June).

Salem: On behalf of BSS, group discursions were organized at different places in Salem District, including the Govt. College of Engineering Salem, the residence of R.Muruganandam, Panamarathupatti (a Village near Salem city), etc.

Sun filters were distributed in Salem, Dharmapuri, Namakkal and Karur Districts. In Salem, 3 Higher Secondary Schools and one Engineering College; in Namakkal District 3 schools; in Dharmapuri one Higher Secondary school and in Karur 5 schools were covered.

Public Viewing of ToV on June 6

On June 6, a massive public viewing program was arranged in Elliots beach, Chennai jointly by BSS and Tamilnadu Astronomical Society (TAS) and Exnora. Seven telescopes fitted with solar filters were arranged and volunteers numbering 40 (20 from BSS and 20 from TAS) managed the viewing program. More than a thousand people came to watch the event. Media reporters from Hindu, Indian Express, Thinathanthi, Thinamalar, Times Now channel, AAHA FM, Shalini TV were present and the media coverage was also good.

The other places where viewing programs were arranged are as follows.

Chennai: Annannur, near Chennai (organised by Mr.Umapathy Thangaraj), Ambattur–T I Cycles Ground and Varadharajapram station road (conducted by Mr. Balajibabu), Vyasarpadi (conducted by Mr. Sebastin), Korukkupet (organized by Ms. Sarath), Otteri school (organized by Mr. Mohanraj), Pallikaranai (conducted by Mr.Janakiraman).

Madurai: Public observation camps were organized at the KV School, and near Periyar bus stand.

Theni: Public viewing was conducted at Theni town and in 5 Villages.

Virudhunagar: Public viewing was organized at Thiruthangal Railway Station, SRN Girls HSS, VSKD Matriculation Girls Higher Secondary School, Sivakasi, Kalaimagal Higher Secondary School, SNG Girls Higher Secondary School, Sundaravel Matric HSS, Glory Matric HSS, Muthumari Matric HSS and KMKA Matric HSS, Thiruthangal. Arrangements were also made for public viewing at a Government School in the Reserve line, and at the Sankaralingam Bhuvaneswari College of Pharmacy, Sivakasi.

Salem: On June 6th mass viewing of event was organized at Salem New bus stand, at the Little Flower Hr.Sec.School in Salem corporation, and at the Panamarathupatti village.

The Indian express news paper covered the Salem event, Tamil Murasu news paper covered the Panamarathupatti village event.

Neyveli: Widespread public viewing was organised in and around Neyveli township, at Mines-1, Workshop gate, in the Plant site, Township; Periya Kurichy and Indira Nagar outside township.

In addition, public viewing was also organized in a few places in the districts of Villupuram, Nagercoil, Dindikkal, and Kalpakkam. At Kalpakkam, the Community FM radio conducted live broadcast of reports and interviews from people viewing ToV from different places.

4000 sun filters, 400 booklets in Tamil

View of an observation camp in Orissa.

and 300 booklets in English were distributed in the state during the ToV program.

ORISSA

On the occasion of Transit of Venus, the Bigyan Chetana Mancha, Odisha, organized a number of programs across various districts of the state. Lectures with slide shows and group discussions were organized which covered a wide group of audience including school students, college students, school teachers, lecturers, and general public.

A talk was delivered by Dr. Sidhartha Varadwaj, state secretary of Bigyana Chetana Mancha (BCM) to the general public at The Universe, Cuttack which was followed by a short movie on the Transit of Venus. A few more lectures were also organized at NTPC (officers club) Talcher and in various educational institutions at Rourkela, Athagarh, Bari, Jashipur, Balangir, Jajpur (Mohantypatna) and Bhubaneswar, all of which were addressed by Dr. Sidhartha Varadwaj. Dr Ramesh Nayak, advisor of BCM, addressed students, teachers and general public on the transit of Venus at Chandaneswar. Dr. Jaya Prakash Das, state President of BCM delivered lectures on the transit of Venus in several educational institutions at Cuttack, Kendrapara and Chandikhol.

On 6th June, 2012, several mass observation camps were organized at Tushra in Bolangir district, Jubilee Park, sector-1, and civil township in Rourkela, Rajgangpur, Biramaharajpur, Bhubaneswar, Jajpur, and Berhampur. A mass observation camp was also organized in the Ravenshaw University, Cuttack.

MAHARASHTRA

Yavatmal: An awareness seminar on transit of Venus was organised at the Municipal Hall, Yavatmal on 30-5-2012. Mrs. Meenatai Masram (Shikshan Sabhapati Nagar Parishad Yavatmal) was the chairperson while Niraj Wagh and Ravindra Kharabe were the main speakers of the programme.

On June 6, 2012, a public viewing was organized in which around 125 people participated. Such an activity was the first of its kind in the city.

JHARKAND

Chandrapura: The Discovery of Science Society, a science organisation affiliated to BSS organised the transit of Venus viewing programme at Chandrapura and Chandankyari (Bokaro). On this occasion about 100 students from various schools and col-

View of the observation camp near Ghatsila.

leges witnessed the transit. Around 10 teachers delivered lectures on various aspects of ToV.

Ghatsila: On the occasion of the Transit of Venus, the Einstein club of Ghatsila organized a science fair at Dahigora Circus Ground. More than 1000 students, teachers, professors, parents of 40 high schools and 3 colleges and general public participated in the programme, and observed the rare astronomical event. The Ghatshila unit organised an Essay competition on the topic "If I were a scientist" and "Life struggle of Galileo" along with a model competition on celestial objects.

MADHYA PRADESH

Gwalior:

The members, volunteers and supporters of Breakthrough Science Society (Gwalior chapter) had launched awareness campaign one month before 6th June by organising discussions, seminars and exhibitions in various schools, colleges, coaching centres, localities and among common people. On 6th June 15 observation centres were organized all over the city. The various spots were: Tekanpur, Phoolbagh square, Qilagate, Sewanagar, Dwarikapuri, Nehru park, Idgah, Kampoo area, Tansen tomb, Jawahar colony, Science College, and Morar girls college. Exhibitions, quotation charts and posters were on display at the observation centres for awareness among the people. Thousands of sun-filters and hundreds of books on transit of Venus were circulated among the students, intellectuals and common people.

UTTAR PRADESH

The transit of Venus observation centres were set up in the following districts.

Allahabad: Mass observation programmes were organized at the Harish Chandra Research Institute (HRI), Allahabad University (AU), Allahabad Medical College (AMC), and Chandra Shekhar Azad Park. In all these places around 500 people have witnessed the event, many became members of Breakthrough Science Society.

Lucknow: A Seminar on Transit of Venus was organised by the BSS State Chapter at Rai Umanath Bali Prekshagriha, Kaiserbagh for State Lavel Organisers' Training in which a documentary film on the transit prepared by All India BSS was screened.

On 6th June, mass observation was organized at the Dubagga Town Area and the Jiyamau Area. In these two venues around

800 people participated directly in the event at Lucknow alone.

Similar programmes were organized in the Balia, Jaunpur, Pratapgarh, Sultanpur, Kanpur, and Moradabad districts of UP.

ANDHRA PRADESH

The Andhra Praddesh Chapter of Breakthrough Science Society organised the transit of Venus observation programmes in Hyderabad, Ananthpur and Mehabubnagar districts.

HYDERABAD DISTRICT: Awareness programme and quotation exhibition were organised at Indira Park, Hyderabad, on 4th June and at Khairatabad Railway station, Hyderabad, on 5th June.

On the 6th of June, mass observation camps were organized at Oasis School of Excellence, Raydarg, D.Ed College, Secunderabad, Pioneer Concept School, old city, Hyderabad, St. Christopher School, Ratna Grammer School, Balapur, Hyderabad, Delta College, Akshara Foundation (one of the schools in a slum area of Hyderabad), Dr. Reddy's Laboratory premises, Asraju nagar, Hyderabad, Peoples Plaza (a public place), Kukat Pally Junior College, Hyderabad, and at the Slate School, Hyderabad.

View of the observation camp at the Allahabad University, UP.

Prof. Ramakanth (Retd. Professor of Physics, Kakatiya University, releasing the booklet on Madame Curie in Hyderabad. Also on the dias are Prof. A. Ramakanth, Dr. G. Ravinder Reddy, and Prof. P. Seshi Reddy.

ANANTAPUR DISTRICT: On the 6th of June, observation camps were organized at the SSBN Degree College Ground and the LRG group of institutions.

MAHABUB NAGAR DIST: An observation camp was organized at the Govt. Junior College, Mehbubnagar.

Thousands of people watched the event under our direct supervision in the different observations camps.

Other programmes in Andhra Pradesh:

The Andhra Pradesh Chapter of BSS published a booklet on Madame Curie which was released through a programme at the Stanley College of Engg. & Tech. for Women, hyderabad.

The BSS activists participated in a Childrens' Camp held at the Oasis School, Hyderabad, on 7-9 May 2012. Mr. Praful performed a miracle-exposure show, and Mr. Gangadhar gave a lecture on science and scientific method.

The Mahabub Nagar district education authorities organized a one-week science camp starting on 15 May 2012. Mr. Gangadhar acted as a resource person and discussed about the life of great scientists and on the periodic table in two sessions.

Students of the Oasis School in Hyderabad watching the transit.

The Hyderabad Chapter of the BSS observed the Hiroshima Day on 6 August 2012 at the Chadarghat Govt. High School, Abids, Hyderabad, in collaboration with the "Sir C. V. Raman Science Club" of the school.

In 1945 August 6-9th, America attacked Japan with powerful atom bombs. Condemning such a heinous attacks a huge number of students rallied from Erramanjil colony to punjagutta flyover conducted by Breakthrough Science Society, A.P.State Chapter. A good number of students from different schools enthusiastically participated in this program.

KERALA

Kannur District: In the preparatory work, around 200 sun filters and 75 booklets were distributed, talks were arranged in five schools. A regional committee of BSS was formed in Alakode town with Sri. Ramachandran as the president and Sanal Joseph as the secretary.

Kozhikkode District: Ten institutions were covered during the ToV preparatory work. More than 200 sun filters and 50 booklets were distributed in the district.

Trissur District: Two workshops were held before the ToV. Classes conducted at 10 schools. On June 6, observation center at Thrissur town, Naduvilal junction led by Dr. Mukundan and C.K.Sivadasan. Explanation of the phenomenon was done by Amateur astronomer Chandramohan, Dr.P.S.Babu, and Noble Anto. An observation center at Chavakkad town, Municipal Bus stand. In this district, 250 sun filters and 75 copies of Malayalam book distributed.

Palaghat District: Extensive campaign was done in Palghat district in connection with ToV. Total 41 educational institutions were covered. Classes conducted in four places. Public observation centre at six places including one at Palaghat stadium bus stand. 300 sun filters and 125 Malayalam books were distributed.

Ernakulam District: The Ernakulum district chapter of BSS organized a workshop on Transit of Venus' much ahead of the event. Further, a booklet on Transit of Venus published by BSS in Malayalam was unveiled in a public function at Rainbow bridge, Marine drive, Ernakulam by eminent scientist Shri. C. Ramachandran (Retd. From ISRO). Breakthrough district convener Shri. Francis Kalathunkal presided over the function. Prof. Shaji, (Maharajas college, Ernakulum) spoke. Our activists contacted 41 institutions and conducted classes at 20 places including schools, colleges, and libraries and for the public. Public functions explaining the science behind the were held at Thrippunithura, Cochin refinery, Rainbow bridge, Arayankavu and Muvattupuzha. Sun filters and books were widely distributed in all the functions. On the day of transit, many observation centers were organized.

Kottayam District: A workers meeting was conducted in the month of May. After that one day workshop on ToV was organized. Campaign was conducted at most of the institutions in and around the Kottayam

An old woman enjoying the ToV in Baroda, Gujarat.

town. Public distribution centers were organized in Kottayam and Changanacherry Towns. On June 6, an observation centre with a 5.5 inch telescope was organized in Kottayam. Around 800 filters and many Booklets and Leaflets were distributed in the district.

Other Activities:

04 and 05 May 2012: 2 Day Astronomy Camp for Children at Jawahar Balbhavan, Kottayam.

03 July 2012: Madam Curie Photo Poster Exhibition at ABM Govt. UP School, Kumarakam.

04 July 2012: Madam Curie Photo Poster Exhibition at Mount Carmel Girl School, Kottayam.

07 July 2012 : Madam Curie Memorial Meeting at Jawahar Balbhavan Kottayam.

13 May 2012: Class on Astronomy by K.Tkanappan

02 June 2012: Class on ToV by Abraham of BSS

30 June 2012: Madam Curie Documentary

Pathanamthitta District: More than 20 institutions were covered during the ToV work. 220 filters and booklets were distributed.

Alappuzha District: One preparatory workshop was held before the ToV. The campaign covered about 41 institutions. Classes were taken at 12 schools. On June 6, 11 observation centers were arranged, mostly in schools. As many as 380 sun filters and booklets and leaflets were distributed during the work.

Thiruvanathapuram District: Classes were held in 10 institutions. On June 6 Transit of Venus observation was organized by Kerala State Science & Technology Museum in association with BSS. Press and Electronic Media gave a good coverage of the observation. District chapter members Benny Joseph, Shaji Albert, Jyothis Babu and Sandeep participated. Public observation were also held at organized at Statue Junction, state secretariat, Medical College Junction, Muttathara Coastal Area. More than 850 sun filters and large number of books and leaflets distributed.

HARYANA

Rohtak: An observation centre was organized at Choturam Stadium, Rohtak. Mr. Harish Kumar, In-charge, Breakthrough Rohtak Unit, and other organizers helped the general public in a scientific viewing of the event.

Rewari: At Rajesh Pilot Chowk, near Rejangala Shaheed Park, Rewari, a public observation centre was organised. Around 500 people participated in the event. Prof. Aniruddh Yadav, Social Activist, explained the event to the general public. He also spoke against astrology and encouraged people to look up to the sky and enjoy the celestial spectacle.

Public viewing was independently organised in many villages like Kanvali, Moondi, Jaitavad, Timot, Dahin, Mirpur, Turkiabad and Katina. School children from these vil-


View of the observation camp at Rewari, Haryana.

lages organised elders to view the event and many travelled to Rewari early in the morning to volunteer for the activities.

CHATTISGARH

Bilaspur: On 15th April, 2012, an "open group discussion on Transit of Venus" and sky observation was held in Bilaspur, one of the districts of Chattisgarh. Students of several colleges took part in the programme. Mr. Moinak Mondal, a student science activist, and Mr. Kanai Barik, an organizer of the BSS discussed on the ToV, the general rules of sky observation, and provided a sky chart of the month of April. It was followed by a skywatching session. At the end, a 16 member committee was formed.

Durg: On the day of ToV, an observation centre was organised at Malwia nagar Chowk, Durg. Science models explaining the event were on display. Later with the help of sun filters more than 500 people witnessed the event. Campaigning about the event was widely done at Aditya Nagar, Titurdi, Sicola Bhata, Agrasena Chowk, Pachri Paara Chowk, Indira Chowk.

Organizational News

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WEST BENGAL

In this state the ToV related activities were conducted in massive proportions. It is impossible to give an account of the whole activity within the space allowed. So we shall enumerate only the major landmarks.

In the preparatory phase, workshops were conducted in all the districts to acquaint the organizers about the scientific aspects of the event. They then contacted the schools and colleges and launched a campaign to educate the people about the science behind the ToV.

In order to aid this campaign, a documentary video was prepared, which was shown in most schools and colleges. Books were published in English and Bengali. Most importantly, more than a lakh sun-filters were made in the state by BSS volunteers out of which about 60,000 were consumed within the state and the rest were sent to the other states.

On the 6th of June, 320 observation centres were organized all over the state, and the average attendance in each centre was around 200. This gives an idea of the number of people who observed the event under our direct supervision, apart from the thousands who collected the sun-filters from us and observed on their own from their houses. The main observation centre was organized in the Bengal Engineering & Science University (BESU) campus.

The gigantic effort received widespread appreciation of the science-loving people of the state.