Editorial

Research is the Foundation of Knowledge

The above phrase was the motto inscribed in the insignia of the Natural Resources Energy and Science Authority (NARESA), the predecessor of the National Science Foundation. The basis for this maxim has been explained by the present writer in a report titled 'Sri Lanka Science and Technology Indicators', Part IV, published by NARESA in 1996, wherein the "research process" has been conceptually and diagrammatically conceived as an "input-output" activity. The inputs in this system mainly comprise, human resources, financial resources, physical resources (infrastructure), and science and technology information flow. These inputs facilitate initiation of scientific investigations, which are carried out through established pathways identified as 'Fundamental Research', 'Basic Research', 'Applied Research' or 'Experimental Development'. The first primary outcome of this activity is New Knowledge or New Information as postulated in the NARESA insignia, from which intermediary outputs are articulated as scientific publications, research reports, innovations, inventions, new insights, patents, postgraduate degrees, laboratory certification, as well as negative results. The final phase identified as commercialization of research takes place through a variety of pathways, considered to be the most costly and time consuming phase in research and development.

Observing the research system from a "Science Policy" perspective, the question that has been relevant for purposes of allocating resources, especially financial resources, was the proportion of time and effort devoted to Fundamental, Basic, and Applied Research, as well as to Experimental Development. Historically, commencing from the mid decades of the last century, the so-called developing countries were under formidable pressure from organizations such as UNESCO and the Commonwealth Science Council (CSC), to give priority consideration to science planning and policy formulation, which were considered pre-requisites for national development. Consequently these organizations conducted extensive awareness and training programmes on science policy formulation with the intention of facilitating the integration of scientific considerations in national development planning. It is in this context that clear definitions of what could be considered as fundamental and basic research became relevant.

In some definitions fundamental research was generally identified with basic research and defined as "curiosity-oriented research", which leads to an increase in the stock of useful knowledge. However, for the purpose of international comparison UNESCO defined basic (or fundamental) research as any experimental or theoretical work undertaken primarily to acquire new knowledge without any specific application in view. According to these two definitions, basic research (or more appropriately Fundamental Research), may include for example, theoretical and experimental nuclear physics, space research, astro-physics etc., which can functionally probe the mysterious insights of natural phenomena, thereby widening the frontier boundaries of research disciplines. Such investigatory research however, may not be of vital significance to developing countries, and hence may be referred to as "Less Expedient Basic Research". On the other hand, exploratory studies such as those leading to the isolation, synthesis, and identification of active principles in biological materials, which are of great significance to the developing world, could be identified as "Expedient (or Strategic) Basic Research" or simply as basic Research. Such delineation was of great importance for allocation of scarce resources for research in developing countries, and in fact these were the broad conclusions of a 'policy dialogue' initiated by Commonwealth Science Council in the mid 1980's for science planners and science policy analysts of developing countries.

Mr M. Asoka T. De Silva

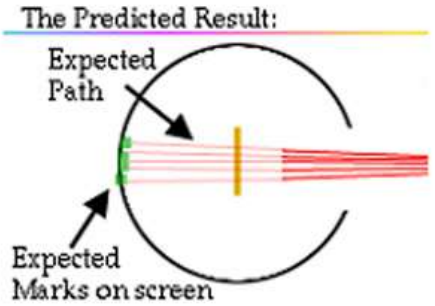
Particle Accelerators

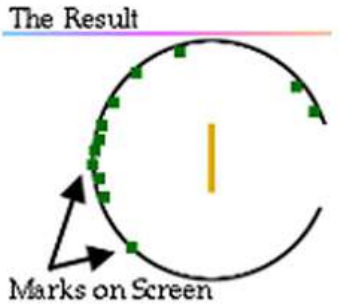
Prof. S.R.D. Rosa



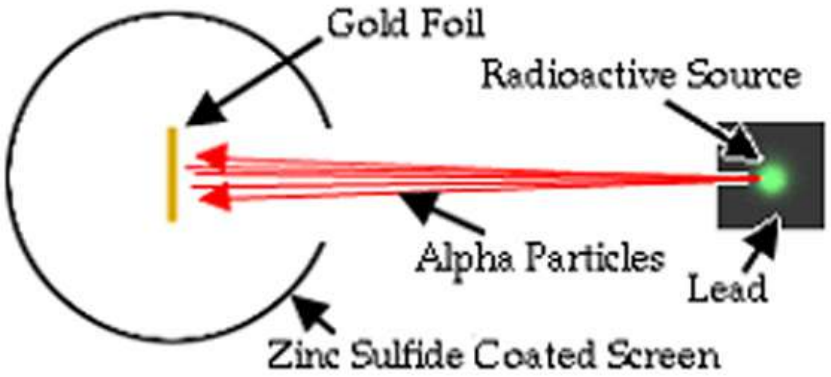
In 1909, the prevailing theory of the atom's structure was that atoms were mushy, semi- permeable balls. So in 1909 a man named Ernest Rutherford set up an experiment to test the validity of the prevailing theory. In doing so he established a way for the first time where physicists could "look into" tiny particles they could not otherwise see with microscopes.
In Rutherford's experiment, a radioactive source shot a stream of alpha particles at a sheet of very thin gold foil which stood in front of a screen. The alpha particles would make little flashes of light where they hit the screen.

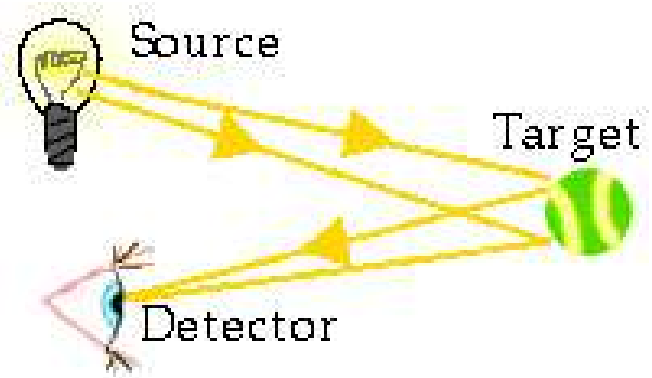
The alpha particles were expected to pass right through the very thin gold foil and make their marks in a small cluster on the screen.
If atoms were permeables neutral balls, then the alpha particles should simply pass through the gold foil and strike the back of the screen. But much to everyone's surprise, some of the alpha particles were deflected at large angles to the foil; some even hit the screen in front of the foil! Obviously some other explanation was needed.





Since some of the positive alpha particles were substantially deflected, Rutherford concluded that there must be something inside an atom for the alpha particles to bounce off of, that is, small, dense, and positively charged: the nucleus. Rutherford's experiment set the tone for the realm of experimentation in particle physics. In fact, almost all particle physics experiments today use the same basic elements that Rutherford did:
• A beam (in this case, the alpha particles)
• A target (the gold atoms in the foil)
• A detector (the zinc sulfide screen)
In addition, Rutherford established the practice of "seeing" into the sub-atomic realm by using particle beams, and particle physicists today follow his experimental lead by inferring the actual nature of particles and interactions from the frequently counterintuitive results they find.
Let us look at the most familiar example of this source/target/ detection scheme: the way in which we perceive the world.
Imagine that there is a light bulb behind you, and a tennis ball in front of you. Photons travel from the light bulb (source), bounce off the tennis ball (target), and when these photons hit your eye (detector), you infer from the



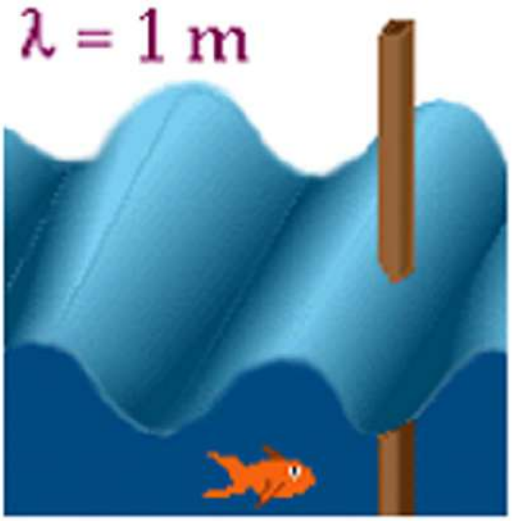


direction the photons came from that there is a round object in front of you. Moreover, you can tell by the different photon wavelengths that the object is green and tan. Our brain analyzes the information, and creates the sense of a "tennis ball" in our minds, and this mental model of the tennis ball helps us to describe the reality around us.

We use the information of bounced-around light waves to perceive our world. Other animals, like dolphins and bats, emit and detect sound waves. In fact, any kind of reflected wave can be used to get information about the surroundings.

The problem with using waves to detect the physical world is that the quality of the image is limited by the wavelength that is used.

Our eyes are tuned to visible light, which has wavelengths in the neighborhood of 0.0000005 meters. That is small enough that we usually do not need to worry about the wavelength-resolution problem since we do not look at things that are 0.0000005 meters wide.



However, the wavelength of visible light is too wide to analyze anything smaller than a cell. To observe things under higher magnification, you must use waves with smaller wavelengths. That is why people turn to scanning electron microscopes when studying sub-microscopic things like viruses. However, even the best scanning electron microscope can only show a fuzzy picture of an atom.

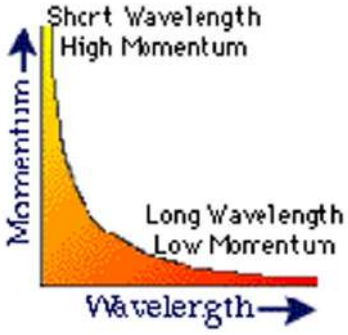


Things with long wavelengths cannot provide too much detail about what they hit. Things with short wavelengths can provide you with fairly detailed information about what they hit. The shorter the probe's wavelength is, the more information you can get about the target.

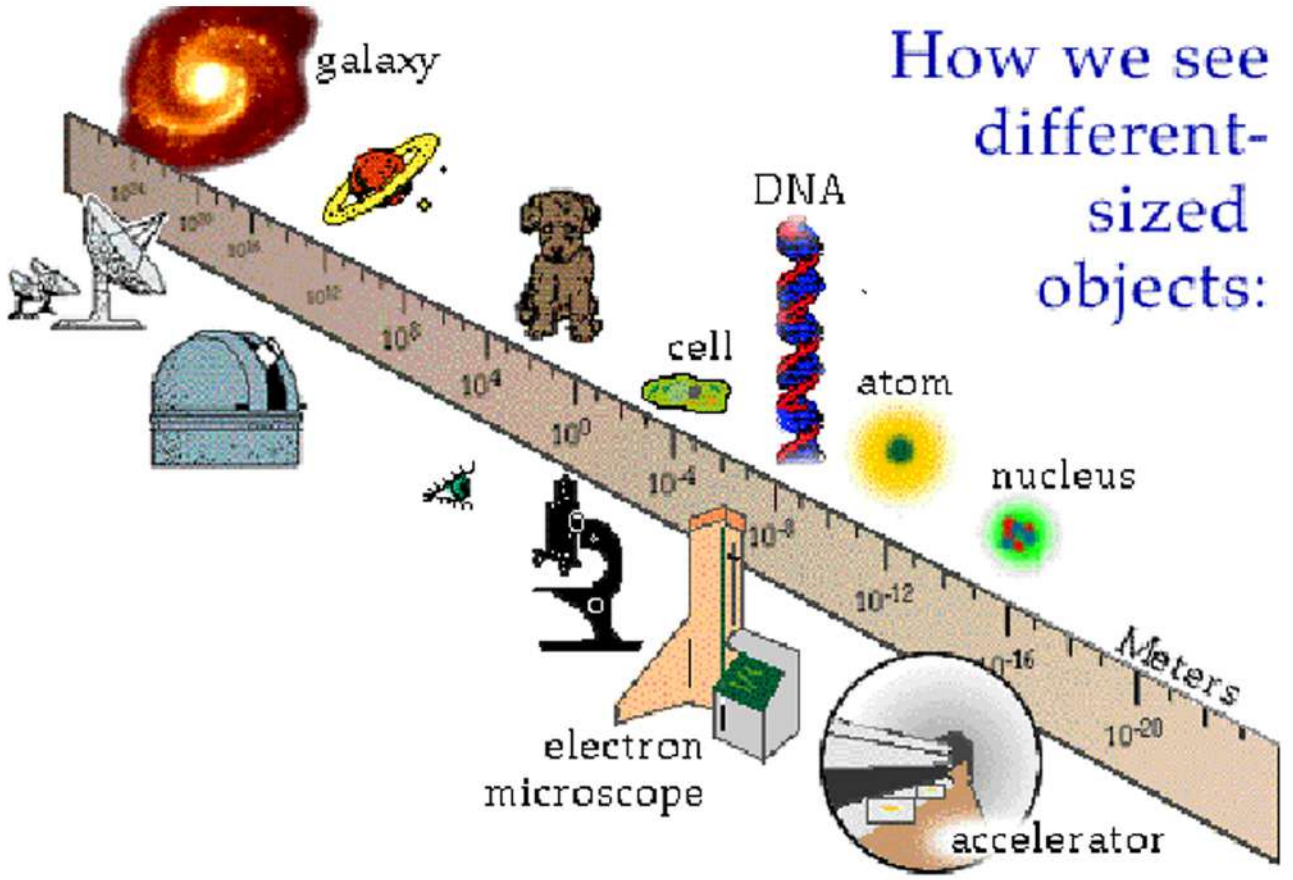
A good example of the wavelength vs. resolution issue is a swimming pool. If you have a swimming pool with waves which are 1 meter apart (a 1 meter wavelength) and push a stick into the water, the pool's waves just pass around the stick because the 1 meter wavelength means that the pool's waves would not be affected by such a tiny target.

All particles have wave properties. So, when using a particle as a probe, we need to use particles with short wavelengths to get detailed information about small things. As a rough rule of thumb, a particle can only probe down to distances equal to the particle's wavelength. To probe down to smaller scales, the probe's wavelength has to be made smaller.

Physicists can not use light to explore atomic and sub-atomic structures because light's wavelength is too long. However, since ALL particles have wave properties, physicists can use particles as their probes. In order to see the smallest particles, physicists need a particle with the shortest possible wavelength. However, most of the particles around us in the natural world have fairly long wavelengths. How do physicists decrease a particle's wavelength so that it can be used as a probe?



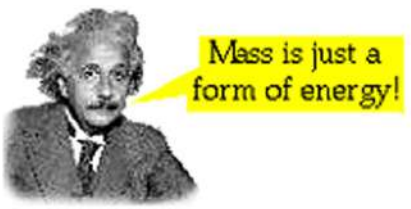
A particle's momentum (p) and its



wavelengths are inversely related. In fact , where h is the Planck constant.

High-energy physicists apply this principle when they use particle accelerators to increase the momentum of a probing particle, thus decreasing its wavelength. The steps followed by particle Physicist's are,

- Put your probing particle into an accelerator.
- Give your particle lots of momentum by speeding it up to very nearly the speed of light.
- Since the particle now has a lot of momentum, its wavelength is very short.

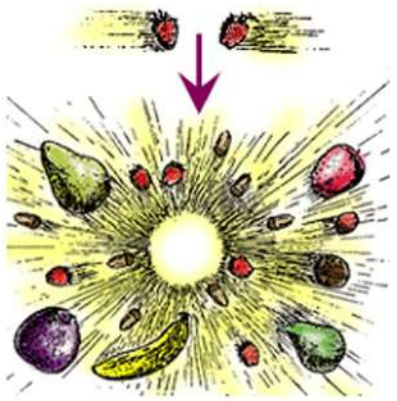


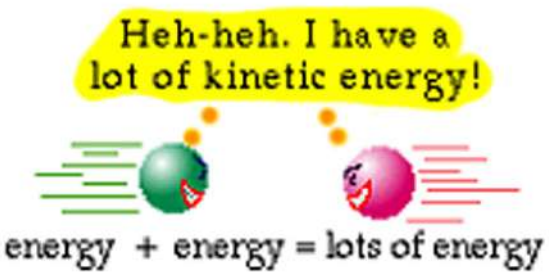
- Slam this probing particle into the target and record what happens.

The above image represents a meter stick measuring powers of ten. As you can see, there are different methods to view the world corresponding to the size of the thing you are viewing.

- Accelerators solve two problems for physicists. Firstly, physicists use accelerators to increase a particle's momentum, thereby decreasing its wavelength sufficiantly that it could be pushed inside atoms. Secondly, the energy of speedy particles is used to create massive particles that physicists want to study.
- Quite often, physicists want to study massive, unstable particles. However, all that physicists have around them are very low-mass particles. How does one perform this amazing feat of using particles with lesser mass to obtain particles of greater mass?

- You know Albert Einstein's famous equation where E is the energy, m is the mass, and c is the speed of light.
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- When physicists want to





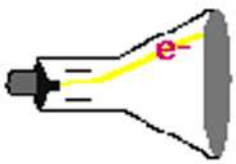
use particles with low mass to produce particles with greater mass, all they have to do is put the low-mass particles into an accelerator, give them a lot of kinetic energy (speed), and then collide them together. During this collision, the particle's kinetic energy is converted into the formation of new massive particles. It is through this process that we can create massive unstable particles and study their properties.

How do accelerators work?

- Basically, an accelerator takes a particle, speeds it up using electric fields, and bashes the particle into a target or other particles.

How do physicists get the particles they want to accelerate?

- Electrons: Heating a metal causes electrons to be ejected. A television, like a cathode ray tube, uses this mechanism
- Protons: They can easily be obtained by ionizing hydrogen





There are several different ways to design these accelerators, each with its benefits and drawbacks. Here is a quick list of the major accelerator design choices:

Fixed target: In a fixed-target experiment, a charged particle such as an electron or a proton is accelerated by an electric field and collides with a target, which can be a solid, liquid, or gas.

Colliding beams: In a colliding-beam experiment two beams of high-energy particles are made to cross each other.

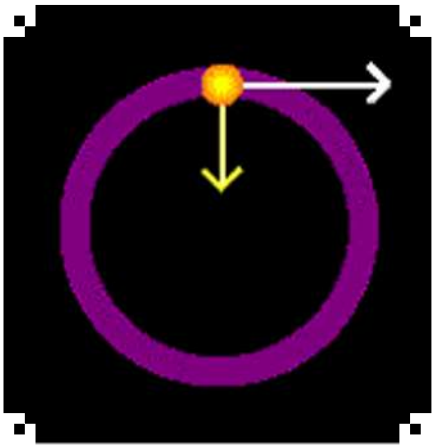
- The advantage of this arrangement is that both beams



have significant kinetic energy, so a collision between them is more likely to produce a higher mass particle than would a fixed-target collision (with the one beam) at the same energy. Since we are dealing with particles with a lot of momentum, these particles have short wavelengths and make excellent probes

Accelerators are shaped in one of two ways:

- Linacs: Linear accelerators, in which the particle starts at one end and comes out the other.



- Cyclotrons: Accelerators built in a circle, in which the particles go around and around and around.

All accelerators are either linear or circular, the difference being whether the particle is shot like a bullet from a gun (the linear accelerator) or whether the particle is twirled in a very fast circle, receiving a bunch of little kicks each time around (the circular accelerator). Both types accelerate particles by pushing them with an electric-field.

The particles in a circular accelerator go around in circles because large magnets tweak the particle's path enough to keep it in the accelerator. How do a circular accelerator's magnets make particles go in a circle?

To keep any object going in a circle, there needs to be a constant force on that object towards the center of the circle. In a circular accelerator, an electric field makes the charged particle accelerate,



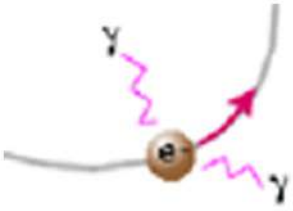


while large magnets provide the necessary inward force to bend the particle's path in a circle. (In the image shown, the particle's velocity is represented by the tangential arrow, while the inward force supplied by the magnet is shown by the arrow directed towards the center)

The presence of a magnetic field does not add or subtract energy from the particles. The magnetic field only bends the particles' paths along the arc of the accelerator. Magnets are also used to direct charged particle beams toward targets and to "focus" the beams, just as optical lenses focus light.

The advantage of a circular accelerator over a linear accelerator is that the particles in a circular accelerator go around many times, getting multiple kicks of energy each time around. Therefore, synchrotrons can provide very high-energy particles without having to be of tremendous length. Moreover, the fact that the particles go around many times means that there are many chances for collisions at those places where particle beams are made to cross.

On the other hand, linear accelerators are much easier to build than circular accelerators because they do not need the large magnets required to guide particles into going in a circle. Circular accelerators also need an enormous radii in order to get particles to high enough energies, so they are expensive to build. Another thing that physicists need to consider is that when a charged particle is accelerated, it radiates away energy. At high energies the radiation loss is larger for circular acceleration than for linear acceleration. In addition, the radiation loss is much worse for accelerating light electrons than for heavier protons. Electrons and anti-electrons (positrons) can be brought to high energies only in linear accelerators or in circular ones with large radii.



We invite you to explore the basic plans of the world's major accelerators so that you can truly appreciate the differences in accelerator designs.

SLAC: Stanford Linear Accelerator Center, in California, discovered the charm quark (also discovered at Brookhaven) and tau lepton; now running an accelerator producing huge numbers of B mesons.

Fermilab: Fermi National Laboratory Accelerator, in Illinois, where the bottom and top quarks and the tau neutrino were discovered.

CERN: European Laboratory for Particle Physics, crossing the Swiss-French border, where the W and Z particles were discovered.

BNL: Brookhaven National Lab, in New York, simultaneously with SLAC discovered the charm quark.

CESR: Cornell Electron-Positron Storage Ring, in New York. CESR performs detailed studies of the bottom quark.

DESY: Deutsches Elektronen-Synchrotron, in Germany; gluons were discovered here.

KEK: High Energy Accelerator Research Organization, in Japan, is now running an accelerator producing huge numbers of B mesons.

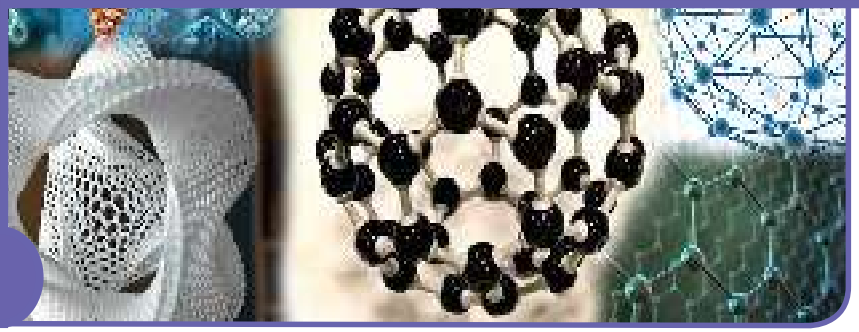
IHEP: Institute for High-Energy Physics, in the People's Republic of China, performs detailed studies of the tau lepton and charm quark.



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New Frontiers in Scientific Research

Prof. Ajith de Alwis



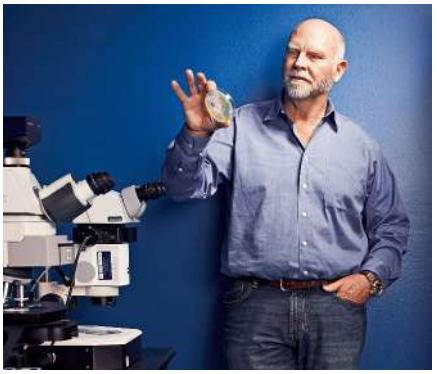
"Every great advance in science has issued from a new audacity of imagination"
John Dewey

As I write this the most expensive research program on earth is set to embark on an even grandeur journey. The Large Hadron Collider (LHC) is set to start with additional energy and power to detect and reveal with even more of an in-depth examination of particle physics in the coming days. This machine which is the largest single machine on earth is situated in Geneva and belongs to CERN (European Organisation for Nuclear Research) which supports an international research program. If an area of research is to be identified that is on the cutting edge of science this is it. The scientists there expect to understand dark matter, and what exactly happened after the 'Big Bang' through the proton beam collisions during this process advancing our understanding of physics into a new level. At LHC, two high energy particle beams will travel at close to speed of light before they are made to collide. The space in which they travel is kept at ultra high vacuum, and the guidance for the beams is by a strong magnetic field maintained by superconducting magnets. To achieve this magnets require chilling at -271.3C which is a temperature lower than at outer space. It is easy to understand how many additional sciences and technology developments should have proceeded to run this one beam collision study for testing advance scientific hypotheses. Realizing these developments would have entailed significant research in earlier days though today the frontiers in these areas have shifted. Data analysis is another frontier as millions of images are taken per second, which now pushes the computing science into grid computing, another frontier area. If one considers research into particle physics is not without any returns, CERN is quick to point out that 25% - 30% of modern world's economic activities are directly or indirectly driven as a result of work done in Quantum Mechanics! While research at CERN is exceptionally expensive as well as at a cutting edge, one can identify cutting edge research in many other subject areas. It is the research and the subsequent new findings that advances the boundaries of these subjects, and at times spawn brand new areas of study.

Research happen in many spheres though all will not take place at frontiers. Hence an understanding of current frontiers too is of importance if one needs to immerse oneself in such an endeavor. Today major research universities actually plan their research engagements accordingly. All subject areas owe their growth to research, and the consequent generation of knowledge. In 20th century perhaps the most important research result was the elucidation of DNA by Watson and Crick, which yielded knowledge on how information is transferred and the way by which nature codifies information – DNA was unraveled. The pathway to derive the answer was not paved in gold, and lots of efforts and sacrifices were involved. The work was also built on the hard work of others, and in this regard Rosalind Franklin whose X-ray images provided clues and whose presentations Watson and Crick listened while travelling from Cambridge to London, played an important role. Science is not a



Rosalind Franklin

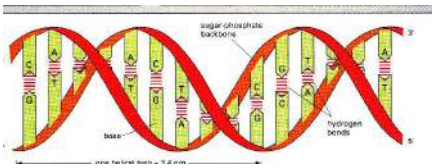


Venter

lonely enterprise though many a time's research scientists have to identify their own paths against many odds, and this is especially true when researching in the frontiers of science. Identifying the double helix structure of DNA was the start. There still remains the epic task of unraveling the code from 3 billion genetic letters of the human genome. The story of genome sequencing which is a laboratory process that determines the complete DNA sequence of an organism's genome at a single time- too is interesting, from which much can be learnt.

Today research in genomics and stem cell research are frontier areas. Stem cell research is an area that pushes the research frontiers into conflict areas, since ethical issues involving even possibilities of human cloning and designer babies are discussed. This possibility has led governments to declare off limits for certain areas of research. The cutting edge research on using genomics in eradicating diseases through early detection and treatment, as well as in finding cures for the so far known incurables etc. have immense possibilities. Genomics is supported by research on computing systems. It is inconceivable to think about modern day genomics without access to advanced computational facilities.

Human Genome Project (HGP) of United States is considered to be one of the most successful science programs supported by the United States Government. HGP was an international research effort to sequence and map all of the genes - together known as the genome

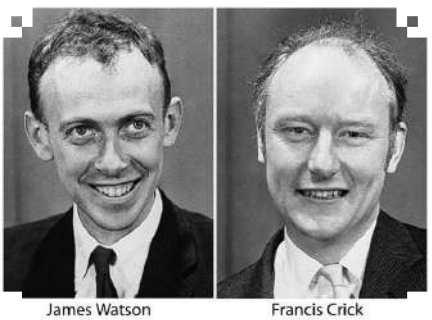


DNA-Helix

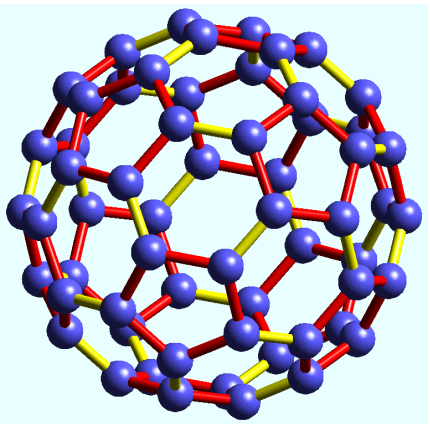
- of us, the human beings. The effort which was completed in April 2003 provided us the ability, for the first time, to read nature's complete genetic blueprint for building a human being. Craig Venter is a pioneering researcher who creatively increased the speed of the genome project through the introduction of information technology thereby revolutionizing the process. For Craig Venter who started with the Human Genome project in 1990, a decade of time, effort and intellect had to be invested before this announcement in 2000. Many a member of the team spent time and effort over this decade in deciphering the correct sequence of 3 billion letters.

Another emerging research frontier is Synthetic Biology which is the design and construction of new biological parts, devices, and systems, and is one of the most exciting emerging areas today with boundless opportunities. In 2010, Venter again grabbed the attention of scientists around the world by announcing what he calls the "world's first synthetic life". Venter's novelty had been a synthetic bacterial genome constructed from chemicals in the laboratory. He had then inserted it into a living bacterium. The cell replicated itself into a colony of organisms containing only the synthetic DNA. The replication process gave him the opportunity to claim the creating of the 'world's first synthetic life'. One area of application is production of fuels by specially engineered organisms. The potential prophesied with next generation biofuels certainly is quite interesting. The opportunities are not limited to fuels, but making medicine, combating climate change are all possibilities. Synthetic genomics may be the standard for making anything – a Venter prophecy. May be man will move from genomics to proteome, and another expansion to the frontier may happen. It is the research scientists imagination and the pioneering spirit that defines the frontiers and the research therein.

Nanotechnology is considered by many to usher in a new



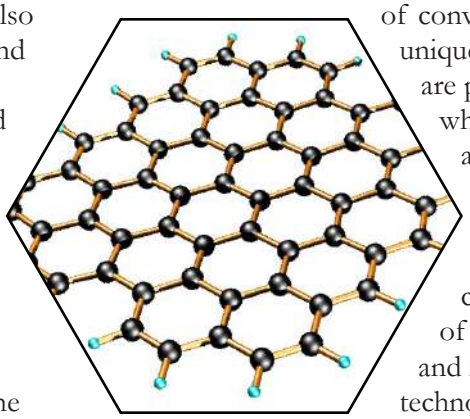
James Watson Francis Crick



Bucky Ball

world through its wide ranging opportunities. It is a science that is opening up numerous windows and all aspects of our lives are supposed to be touched and enhanced as a result of creative use of this technology. When Smalley, Kurl and Kroto discovered carbon buckyballs, it was not simply another addition to the family of carbon allotrophes. The buckyballs are set to revolutionise medicine and may even offer solutions to the modern scourge – cancer. Prof Ijjiam's subsequent research contribution with carbon nanotubes (CNT) could well transform construction, energy storage and transport, water desalination etc. Research has revealed the exciting properties of this material – thermal, structural and electrical etc. Research is now being carried out on applications and commercialization. Wearable electronic devices, shatterproof screens have already emerged into the commercial arena using CNT's. This stems from applied research and product developments. Each such development also requires retooling of manufacturing systems as well.

Going with carbon research, 2013 Nobel Physics prize when awarded to Andre Greim and Konstantin Novosolov marked the celebrated entry of another material – graphene. The European Union has currently initiated a research program with a funding of 1 billion Euros across 27 member states on graphene. Graphene is considered to be the material for the 21st century and research efforts are significant. Graphene has the potential to replace silicon as the material of choice in computer chips. However, Prof Novosolov has stated that he wants to peel of layers as he did with carbon with other elements of the periodic table. What additional frontiers may be opened up in material science can only be guessed! It is important to realize that this type of advanced research with material systems also require research and development of new and enhanced instrumentation systems. Series of research and development efforts led to instruments that enabled human beings to access the nano world thereby relegating the more humble optical microscopes perhaps to school laboratories. System developments such as Scanning Electron Microscopes and Scanning Probe Microscopes which are the workhorses for nano research, in turn yielded Nobel prizes for their respective developers. Thus it is seen that research and development in different areas coexist that enable growth, and when the frontier advances excitement beckons.



Graphene

The most advanced areas of research can be termed as frontier research. It still is basic research. You can seek frontier research in applied research areas as well. Basic research in Science and Technology is of critical importance though in circles where more economic ideas prevail, the discussion is almost taboo. Frontier research in any case requires research at and beyond the frontiers of understanding. What the economists see is the inherent risk of such ventures.

When research is at frontiers there is the blurring of discipline boundaries. In today's context multi disciplinary teams come into the fore. Today there is so much excitement at subject interfaces. The three dominant technology areas – information technology, biotechnology and nanotechnology are spawning many an area in areas of convergence. Almost unique developments are prophesied where all three are covered. Bioinformatics was the result of the convergence of biotechnology and information technology. Nanobiotechnology and bionanotechnology areas result from the interface of bio and nanotechnologies. The area where triple convergence occurs is an exciting frontier to be considered.

It is possible to derive an idea of where frontiers lie by looking at the emerging disruptive technologies. A Mckinsey Study recently indicated twelve disruptive technologies with trillion dollar impact possibilities to the global economy. This also implies areas of frontier research of today.

The areas identified are mobile internet, automation of knowledge work, internet of things, cloud, advanced robotics, autonomous and near-autonomous vehicles, next-generation genomics, energy storage, 3-D printing (additive manufacturing), advanced materials, advanced oil and gas exploration and recovery and renewable energy. One can identify that the emergence of these certainly would cause disruptions within the existing systems. As an example 3-D printing is poised to advance into bioprinting where organ

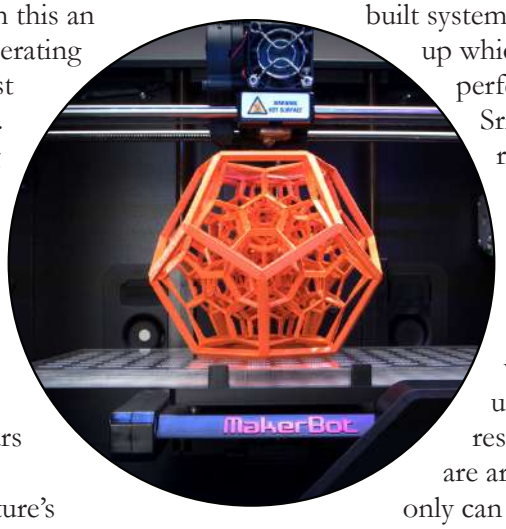
transplants will be made obsolete as what is missing or diseased will be 3-D printed with stemcell technologies. Advances in mobile technologies will bring in remote health monitoring and addressing any issues to be a normal activity. It is also easy to see that these are groupings, and within an individual sector many novel areas could be present. In renewable energy harnessing the sun is a priority as this points to energy self sufficiency to many an economy. While researchers are looking beyond the silicon PV cells what excites a researcher is that an ordinary plant leaf is receiving more than 10 million billions of photons of light each second. Human made molecular energy circuits which can capture, regulate, amplify and direct solar energy are receiving significant interest. We should not forget that most of the sun belt tropical countries including Sri Lanka currently faces significant issues with energy. Following from this an area that is generating quite an interest is Biomimetics. We are coming to understand that nature has so much to offer, and being a system which had millions of years in history, the richness of nature's embedded systems has much to offer. Janine Benyus who is the biomimetics pioneer, suggested making use of nature as a model and as a mentor and finally nature as a measure. The latter is to make use of what is present in nature to measure one's own systems as what is present today in nature, after all these are results of 3.8 billion years of evolution. This is already happening in Nanotechnology. Lotus effect, Salvinia effect and ghekko's feet are excellent examples already captured by science through understanding. Nanotechnologists look at self assembly as the final mechanism to built systems from bottom up which nature has perfected. Sri Lankan researchers through networking can engage in frontier research. If we strategically understand the research space there are areas where not only can we participate, but perhaps lead too. Biomimetics offer significant opportunities. The combination of indigenous medicinal systems with modern science is another area. If Sri Lanka understands the value of strategic investments as had been shown with Sri Lanka Institute of Nanotechnology (SLINTEC), host of other areas definitely can open up with possibilities such as advanced nanomaterials and applications, information technologies in interfaces, and renewable energy systems (biogas, microbial fuel cells etc.). With so many opportunities for engagement one should have an eco system which encourages and rewards young researchers to take on the seemingly impossible tasks than stick to well traversed pathways.



Scanning Electro Microscope (Courtesy - SLINTEC)



Transmission Electron Microscope (Courtesy - SLINTEC)



3D printing Machine



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Biotechnology for the improvement of the tea crop

Dr A. Kathiravetpillai



Tea is Sri Lankas prime agricultural asset accounting for 2.6 per each of gross domestic production. Among agricultural exports tea continues to be the major foreign exchange earner with 70 per cent the value of agricultural exports and 13 per cent of total export earnings.

Tea, *Commelia sinensis* (L.)O. Kuntze is a beverage tree crop native to south-east Asia and has been introduced into Sri Lanka from India during 1840s. It is a national commodity of Sri Lanka covering over 222,000 ha of the country and providing 12.8% of the export earnings of the countries economy. Sri Lanka is the second largest tea producing country in the world. Out of about 300 million kg produced annually approximately 92 per cent is exported.

Tea is a perennial crop grown in the low, mid and upper elevations in Sri Lanka.

Several authors have shown that the genetic base of cultivated tea is very narrow due to the recurrent use of same parents for the tea breeding programme over the years. The limited diversity of the crop bears with it several risks, including greater genetic vulnerability to pest and disease epidemics, lack of adaptation to climatic change related stresses, lack of genetic variation for specific quality traits reaching performance plateaus and causes conflict with the potential for sustainable genetic improvement in the long term. Breeding strategies in tea depend on its out breed nature, long generation time from seed to flower and its potential for vegetative propagation.

Although clonal selection has helped to increase yield it tends to exploit only the available natural variability which has been low due to the use of primarily a single seed source, Manipuri jat introduced from Assam. As a result the resultant progeny appear to be genetically less diverse than their parents. Since diverse germplasm is a fundamental requirement for crop improvement it has become essential to utilize non-conventional methods for broadening the genetic base. The variants generated through non-conventional methods could then be exploited in conventional breeding programmes to develop superior clones with a combination of desirable agricultural traits.

Micropropagation

Work on the micropropagation of tea was initiated at the Tea Research Institute of Sri Lanka during the latter part of 1984. The main objective was to investigate the possibility of propagation of tea by tissue culture. Work was initially carried out on clones TRI 2025, CY 9 and PK2. Shoot tips 4-5 cm in length were collected in polythene bags and the leaves with the petioles were stripped off as close as possible to the stem without damaging the axillary buds. As many as possible of the tightly furled leaves around the shoot apex were loosened and removed. They were then surface sterilized in chlorox solution and the shoot tips were then trimmed to 10-15mm in length It was virtually impossible to culture the shoot tips without contamination. However the level of contamination was reduced to about 25% using different media. Browning of the explants was a problem to start with but it was overcome by using the mineral salts at half strength and by adjusting the strength of the sterilant and sterilization time.

The shoot tip explants began to grow within one week of culture when the tightly furled leaves started to elongate and unfurl. The axillary bud of the nodal explant began to show signs of growth by the 2nd week (Fig 1). After 2 weeks the explants were transferred to fresh media with full strength mineral salts. The axillary buds of the shoot tips began to grow about the 4th week from explanting.



Fig. 1 - Growth of the explant within one week of culture.

Tea responds well to propagation by tissue culture and micropropagation of tea is a distinct possibility in the near future. Using this technique it would be possible to produce hundreds of thousands of clonal plants.

In another study micropropagated shoots of different clones were used to study the effect of auxins (IBA) on micropropagated shoots. The roots formed resembled a tap root system (Fig 4).

In a separate study cotyledon tissue was selected as the explants because it would be free of contamination. Pieces of cotyledon were taken and callus formation was induced and embryoid like structures were formed in 8-12 weeks. The embroids developed shoots and roots within one month of transferring to a medium with less sucrose (Fig.5). After one month in the regeneration medium these plants were successfully acclimatized to plant in the soil.

The present system of vegetative propagation alone is unable to meet the high demand of planting materials. The introduction of new clones takes near by 4-6 years which is the period required to establish the mother bushers for large scale supply. Therefore the use of *in vitro* multiplication technique will be useful in producing a large number of plants within a short period using a few stock plants. The development of a reproducible micropropagation technique for rapid multiplication using various explants is therefore an urgent need. With this primary aim in mind research has been initiated to establish protocols for manipulation of tissues *in vitro*.

In 1986 a method for surface sterilisation for various explants of tea was perfected (modal segments, shoot tips). Differentiated shoot organs as well as tissues (coylodons, stems and leaf tissues) were used as explants to achieve both direct and indirect plant regeneration through different development pathways.

In 1987 research on tissue culture focused on the induction of callus on various explants (cotyledons, leaf and stem) to regerate plants indirethy through the callus phase in colyladom explants. Although embroid structures were found to form in callus initiated from leaf tissue whole plants could not be regenerated.

A protocol for shoot multiplication using rodal explants was patented in 1990.

Efforts were carried out to perfect *in vitro* rooting for the micro shoots from nodal explants. Although the method developed was successful for young seedling explants several limitations were encounterel with clonal material. The major limitations were the contamination with explants, induction of rooting and the long procedure for hardening. At present efforts are being done to scaling up the system for micropropagation.

Haploid Production

Since tea is heterozygous and virtually a self incompatible perennial crop development of homozygous lines through conventional breeding is practically impossible. Therefore studies were undertaken to establish homozygous lines through anther and microspore cultures. In 1997 requirements for initiation of callus from anthers were established. Work is in progress to regenerate plants from anther induced calli.

Manipulation of reproductive cells has a great potential in plant biotechnology. Pollen protoplasts offer a superior source for cell fusion and mutation as they contain a haploid genome. A method for isolating protoplasts from germinating pollen tubes and characterization of the nuclear state of the pollen protoplasts has been established.

Somatic Hybridization

Somatic hybridization through fusion of protoplasms can be used to develop unique hybrids via sexual hybridization. In addition, protoclonal variations which may result in culture could produce novel genotypes with agronomically useful traits without any need for prior hybridization.



Fig. 2 - Growth of the explant and development of axillary buds (one week).



Fig. 3 - Growth of the explant and axillary buds (3-4 week). Note growth of axillary buds.



Fig. 4 - Proliferation of shoots. The large leaves have been trimmed to show axillary shoot development (5-6 week).

An isolated protocol that can release an adequate yield of viable protoplasts from leaf tissue has been accomplished recently. This was developed by optimizing the concentrations and combinations of the enzyme mixture etc.
As sustained cell division was not observed under the tested culture conditions current work is aimed at refining culture requirements which permit sustained cell division and to regenerate plants.



Fig. 5 - Proliferation of shoots in nodal explants.

Wide Hybridization

In the genus *Camellia* post zygotic incompatibilities are very common as the hybrid embryo dies at an early stage of the development in many years owing to endosperm incompatibility. Therefore by growing excised immature embryos *in vitro* it may be possible to rescue hybrid embryos and raise hybrid plants A protocol is now available for culture of embryos and hardening of plamlets raised from immature embryos.

In Vitro **Conservation of Germplasm**

Secure geneic stocks are fundamatal to crop improvement programmes. However the widespread cultivation of a relatively small number of cultivars with the aim of achieving high yield results in loss of diverse genetic materials.
Therefore to reduce the genetic erosion of such germplasm further it is necessary to preserve them for future exploitation. Under the existing *ex-situ* conservation of tea germplasm, establishment and maintenance of tea genetic resources are being carried out only as field gene banks. To further strengthen this *ex-situ* conservation use of *in-vitro* techniques for preservation of plant material is being investigated. In 1998 a preliminary study was undertaken to test the suitability of various explants for preservation under the slow growth method. To increase the rate of survival and revivng efficiency, encapsulation of explants is also being investigated. It is intended to carry out long term *in-vitro* preservation of plant material.

Isozyme Analysis

Conventional breeding methods like selection and hybridization have helped in providing over 60 clones of which 5-7 clones presently occupy over 80 per cent of the clonal extent. This accounts for about 50 per cent of the total Sri Lankan tea acreage. Furthermore of the popular clones 3-4 clones of the TRI 2000 series occupy a large extent. These clones have originated primarily from a single genetic source designated as ASM 4/10 and this has narrowed the genetic base. A detailed genetic analysis of the percentage of commercially cultivated tea based on their isozyme phenotypes, was undertaken in order to confirm the extent of genetic diversity and to check the existing information on perentages. Based on the isozyme on phenotypes of the two parents observed at the G/P locus the 85 clones tested were categorised into seven groups. On observing the isozyme phenotypes of the two parents with the offspring clones 41 out of 46 clones for which both parents were known confirmed the presence of parental bands. The parental analysis further revealed that out of the 46 clones all except four could be traced back to the single ASM 4/10 genotypes thereby proving the narrow genetic base.
A detailed genetic analysis of the percentage of commercially cultivated tea based on their isozyne phenotypes was undertaken in order to confirm the extent at genetic diversity and to check the existing information percentages.

Molecular Markers

Study on isozyme analysis in commercially cultivated tea clones have shown that the genetic diversity of our clones is very narrow. Work with DNA markers would provide an opportunity of allowing a higher level of variability. The results of this project will help determine the genetic identity and determine the genetic diversity between existing tea clones.

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Advances in Genetics and Stem Cell Research open New Frontiers

Dr Aruna Dharshan De Silva
Mr Harindra Sathkumara



Humans are a complex life form made up of trillions (~1012) of cells, the basic building block of all living things. We all start this amazing journey of becoming a full grown human from a single cell stage called a 'zygote' which results from fertilization of two gametes, one from each parent. But how does a simple single-celled zygote give rise to a multicellular organism with all of its specialized organs? The basis of growth and development of all biological systems is cellular growth, cell division, and cell differentiation. The perfect balance between these exquisitely choreographed sequential events is the key for human development, which entails growth from a single cell to an adult human being. A group of cells called 'stem cells' play a key role in the process of human growth to become an adult human from the zygote stage. So what makes the stem cells differ from other types of cells? Stem cells have a remarkable potential to self-replicate and to differentiate into many specialized cell types throughout the embryonic development and growth, rendering them one of the most fascinating areas to explore (Figure 1). But what truly determines who we are, is the genetic code (DNA) that is embedded in our cells which contains all of our genes. DNA was not known for carrying information in cells until 1944 when it was discovered by Avery, McLeod and McCarty as being responsible for transferring "genetic material". We now understand how we inherit

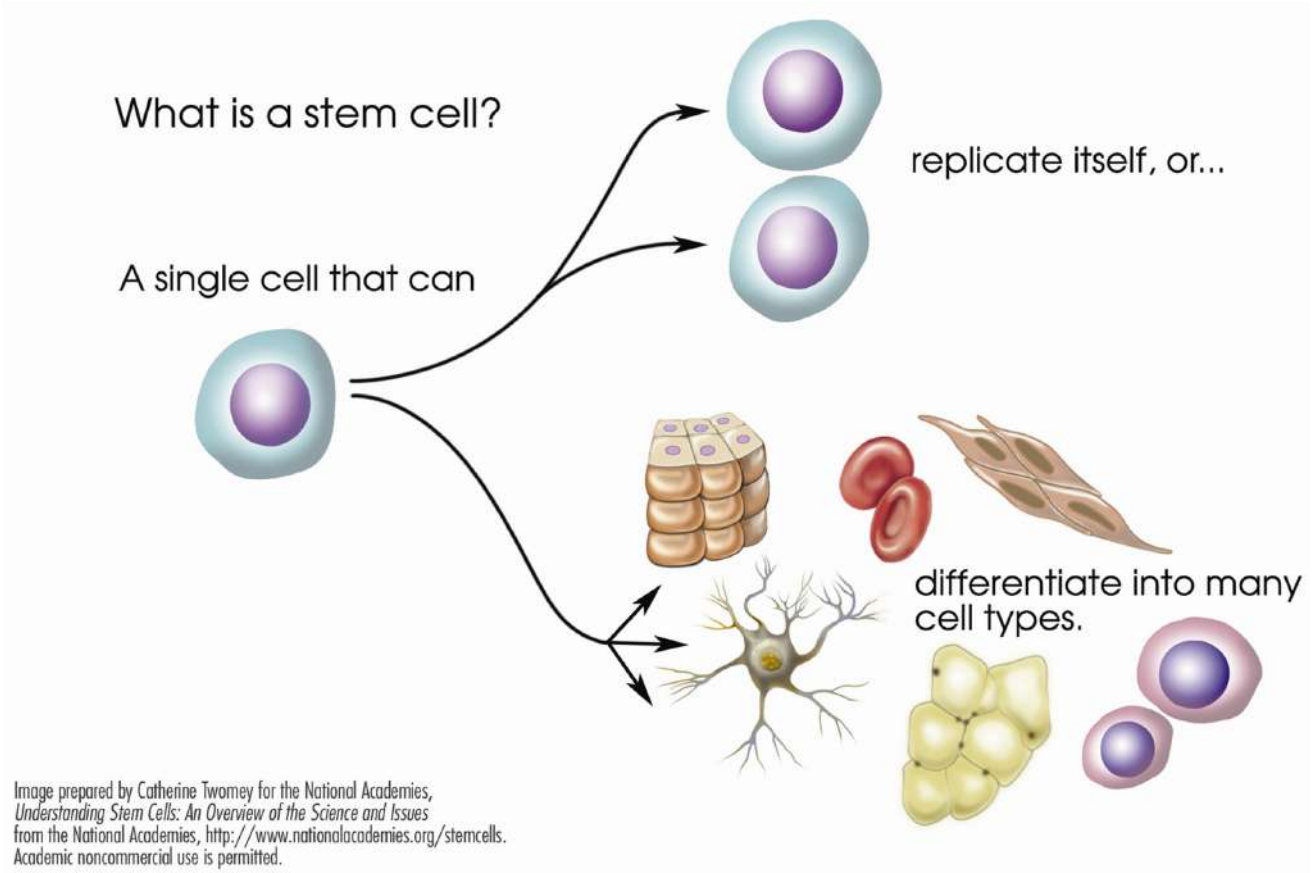


Fig 1: What is a stem cell?

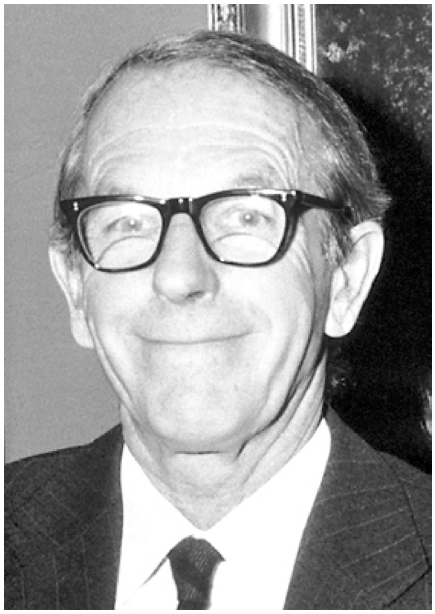


Fig 2: Frederick Sanger (1918-2013)

the characteristics or traits from our parents. This article outlines how advances in our knowledge of genomes and genetic sequencing have opened new frontiers in the areas of genetics and stem cell research.

Our genetic information is stored in the form of four bases (i.e. adenine (A), thymine (T), cytosine (C), and guanine (G)), arranged in different ways and in different lengths. This order spells out the exact instructions required to create a particular organism with its own unique traits. The human genome occupies about three billion (~3x109) base pairs and surprisingly only about 1.5-2% codes for a protein while a large portion of the genome consists of non-coding RNA genes, regulatory sequences, introns, and noncoding DNA. Furthermore all the cells in the human body contain the exactly same DNA or genome. If all the genes are directly expressed as they are, then all the trillions of cells in our body should be morphologically and functionally identical. Then what makes a skin cell different from a red blood cell or a neuron? The answer lies on how each cell deploys its genome, or in other words, how the combination of genes that are turned on (expressed) or turned off (repressed) determines its fate. With ever increasing enigmas, scientists began to realize that cracking the human genetic code would be the only way to decipher the unsolved mysteries behind the complex human living organism. It was believed that learning to decipher the DNA code may lead to revolutionary new ways to diagnose, treat, and someday prevent the thousands of disorders that affect us.

The Human Genome Project (HGP) revealed the initial draft of mankind's DNA sequence in 2001. The primary goal of HGP was to figure out the sequence of billions of letters that make up the human genome. . It was not an easy task deploying the effort of hundreds of scientists across dozens of countries, and costing over three billion dollars (US$ ~3x109). It took thirteen years (1990 to 2003) to sequence and map all the genes in this effort. Development of the chain termination method (commonly referred to as the Sanger method) by Sanger and colleagues in 1970s was considered the gold standard for nucleic acid sequencing for the subsequent two and a half decades, that established the groundwork for decades of sequence-driven research that followed. The most notable use of Sanger technology in DNA sequencing was the HGP. Frederick Sanger (Figure 2) won his

What NGS does?
• NGS provides a much cheaper and higher-throughput alternative to sequencing DNA than traditional Sanger sequencing. Whole small genomes can now be sequenced in a day. • High-throughput sequencing of the human genome facilitates the discovery of genes and regulatory elements associated with disease. • Targeted sequencing allows the identification of disease-causing mutations for diagnosis of pathological conditions. • RNA-seq can provide information on the entire transcriptome of a sample in a single analysis without requiring previous knowledge of the genetic sequence of an organism. This technique offers a strong alternative to the use of microarrays in gene expression studies.
And limitations
• NGS, although much less costly in time and money in comparison to first-generation sequencing, the initial costs are too high for many labs. NGS platforms can cost more than $100,000 in start-up costs, and individual sequencing reactions can cost upward of $1,000 per genome. • Inaccurate sequencing of homopolymer regions (spans of repeating nucleotides) on certain NGS platforms, including the Ion Torrent PGM, and short-sequencing read lengths (on average 200–500 nucleotides) can lead to sequence errors. • Data analysis can be time-consuming and may require special knowledge of bioinformatics to garner accurate information from sequence data.



Fig 3: Popular NGS platforms currently available at the market

second Nobel Prize in 1980 for his contribution in the determination of base sequences in nucleic acids. An educational animation on how Sanger method works in relatively modern automated sequencers can be found at Wellcome Trust Sanger Institute's website. http://www.wellcome.ac.uk/Education-resources/Education-and-learning/Resources/Animation/WTDV026689.htm

Sequencing technology has evolved at a very fast pace over the past ten years, and the Sanger method has now been partially replaced by several next generation sequence (NGS) platforms that offer dramatic increases in cost-effective sequence throughput, which have had a tremendous impact on genomic research. The most remarkable feature of NGS technologies is its capacity to perform massively parallel sequencing, during which millions of fragments of DNA from a single sample are sequenced simultaneously allowing an entire genome to be sequenced in a very short time in contrast to decades with Sanger. Several NGS technologies (2nd generation) have been developed using varied approaches since the HGP, each with its own unique strengths and shortcomings (Figure 3).

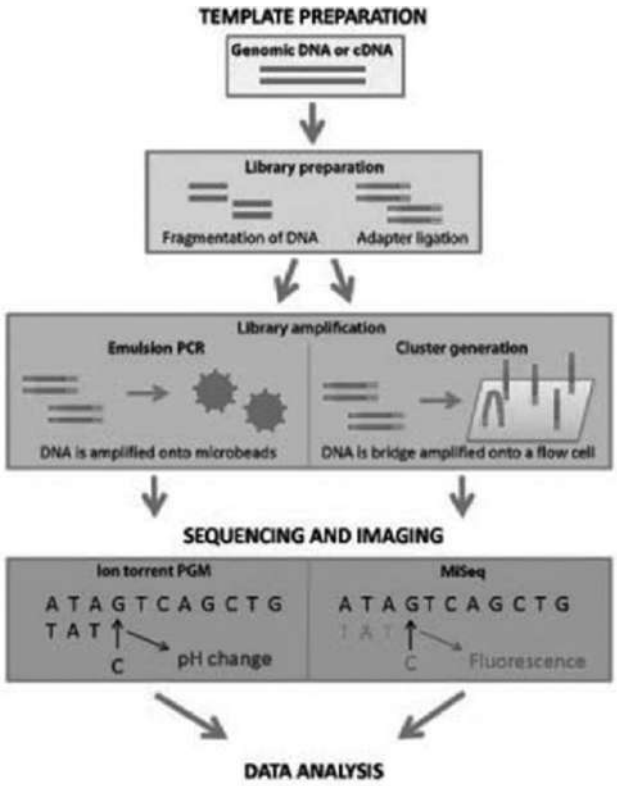


Figure 4: Basic workflow for Ion Torrent (left) and illumina MiSeq (right) sequencing technologies

Although each NGS platform is unique in how sequencing is accomplished, the Ion Torrent PGM and the Illumina MiSeq have a similar base methodology that includes template preparation, sequencing and imaging, and data analysis (Figure 4). Both platforms are more popular and currently available in Sri Lanka.

Table 1 shows some characteristic features of high-end 2nd generation sequencing platforms and more recent bench-top platforms. While Ion Torrent relies on detection of pH changes that occur during the incorporation of nucleotide into the growing DNA strand, in the MiSeq, template molecules are sequenced in a massively parallel fashion using a DNA sequencing by synthesis (SBS) approach and relies on the detection of fluorescence generated by the incorporation of fluorescently labeled nucleotides into the growing strand of DNA (Life Technologies and Illumina's company websites have more info).

Regardless of the different sequencing approaches, all NGS platforms have enabled scientists to

Table 1: Characteristic features of 2nd generation sequencing platforms 5

High-end sequencing- Platform†	Sequencing chemistry	Read lengths/ through put	Run time	Template prep	Application
Roche 454 -Titanium FLX	Pyrosequencing	400 bp 400 Mb/run	10 hours	Emulsion PCR	Denovo WGS of microbes, pathogen discovery, Exome seq
Illumina/Solexa -HiSeq 2000	Reversible terminator chemistry	2×100bp 600 GB/ run (dual cell)	11.5 days	Solid-phase	Human WGS, exome seq, RNA-seq, Methylation
ABI/LifeTechnology-SOLiD 5550XL	Sequencing by ligation	2×60bp 15 GB/day	8 days	Emulsion PCR	Human WGS, exome seq, RNA-seq, Methylation
HelicosBiotechnologies	Reversible Terminator chemistry	25-55 bp 28 GB/run (avg)	>1 GB/hour	Single molecule	Human WGS, exome seq, RNA-seq, Methylation
Roche 454- GS Junior	Pyrosequencing	400 bp 50 Mb/run	10 hours	Emulsion PCR	Denovo WGS of microbes, pathogen discovery, Exome seq
Illumina/Solexa- MiSeq	Reversible terminator chemistry	2×150bp 1.0-1.4 Gb	26 hours	Solid-phase	Microbial discovery, Exome seq, Targeted capture
ABI/ Lifetechnology- Iontorrent	H+ Ion sensitive transistor	320 Mb/run	8 hours*	Emulsion PCR	Microbial discovery, Exome seq, Targeted capture

*Sample preparation – 6 hours, sequencing time – 2 hours, †Data shown here represent the highest figures currently available on the company website and is highly likely to change by the time this article is published

not only sequence a whole genome of a human in a week, but also to appreciate the new aspects of the sequencing such as advances in the characterization and quantification of transcriptomes using RNA-seq. Most importantly previously unknown coding and non-coding RNA species, particularly small RNAs, including microRNAs (miRNA) and small interfering RNAs (siRNA) which seem to play a pivotal role in gene expression regulation in patients with certain disease conditions such as cancers. Currently, scientists are hard at work interpreting the genome. While not every difference is consequential, some of these differences are responsible for how we look, how we act and even how likely we are to get sick or to respond to specific medicines. Better understanding on how disparities between our genomes account for these differences is sure to change the way we think. The applications of NGS seem almost endless, allowing for rapid advances in many novel fields related to the biological sciences including analysis of epigenetic modifications and metagenomics.

With all the sequencing information in hand, scientists were not keen on assessing the impact of genes of interest in an *in vitro* disease model No 5, preferably an animal model since human is the mammal we cannot use for genetic experiments for obvious ethical reasons. Interestingly, mice naturally develop conditions that mimic human disease. Recent development in molecular biology and stem cell biology has allowed scientists to induce diseases in mice by manipulating its genome or to create custom-made mice through a process called site-directed mutagenesis in mouse embryonic stem (ES) cells. There are 2 major mice genetic mutation models, transgenic and knockout. In transgenic mice, an additional piece of DNA is inserted and depends on the expected goals of the experiment; mice will exhibit different expression levels of proteins, such as GFP (Figure 5). Functional aspects of a protein can only be learnt by deleting the gene that codes the protein or the deletion

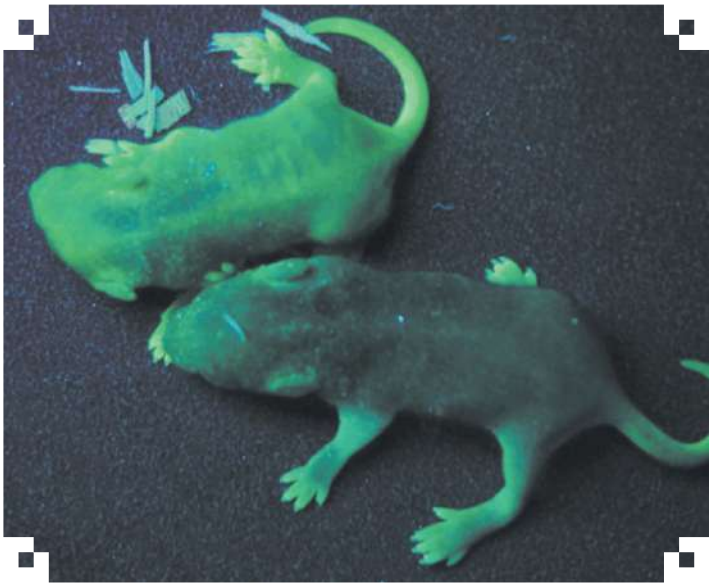


Fig 5: Transgenic mice expressing Green Fluorescence Protein (GFP)8



Fig 6 : Mario R. Capecchi

of a functional domain of the protein. This can be achieved by using gene knockout mice. Dr. Mario R. Capecchi (Figure 6) of the University of Utah won the 2007 Nobel Prize in Physiology or Medicine for his pioneering work on knockout mice technology. This technology has given scientists worldwide; an amazing set of tools to make important discoveries about how defective genes could lead to human diseases.

Mutations (either inherited or sporadic) in the coding sequence (CDS) and/or defective gene expression mechanisms have been found to cause a spectrum of diseases in humans, ranging from obesity to cancer. Bone marrow transplantation (BMT) has now been considered the most effective way of treating a number of blood cancers and primary immunodeficiency disorders (i.e. leukemia, severe combined immunodeficiency). The driving force behind BMT is the hematopoietic stem cells. BMT replaces damaged stem cells with healthy ones, which give rise to blood-forming cells, restoring the normal function.

Stem cell research and gene therapy studies hold great promise of bringing new ways of identifying potential disease targets and developing novel therapies. There are 2 types of stem cells, embryonic stem(ES) cells and adult stem cells. While ES cells can generate all types of cells, adult stem cells can differentiate to yield the major specialized cell types of the specific tissue or organ. For instance, adult stem cells in heart can only give rise to heart tissues. Ongoing stem cell research has passed major milestones over the last few years and is rapidly moving towards achieving the ultimate goal of personalized medicine. Some research groups have already taken initiative to test possibilities of making specialized disease cells using induced pluripotent stem cells (iPSCs) thus the efficacy and safety of various existing and novel drugs could be tested on the cultured cells instead of directly on the patient. This will allow us for the first time to figure out what exactly has gone wrong in rare genetic diseases such as Riley-Day syndrome(disorder of the autonomic nervous system). Regenerative medicine is also moving towards a day when we can repair and replace damaged tissues like we have seen in many futuristic science fiction movies. Scientists have already been able to successfully grow whole functional organs not only inside a living organism (a thymus inside a mice) but also in a research lab (a lab-grown rat kidney is shown in Figure 6). Gene therapy is rapidly moving forward with advanced knowledge in genetics and breakthroughs in the understanding of stem cell functions. In time, we will be able to seek treatments such as insulin-secreting pancreatic cells, bone cells capable of healing breaks and defects, and eye and ear cells to restore vision and hearing.



Fig 7 : Lab-grown rat kidney 10



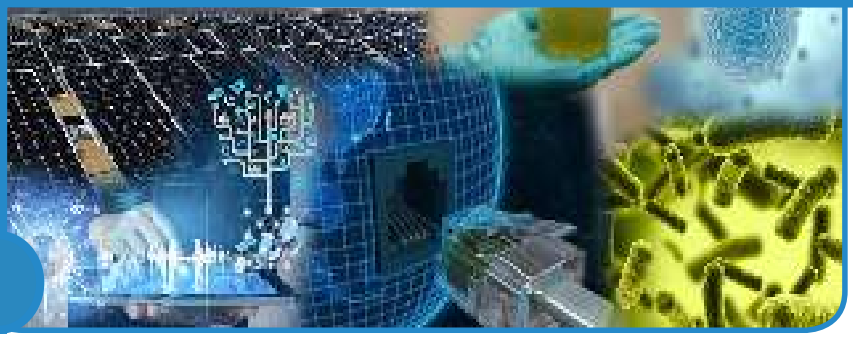
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14 Tech Predictions for our World in 2020

Fulvia Montresor



We asked our 2015 intake of Technology Pioneers for their views on how technology will change the world. From printable organs to the "internet of everywhere", here are their predictions for our near-term future.



(1) The 'humanized' internet

The evolution of modern connectivity is often summarized as: the internet – the world wide web – mobile devices – big data/the cloud – the internet of things. For the next stage, it seems inevitable that even more personalization will be an important component. What we refer to as the internet of things will be central. However, more than simply connecting humans with devices, the next stage in connectivity will include "humanized" interfaces that constantly evolve to understand the user's patterns and needs and, in a sense, self-optimize. This would include the functions and features on our devices, as well as the selection/curation of information we receive. It may not be the kind of artificial intelligence found in science fiction, but I expect this injection of personalization will bring monumental changes as our level of connectivity continues to grow. Sirgoo Lee, co-CEO of Kakao

(2) The end of the 19th-century grid

One of the biggest changes we will see, or at least have made substantial progress towards 2020, is global electrification. In the US and Europe, most people take electricity for granted. But that is not the case in many parts of Latin America, Africa and Asia. More than 1.3 billion people still aren't connected to the grid. More than 1.5 billion people still don't have regular access to electric light: they use oil lamps, which are a safety hazard. Even where the grid exists, it is fragile: power blackouts are a major problem in many megacities. Power theft also plagues Brazil, India and South Africa. Safe, reliable power will have a transformative effect on these countries. Not only will there be near-term benefits such as greater productivity, but we will see long-term quantum leaps in educational achievement, healthcare and quality of life. These communities don't have power now because our 19th-century grid is too expensive. The advent of new technologies is changing both the business models and use-case scenarios to make it possible. In a few years, the world will finally, truly, be wired. Amit Narayan, CEO of AutoGrid





(3) The end of scarcity

The world said humans were not meant to fly, and hundreds of years of human invention had been unable to make it work. But in a small bicycle-repair shop, two brothers with no government funding and only a basic education had a vision and a will to invent. And in 1903, thanks to the determination of these two unsuspecting inventors, humans flew. The distance of the first human flight was 120 ft. Years later, one of the inventors of that breakthrough would marvel that the wingspan of modern airplanes

was longer than the entire distance his first plane had flown. The potential of technology is limited only by our imagination and our will. Abundance of water, food, clean air … peace: the end of scarcity in the supply of our basic needs is possible. Perhaps not by 2020, but it starts with the dream, the determination to turn dreams into reality, and the understanding of this truth, so well embodied in the invention and rapid evolution of human flight: that all things are possible. Mark Herrema, CEO of Newlight Technologies



(4) Fewer fancy phones, more fulfilment

The world many of us live in is changing at an exciting pace. Innovations are generating new gadgets, more convenient services and greater opportunities. But many of these changes target a small percentage of the globe's population. In the villages I've worked in, nobody has seen an iPhone or can download an app. However, there is tremendous room for entrepreneurs to adapt innovations intended for the wealthy to serve the world's poor. Solar panels and LED lights, designed for sale in rich nations, are stimulating growth in commercial off-grid electrification in India and Africa. Mobile telecommunication is being used to facilitate financial inclusion in developing countries across the world. Once-expensive

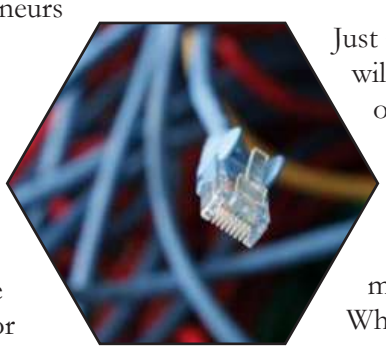


medical procedures can be done amazingly cheaply. Even the financial sector is innovating in order to reach the world's poor; as well as investors looking for opportunities that not only help them increase their net worth but also improve the world. Better financing opportunities are opening up for social entrepreneurs who build businesses to serve the poor profitably. I see a slight but significant shift in innovation, that instead of producing fancier phones, we will create more fulfilling lives for people who have been mostly ignored to date. Nikhil Jaisinghani, co-founder,Mera Gao Power

(5) Cheaper, more widespread solar power

By 2020, solar technologies could account for a significant portion of global power generation, helping economies and businesses guard against rising energy costs and the impact of climate change. However, finding opportunities to further reduce the cost of solar technologies will be key to unlocking this potential. Because polysilicon, the primary raw material used by solar module manufacturers, is the single largest cost in the solar supply chain, it represents the most significant opportunity for cost reduction. Over the next several years, new lower-cost methods of polysilicon production will commercialize, providing the solar industry with a more affordable source of raw material. In turn, these cost improvements will trickle down throughout the solar supply chain, accelerating the adoption of solar energy around the world and helping the industry realize its global potential. Terry Jester, CEO of Silicor

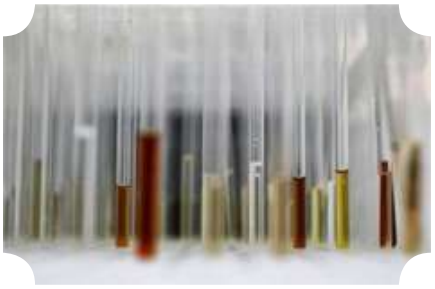
(6) Internet of things no longer about things



Just about every business will become an internet of things (IoT) business. The convergence of the digital and physical worlds makes this inevitable. When the products companies sell are connected 24/7/365, dynamic and ever-improving value can be delivered to customers throughout the product's life cycle. This will become the norm. Therefore, launching a successful IoT business requires a fundamental shift, a transition from product-centric to service-centric business models. Companies looking to capitalize on IoT will become IoT service businesses. Operations dependent on one-time product sales will become obsolete as business value moves from products to the experiences they enable. This transformation will fundamentally change how businesses operate,



interact with customers and make money. Those who recognize that the internet of things is not about things but about service will be positioned to meet these new customer demands, unlock new sources of revenue and thrive in this connected world. Jahangir



Mohammed, CEO of Jasper Technologies, Inc

(7) New cures from the bacteria that live in the human body

In life sciences, we will have greater understanding of the dynamics of how our microbiome – the tiny organisms, including bacteria, that live in the human body – influences multiple systems in our body, including our immune systems, metabolic processes and other areas. This will result in seminal discoveries related to a variety of conditions, including autoimmune diseases, pre-term birth and how our metabolism is regulated. Regenerative medicine approaches to creating new tissues and organs from progenitor cells will expand significantly. Finally, the long-awaited ability to employ precision medicine, providing specific treatments to a specific patients, will become much more common. Mark Fischer-Colbrie, CEO of Labcyte Inc

(8) The beginning of the end for cancer

The emergence of real-time diagnostics for complex diseases will mark the beginning of the end of their debilitating reign by 2020. The ability to monitor cancer, the dynamic immune system, intestinal flora and pre-diabetes in real-time will change the nature of medicine and usher in a new era of human health where wellness is protected versus illness treated. As a result, fundamental shifts in healthcare will occur, causing it to become largely preventative rather than fire-fighting. It is far more productive and economical to stop a fire from happening in the first place than to rebuild something after the fire has taken its course. Helmy Eltoukhy, CEO of Guardant Health

(9) Data-driven healthcare



The amount of data available in the world is growing exponentially, and analyzing large data sets (so-called big data) is becoming key for market analysis and competition. Analytics will dramatically shift away from reporting and towards predictive and prescriptive practices, dramatically improving the ability of healthcare providers to help the ill and injured. Even more importantly, it will create the possibility for truly personalized healthcare by allowing providers to impact the biggest determinants of health, including behaviours, genetics and environmental



factors. John L Haughom, MD, senior advisor, Health Catalyst



(10) Printable organs

Today, we are already at a turning point in our ability to 3D "bioprint" organ tissues, a process that involves depositing a "bio-ink" made of cells precisely in layers, resulting in a functional living human tissue for use in the lab. These tissues should be better predictors of drug function than animal models in many cases. In the long-term, this has the potential to pave the way to "printing" human organs, such as kidneys, livers and hearts. By 2020, our goal is to have the technology be broadly used by pharmaceutical companies, resulting in the identification of safer and better drug candidates and fewer failures in clinical trials. Keith Murphy, CEO of Organovo

(11) The 'internet of everywhere'

We are on the verge of the "internet of everywhere". It will be far more democratic: accessible to everyone, rich and poor. The excitement of the internet of things will be a small footnote in history as the internet of everywhere becomes our reality. Do you remember the old movie, Minority Report, with Tom Cruise? Ultra cheap, internet-enabled solar-powered screens that display in HDTV resolution will be on bus stops, in shopping centres, at tables in restaurants – all operating on a centralized advertising model. Gone are the days of the static acetate poster on the wall of a shopping mall. And finally, since these HD monitors have beacons, they will



dynamically change content as your phone passes by, telling the monitor all your preferences. Yobie Benjamin, COO of Avegant

(12) Renewables will power mobile networks

We have become dependent on mobile communications in our daily lives, but the dirty secret is that mobile networks around the globe are notoriously energy inefficient. In fact, we are stuck with outdated mobile network technology that basically performs as poorly as incandescent lightbulbs, with the result that 70% of the energy used is wasted as heat. By 2020, we predict that pioneering innovations in radio engineering will have a positive impact on the world's economy, environment and quality of life. We even foresee a time when advances allow renewable energy to power the mobile industry, helping bridge the digital divide and extend communications to the 1.7 billion people living off-grid. Mattias Astrom, CEO, Eta Devices

(13) Learning on the job will never stop



The skills gap is actually an information gap. The problem is not that workers are unskilled; it is that workers do not know what skills employers need. Technology is already disrupting existing jobs, and creating new jobs that never existed before. In fact, the top 10 in-demand jobs in 2010 did not even exist in 2004. Change is happening so rapidly that 65 percent of today's grade school kids in the U.S. will end up at jobs that have not even been invented yet. How will our education institutions keep up? Today, there is a disconnect between education providers and employers.
In the future, however, technology will enable education and training to respond dynamically to real-time labor market changes. With widespread access to training and courses online and available on-



demand, workers can be informed of skill updates while they work, and will regularly top up their education with the skills they need to remain relevant in the workforce. Alexis Ringwald, Cofounder and CEO, LearnUp

(14) Wastewater is an asset, not a liability

Water is one of our most precious resources, yet our infrastructure is failing. Driven by global population growth and rising water scarcity, the UN reports that 75 percent of the world's available freshwater is already polluted. Under-investment in water management is exacerbating the problem, causing serious impacts on human health and the environment. A key challenge is the high capital cost, and high energy requirements, of current wastewater treatment and management systems.
By 2020 I predict that a new class of distributed systems, powered by advances in our ability to use biotechnology to extract resources, such as energy, from waste, and the dropping cost of industrial automation, will begin to change our approach to managing water globally. Rather than a liability, wastewater will be viewed as an environmental resource, providing energy and clean water to communities and industry, and ushering in a truly sustainable and economical approach to managing our water resources. Matthew Silver, CEO of Cambrian Innovation
Author: Fulvia Montresor is Director, Head of Technology Pioneers for the World Economic Forum
All images provided by Reuters.



Fulvia Montresor
Director
Head of Technology Pioneers
World Economic Forum
(Source : https://afenda.weforum.org)

Are Plastics suitable for Packaging Food

Gemunu Saliya Perera



Modern changes in food technology and food consumption habits have made our lives more comfortable. However, recent research is in the process of proving that by being attracted to comforts and modernization, and not taking certain factors into consideration there is the possibility of subjecting our health to grave risks.It should be recognized that consumption of healthy food and food safety depends not only on what we eat but also on how food is packaged, prepared, stored, and on the utensils and equipment used in the preparation of food. It is beneficial for all consumers to be aware of the possible injurious effects on public health of the commonly used polythene shopping bags and food packaging in plastics.

How are plastics injurious to health?

The primary origin of plastics is petroleum. Plastics are categorized into many types based on their composition. (The code number is indicated on the bottom of plastic containers)
01: PET/PETE – Polyethylene Terephthalate (code number #1) used in the production of bottles for water and soft drinks.
02: HDPE : High density polyethylene (#2) Plastic chairs, various goods, containers
03: PVC – Polyvynyl Chloride (#3) PVC pipes, packaging for certain foods
04: LDPE – Low density polyethylene (#4) Types of plastic cans, toys
05: PP – Polypropylene (#5) – Shopping bags, lunch sheets etc.
06: PS – Polystyrene (#6) Rigitorm, lunch boxes etc.
07: Polycarbonate plastic (#7) – Very strong plastic equipment and containers.
Out of these the internationally recommended (as less dangerous plastics) for packaging foods use the types HDPE - #2, LDPE - #4 and PP - #5. The fact that plastics are not a harmless type of material has been experimentally confirmed over about 50 yrs ago. The various toxic chemicals that are added to plastics or present in the plastic itself are commonly and generally refered to as "plasticizers".When food is packed in these plastic containers plasticizers leach into food with time.This leaching process is activated by temparature, oil and alcohol. In addition when food placed in plastic containers is cooked in microwave ovens, when plastic vessels are washed with detergent type soaps, when they are expossel to sunlight or when crushed or scraped, the plasticizers get mixed into food. (It has been found that from "PET" bottles alone 19 dangerous chemicals have been found to leach out.) Among these following chemicals have a greater effect on human health.

Phthalate

Phthalate is used to soften and make the plastic flexible. Phthalate is a caroinogen. It has a strong



Prof. Shana Swan

effect in bringing about hormonal changes and is a powerful endocrine disrupter. It has been discovered that phthalate has damaging effects even in very small concentrations. In an experiment conducted by the Enviromental Health section of the Harvard University it has been confirmed that in the urine of males with sub fertility, phthalate constituents are high and the DNA in their sperms was mutated (The reason for infertility is the mutation of DNA)
According to studies carried out by Professor Shana Swann of the Section an Obstetrics, Gynaecology and Reproduction at the Rochester, Medical University, mothers who had excessive amount of phthalate in their urine have given birth to children with very little space between the reproductive system and the anus and also their reproductive organs were very small in size and their testicles were positioned in an irregular manner. A group of scientists working in the United States at the centre investigating the factors adversely affecting the human reproductive system has stated that in comparison with adults, phthalate has greater effects on small children, and it may contribute specially to weaken the reproductive capability of boys.


Prof. Fedrick Vomsal

Bisphenol A/BPA

This is a building block of thick plastics and is responsible for the transparency and strength of plastics, and also important in its ability to resist vibrations and shock. Plastics with BPA is used in the manufacture of various items such as vessels used in the kitchen, items used in the storage of food, plastic cups (travel mugs), water bottles, bottles for storing mineral drinks, the thin film covering the inner face of food storing tins (tinned food), plastic products for infants, bottles for infants, mobile phones, sun glasses and compact discs. Bisphenol A exhibits characteristics similar to that of the human hormone oestrogen. Xenoestrogen is a synthetic oestrogenic compound. Research has proven that it affects the endocrine system and the reproductive system. Also it is 100 times stronger than the natural hormone oestrogen.
Entry of BPA into the body may cause many health problems such as infertility, prostrate cancer, breast cancer, early puberty in female children, obesity and type 2 diabetes. Therefore Professor Federicle Wamsal has pointed out that exposure especially of pregnant mothers, infants and youth is dangerous.

Acetaldehyde and other types of aldehydes

These are colourless and possess a characteristic fruity smell. These chemicals may cause cancers and many other health problems. These may be present in greater concentrations in cool drinks and sweetened drinks and in bottles which have been subjected to temperatures of about 600 C.

Antimony

Antimony is added during the process of plastic (PET) manufacture. Recent research carried out by William Shotyk – a famous German scientist, has discovered that Antimony which is a heavy metal with harmful effects is present in the drinking water stored in plastic bottles. Research has also found that in foods packed or stored in "PET" bottles the concentration of Antinomy increases considerality after the expiry of 3 months, and relative to the time period. (This research calls to attention to reconsider the expiry period of 2 years specified for water and cool drinks stored in plastic bottles.)

Dealing with packaging of food in plastics

• In European countries the use of plastics with Phthalates and Bisphenol A in infant products, toys and food packaging has been prohibited or subjected to rigid

limitations (Example Canadian Department of Health Phthalate Regulation, Canada Gazette 2009. June 20 [accessed 14 November 2009].
• In America in the state of San Francisco the use of "PET" plastic bottles has been completely prohibited.
• The Government of India has legal provisions to prevent the use of plastic packaging with phthalate in packing pharmaceuticals.

The Standards for plastic food packaging in Sri Lanka

• It is satisfying that a reasonable step has been taken to control to some extent the use of food packaging materials which are injurious to health. In this regard, by 2010 instructions issued by the Ministry of Health on each food package, requires the printing of the following statement. "To be used for food", or the relevant symbol. In addition, it should also indicate any special conditions that should be followed when using them, including the name and address or registered trademark of the manufacturer. Instructions also indude that recycled plastic should not be used in packaging.
• Medical specialist Dr. Waruna Gunathilake of the National Toxic Information Centre Sri Lanka has stated that experiments have shown that the risk of developing many health problems including cancers and dangerous respiratory problems are at a high level, due to the packaging of food in wrappings and containers manufactured using various types of plastics. These include even the teats and soothers for infants.
However many school children, teachers as well as health workers carry drinking water in re used PET bottles due to being ignorant of the adverse effects of plastics. Many house wives use the immersion heaters to heat water and make tea in the plastic vessels of low quality having the above mentioned toxic substances. Most food items such as "bites" "mixture" murukku, wade and pattices are deep fried in oil brought in PET bottles and polythene shopping bags. Presently many people in Sri Lanka use grocery bags for carrying coconut oil. Steaming hot rice and the koththu are wrapped in "lunch sheets". Curries are supplied in "grocery bags". One can imagine

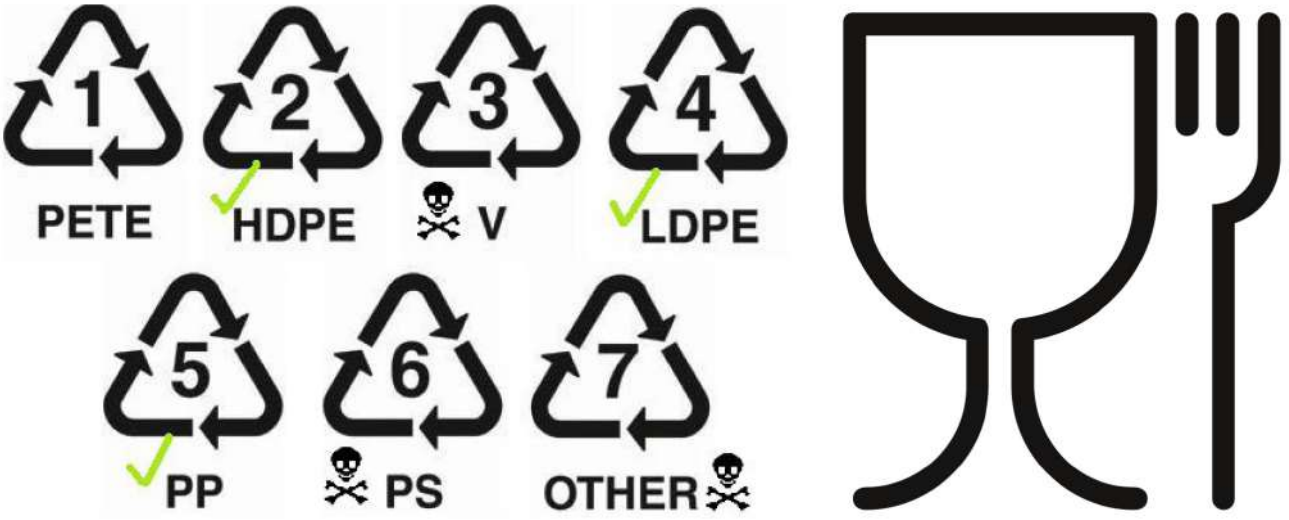
Limit as far as possible the use of food and drink packed in plastics and polythene. Try to see the extent to which plastic vessels without a code number, a trade mark or any, standard or any are used in your household to store food.

the exlent of undesirable effects on our health through the use of plastic and polythene to store salt (substituted for the humble Lunu pol katta or coconut shell) bite packet, ice packets, lime pickle, water, various fruit and other drinks, as plates, to drink tea in, and many more.

How can the plastic risk be minimized

The following advice can be suggested for the benefit of those who are concerned about their health and the health of their family by preventing the problems that may arise by using plastic and polythene food packaging.
• Limit as far as possible the use of food and drink packed in plastics and polythene. Try to see the extent to which plastic vessels without a code number, a trade mark or any, standard or any are used in your household to store food.
• Do not use acidic, hot, as well as food containing alcohol stored in plastic vessels. (These conditions enhances the leaching of toxic chemicals in plastics).
• Filter the water stored in plastic containers using a Reverse Osmosis water Purification Filter before drinking, or using for cooking. (The cost of one of these filters with lowest capacity is about Rs: 40000/=)

• If you are using a plastic water tank for strong water check whether the tank is manufactured out of material approved for use in food storage. Also never keep such plastic tanks so that they are exposed to sun light.
• Do not use plastic infant bottles, soothers teats and other infant products.
• Do not use plastic vessels for cooking in microwave ovens.
• Do not use shopping bags and grocery bags to carry cooked food, sugar, tea leaf, coconut oil, meat, fish and other food substances. (During the manufacturing process talcum powder is used to prevent the bags from sticking to each other. The frequent entry of



talc into the body causes many health problems. Also the harmful dyes that are used to colour the shopping bags may get leached into the food).

• Pay attention to the use of alternate vessels made of stainless steel and pyrex to carry rice instead of using "lunch sheets"

• Do not reuse over and over again the PET bottles for carrying drinking water. Use glass bottles or stainless steel bottles for the purpose.

• If it is essential for you to use plastic bottles use bottles made of a food grade plastic type but not made out of PET plastic.

• Do not purchase water stored in plastic bottles and kept exposed to sun light. (The harmful chemicals in plastic leach). The leaching of harmful chemicals in plastic increases 55 fold at higher temperatures.

• Discard the old, damaged plastic vessels.

• Take extra care when using plastic ware for women in reproductive stage, pregnant mothers, infants and children.

• Do not inhale the smoke produced when plastics and polythene are burnt, as extremely harmful chemicals such as Dioxins and Furans are released from them during burning. Many housewives in this country use "shopping bags" even to light the hearth.

• Avoid purchasing tinned food as far as possible. It is very likely that with time the film of B.P.A applied on the inner face of the vessel to prevent the metal Tin (Sn) reacting with the food in the vessel (tin container), will dissolve and leach into the food.

• Include more foods containing folic acid and fresh vegetables and fruits to your meal (examples, leguminous pulses, fresh dark green vegetables, fruits, eggs). It has been found that these foods reduce the harm caused to the developing embryo, and also reduce the B.P.A concerntration in the blood.

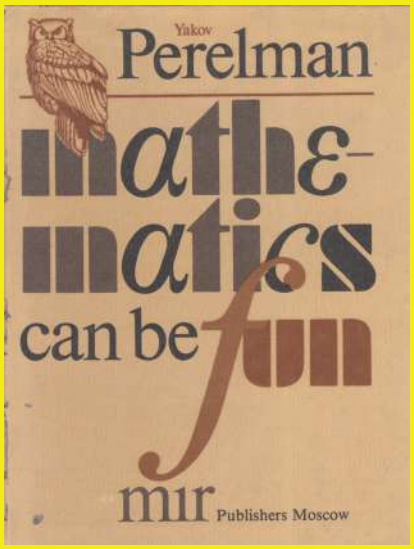
• Use traditional, alternative food packaging materials vessels such as reed bags cloth bags, clay, glass, pyrex and rust resistant steel, and porcelain vessels.

• Drink king coconut water which is more beneficial to health and has more nutritive value, intead of purchasing bottled drinking water and cooled bottled drinks. When travelling a long distance take your drinking water in a suitable bottle.

Our bodies have a remarkable ability to act against various toxic substances and infections, and has the capacity to protect itself from many toxic substances. However, there will reach a point when artificial toxic substances enter the body over a prolonged period and get stored, and the body will not be able to withstand them anymore. So it is extremely important to take the necessary precautions to protect ourselves rather than be sorry about regligence.



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Continued....

Part by part of this book will be published in the Vidurava issues for the benefit of the readers.

In November 2014 issue we published Questions 9 - 13 of the above publication. In this issue, you can read Questions 14- 18.

14. Guessing a Number Without Asking Anything

Tell your friend to take any three-digit number not ending with a nought (but one in which the difference between the extreme digits is not less than 2) and ask him to reverse the order of the digits. After that he must subtract the smaller number from the bigger and add the result to itself, only written in reversw order. Without asking him anything, you tell him the final result.

For instance, if the number he thought of is 467, then he must do the following:

467; 764; 764 297
-467 +792
297 1089

It is this final result that you tell your friend. How do you find it? Let us examine the problem in general. Let us take a number with digits a,b, and c, with a bigger than c by at least two units. Here is how it will look:

100a + 10b + c.

The number with the digits reversed will look thus:

100c + 10b + a.

The difference between the first and the second will equal:

99a – 99c.

We then do the following transformations:

99a - 99c = 99 (a-c) = 100 (a-c) - (a-c)
= 100 (a-c) - 100+100 -10+10 – a+c
= 100 (a-c-1) +90+ (10-a+c).

Consequently, the difference consists of the following three digits:

Number of hundreds : a - c - 1,
Number of tens: 9,
Number of units : 10 + c – a.

The number with the digits reversed will look thus:
100 (10+c-a) + 90 + (a-c-1).

Adding the two expressions
100 (a-c-1) + 90 + 10+c-a
+
100 (10+c-a) + 90 + a-c-1,

We get
100 x 9 + 180 + 9 = 1089.

And so, irrespective of the choice of digits a,b, and c, we always get the same number : 1089. It is not difficult, therefore, to guess the result of these calculations: you have known it all along.
Naturally, you should not pose this problem twice to the same man. He will guess the trick.

15. Who has it?

This clever trick requires three little things that can be put into a pocket: a pencil, a key, and a penknife will do very well. In addition to that, put a plate with 24 nuts (draughts or domino pieces or matches will do just as well) on the table.
Having completed these preparations, ask each of your three friends to put one of the three things into his pocket, the first the pencil, the second the key and the third the penknife. This they must do in your absence, and when you return to the room, you guess correctly where each object is.
The process of guessing is as follows: on your return (i.e. after each has concealed the object) you ask your friends to take care of some nuts, you give one nut to the first, two to the second and three to the third. Then you leave the room again, telling them that they must take more nuts – the one who has the pencil should take as many nuts as he was given the first time; the one with the key twice as many as he has been given; and the one with the penknife four times the number. The rest, you tell them, should remain in the plate.
When they have done that, they call you into the room. You walk in, look at the plate and anounce what each of your friends has in his pocket.
The trick is all the more mystifying

since you do it solo, so to speak, without any assistant who could signal to you secretly. There is really nothing tricky in the riddle – the whole thing is based on calculation. You guess who has each of the things from the number of nuts remaining in the plate. Usually there are not many of them left, from one to seven, and you can count them at one glance. How, then, do you know who has what thing? Simple. Each different distribution of the three objects leaves a different number of nuts in the plate. Here is how it is done.

Let us call your three friends Dan, Ed, and Frank, or simply D,E,F. The three things will be as follows: the pencil, a, the key, b, and the penknife, c. The three objects can be distributed among the trio in just six ways:

D	E	F
a	b	c
a	c	b
b	a	c
b	c	a
c	a	b
c	b	a

There can be no other combinations, the table above exhausts all of them.

Now let us see how many nuts remain after each combination:

You will see that the remainder is each time different. Knowing what it is, you will easily establish who has what in his pocket. Once again, for the third time, you leave the room, look at your notebook into which you have written the table above (frankly speaking, you need only the first and last columns). It is difficult to memorise this table, but then there is really no need for that. The table will tell where each thing is. If, for example, there are five nuts remaining in the plate, the combination is bca, i.e.

Dan has the key,
Ed has the penknife, and
Frank has the pencil.

If you want to succeed, you must remember how many nuts you gave each of your three friends (the best way is to do so in alphabetic order, as we have done here).

16. A Chain of 28 Dominoes
Can you lay out the 28 dominoes in a chain, observing all the rules of the game?

17. The Two Ends of a Chain
The chain of the 28 dominoes begins with five dots. How many dots are there on the other end of the chain?

18. A Domino Trick

Your friend takes a domino and asks you to build a chain with the remaining 27, affirming that this can be done no matter what piece is missing. After that he leaves the room.

You lay out the dominoes in a chain, and find that your friend is right. What is even more wonderful is that your friend, without seeing your chain, can tell you the number of dots on each of the end dominoes.

How can he know that? And why is he so certain that a chain can be built up of any 27 dominoes?

Answer 16 - 18

16. To simplify the problem let us set aside all the seven double dominoes: 0-0, 1-1, 2-2, etc. There will remain 21 pieces with wach number repeated six times. For instance, there will be four dots (on one half of the domino) on the following size dominoes:
4-0, 4-1, 4-2, 4-3, 4-5, and 4-6.

DEF Number of nuts taken			Total	Remainder
abc 1+1=2;	2+4=6;	3+12=15	23	1
acb 1+1=2;	2+8=10;	3+6=9	21	3
bac 1+2=3;	2+2=4;	3+12=15	22	2
bca 1+2=3;	2+8=10;	3+3=6	19	5
cab 1+4=5;	2+2=4;	3+6=9	18	6
cba 1+4=5;	2+4=6;	3+3=6	17	7



We thus see that each number is repeated an even number of times. It is obvious that these dominoes can be linked up. And when this is done, when the 21 pieces are arranged in an uninterrupted chain, then we insert the seven double dominoes between dominoes ending with the same number of dots, i.e. between two 0's, two 1's, two 2's, etc. After that all the 28 dominoes will be drawn into the chain according to the rules of the game.

17. It is easy to prove that a chain of 28 dominoes must end with the same number of dots as it begins. Indeed, if it were not so, the number of dots on the ends of the chain would be repeated an odd number of times (inside the chain the numbers always lie in pairs). However, we know that in a complete set each number is repeated eight times, i.e. an even number of times. Therefore, our assumption about the unequal number of dots on the ends of the chain is wrong: the number of dots must be the same (in mathematics arguments of this sort are called reduction ad absurdum).

Incidentally, this property of the chain has another extremely interesting aspect: namely, that the ends of a 28-piece chain can always be linked to form a ring. Thus, a complete domino set may be arranged according to the rules of the game both into a chain with loose ends or into a ring.

The reader may be interested to know how many ways there are of arranging this ring or chain. Without going into tiresome calculations we can say that there is a gigantic number of ways of doing this. It is exactly 7 959 229 931 520 (representing the value of 213 x 38 x 5 x 7 x 4231).

18. The solution of this problem is similar to the one described above. We know that the 28 dominoes can always be arranged to form a ring. Therefore, if we take one piece away,

(1) the remaining 27 will always form an uninterrupted chain with loose ends, and (2) the numbers on the loose ends of this chain will always be those on the two halves of the domino taken away. Concealing a domino, you can always tell beforehand the number of dots on each end of the chain.