PeMSAA-UK
Peradeniya Medical School Alumni Association UK

Professor T Varagunam Memorial Lecture, 9th June 2018

HEALTHCARE 2025 AND BEYOND

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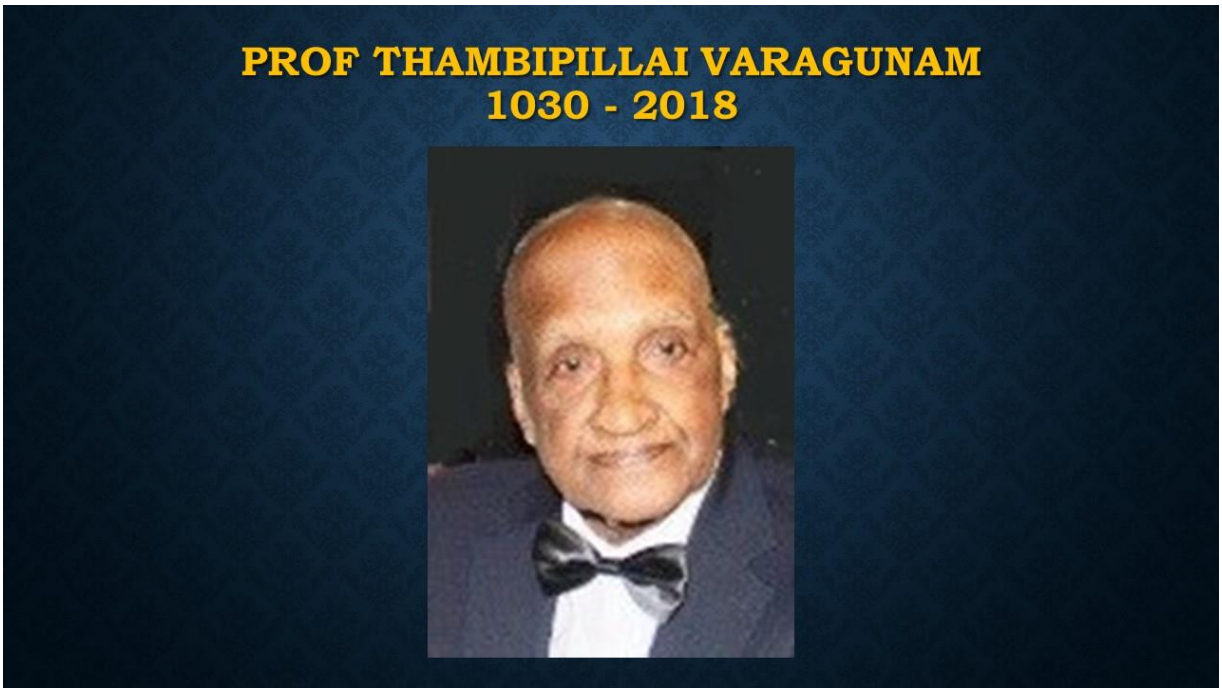


Mrs Varagunam, friends & family of Prof Varagunam, Ladies & Gentlemen,

First of all. I would like to thank the committee of PEMSAA UK for granting me the privilege to deliver the inaugural Prof Varagunam Memorial Lecture commemorating the memory of a caring physician, a great medical educationist and above all an honest and humble human being**.** I belong to a long array of students, colleagues and academics whose lives have been enriched by being touched by Prof Varagunam.

The topic I have selected today, “Healthcare in 2025 and beyond” is in a way reflective of, and testimonial to, the culture that Prof Varagunam created in Peradeniya; he was a pioneer, ahead of the game, thought outside the box and was a visionary. It is what made him, and his other colleagues, leave the portals of Colombo

(when very few wished to do so) and set up the Peradeniya Medical Faculty. It was the same vision that made Prof Varagunam set up the Medical Education Unit in Peradeniya (when many questioned the need or the wisdom to do so) and it was the same pioneering spirit that made him take up the position in the WHO to address the unmet research needs of the neglected diseases and subsequently the global programs in women's health. I hope that I will be able to do justice to his memory in attempting to address this complex topic.

Many would argue, with some justification, that predicting the future is a role for the clairvoyant and not for a scientist or a physician. However, there is a distinction. A prophesy, which is what clairvoyants and prophets display (they prophesise) is based on special mystical or metaphysical experiences. I hasten to add that I have none of those special attributes. Predictions on the other hand should be evidence based, exploring trends and signals and that is what I propose to do.

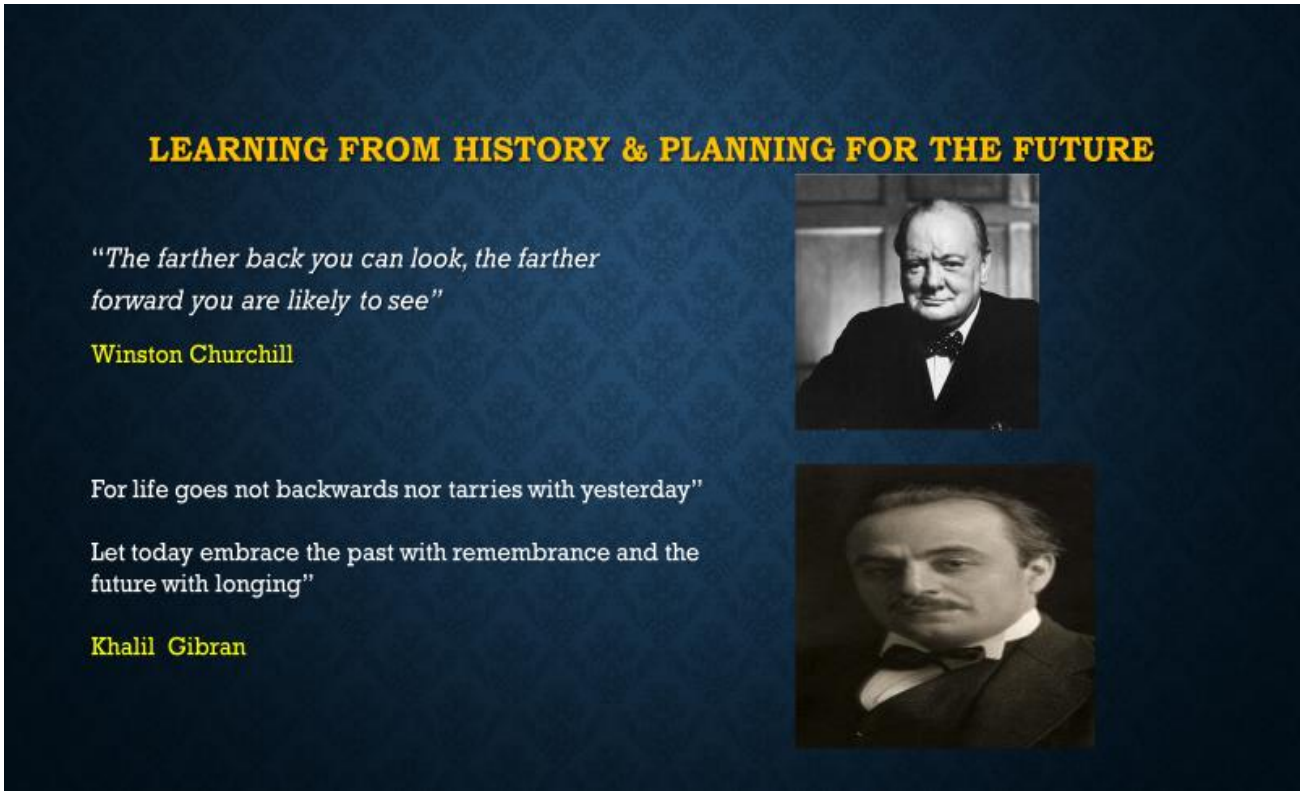
The difficulty in making predictions, especially those linked to Healthcare, is that the events and signals are *firstly*, "dispersed in time", moving from the past, to the present and then to the future. But the impact of time on our lives is relative. Everyone's future is dependent on many factors including our thoughts, experiences and how we respond to events in the future. *Secondly*, they are also dispersed in space and geography. The healthcare in the developed world would be, at any moment, very different to that in resource poor settings. However, over time, this "gap" is narrowed due to transfer of technology and health care practices. Unfortunately, some parts of the world, especially sub-Saharan Africa do get left behind. It is also important to note that this "lag period" has shortened in the recent past due to globalisation, the rise in prosperity and the impact of social media

Significant shifts in paradigm in the delivery of healthcare occur either by EVOLUTION in small incremental steps (as with most of the changes in the recent past) or by "rapid evolution" or REVOLUTION, as would be the case with most of the changes that we would see in the future

There have been significant technological revolutions in the past that have impacted on humanity. The **AGRICULTURAL REVOLUTION** which started around 10000 BC in the fertile plains of Mesopotamia and spread globally over many millennia (thousands of years); The **INDUSTRIAL REVOLUTION** originated in Britain and Western Europe in the 18th century and spread more rapidly (in hundreds of years); In our own times, The **DIGITAL OR IT REVOLUTION** influencing our lives from around the late 70s and early 80s globalised with exceptional speed in a few decades (10s of years), impacting even the livelihoods of farmers in Africa through the use of mobile phones. The 21st century **REVOLUTION** in **HEALTHCARE** will be even more transformative, since we are seeing for the first time in human history, the coming together or the merger of the advances in the physical and biological sciences. The IT platform including artificial intelligence is being used as a vehicle to disseminate the biotechnological advances. Advances in IT follow **MOORE'S LAW** and develop in geometrical and not arithmetical progression. As a result, every 2 years the cost of the technology gets halved or the productivity doubled. This has continued in the computer and IT industry unabated for the past 50 years and shows no sign of slowing down.

In contrast, the medical and biotechnological advances in the past were untouched by Moore's Law and have been slow to be adopted into medical practice or to demonstrate productivity benefits. For example, the use of thrombolytics in post MI patients were shown to demonstrate mortality benefits in land mark outcome trials in the 80s but their initial adoption into clinical practice was extremely slow in the UK, as shown in a study conducted by the British Heart Foundation. The full incorporation into clinical practice occurred much later with the development of clinical guidelines with consequential ethical and legal penalties. However, the Healthcare revolution of the future will be touched by aspects of Moore's Law and the productivity benefits should follow.

Let us now move on to explore the METHODS that I have employed for making these predictions; They are *firstly*, by looking at the changes that have taken place over the past 50 years and *secondly* by exploring the new SIGNALS and trends that we see today. The prediction is then based on a fundamental assumption that the changes we have seen over the past 50 years and the signals we see today will be AMPLIFIED many folds in the next 50 years due to the merged advances in Biotechnology and Information Technology.



It is often said that one needs to learn from history whilst planning for the future; in our personal and professional lives, as a society and nation and as human beings. Winston Churchill said that "*The farther you can look back, the farther forward you are likely to see" AND* Khalil Gibran, the Lebanese Christian Poet in his wonderful sets of poems encouraged the need to move forward:

"*For life goes not backward nor tarries with yesterday"*

but at the same time to be cognisant of the past experiences:

"Let today embrace the past with remembrance and the future with longing"

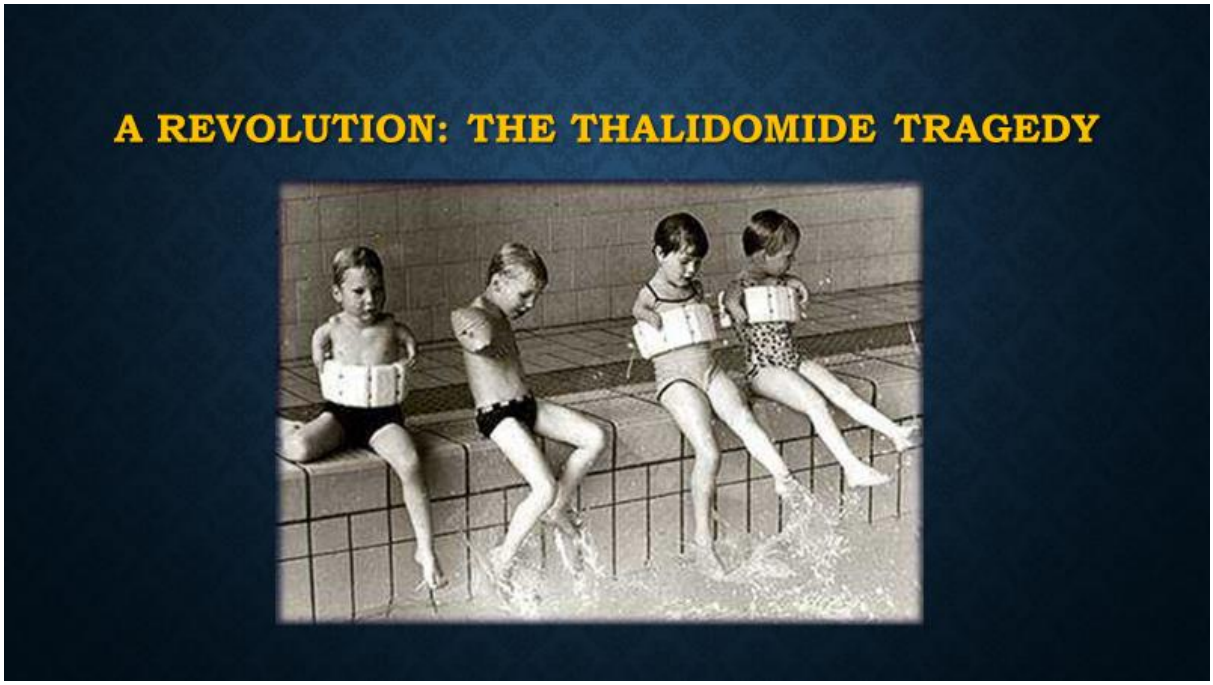
Let us now go down memory lane, back to the mid-60s, around the time the first batch of students were graduating from Peradeniya and recollect some specifics in the healthcare environment at that time. In late 1966, I lost my father when I was a second-year medical student; he was 51 years old and we lost him primarily because of uncontrollable BP or Resistant Hypertension. Not because his medical care was bad but solely due to the lack of effective medications. I still remember the conversation with his physician offering him the "latest medicine" for hypertension

which was “RESERPINE”!!! There were no ACEI/ARBs, no CA Channel Blockers; the only other effective medication was methyl Dopa and hydrochlorothiazide.

The same could be said of many other common diseases: sulphonyl-ureas were the first line agents to treat Type 2 DM (worries about lactic acidosis prevented the wide use of metformin); theophyllines, both orally and intravenously were used for bronchial asthma (many of us remember the acute take days, full of patients being administered 50 mls of Aminophylline for Status Asthmaticus). No inhaled steroids, No LABAs (Long acting beta agonists) or LAMAs (Long acting muscarinic antagonists). Peptic ulcers were handed over to the surgeons for vagotomy or gastrectomy. It is interesting to note that the subsequent era in the 70s and 80s saw the introduction of H2 receptor antagonists and Proton Pump Inhibitors and a whole spectrum of upper GI surgery disappeared. At the same time, the significant advances in immunotherapy created another cadre of surgeons: viz. the Transplant surgeons.

The researchers who contributed to the dramatic advances in specific therapeutics were recognised by the award of the Nobel Prize in Medicine. I am pleased to say that they were all from GSK and its legacy companies: James Black, Gertrude Elion, George Hitchins and John Vane.

Just pause for a moment and recollect the practice of medicine today and compare it to 50 years ago. Multiply the nature and rate of these changes ten-fold as a minimum, and you begin to see the enormity of the change in landscape of healthcare that will be functional 50 years further into the future.



Although many of the developments in the past evolved slowly, we should also note that there were some TRANSFORMATIVE and REVOLUTIONARY developments: The THALIDOMIDE DISASTER, which arose in the 1950s from the use of the drug as an anti-emetic in pregnancy, resulting in children with Phocomelia (absent or shortened limbs) completely changed the approach to the development of new medicines and the introduction of the concept of BENEFIT TO RISK OF MEDICINES. "Medicines are nothing more than **beneficial** poisons"; when you write A prescription to A patient, you do so because you feel that the Benefit of that medicine to that patient overrides the RISK. Also, whenever you write a prescription to a patient, you are indeed starting on a new experiment, because you do not know how that patient will respond to that medicine. A medicine without any risk is NOT A MEDICINE, it is a PLACEBO. The risk of a medicine is never discharged even after many years in use. The risk is minimised, but never discharged. Therefore, considerable care should be taken in prescribing any medicine. It is often said that there are "NO GOOD MEDICINES", only "GOOD PRESCRIPTIONS".

Another example of a REVOLUTION in healthcare was the HIV epidemic of the 80s. It was seen at that time as Black Death with a risk to humanity. The revolution was driven by the advocacy of the gay community and the scientific and pharma communities responded with rapid advances in therapies, including the use of a cocktail of drugs (QUAD THERAPY), which sees a patient with HIV today dying WITH the illness, from some other cause, rather than FROM the illness

FORWARD LEAPS; "20 YEAR CYCLES"

If one looks at most of the significant advances in the past, certainly in therapeutics, one notices "20-year cycles" from the establishment of the scientific advances to seeing the medicines in the clinic. I would term them "Forward Leaps":

i) Many advances in CV physiology (for example, the unravelling of the adrenergic receptor, the Renin angiotensin pathway and the HMG Co A reductase) in the 60s & 70s resulted in major developments in CV therapeutics 20 years later, in the 80s & 90s
ii) The developments we are seeing today in cancer therapeutics are consequential of dramatic advances 20 years earlier, in the 80s, in Molecular Biology.

One could expect that the future "Forward Leaps" will have shorter cycles.

RECENT SIGNALS & TRENDS

I would now like to move on and look at some of the signals and trends we see today that will have a major impact on the developments in healthcare of the future. It is not my intention nor is it possible to be comprehensive in this exercise. The objective would be to focus on the philosophy and process rather than entirely on the content of change, giving some select developments in my own area of expertise. Many of you will no doubt join me in exploring signals and areas of change in your own specialties. Further, my intention is to focus on two future periods: *firstly*, the next decade or so when as practitioners, researchers & academics, the change would be of more immediate relevance and *secondly* a period further down the line with futuristic "blue sky" predictions.

When looking at signals, it is important to separate "real" versus "false" signals. In case this looks like Donald Trump territory, I hasten to point out that I am referring to signals and not "news". Let me give you a couple of examples.

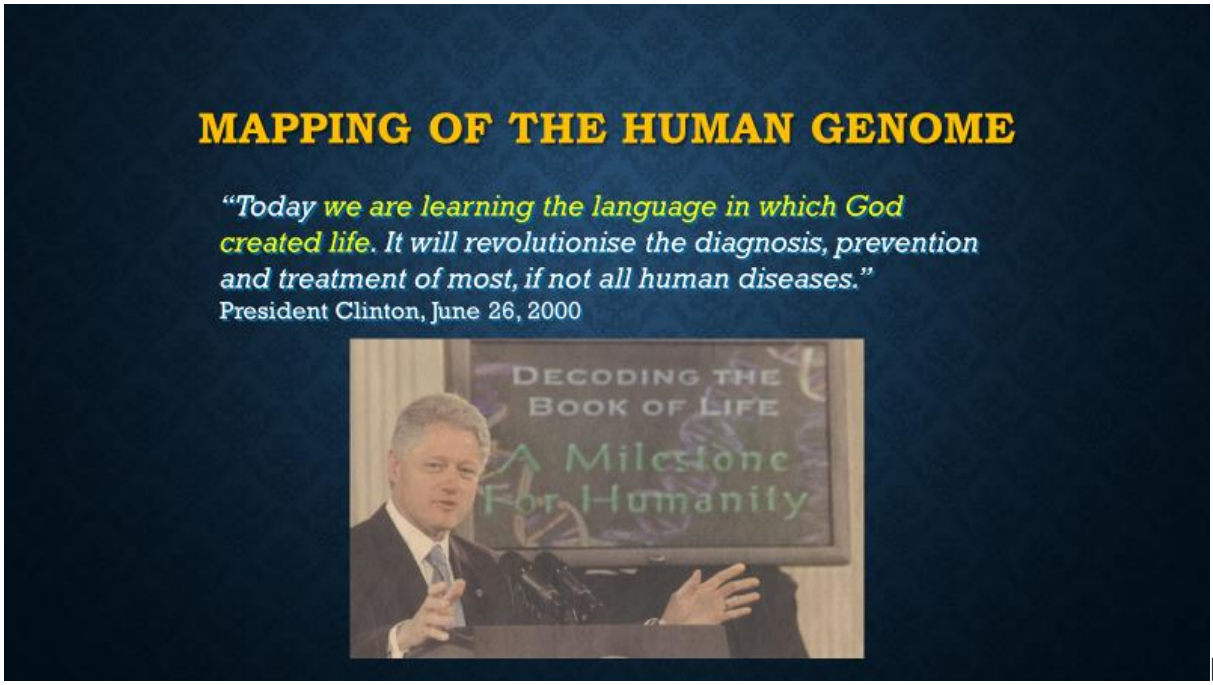
The discovery of penicillin by Fleming resulted from a serendipitous observation of a contaminated petri dish by an overgrown fungus. But it needed the brilliance of the mind of Fleming to convert this insidious observation into a major medical breakthrough. Many of us would have binned the dish as a failed experiment or a false signal!!! Fleming's discovery kick started the rapid development of many more natural and synthesised antibiotics in the following decades.

Another difficulty is to separate a signal from "background noise", a phenomenon commonly encountered in looking for adverse event signals during the development of new medicines. A difficulty that society and the media often do not understand. How does one separate a "signal" of risk from background events, many of which are

related to the underlying disease? With extreme difficulty is the answer involving a lot of analyses and deliberations. Recently, the advent of electronic records has eased the difficulty to some extent and the hope is that data mining with artificial intelligence support will provide a welcome relief in finding the "needle in a haystack" signal.

I wish to move now to discuss some categories of trends that will have a major impact in the future delivery of healthcare. *Firstly*, **technological advances in medicine and biotechnology** and *secondly* the impact of the **developments in information technology including" artificial intelligence"**. These technological advances will also have SOCIAL CONSEQUENCES": how would society support the resourcing for healthcare including the funding of technology, the changing role of doctors and other HCPs and the nature of Healthcare institutions like hospitals and GP surgeries. The other big societal impact would be in our perspective of Health, Disease, Dying and Death itself. Humans have always been in search of immortality by postponing death, from the time of the pharaohs in Egypt building the pyramids for after life and many theological philosophies linked to after life and rebirth. Today and in the future, we will see even a greater search for postponing death through technological advances

BIOTECHNOLOGICAL ADVANCES



Let me give you a "birds eye" view of some of the Biotechnological advances and signals that will influence our practice within the next decade.

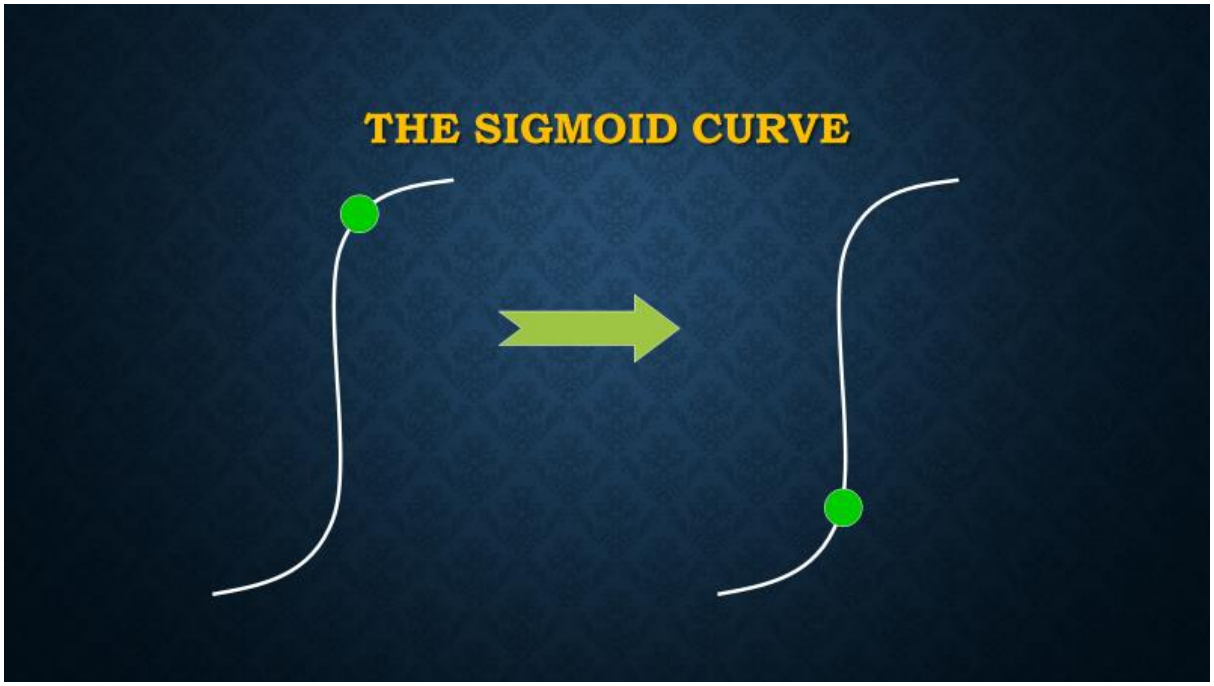
Firstly, the impact of the Genomic Revolution with the mapping of the human genome around the turn of the century.

You will see the excitement in the flowery language used by President Clinton ("learning the language in which god created life") and the expectation that it will revolutionise the diagnosis, prevention & treatment of most diseases. This exercise was a tremendous success for the public sector (the NIH and the Cambridge group) and the private sector (Craig Venter from Human Genomic Sciences) not so much for collaborating but for competing to the tape. Sometimes healthy competition does facilitate innovation and scientific advances.

There has been disappointment expressed in some quarters that the Genome Project has not borne the expected rewards a decade later. I tend to disagree. Perhaps we have not seen the many solutions that were expected but the direct and indirect benefits have been enormous. Just to name a few:

- The number of targets for new drugs have increased many folds
- The project has given birth to new fields of science: the study of proteins (Proteomics) and the study of metabolites (Metabolomics) and of course many examples of the impact of pharmacogenetics in improving the benefit to risk of medicines through personalised medicines.

Yes, the numbers are still not there but the story is still not complete and only time will tell.

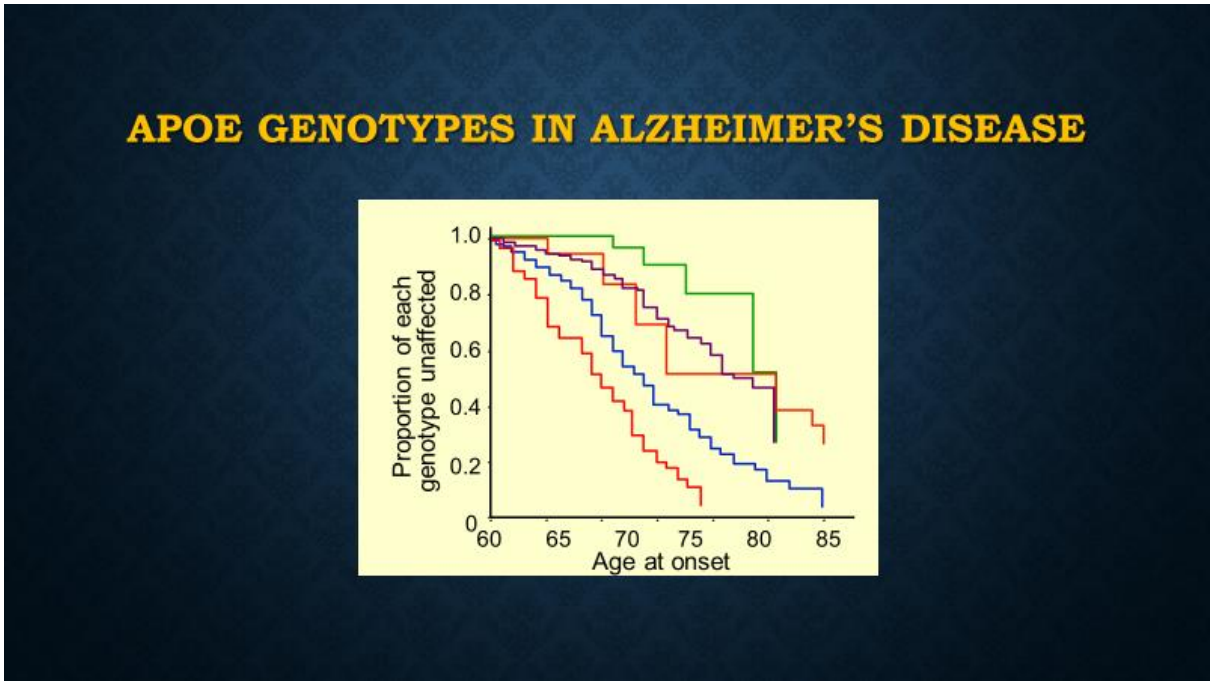


Some of you know of my interest and fascination with the SIGMOID CURVE. (Life progresses, personally & professionally through a series of sigmoid curves; It is a question of realising when one has reached the top end of a curve and then creating the next curve. If not, someone else will create the curve for you!!!). The curve also

comes into play in medical advances. If one looks at CV & Respiratory therapeutics, we have probably reached or very close to the top end of the curve. A very different story for Cancer therapeutics, where we are now in the steep part of the curve and entering the “golden period”. For CNS therapeutics, we are still struggling to understand the “black-box” of the brain and are perhaps at the bottom of the curve and more work needs to be done to get to that golden period, perhaps another 10-20 years before we even start seeing real advances that will change medical practice. Let us look at some opportunities and emerging signals that would create the “NEW SIGMOID CURVE” which will impact on healthcare in the next decade or so.

EMERGENCE OF NEW DISEASES & REDEFINITION OF EXISTING DISEASES

We need to redefine diseases by learning from the Oncologists. Oncologists have perhaps been fortunate to be dealing with diseases at a cellular level, whereas most diseases have traditionally been system or organ specific disorders. The days of developing global therapies for many cancers are over. The cancer therapies are now targeted to specific molecular targets in sub sets of patients. (e.g. Herceptin for Her-2 + breast cancer or Zelboraf for BRAF + melanomas and so on).

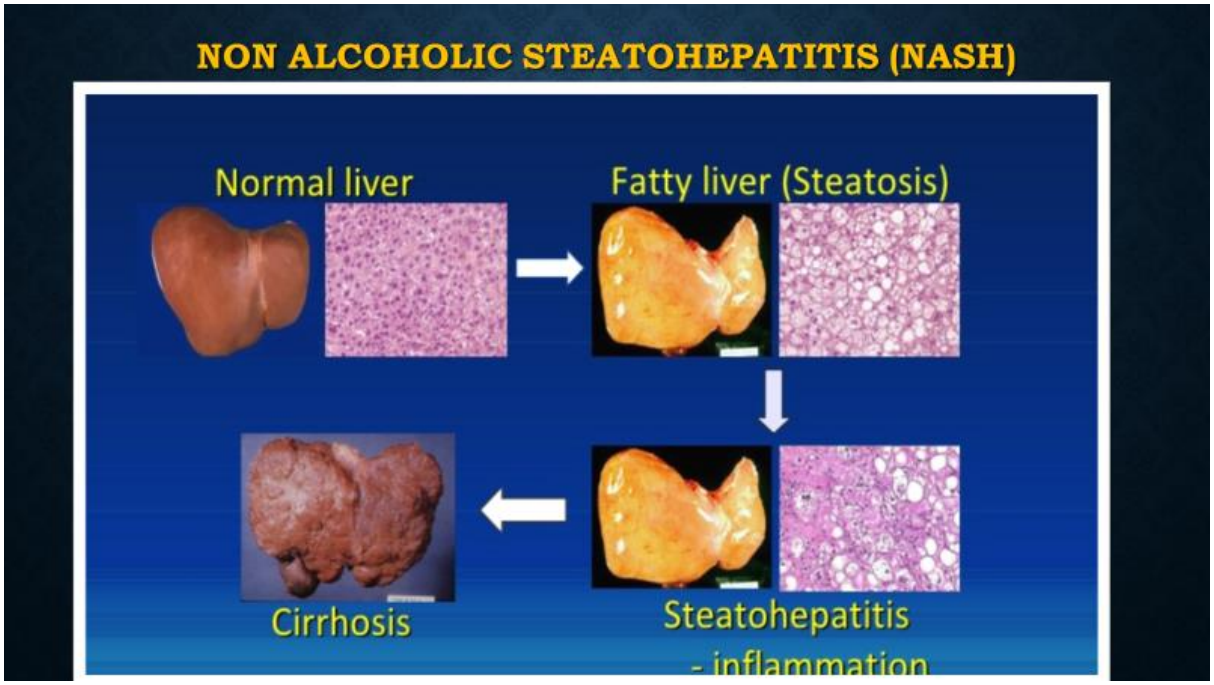


This need for redefinition is best illustrated with Alzheimer’s disease. Many potential new medicines have failed to show clinical benefit when tested in a broad group of

Alzheimer patients but do demonstrate benefit when tested in sub groups with specific APOE4 genetic pleomorphisms, confirming that Alzheimer's is NOT a single disease but perhaps a syndrome with different ages of onset and prognosis based on genetic and biomarkers (APOE4 pleomorphism being just one of these). With a dementia epidemic confronting society, I hope progress will be made in offering some real relief to this debilitating disease.

A similar approach is necessary in CV diseases (and indeed other disease areas) by sub setting common diseases such as HT and CHF using genetic and biomarkers to develop more specific and targeted therapies. If we do not do so, we will continue to have a significant RESIDUAL CV RISK. Until we get further advances in CV therapeutics, including drugs to more effectively reduce triglycerides, which is now accepted as an independent CV risk factor, the focus in the near future should be to get "BACK TO THE BASICS", of better screening, diagnosis and management of diseases such as HT, diabetes and obesity…. the SILENT KILLERS.

We are also seeing, as we have done in the past, the emergence of "NEW DISEASES". Some of these will be **real** "new diseases" due to genetic mutations, environmental toxins and new pathogens. There will also be **geographical** "new diseases" as a result of existing diseases spreading across the globe. CV disorders, Diabetes, asthma and cancers are no longer western diseases; they are global diseases. As these western diseases get globalised, it has created the need for training and educating HCPs to diagnose and manage these diseases and indeed educating the wider society that, for example, hypertension goes underdiagnosed and undertreated across the globe. One of the paradoxes of technological advances is the fact that, by using newer diagnostic tools and criteria, we are also redefining existing diseases. Is the CAD diagnosed several decades ago using exercise ECG and coronary angiograms the same disease today, when diagnosed using much more sensitive imaging and biomarker led technologies? Could we extrapolate the same outcomes data and prognosis generated from older studies to today's patients? What is the impact on the economic burden of healthcare systems when Hypertension is diagnosed at a lower target of 130/80 mm Hg using the recent American guidelines? These are questions that need to be asked constantly as the advances influence the way we diagnose and manage disease and the impact our decisions will have on healthcare systems and societies at large.



Non-Alcoholic Steatohepatitis (NASH) is a disease that has come into prominence recently, will have a major impact on many healthcare systems and is of special significance to South Asians. I have no doubt that it is an “old disease” that is being increasingly recognised due to the growing global epidemic of obesity and Type 2 DM as well as the availability of newer technologies and diagnostic criteria. As the hepatic manifestation of the metabolic syndrome, NASH will soon become the commonest cause of Hepatic Carcinoma and Liver transplantation. There are currently no approved therapies although metformin or pioglitazone may help by improving insulin sensitivity. Fortunately, promising molecules targeting the liver pathways in bile acid & lipid synthesis are currently in phase 3 trials and should reach clinical practice in the coming years.

EMERGENCE OF BIOPHARMACEUTICALS

Most of the medicines in clinical practice, especially in primary care, have traditionally been SMALL NON PROTEINOUS MOLECULES. Since the first approval of a murine monoclonal Antibody for transplant rejection in 1986, a significant growth in humanised PROTEIN BASED biopharmaceutical molecules has occurred, especially as cancer and immune therapeutics. This will accelerate further in the next decade, including exciting options for other disease areas. The recent approval by the European Medicines Agency of an antibody to block the calcitonin gene related peptide for the prevention of migraine is one such example. The disadvantages of

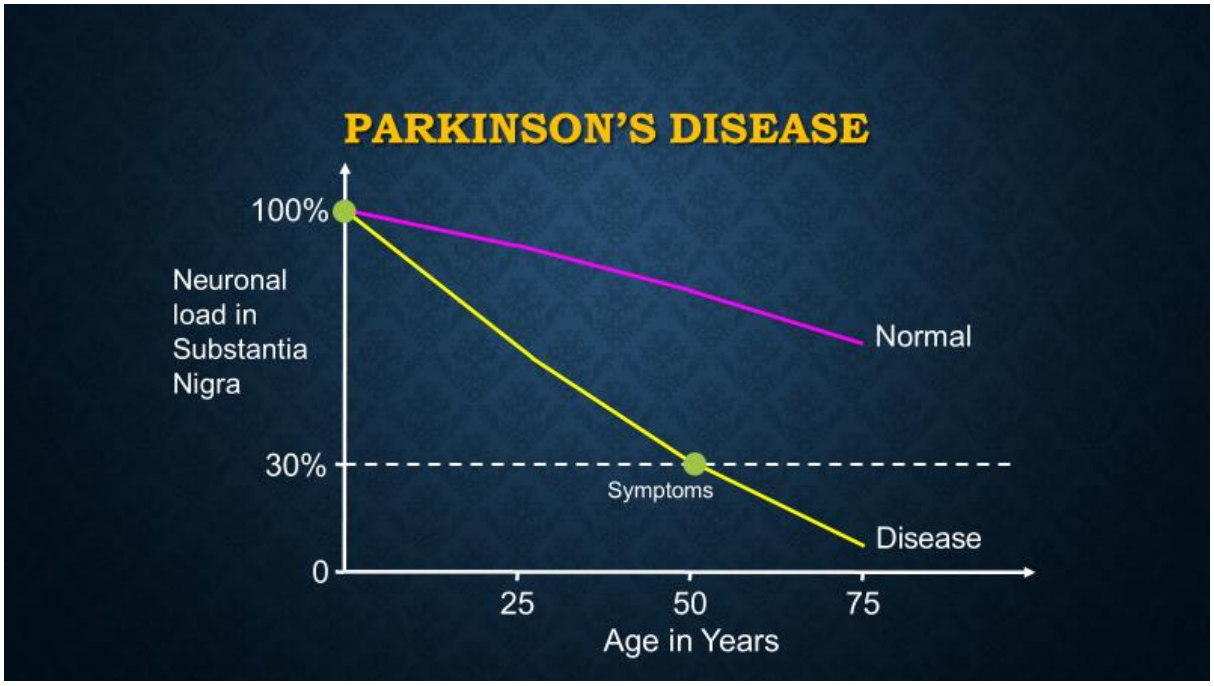
Biopharmaceuticals include the cost, parenteral administration and the difficulty to make and approve generics (biosimilars). Ongoing research on nanoparticles as transporters and the synthesis and administration of the active sites of these antibodies may perhaps see non-parenteral (perhaps even oral) modes of delivery in the future.

THE ADVENT OF COMBINATION THERAPIES

In the past, there has been a negative perception of combination therapies since most were SIMPLE COMBINATIONS of 2 molecules. Yes, they do have some positive impact on patient compliance but have limited additional benefits to patients. However, we are now moving to some very exciting INNOVATIVE COMBINATIONS which will have significant patient benefits. The development of inhaler devices to deliver inhaled steroids with either LABA or LAMA and the recent approval of triple therapy for COPD are indeed difficult technological innovations that have not been well appreciated. As we look at the molecular pathways of disease, whether they be HIV, Type 2 DM, NASH, cancer and immunological disorders, the opportunity to develop a “cocktail” of targeted medicines in the form of combination therapies will become important therapeutic options. The FDA has recognised this approach and introduced new regulatory pathways for the rapid review and approval of such therapies. COMPANION DIAGNOSITCS (i.e. a drug and a diagnostic going together) is another development that will expand further as we subset diseases based on biomarkers and offer targeted therapies. Improved efficacy and reduced risk to patients will come at a financial cost to healthcare systems.

PREVENTATIVE THERAPEUTICS

Most of the medicines we have today for CHRONIC DISORDERS are NOT CURATIVE of the disease, with some notable exceptions obviously in infectious diseases and perhaps in Oncology. Many medicines alter the course of the disease, in changing the curve of progression with significant impact on morbidity and mortality, but they are still NOT curative. One of the reasons for this is that the intervention takes place too late in the pathophysiological process.

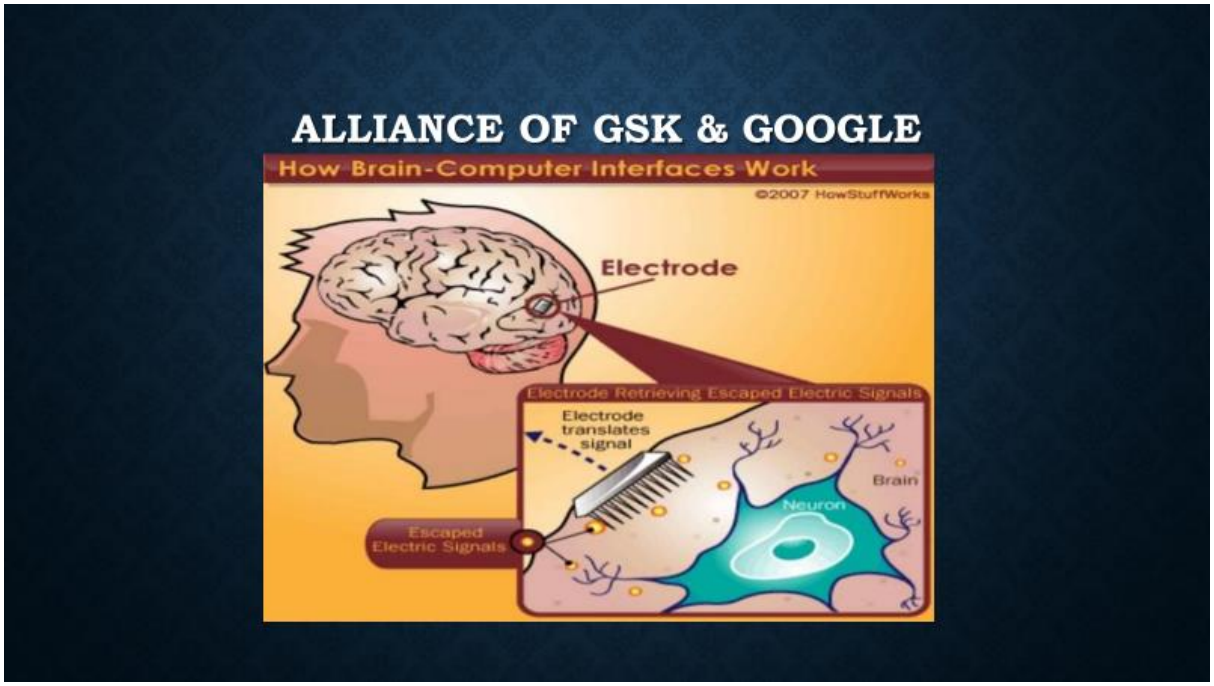


A good example of this issue is the treatment of Parkinson's disease. The disease is only diagnosed when the patient has lost around 70% of the nigrostriatal neurones and consequently develops symptoms. Although the therapies, even at this late stage, do offer significant improvements in the symptoms by modulating dopamine related pathways, the future developments are focusing on early diagnosis before symptoms emerge. The availability of neuroimaging and the ongoing research on biomarkers will allow potential patients to be screened noninvasively earlier in the disease process. The challenges include the identification of the high-risk population for screening and the limited availability of therapeutic options to treat patients at this early stage. Early therapeutic interventions using inhibitors of neuronal growth factors are possible options for this therapeutic strategy.

However, the search for therapies for common degenerative neurological disorders (including Parkinson's Disease, Dementia & Motor Neurone Disease) have been disappointing. The question arises whether we have been barking at the wrong tree!!! Here is an organ which is primarily driven by **neuro-electrical impulses** with neurochemicals only facilitating their transfer across synaptic junctions. Furthermore, the Blood Brain Barrier has evolved to **prevent** the transfer of toxins and by implication, medicines into the brain. One therefore could argue that trying pharmaceuticals to treat CNS disorders has not been a great strategy!!

ELECTROCEUTICALS

Now comes this exciting new development: the field of Electroceuticals or Bioelectronic medicine development. This is the technology of introducing biochips into the brain to enhance neural transmission. One could postulate the future development of Bioelectronics together with advanced pharmaceuticals, such as neural growth factors, perhaps as a drug device combination. It would be analogous to the use of drug eluting stents in the coronary arteries.



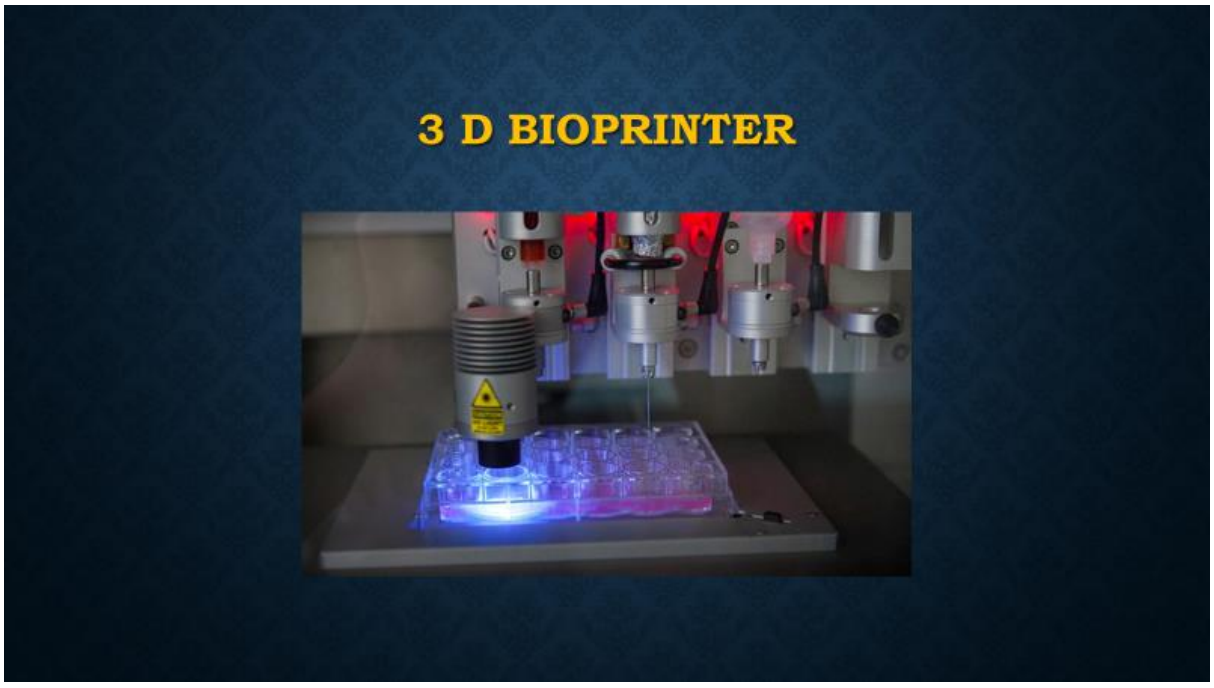
And we have a first: an alliance between the R&D organisations of two global companies (GSK & Google) from widely different industries (Pharma and IT). This alliance has been set up as a new subsidiary solely focused on neuroscience development. Watch this space!!

THE MICROBES ARE WINNING; OR ARE THEY?

One of the great disappointments of the recent past, has been the lack of major breakthroughs in developing new classes of antibiotics. In the interaction between humans and pathogenic microbes, there is a worry that we are losing the battle with the advent of MRSA and other resistance organisms. The mapping of the bacterial genomes followed the human genome project and the genetic make-up of all known human pathogens have been made available to explore new drug targets. Unfortunately, nothing has materialised from projects such as the Manhattan project at GSK and other similar projects across the Pharmaceutical Industry.

On the bright side, the field of Vaccines has seen and will continue to see enormous progress. The development of targeted vaccines will transform in the coming decade or two with vaccines against Malaria and other neglected diseases, perhaps a universal flu vaccine, preparatory vaccine against a possible Avian flu epidemic and the development of therapeutic vaccines in Cancer and other diseases such as the various forms of Viral Hepatitis. Perhaps, at some stage, even a vaccine against the difficult and rapidly mutating HIV virus? The Therapeutic Vaccines, unlike preventative vaccines, target an immune response soon after the disease has been established. The strategy for these complex options has been to target the stable core part of the pathogen rather than the mutating surface antigen (which has been the problem so far) and use recombinant technology and novel adjuvants to elicit a powerful immune response.

3 D BIOPRINTING



The 3D Bio Printer is another mind-boggling technology that is already making inroads insidiously in many industries and beginning to do so in healthcare as well. If it progresses as predicted (and I think it will, as we are already seeing some strong signals), this will dramatically change many aspects in the delivery of healthcare.

Printing exact plastic replicas of an individual patient's organ has contributed to the training programs of surgeons and enabled pre-operative preparations for complex surgical procedures. Going beyond plastics, the 3D printing has delivered partially humanised organs using stem cell culture as was the case of the ear that went into 3-year-old Lucy Boucher from Northern Ireland. I believe this was probably the first stem cell culture based and 3D printed organ transplant in the world.

There is no doubt that this technology is already making its presence, will now expand to supply medical devices, prostheses and laboratory equipment and perhaps further down the line even MEDICINES; not all but some medicines, so that they can be made available bespoke to the patient, in hospitals & pharmacies and eventually, the possibility of patients printing their own medical supplies at home!!!

We are slowly getting into the futuristic Arthur C Clarke territory but look at the history; see what happened to Arthur C Clarke's predictions in Space Odyssey and his other novels. What was then thought as pure science fantasy is becoming the reality of space travel today and tomorrow; you only need to listen to Richard Branson.

DIGITAL REVOLUTION AND ARTIFICIAL INTELLIGENCE

As my final inroad into these predictions, I wish to touch upon the technology that will probably have the biggest impact in transforming the healthcare systems and will also have enormous ethical ad social implications: ARTIFICIAL INTELLIGENCE (AI). There is a lot of misunderstanding of Artificial Intelligence. It is the technology that allowed a great scientist, Stephen Hawking, to overcome a debilitating illness and make astounding contributions to theoretical physics and beyond. A rudimentary form of AI, although we never call it that, is already available in our computers, mobile phones and software applications

AI is often used interchangeably with Robots. Yes, Robotic intelligence is a very visible and often exaggerated part of AI and does create the illusion of a world run by robots. However, AI goes beyond robots and can be defined as a scientific endeavour which allows Machines to find solutions to complex problems in a human like fashion. It is all about accumulation and analysis of big data through algorithms,

which are primarily and initially designed by humans. The key component of AI is to allow the machines to learn and then design secondary or even tertiary algorithms themselves. These subsequent phases of Artificial General and Super Intelligence are difficult to comprehend today but will certainly transform our healthcare systems and our lives in general. AI is NOT intended to replace humans but to act as adjuncts to human tasks. It is the same way that we used MACHINES to replace human tasks in agriculture and other physical endeavours. Anyway, that is the INTENT; who knows where it will take us! The key is to be aware of the risks and manage them accordingly, as our forefathers managed fire and we are managing the risks of medicines and more recently the social media

Without going into all the possible future applications of AI based technologies, let me take you through a well-publicised **CARE PATHWAY SCENARIO** of the future

- A patient with multiple falls discusses the symptoms with the CHATBOT. The dialogue is brief but pleasant, and an appointment is booked on your behalf.
- At the GP surgery, your arrival has already been recorded and your gait analysed by CAMERAS & SENSORS in the reception
- GP scans your body, takes a portable x-ray of your hip, relays the results in real-time to the hospital and your new hip is 3D PRINTED ready for your arrival
- You're AUTOMATICALLY REGISTERED at the hospital reception through BIOMETRICS AND FACIAL RECOGNITION
- The surgeon will show your new hip. The surgery will be done most likely by a ROBOT
- You will arrive and leave hospital by a DRIVERLESS SHUTTLE SERVICE
- ROBOT CARE ASSITANT has already been assigned at your home.
- ALARMS have automatically been set to remind to take the prescribed medications
- SMART HOME DEVICES act as your HEALTH MONITORS, relaying your progress to the surgery in real time

TOMORROW'S HOSPITAL WILL BE YOUR **HOME**!!!

It is natural to think that this scenario is many decades away and perhaps it is so, in terms of being uniformly or universally applicable BUT some elements of these AI related activities, in basic forms, are already occurring in many health-related situations and institutions.

The move to eventually make OUR HOMES AS TOMORROW'S HOSPITAL is already underway.

What makes remote home care possible is not only the development of Artificial & Robotic assistance but also the development of biosensors in our homes (e.g. in smart toilets). Bodily fluids of patients could be continuously monitored virtually and in real time and appropriate actions taken. The smart toilets are a reality even today as research projects. The only questions of universal usage will be when and where?

Apart from the "Medicalised Home Care" the merged bio and physical science technologies will create new sophisticated healthcare institutions. We would see

- **Global Network of Hospitals and HCPs** with tools of Telemedicine & remote Robotic surgeries. This is already happening with doctors in India providing radiology reports to hospitals in the western world.
- **Medical Supermarkets** providing diagnostics and treatments. How about a supermarket where you can pick up your bespoke stem cell-based organ for transplantation based on your genetic and biomarker status, already digitised in your smart card?
- **Virtual, Remote & Mobile surgeries:** As every aspect of healthcare becomes virtual, remote and home based, why have a doctor sitting in a surgery seeing patients. Yes, the doctor or a HCP could be in a surgery but having remote consultations with the patients sitting at home.

- **Development of a plethora of new industries** with cross fertilisation to deliver a wide range of healthcare related services: Biotechnology, Robotics, IT, Manufacturing, the list is limitless.

BLURRING OF BOUNDARIES WILL BE THE NORM: between the various industries and their roles in the delivery of healthcare, between the state and private sectors and indeed the roles of doctors, other HCPs, including physician assistants, nurse consultants and indeed patients with their care givers.

How does one resource for this future scenario; with a lot of difficulty, is the simple answer but one thing is for sure; it will need considerable changes in attitudes, education & training of not only doctors and HCPs but the wider society. Many professions currently not designated as HCPs will be core players in many areas of delivery of healthcare

There will be significant shifts in DOCTOR-PATIENT relationships. This shift, as everyone knows, has already started and very different today compared to 50 years ago. Some aspects of this shift have been welcomed; for example, in terms of patient empowerment, but some have been confusing with clouding of ownership and responsibilities between HCPs and patients.
The future scenario will be something like this: The patient will not approach and disturb the eminent and busy GP; He or she will initially seek help from Dr Google Watson (this application is available today although not even 10% complete). The completed version and other similar software applications will be quite sophisticated and have the algorithm-based capacity to provide solutions to many basic problems. With the machine learning technology, the programs could we made bespoke to individual patients: YOUR PERSONAL DOCTOR AT HOME. Dr Google Watson will do so without all the emotional hassles that can affect decision making in humans (a bad night sleep, getting on the wrong side of the bed or even a tiff with your spouse!!). This progression will eventually result in what the ECONOMIST magazine has called the Dr YOU: the patient functioning as his/her own doctor.

So, what happens to the doctors. Do the jobs disappear? NO; jobs won't disappear, BUT some tasks will disappear and be handed over to Robots & AI applications. Doctors and HCPs will need to develop a culture of acceptance and partnership with AI with consequent <u>enhancement</u> of their roles. Doctors will be relieved of low-level tasks, will retain and enhance "high level" & specialised, including cognitive & emotional tasks, and most importantly AI will create opportunities for medical

careers to be extended to later life. The word retirement has become a misnomer in today' world. With the increase in life span and survival, the "Third Age" will be a significant part of human life. You don't need to practice medicine in your "Third age" but if you wish to, AI will be an excellent partner to enhance your career with cognitive and memory-based support. The AI will be your CPD and free of charge!!

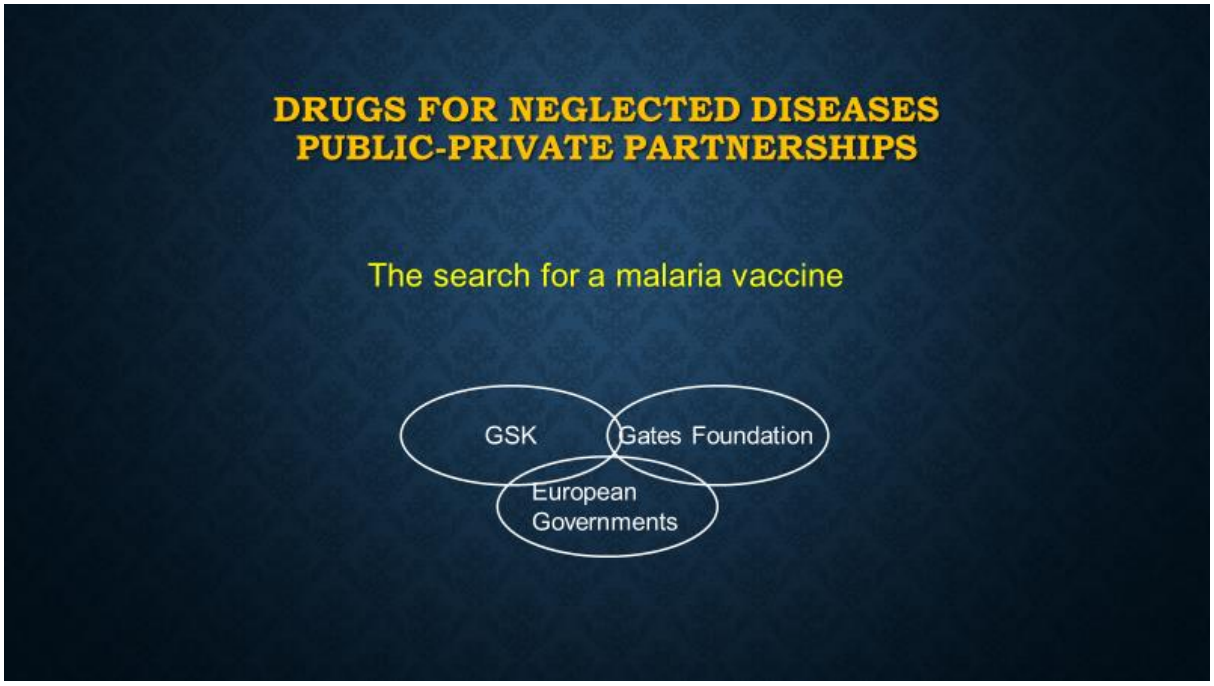
Another big change we will encounter is the development of a portfolio of jobs. As doctors begin to hand over tasks to AI, they will take on additional roles, perhaps across multiple institutions.

All this will need a fundamental shift in the training of tomorrow's doctors and also in continuous education and reskilling of competencies. The need has already arisen for the both the Undergraduate and Postgraduate Curriculum to shift from excessive focus on content to refocus on areas such as Principle in the practice of medicine, patient centricity, changing roles of HCPs, Leadership & Management and Medical Professionalism. Why load the curriculum with content that gets rapidly outdated? Furthermore, the human brain cannot compete with AI in the provision of rapidly changing information. The Medical Schools, as is already happening, will have to expand to become Faculties of Healthcare, training a wide variety of stakeholders who will participate, cooperate and deliver the future care of patients.

FUNDING OF THE NEW TECHNOLOGIES

This is the million-dollar question, no pun intended. Where will all the funding come from? Can the resource poor countries afford the technology, even if it is made available and accessible. Would it create a two-tier system and two-tier world? I am not going to give you any solutions today but society, the medical profession and politicians need to discuss all the politically sensitive options: taxation, mean testing, relative rationing. Funding of healthcare is not just an NHS problem but a global issue. The bad news is that it is only going to get worse if the proposed technological advances become a reality. Novel approaches need to be entertained.

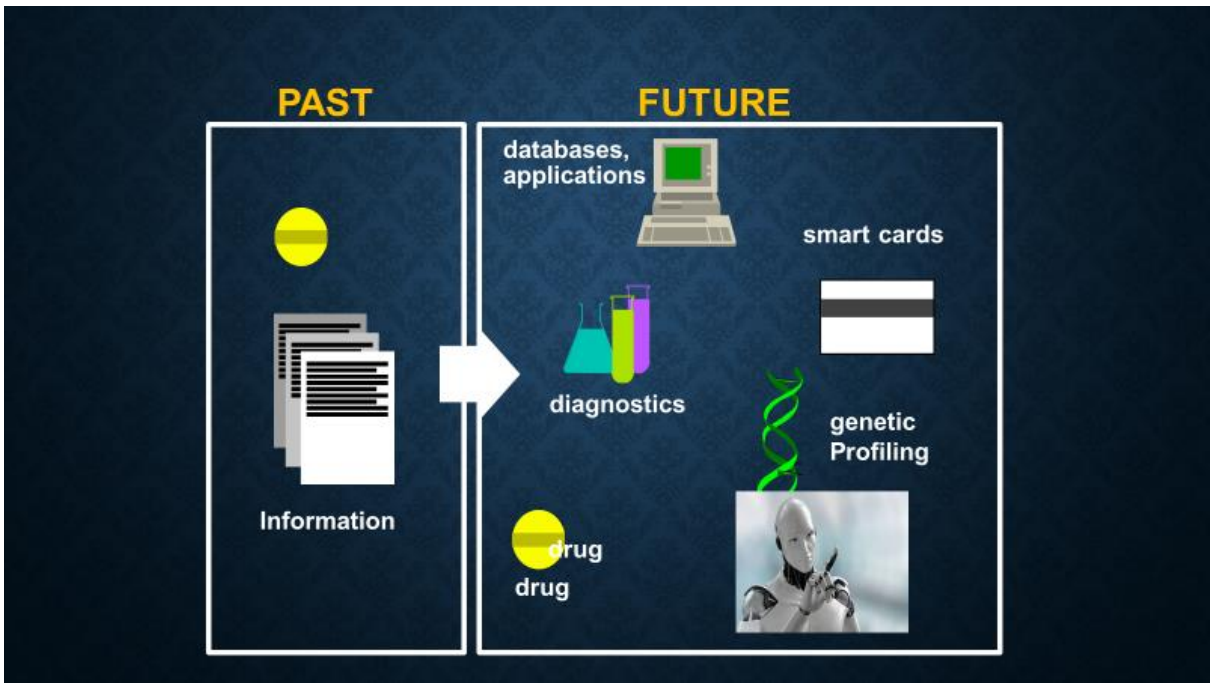
Just to give an example, from my own experience, that breaking down barriers and blurring of boundaries could result in benefits to all. The key in today's world is not to build WALLS but to build BRIDGES. Public Private Partnerships, at least in the UK, have a bad reputation because of the PFI (Private Finance Initiative), which by the way is not a true Public Private Partnership but more privatisation through the back door. And it was badly implemented.



The first paediatric vaccine for Malaria is available today because of the sharing of risks in development and partnership between a Pharma company (GSK), an NGO (Gates foundation) and the European Governments. In this model, the cost and risks of R&D were shared by GSK and the Gates Foundation and the European Governments signed an agreement (Advanced Market Purchase) to acquire the supply of vaccines and distribute through their overseas aid program. A very innovative approach and a wonderful outcome.

THE HEALTHCARE ENVIRONMENT OF THE FUTURE

I have schematically summarised the PAST & the FUTURE healthcare environment.



Today, we are at a cross road in making this transition. When I lost my father, it was a simple healthcare system: the patient, the doctor & the pill. None of us want to go back to that but the future will be complex with multiple stakeholders, institutions and industries with complex relationships with companion therapeutics & diagnostics, smart cards & genetic profiling and databases and robots. Society can benefit from these advances, if we nurture them carefully and optimise the impact.

RISKS & CHALLENGES IN MANAGING TECHNOLOGICAL ADVANCES

However, we also need to be aware of the dangers and risks of deploying these technological advances within the traditional healthcare systems and nurture them carefully, as our ancestors learnt to manage fire as a tool and we are learning to manage the rational use of medicines. Technological advances can develop insidiously and in no time can take over our lives: as we have seen with the social media. "*By plucking a chicken one feather at a time, no one notices",* so said non-other than Mussolini when he was trying to introduce fascism in Europe!!

We must also be adaptive and learn not to resist but embrace change. T20 cricket was and still is resisted by many. It will damage the purity of test cricket, they hasten to complain. But doesn't the combined purity of test cricket and the innovative strokes of T20 cricket show in the batting displays of a Sangakkara or a Kohli or a Kane Williamson. As a profession, we are conservative and not good in embracing change. The white coat and the stethoscope have lost their usefulness, the latter as a diagnostic tool and even as a status symbol. Why search tediously for that mid diastolic murmur and an opening snap when a simple echocardiogram gives you all the information of the mitral valve, BUT the key is to ensure that we embrace the advances in technology without losing the basics of medicine and the values of society.

How can we talk about these technological advances and their impact when today, in the 21st century, we have over a billion adults and children who can't afford glasses to correct their vision and when half the population of the world doesn't have basic sanitation and clean water supply?

How do we handle the enormous ethical and social aspects of AI? The initial algorithms are built by humans. Any biases and prejudices introduced by the humans could and would be magnified by machine learning robots. Remember Robots are

machines not humans; They do not differentiate between right and wrong, at least at the outset.

What about the ongoing issues of confidentiality, data privacy and consent.

Indeed, a world with robots and AI could dehumanise emotions. Susan Greenfield the neuro-pharmacologist, has already expressed serious concerns on a generation of youngsters growing up on social media with dehumanised emotions.

What would the world be if, as some experts are suggesting, Robots eventually develop emotion and even conscious self-awareness. Would this be the doomsday scenario for Homo sapiens?

LIFE, END OF LIFE & DEATH

This, for me, is the most important consideration not just for AI but for all technological advances in healthcare. Medical advances have without doubt prolonged life, especially over the latter half of the 20th century and will continue to do so at an accelerated pace in the future. Living to reach 100 and beyond will become the norm. Human beings have always searched for immortality or created narratives to ensure life doesn't end for them in the current form. We now have venture capital funds investing into research in search of the ELIXIR or AMIRTHAM of immortality!!

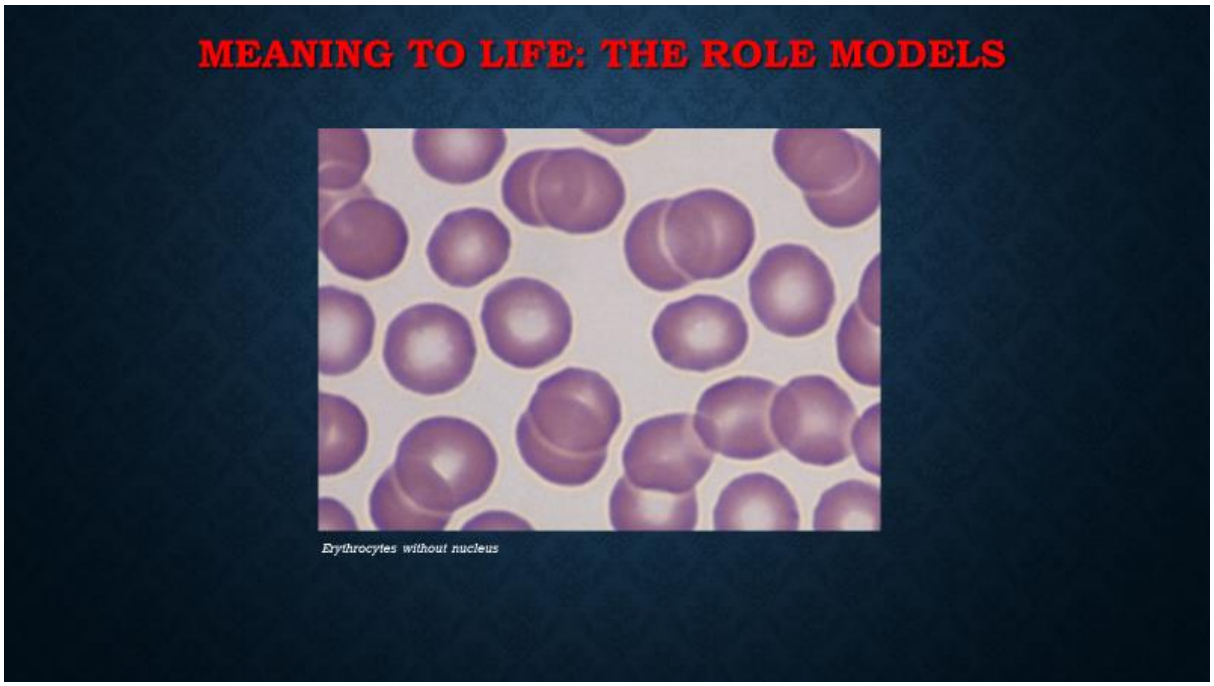
But prolonging life is not the end of the story. It takes us to the beginning of life and the search for the meaning and purpose of life.

We have through medical advances taken some control of our lives but the question now being asked, in many quarters, is whether we should have control of our death. Difficult and sensitive questions on end of life decisions and even euthanasia will become discussed more and more. I am not saying there is a right or wrong answer, and these are complex questions on ethics, religion and society. But as a medical community, we need to engage, contribute and participate in these discussions. Assisted dying has literally got closer here in UK with the impending change to the laws in Guernsey

In conclusion, enormous advances in Healthcare will continue unabated. The combined force of biotechnology, digitalisation and artificial intelligence will be transformative. As we cherish these advances which will bring considerable benefits to society, we should be willing to address the complex ethical and social implications

of these advances. But above all, we should pause and reflect on the optimal balance of life, its well-being and purpose, end of life decisions and death itself.

In doing so, we could take a leaf from the life of the RED CELLS.



The red cells do not have a nucleus and as such they do not possess, what some geneticists label as the SELFISH GENES, seeking survival at all costs. They come to life, serve every other cell in the body, carrying the vital O2 day in and day out, do not seek immortality and after 120 days, quietly leave their world with a smile and satisfaction that the JOB has been well done.

THANK YOU FOR LISTENING AND FOR YOUR PATIENCE