

A Global Village

WHERE POLICY AND POLITICS MEET SCIENCE AND ENGINEERING



Ageing

Alzheimer's Disease | Ageing Societies | Cardiovascular Health



Technology for Disability

Artificial Organs | Prosthetics



Gender Economics

Getting Women on The Board | Women in Science

From the Editors



Is it possible to have it all? Facebook's Sheryl Sandberg thinks so – placing the emphasis on individual action and encouraging women need to 'lean in' to opportunities rather than step back when embarking on motherhood. On page 30, *Calypto Montouchet* eloquently balances this theory with the need for attitude and institutional change, probing the range of reasons why women struggle to make it to the top.

Neave O'Clery [Editor In Chief](#)

Cardiovascular disease is responsible for a third of all deaths worldwide, and this statistic is likely to worsen given today's ageing population. On page 12, *Prof. Thomas Brand* looks beyond traditional risk factors to explore genetic mechanisms that could provide novel therapeutic targets for the ageing heart.

Nazeeha Hasan [Deputy Editor Design](#)



Cancer is still a leading cause of premature death around the globe, claiming 15% of all deaths worldwide. On page 21, *Carina Crawford* addresses how this worrying number is inexorably rising as the world population grows and lives longer, and explores the tools available to tackle this killer disease.

Claire Roseren [Managing Editor Content](#)

Both normal ageing processes, as well as pathological diseases prevalent in the ageing population, put a huge amount of pressure on our healthcare systems. *Steve Beales* argues on page 8 that we need a more coordinated approach to healthcare, in order to effectively deal with the rising demand of different care and needs required by the changing population.

Georgia Lockwood-Estrin [Ageing](#)



Urbanisation, population growth and poverty in Kenya have increased demand for a cheap, easily available cooking fuel. Fuel briquettes are emerging as a viable alternative energy source, which is affordable, eco-friendly and supports the poorest communities. On page 39, *Mary Njenga* describes how this technology is creating livelihoods for women and other marginalised groups and helping to increase community resilience.

Dharshani Weerasekera [Gender Economics](#)



Hands are a very important functional part of our body, both for practical tasks and communication purposes. On page 27, *Prof. Silvestro Micera* describes recent progress in research on neural interfaces-based prostheses – currently the best substitute for the natural limb. It is hoped this emerging technology will overcome the limitations of existing prosthetics, both from the functional and aesthetic point of view.

Antonio Torrisi [Managing Editor Design](#)

Alzheimer's disease is unambiguously connected with ageing. On page 18, *Ioanna Stefani* explores the fundamentals of this disease, with an emphasis on the role of an organelle called the Endoplasmic Reticulum, and explains how we might be able to manipulate this organelle to develop effective treatments.

Eftychios Hadjittofis [Ageing](#)



Despite the rise in organ donation in the UK, three people die every day while on the waiting list for organs. The present debate is on the matter of consent with some arguing that consent should be presumed for all unless otherwise stated to address the shortage of organs. On page 24, *Stephen McCarthy* discusses how the field of tissue engineering may settle this debate by growing artificial biological organs from a patient's own cells.

Mohammad Yaqub Chaudhary [Technology for Disability](#)

Women face many obstacles on the career ladder, not least the risks posed by sexual harassment. On page 34, *Renate van Oosten* reveals how unchecked discrimination, harassment and sexual violence can permeate the workplace, and showcases the legal efforts that draw attention to people's rights to earn in safety and security.

Jayraj Rathod [Gender Economics](#)



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Foreword

We are all born and we all die. Happily for many of us the time between these two events is increasing. Advances in science and medicine have led to sustained increases in life expectancy in many countries. In developed countries, life expectancy is increasing by an astonishing five hours every day. Good news for those expecting to live over ten years longer than their grandparents' generation; however, this presents a significant challenge to society. Older peoples' needs are very different to those of the younger population, in particular their healthcare and care needs.

As the articles in this issue demonstrate, more older people will mean we face a growing burden of disease. Older people are more likely to live with multiple health conditions, from dementia to heart disease to cancers. Older people are also increasingly (and rightly) expecting more from what they are able to do in their later years and the support that they will receive if their health deteriorates. Meanwhile, there are fewer people available to provide care as the working age population shrinks relative to the older population. These opposing forces will lead to strong new pressures being placed on ageing societies. Individuals will have to accept a greater role in taking responsibility for their own care and for the care of those closest to them – notably in the developed countries.

Greater demand for more and higher quality care along with constrained supply means there has never been a more important time to consider the implications that ageing will have on societies and so I am pleased to see this as the focus for this issue of *A Global Village*.

Developing countries may not yet be facing quite the same pressures as developed countries, but in time they will and there is much to be learnt from a global approach. The challenges are substantial, but by no means insurmountable and progress in tackling them is being made.

Society has advanced to allow life expectancy to be the highest it has ever been. It must now focus on how to ensure that those reaching old age do so, as far as possible, free from ill-health and when illness does strike we must ensure that care is of the highest quality. Looking at the innovations and advances that are already being made in this area we can feel optimistic about the future, but only if we continue our relentless search for new and better ways of balancing demand and supply.

Sir Thomas Hughes-Hallett

Newly appointed Chairman of the Institute of Global Health Innovation at Imperial College. A self-described reformed banker, Sir Thomas was formerly Chief Executive of Marie Curie Cancer Care and has a particular interest in palliative care.



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Submissions for the October Issue

A Global Village focuses on key areas where politics and policy meet science and engineering from global health to climate change and energy, food security and development. Article lengths should be within the range 1000-2500 words.

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first draft

Topics: Technology for Democracy, Space: The Next Suburbia?, Biotechnology

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Ageing Societies: A Coordinated Approach

Steve Beales, Imperial College London

Increasing life expectancy and a greater number of older people are powerful signs of progress. Advances in science and medicine over the last 50 years have led to substantial declines in the number of deaths from infectious diseases and malnutrition. But ageing populations also pose important challenges for societies around the world by putting substantial pressure on healthcare systems to reform.

Older people require a different type of care than the rest of the population – with conditions typically requiring management, rather than treatment. This, combined with rising demand from a greater number of older people with higher expectations of care and falling supply of both formal and informal care, is leading to health and social care services that are ill-equipped to deal with these demographic developments.

Today, too little is being spent on the 'basic' care that older people often require and, where care is provided, it is often done so in a disjointed fashion. Getting the correct funding mechanisms in place, improving the flow of patient information and better co-ordination of care is crucial if societies are to deal with the challenges posed by ageing societies.

There are currently 800 million people aged 60 years and over, making up 11% of the world's population. By 2030, they will number 1.4 billion and make up 17%.

Ageing has only had a small impact on overall health expenditure. Instead it is proximity to death, rather than age, which is the most accurate predictor of healthcare expenditure

In 2047, for the first time in human history, a higher proportion of people in the world will be aged 60 and over (21.0%) than under 15 (20.8%).¹ Ageing is affecting all countries, both high and low-income. Lower life expectancy disguises the fact that there are many older people in developing countries, and by 2050, 68% of the world's over-80 population will be living in Asia or Latin America and the Caribbean.

There will also be fewer working age people per older person. By 2050, there will be just 3.9 people of working age for each individual over 65. This matters, not just because healthcare funding is drawn from the working age population, but also because it means that there will be fewer people to be the carers and doctors.

Does Older Mean More Expensive?

During a typical person's lifetime their healthcare costs will be greater the older they get. However, this does not necessarily imply that the total cost of healthcare increases as people live longer. In fact research has shown² that ageing has only had a small impact on overall health expenditure. Instead it is proximity to death, rather than age, which is the most accurate predictor of healthcare

expenditure. Several non-demographic factors, notably per capita income, medical technology and workforce costs, are also thought to have a stronger impact on increases in healthcare expenditure than ageing.³

[1] United Nations, Department of Economic and Social Affairs, Population Division. (2011) World Population Prospects: The 2010 Revision. New York: United Nations.
[2] Dormont B. (2006) Health expenditure growth: Reassessing the threat of ageing. *Health Economics*. 15(9): 947-963.
[3] Reinhardt U. E. (2003) Does the aging of the population really drive the demand for health care?, *Health Affairs*. 22(6): 27-39.

1950



11.75 working people to 1 aged 65+

2011



8.5 working people to 1 aged 65+

2050



3.9 working people to 1 aged 65+

The number of people of working age (15-64) for each person aged 65+ in 1950, 2011 and 2050.

Unlike life expectancy, the way people age makes a big difference to a population's healthcare bill. If a longer life means more time spent in ill-health costs will rise. However, if the extra years are spent in good health, expenditure remains steady or can even be reduced. The so-called 'compression of morbidity' – minimising the time people spend in sub-optimal health – is therefore an important aim for societies as their populations age.

Caring for Non-Communicable Diseases

Today the demand for care is increasing, driven by larger elderly populations, increasing levels of non-communicable diseases (NCDs) and higher expectations of the quality and quantity of care that individuals wish to receive, in particular in high-income countries.

Simultaneously the supply of care is falling. Informal caring arrangements – care provided by a spouse, family or children – are critical to many older people. It has been estimated that the care provided by informal carers in the UK is worth £119 billion per year⁴ – the same as all traditional healthcare spending combined.

However, four global trends are leading to a dramatic decline in the number of informal carers: increased female education and participation in the workforce; migration

and urbanisation; declining fertility rates; and, in Sub-Saharan Africa, the HIV/AIDS epidemic which has led to 'orphaned' parents. Formal care is also being squeezed due to a lack of availability of carers and clinicians due to the lower ratio of working age to elderly populations described above. Finally, older people tend to suffer from a greater number of conditions simultaneously. This creates demand for a different, more holistic, type of care than that required by the younger population that will typically suffer from a single, isolated disease.

Some conditions are primarily associated with old age, such as dementia. There are an estimated 35.6 million people living with dementia worldwide, with the number set to double every twenty years to 115.4 million in 2050. Among people aged 60 and above in high income countries, Alzheimer's and other dementias account for 9 per cent of healthy years lost to premature death or disability, the largest share of any single NCD.⁵ However, it is not just a high-income country issue as two thirds of people are living with dementia in low and middle income countries. Old-age conditions like dementia typically need to be managed rather than treated – requiring care, rather than healthcare.

These three key trends – increased demand from a larger number of older people with higher expectations of care; reduced supply of both informal care and traditional care; and a shift in demand to management rather than treatment all imply that health and social care services – in particular in the UK, but also elsewhere – are ill-equipped to deal with the pressures of an ageing society.

Coordinating Care

With a decreasing availability of care workers, it will become more important that the right type of care is provided at the right time in the right place by the right people.

Too much money is spent on secondary care (the type typically provided in the hospital setting) as nearly two thirds (65%) of people admitted to hospital in the UK are over 65 years old. Many of them would not need to be there if proper care and support were provided outside the hospital such as that provided by district nurses that might include help eating or ensuring medicines are taken correctly. This leads to massive waste as basic care is delivered by highly paid specialists.

Studies suggest that as many as 40% of patients who die in hospital do not have the medical needs that require them to be there.⁶ Less than 20% of people die in their own homes even though most people would prefer to do so. As the focus shifts from curing patients to managing their conditions, hospitals look increasingly poorly equipped. Resources need to be re-allocated from hospitals to long term care, provided by the community and general practice.

More needs to be done to enhance existing services and to expand them to be capable of dealing with the higher expectations people have from them. Carers, many of whom are old themselves, require support to ensure they do not become overburdened by, for instance, providing them with respite assistance. Primary care (and community care) needs to be available at weekends and at night to ensure that people are not in the position of having no alternative but to go into hospital to seek care.

As well as more care being provided outside of hospital, all care – whether it be specialist, primary or social – needs to be coordinated around the patient. Healthcare, mental healthcare and social care are currently delivered separately, with little integration. Older people, more than the rest

Old-age conditions like dementia typically need to be managed rather than treated – requiring care, rather than healthcare

of the population, often require two or more out of these. Integration of care within the hospital is just as important. As argued in a paper by the Royal College of Physicians,⁷ organ-based specialties which have, in the past, led to significant improvements in clinical quality are now causing issues as older patients (who typically have more than one condition) are passed around between specialties with insufficient co-ordination. For care to be delivered in the optimum location and for care to be better coordinated, two key things need to change: funding and the flow of patient information.

Reimbursement needs to be designed and implemented on a 'whole system' basis and over a sufficient period of time to incentivise care to be delivered by the most appropriate person, at the most appropriate time, in the most appropriate place. Such capitation budgets would cover a population for their entire healthcare, mental health and social care needs and would reflect the risk profile of the population being covered. Only once these budget components are combined can a proper distribution be made to services based on the value they create for the patient.

Information about the patient's needs and the type of care and treatment that is being given needs to be available to everyone involved in the whole of the patient's pathway, in real-time. The patient must also be able to provide feedback – both their impression of the outcomes and their experience of care delivery. This input should be used for continuous improvement in the system. A good

example of where a version of this is being implemented is the North West London Integrated Care Pilot, which is integrating the care record between secondary, primary and social care for patients with diabetes and the over 75s. However, this needs to be taken further to give the patient access and the ability to interact with the patient record and further to be expanded to include more information, accessible in real-time.

Ageing populations will create significant challenges for societies and how we fund and deliver all types of care. But the pressures they create may also hasten the move to a more patient-centric approach that is better able to keep people healthy, rather than just treating them once they fall ill. This coordinated approach will benefit the whole population, young and old.

Steve Beales is a health policy analyst in the Centre for Health Policy at the Institute of Global Health Innovation.

[4] Buckner L. (2011) Valuing Carers 2011. London: CarersUK.

[5] World Health Organisation (2008) Global Burden of Disease 2004 Summary Tables. [online] Available at: <<http://apps.who.int/ghodata/#>>.

[6] National Confidential Enquiry into Patient Outcome and Death (NCEPOD). (2009) Caring to the end? A review of the care of patients who died in hospital within four days of admission. London: NCEPOD.

[7] Royal College of Physicians. (2012) Hospitals on the edge? The time for action. London: Royal College of Physicians.



Smoking is one of the major risk factors for cardiovascular disease, which is the cause for over a half of all non-communicable disease deaths.

The Ageing Heart: The Popeye Domain Containing Gene Family

Prof. Thomas Brand, Imperial College London



Age has a major impact on the cardiovascular system, affecting many aspects including cardiac rhythmicity, pumping ability, blood pressure and the vasculature. However, the effects of ageing are more than the result of a life-long exposure to detrimental factors such as hypertension, diabetes, cholesterol, smoking, and other risk factors. There is also an intrinsic physiology of ageing of the cardiovascular system, which is a slow and cumulative process, where only minute changes are observable over the short-term. These changes, however, accumulate over time, causing a progressive decline of cardiac function.

The Popeye domain containing (*Popdc*) genes encode a family of membrane proteins with high expression levels in cardiac muscle cells. Mutations in these genes in model organisms cause age-sensitive heart rhythm disorders, where the ageing-dependent traits resemble pathologies that are frequently observed in elderly patients. Research based at Imperial College in this area aims to provide a novel insight into the ageing process and potentially provide new therapeutic opportunities to help the ageing heart.

Cardiovascular disease is the leading cause of death and is responsible for about one third of all deaths. Population data such as that of the Framingham Heart Study demonstrate that the average incidence of the first cardiovascular event increases progressively with age, with 0.3% chance at the age of 40 and multiplying almost 25-fold to reach 7.4% at the age of 90.

The heart is the first developing organ that becomes functional in our body. Shortly after formation it starts to beat and will do so for the rest of our life.

The average human heart rate is between 60-80 beats per minute, which translates into approximately 2.5 billion heartbeats over the course of a human life. The heart has four chambers that are tightly synchronized to pump blood at exact time intervals. The upper two heart chambers (right and left atria) help to fill the lower two larger chambers (right and left ventricle) with blood. The ventricles, in turn, drive the blood circulation throughout the body.

Cardiovascular disease is the leading cause of death and is responsible for about one third of all deaths

The heart has an electrical network of specialized muscle cells, the cardiac conduction system that synchronizes the contraction of the different heart chambers, but also controls the overall heart rate. A small cluster of cells in the right atrium, called the sinoatrial node, is the 'pacemaker', initiating electrical activation of the heart. Subsequently, electrical signals travel to the atrioventricular node (AV node), located between the atria and the ventricles, that acts as a 'gatekeeper' to control the speed of electrical conduction throughout the heart. Once electrical activity enters the ventricle, a group of specialized 'electrical cables' in the ventricle (the His-Purkinje network) is activated. Activation results in the rapid spread of electrical signals within the ventricles. The heart beats autonomously, but the autonomous nervous system, which stimulates the heart, has a modulatory role and is involved in speeding up or slowing down the beating rate.

Electrical activity travels in the form of an action potential (which can be understood as a melody) within heart muscles cells. What is also important to understand is that different parts of the heart have slightly different

forms of action potentials. Thereby the melody played in these different muscle cells is similar but not identical. Such variations however are essential for a harmonious cooperation at the organ level assuring a proper heart rhythm from beat to beat.

Model Organisms for Ageing

Ageing induces structural changes in the heart. The number of cells that facilitate contraction (contractile cells) is reduced while the number of non-muscle cells is augmented. The accumulation of non-muscle cells increases the stiffness of the heart resulting in a lower ease of contraction and an impairment of the conduction of electrical signals. Thus, cardiac arrhythmia (i.e. atrial fibrillation, ventricular arrhythmia or insufficient activity of the cardiac pacemaker), are prevalent conditions in the elderly that may cause sudden cardiac death if left untreated.

Ageing can be studied in model systems with a short lifespan since they have a relatively accelerated ageing process (e.g. small rodents and flies). Diastolic dysfunction is an age-related condition where there is an impairment of relaxation of the heart at the end of each contraction cycle causing a reduction in the net transport of blood. The underlying mechanisms of diastolic dysfunction may include an increase in the thickness of the ventricular wall (myocardial hypertrophy), changes in the ratio of non-muscle to contractile cells within the muscle tissue of the heart (myocardium), and changes in gene expression.

Significantly these changes can also be observed in ageing mice and rats. At baseline the heart rate of a mouse amounts to approximately 450 beats per minute and in response to physical activity the beating rate increases to about 700 beats per minute. These beating rates are significantly different from that of a human heart, which beats at rest between 70-80 beats per minute and physical activity causes an increase to up to 200 beats per minute. Such vast differences in the beating rate cast some doubt on the suitability of the mouse as a model

to study the basis of cardiac arrhythmia. However research in the last 15 years has demonstrated that there is sufficient similarity between both mammalian species to study the role of genes as the molecular basis of heart rhythm control in mice.

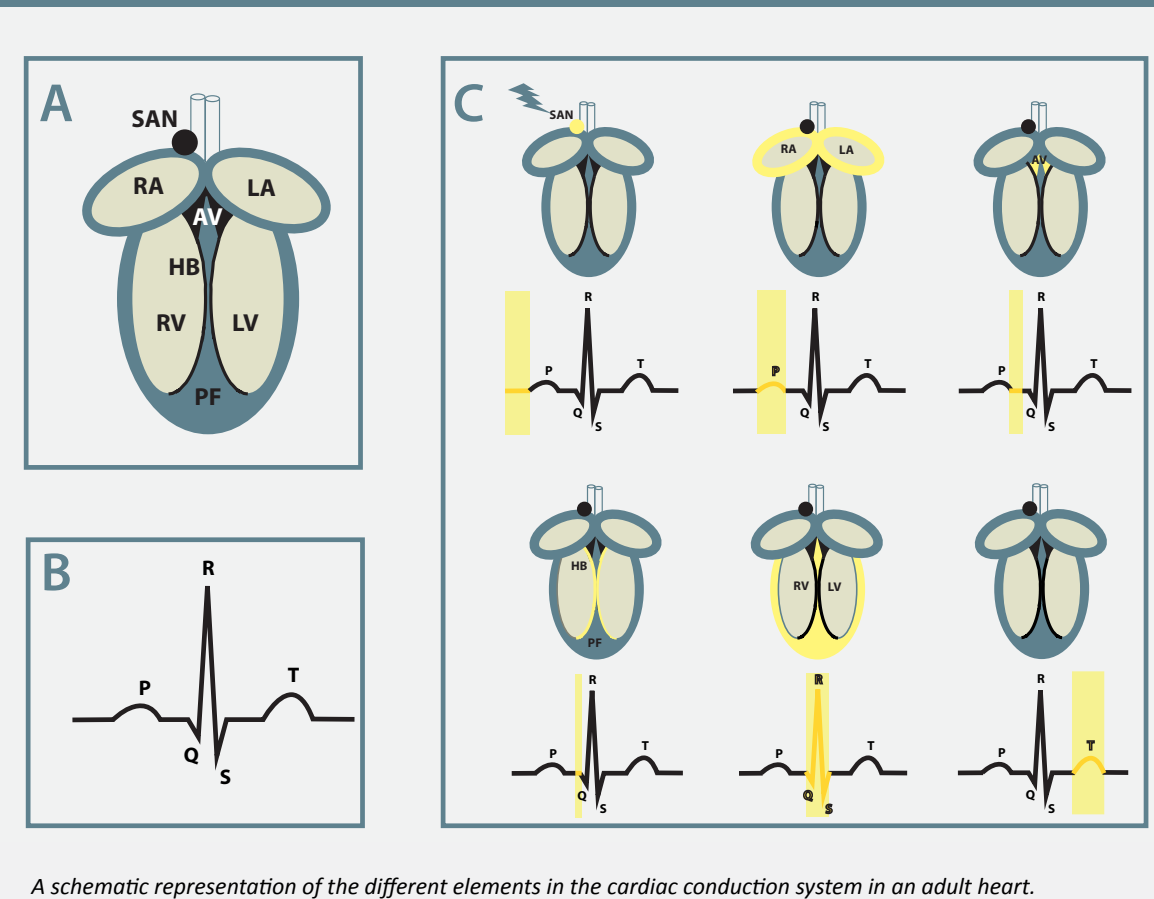
The fruit fly *Drosophila*, which has a life span of only a few weeks, has also been successfully utilized to study the process of ageing. As in humans, *Drosophila's* heart function declines with age and the incidence of many heart conditions increases significantly with the age of the fly. Genetic analysis revealed several pathways that may be responsible for these age-related changes. However, not all pathways are identical between species

and significant further research is required to apply the knowledge gained in model organisms to patients.

The Popeye Domain

When we are running or cycling, the beating rate of our heart starts to ramp up in order to increase blood perfusion of our organs and to meet the increasing oxygen and nutrition demands. This so-called fight-or flight

Ageing induces structural changes in the heart. The number of cells that facilitate contraction (contractile cells) is reduced while the number of non-muscle cells is augmented



A schematic representation of the different elements in the cardiac conduction system in an adult heart.

A. The heart consists of the right and left atrial (RA, LA) and ventricular (RV, LV) chambers, which pump the blood into our body. Electrical activity of the heart is generated in the sinoatrial node (SAN) and transmitted to the atria. Electrical activity is conducted to the ventricular chambers via the atrioventricular node (AV), the His bundle (HB) and the Purkinje fibres (PF), which ultimately activate the ventricular chambers. These different elements are defined as the cardiac conduction system.

B. The electrical activity of the heart can be monitored with an electrocardiogram (ECG). Electrical activation of different parts of the heart causes changes in the electrical signal. The P wave represents activation of the atria, whereas the QRS complex that of the ventricle. The T-wave represents the so-called repolarization phase at the end of the electrical activation cycle.

C. Electrical activation (yellow) in the different parts of the heart is depicted and the resulting changes in the ECG are shown underneath.

response is essential for increasing cardiac output under stress. Elderly people often have an impaired response to physical activity. They frequently suffer from sick sinus syndrome. With this disease the heart rate is often normal at rest. However when affected patients have to perform physical activity, for example, when they are climbing stairs, the impaired ability of the pacemaker to increase the heart rate causes dizziness or even unconsciousness. Therapeutic intervention of sick sinus syndrome involves the implantation of an electrical pacemaker device. Sick sinus syndrome is reasonably prevalent and occurs in about 1/600 cardiac patients aged 65 years or older. About 50% of all pacemaker implantations are due to the diagnosis of sick sinus syndrome, with about 26,000 in the UK alone at a cost of £43 million per year.

In this context the Popeye domain containing (*Popdc*) gene family was discovered in the search for genes with a strong and specific expression in the developing heart. Intriguingly, despite the strong expression in the developing and adult heart, the experimental inactivation of *Popdc* genes in mice had no apparent effect on the developing heart.

Popdc genes are present at high levels in the cardiac conduction system (See schematic representation), but under resting conditions *Popdc* mutant mice display no sign of a cardiac arrhythmia. However, the mutant animals revealed their disease phenotype only when subjected to stress.

In *Popdc* mutants a specific form of cardiac arrhythmia, an abnormally slow heartbeat, (bradycardia) was observed when the animals were subjected to physical activity such as running or swimming. Instead of the 700 beats per minute, seen under stress in normal mice, the mutant animals had a heart rate approximately 100 beats lower. This reduction in the maximal heart rate was due to a specific defect in the sinoatrial node (the heart's pacemaker tissue). Instead of rhythmic pacing of the heart, the mutant sinoatrial node displayed intermittent pauses, which occurred randomly and were of different length in time. This can have a dramatic impact since the heart does not perform according to the physiological demands of the body.

About 50% of all pacemaker implantations are due to the diagnosis of sick sinus syndrome, with about 26,000 in the UK alone at a cost of £43 million per year

Another important aspect, which makes the *Popdc* mutant animals very valuable models, is the fact that the bradycardia is not present in mutant mice at a young age. It only becomes apparent when the animals get older. The *Popdc* mouse mutants are therefore excellent models to study the molecular processes of ageing, which lead to sick sinus syndrome. These animal models may also help to develop novel therapeutic interventions for this disease. The pathological phenotype in the mouse mutants resembles to a large extent the human condition. The stress dependence and the random occurrence of pauses are exactly what have been observed in patients with this condition. Knowing the time-point at which the bradycardia phenotype is first present, one can determine what has changed at the level of the organ, cell or even gene expression. This will allow for the specification of the molecular mechanism through which age has an impact on heart function.

An important question that also needs to be addressed is whether mutations in *Popdc* genes in patients are associated with cardiac arrhythmia. Moreover, will a bradycardia phenotype be always present in patients with a mutation in *Popdc* genes? An answer to this question may come from the search for patients with cardiac arrhythmia that have mutations in *Popdc* genes. This search is currently being pursued through collaborations between Imperial College and various clinics in the UK and in Europe.

It is worthwhile to discuss in this context another set of experimental data that has been obtained in zebrafish. The zebrafish has recently become a prominent model organism, which is now widely used in biomedical research. What makes this animal model so attractive for heart research is the fact that the fish heart beats at a very similar rate to the human heart. Moreover, the zebrafish is transparent and the embryonic heart can be easily monitored with the help of a microscope. Strikingly, the fish heart utilizes a similar set of ion channels to humans and the phenotypes of several genetic mutations are more comparable with humans in the fish than in the mouse. Cardiac arrhythmia is also present in zebrafish lacking *Popdc* gene function. In contrast to the mouse however, the phenotype is associated with a deficiency of the atrioventricular node (AV), which acts as a gatekeeper to regulate electrical activation of the ventricles.

Glossary

The Action Potential (AP) is a form of electrical signal that travels along the plasma membrane of muscle cells. It requires the precise orchestrated activity of a number of ion channels and pumps, which act together to elicit an AP. Different muscle cells in the heart have slightly different forms of AP creating at the organ level a rhythmic beating heart.

Affinity is a physical property and quantifies the binding force of two interaction partners. In case of a ligand-protein interaction, the affinity describes the concentration of the ligand at which half of it is bound to the protein.

Atrial fibrillation (AF) is the most common form of cardiac arrhythmia. It is caused by disordered electrical activity in the atrium despite a normal sinus rhythm. It is believed that an increase in the number of non-muscle cells can cause AF. While the heart is able to cope with AF, it is associated with an increase in the risk of developing a stroke. The number of patients with AF in a population increases with age, with 8% of people over 80.

Bradycardia is a cardiac arrhythmia, which is characterised by a slow heart rhythm. A bradycardia is often tolerated, however it may cause dizziness or fainting due to the fact that the beating rate is sometimes not high enough to meet the oxygen requirements of the body (in particular during exercise such as climbing up the stairs). Implantation of a pacemaker is a therapeutic option in this case.

Cardiac arrhythmia characterises a group of diseases with abnormal electrical activity in the heart. The heart either beats too fast (tachycardia) or too slow (bradycardia) or shows some other irregularities (atrial or ventricular fibrillations). Rhythmic contractions of our heart are essential for our wellbeing and the cardiac conduction system is orchestrating the rhythmic contraction of our heart.

Contractile cells. Contraction is a movement found in muscle cells and involves the shortening and thickening of a functioning muscle. This type of cells are found in many different places in our body such as skeletal muscle and the heart but also include the smooth muscle cells that line up the digestive tract.

Cyclic AMP (cAMP) is a so-called secondary messenger, which is produced in cells from the ubiquitous molecule ATP. The production of cAMP occurs in cells in response to hormonal stimulation such as after the release of the stress hormone adrenaline. cAMP is rapidly accumulating in cells and several proteins bind this messenger molecule with high-affinity, leading to significant alterations in the cell and affecting excitability of the cell, its metabolism and the force and speed of contraction. Collectively these physiological responses are called the fight-or flight response.

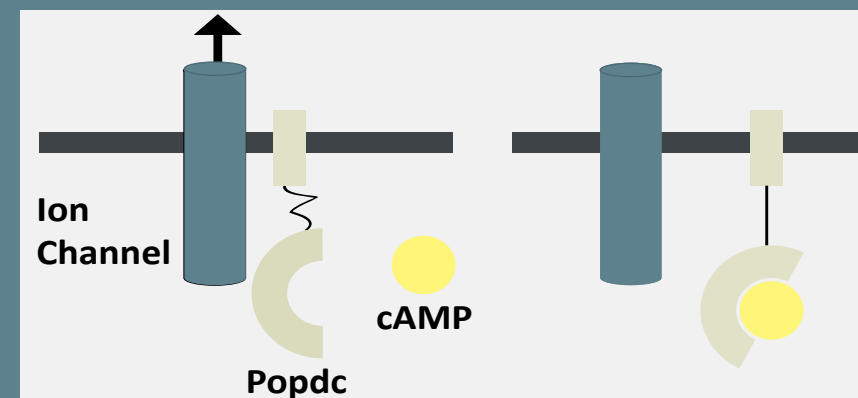
Diastole. The heart cycles through phases of contraction (systole) and relaxation (diastole). During diastole the heart relaxes, and thereby increases its diameter, which results in blood filling the heart, while during contraction in systole the blood is pumped back into the body.

Non-muscle cells. Our heart is made up of muscle cells, which are responsible for the contraction of the heart. However there are also other cell types in the heart, which are collectively called the non-muscle cells. These include for example the cells that line the coronary arteries, but also include connective tissue cells, which are essential to provide strength and integrity to the muscle tissue.

Ventricular arrhythmia (VA) is an electrical disease of the heart chambers. VA is potentially life threatening and needs to be treated either pharmacologically or through the implantation of a defibrillator. VA presents as extra beats (extrasystole), or could be as severe as ventricular fibrillation, which describes a heart which is electrically in complete disorder and is unable to contract and pump blood. Only by an electrical shock with the help of a defibrillator will the heart be brought back to normal rhythmic contraction.

In-Depth: Popeye Domain Binds cAMP

The Popeye domain containing genes encode a novel class of proteins, which are localized at the plasma membrane in cardiac muscle cells. Popdc proteins form complexes with ion channels and pumps and probably modulate their activity. What is very interesting is the fact that Popdc proteins bind cyclic adenosine monophosphate (cAMP) with high affinity. cAMP is produced in cells in response to stress signals and acts as a so-called



The Popdc protein acts as a stress sensor in heart muscle cells. Popdc proteins are interacting with ion channels and have the ability to bind cAMP. Binding of cAMP induces a shape change of Popdc proteins, which leads to a separation from the neighbouring ion channel. As a consequence the ion channel is closed, which has a direct impact on the timing of the next action potential.

A second messenger coordinates the physiologic reactions in a cell and simultaneously alters the biological activity of many hundreds of proteins. In order to do so, cAMP binds to a group of proteins which have a specialized surface by which they specifically recognize cAMP and bind to it with high affinity. The binding event changes the structures of these proteins and this molecular event ultimately starts a chain reaction affecting many different target proteins at the same time.

It is thought that binding of cAMP by Popdc proteins induces structural changes which cause inhibition or activation of the proteins, and in this way Popdc proteins modulate the electrical activity in the heart. The binding site for cAMP in Popdc proteins is structurally unique and only present in Popdc proteins. This provides an opportunity to screen for cAMP-like molecules which only activate Popdc proteins. Such a molecule would form the basis for the development of a novel class of drugs that might prevent cardiac arrhythmia and might even be suitable to treat patients with sick sinus syndrome, or other cardiac diseases in which Popdc proteins might be implicated in the future.

Thus, at present it is unclear what kind of cardiac arrhythmia will be observed in patients with mutations in Popdc genes. Will it be more similar to the zebrafish or the mouse phenotypes? Nonetheless, given that cardiac arrhythmia phenotypes are observed in two model organisms, which are only very distantly related, it is quite likely that mutations in Popdc genes will have an impact on the electrical activation pattern of the human heart.

Studying the role of the Popeye domain containing genes in the heart will help to better understand cardiac arrhythmia and the ageing heart. However, one needs to be cautious about extrapolating results from animal models to humans. This is particularly true for ageing research. A prominent example is caloric restriction. In roundworms, yeast, and fruit flies caloric restriction significantly extended life span, but

a recent study in monkeys did not provide any evidence for a life-extending effect of caloric restriction. It is currently thought that life expectation in man may be mostly influenced by genetic networks and not so much by environmental factors such as diet or lifestyle. It is thus probably very difficult to fully model human ageing in any model organism. Nonetheless ageing research in model organisms will provide us with concepts and biological targets, some of which may indeed have an impact on the ageing process in humans. It may not increase our longevity but possibly improve our health and the quality of life during ageing.

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Alzheimer's Disease: Spotlight on ER Stress

Ioanna Stefani, Imperial College London

Alzheimer's disease (AD) is a progressive and irreversible neurodegenerative disorder affecting over 35 million people worldwide. As the global population ages, AD is projected to reach epidemic proportions. Whilst health care systems worldwide need to act to address this growing economic and social burden, scientific research is under pressure to reach a better understanding of the mechanisms underlying this neurodegenerative disease. At present, the major advances in our understanding of the causes and mechanisms of AD have been achieved by research into molecular biology and protein folding. This article addresses the role of the stress caused in a particular cell organelle, the endoplasmic reticulum (ER), in AD brain cells, and its potential as a therapeutic target.

Alzheimer's disease (AD) is an age-dependent, irreversible neurodegenerative disorder and the most common form of dementia worldwide. In 2010, it is reported that over 35 million people were living with dementia, 2/3 of who were from developing countries. If the incidence of AD continues to rise at the current rate, it is estimated that as many as 115 million individuals will be affected by the disease by 2050¹.

While the brain in healthy ageing individuals may shrink to some extent, it does not lose neuronal brain cells in large numbers. Conversely, patients with AD exhibit significant reduction in brain volume resulting from widespread neuronal degeneration. Initial damage occurs in

neurons and neural connections in specific parts of the brain involved in memory. Early symptoms of AD are often ignored for some time because they resemble natural signs of ageing. However, as the disease progresses, the damage extends to areas involved in reasoning, language and behavior, leading to a series of consequences including loss of memory, impairment of intellectual ability and changes in behaviour and personality. Eventually, large-scale neural destruction renders the AD patient unresponsive to the outside world.

A Tangled Case

AD is characterised by the accumulation and formation of abnormal structures in the brain known as amyloid plaques and neurofibrillary tangles. The disease can be classified into different subtypes, based on the age of the onset and the genetic predisposition. Sporadic or late onset AD (LOAD) is the most common form, while familial AD (FAD) is an inherited form of early onset AD that accounts for around 5% of cases.

Recent scientific and clinical research has revealed a genetic basis underlying AD pathophysiology. It is thought the mutations in certain genes could play a role in the breakdown of amyloid precursor protein (APP), a transmembrane protein whose precise function is not yet known. This breakdown is part of a process that generates of toxic species named amyloid-beta (A β 40 and A β 42), which precede amyloid plaque formation, a hallmark of the disease².

While the brain in healthy aging individuals may shrink to some extent, it does not lose neuronal brain cells in large numbers. Conversely, patients with AD exhibit significant reduction in brain volume resulting from widespread neuronal degeneration

At present, there is no cure for AD. Cholinesterase inhibitor compounds, the most effective treatments available, can delay the neurodegenerative process by 6-18 months. Other drugs, such as Aricept[®], Exelon[®] and Razadyne[®], aim to alleviate behavioural symptoms such as agitation, anxiety and depression, making the patients feel more comfortable and thus easing their care³. The challenge, therefore, is the discovery of novel molecular targets that could aid the development of new therapies to stop or even prevent AD altogether.

ER Protein Machinery – Under Stress Conditions

The Endoplasmic Reticulum (ER) is the cellular compartment where proteins are synthesised. The newly synthesised proteins are not functional until they obtain their correct 3D structure in a process called protein folding. This process makes the ER a unique compartment with a crucial role in the proper functioning of the cell.

The ER environment can be perturbed by pathophysiological processes such as environmental factors and mutant protein expression, but also from natural processes such as the increased biosynthetic load taking place in the ER. This results in the accumulation of immature (unfolded) and abnormal (misfolded) proteins in the cells causing ER stress. Our body counteracts ER stress with an adaptive response called the 'Unfolded Protein Response' (UPR), which activates signalling cascades that elicit changes in metabolism and gene expression required to manage the stress situation. As long as the UPR can reduce ER stress, our body works correctly. However, when the level of stress induced by the accumulation of misfolded proteins cannot be controlled by the UPR, ER stress, which initially acts as a proactive mechanism for the cells, has the capability to induce an inflammatory response and programmed cell death (apoptosis).

Managing ER Stress in AD

ER stress has been proposed as a potential mechanism for age-related decline in general tissue mass and function and, in particular, in neurodegeneration. Research has shown that there is age-related decline in the ability of the ER to overcome stress, mostly through inactivation or decreased synthesis of critical molecular chaperone proteins such as BiP, involved in facilitating the 3D assembly of newly synthesized proteins. Chaperones sense the level of unfolded proteins in the ER and act as ER stress sensors.

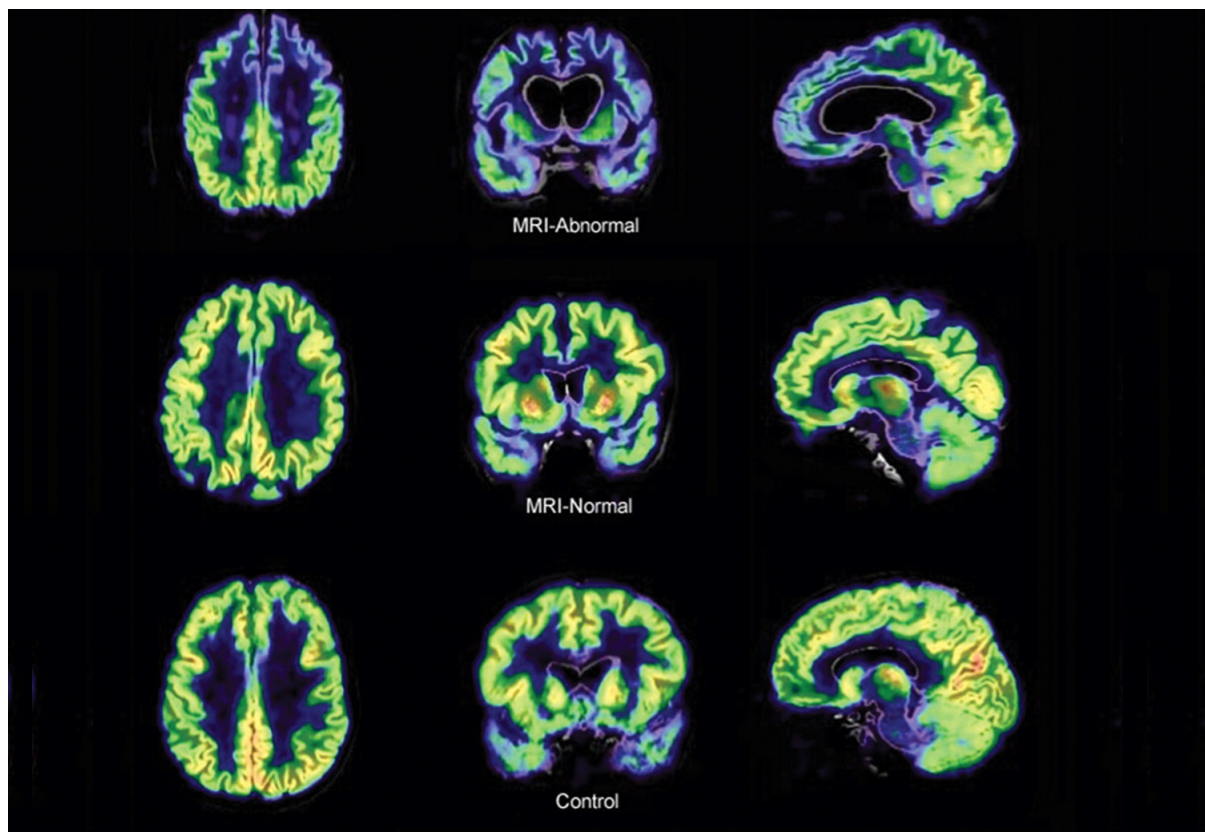
The ER is extremely sensitive to disturbances in cellular homeostasis, therefore it is not surprising that many studies investigating protein misfolding diseases such as Alzheimer's and Parkinson's, have implicated ER stress as being at least partially responsible for neuronal death. Genetic mutations associated with AD (e.g. mutation in the APP gene) impact ER function and likely reduce its capacity to deal with ER stress, shifting the balance of cellular fate towards the apoptotic pathways rather than recovery. Therefore therapeutic strategies that modulate ER function represent a promising approach for prevention or treatment of AD.

Specific targets for ER regulation have been difficult to find, due to the high degree of cross signalling in the UPR pathway. However, recent research suggests that increasing the ability of the UPR to deal with stress by either upregulating molecular chaperones and/or blocking apoptosis, provide likely treatment avenues for neurodegeneration.

One logical strategy is to increase protein-folding capacity by stimulating the over-expression of protein folding chaperones without affecting the activation of other, more detrimental, ER stress events. Related to this is the use of small molecule chaperones to directly affect the solubility and/or folding of the accumulated proteins. Both of these strategies appear promising. A body of evidence from the field of psychiatry suggests that certain mood-altering drugs used in the treatment of diseases, such as bipolar disorder, are able to selectively increase the levels of the chaperone named

At present, there is no cure for AD. Cholinesterase inhibitor compounds, the most effective treatments available, can delay the neurodegenerative process by 6-18 months

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Magnetic Resonance (MR) and Positron Emission Tomography (PET) images are superimposed to get information about the neural activation in neurodegenerative diseases such as frontotemporal dementia⁴.

BiP without triggering ER stress. These include lithium, valproate, and possibly very high (supratherapeutic) doses of carbamazepine. The neuroprotective effects of valproate (such as reduced neuronal cell death and increased cell survival) appear to be particularly noticeable in the frontal cortex, an area affected by AD, and the CA1 region of the hippocampus⁵. Thus, there has been an increased interest in the potential to provide mood stabilizers drugs to treat neurodegenerative disorders.

Another strategy for new therapeutics that target ER stress involves targeting the cellular control points that determine the point that irreversibly initiates apoptosis (cell death). Drug development and clinical studies on neurodegenerative diseases need to focus on promoting the survival mechanisms and inhibiting the

ER stress has been proposed as a potential mechanism for age-related decline in general tissue mass and function and, in particular, in neurodegeneration

pro-apoptotic pathways. Essentially, it would be useful to develop therapeutics that would modulate the same signalling pathway, but with opposite effects to treat different diseases².

With the rising prevalence of AD, the urgency to develop new treatments is increasing. Current insights into the importance of ER stress and the apoptotic molecular cascade in the progression of neurodegenerative diseases supports further research to investigate this as a prominent target for drug discovery. It is hoped that this will lead to the development of novel AD therapies that go beyond alleviating the symptoms, and to a new generation of drugs that aim to cure or even prevent this devastating disease.

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Cancer: A Global Issue

Carina Crawford, Cancer Research UK

The silent global epidemic of non-communicable diseases (NCDs) has recently caught the world's attention, of which cancer is a major contributor to disease. Cancer is one of the biggest killers in the 21st century. As the world's population is ageing in most regions in the world it is predicted that the burden of cancer will continue to increase. There is still a widely held view that cancer only affects those in wealthier regions of the world and the elderly, yet at least half of cancers are diagnosed in developing countries and these carry the greatest burden of premature mortality from cancer.

The leading causes of deaths from NCDs – responsible for 2 out of every 3 deaths globally – are cardiovascular diseases, cancer, respiratory diseases and diabetes. Cancer is a leading cause of death worldwide claiming 8 million lives annually (around 15% of all deaths)¹. This varies four-fold across geographical regions, from around 5% in Africa to 20% in the Western Pacific of all deaths worldwide are due to cancer. More than a quarter of all deaths in the UK are due to cancer².

The growing impact of cancer and other NCDs on global health has placed them on the international agenda. In 2011, NCDs were recognised as a global health priority by Commonwealth Health Ministers at their annual meeting, and by world leaders at the UN High Level Meeting on the Prevention and Control of NCDs. This is only the second High Level Meeting on a health issue convened by the UN General Assembly, following HIV/AIDS, emphasising the threat of NCDs to development worldwide.

Cancer and Ageing

Life expectancy has increased since 1970 on average by 10 years, with a climb to 73 years in women and 67 years in men on average globally. However, although life expectancy has been extended, the number of years lost to disability has also increased; therefore, although people are living longer, they are more likely to be living with disease. The world is witnessing an epidemiological transition from infectious diseases, mainly affecting young children, to chronic diseases in adulthood. Even in the African region, where life expectancy is lower¹, this shift is predicted to occur by 2030³.

A person's risk of developing cancer increases with age. The biological process of ageing is itself a risk factor for developing cancer due to accumulation

of genetic mutations and cell damage over a lifetime of exposure to carcinogens from lifestyle and environmental factors. As the world's population

The biological process of ageing is itself a risk factor for developing cancer due to accumulation of genetic mutations and cell damage over a lifetime of exposure to carcinogens from lifestyle and environmental factors

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continues to age and grow, the burden of cancer will inevitably increase, even if current incidence rates remain the same².

The annual number of new cancer cases is projected to exceed 20 million by 2030⁴, whereas the number of deaths associated with NCDs (in general) are projected to rise substantially by 15% by 2020³.

Many of the lifestyle factors associated with cancer and other NCDs begin in childhood

Although cancer is predominantly a disease associated with the elderly, the distribution of cancer worldwide is not exclusive to the old and frail. It is estimated that potentially half of all cancers in developing countries occur in those less than 65 years of age⁵. Although globally more than two thirds of breast and cervical cancer deaths are estimated to occur in women over 50, more women are dying from breast and cervical cancer at a younger age in low and middle income countries⁶. Many of the lifestyle factors associated with cancer and other NCDs begin in childhood, and hence prevention efforts targeting young people are extremely important to promote behavioural change that will reduce the risk of these diseases blighting them in later life.

Lifestyle Factors

Lung, female breast, colorectal, stomach and liver cancers cause the majority of cancer morbidity and mortality worldwide. There is wide geographical variation in cancer patterns worldwide, depending on the prevalence of underlying risk factors. The major risk factors for cancer include the main four shared behavioural factors for all NCDs; tobacco use, unhealthy diet, insufficient physical activity and

the harmful use of alcohol. In the UK the most common cancers diagnosed are breast, lung, colorectum and prostate, and together these cancers account for almost half of the UK's total⁷.

Breast cancer has increased in most countries worldwide – cases have more than doubled globally since 1980 – with just

over half of these cases now occurring in developing countries⁶. This increase is only in part explained by population growth and ageing, and the rapid increase in cases seen in low and middle-income countries is thought to be due to the adoption of lifestyle factors, which are associated with higher breast cancer risk as these countries develop². Approximately 47% of cancer cases and 55% of cancer deaths occur in less developed regions of the world⁴. Rapid economic growth in many developing countries,

accompanied by rapid urbanization, is leading to the adoption of 'Western' lifestyle habits and diets and the associated disease burden. Low and middle income countries already bearing the burden of infectious diseases are now facing a double burden from cancer and other NCDs. Cancers that were previously uncommon in these countries are now becoming more prevalent, such as lung, breast and colorectal cancer.

Infectious Diseases

Infectious diseases also contribute to the burden of cancer. Around one in six cancers are caused by chronic infection, most of which are cancers of the cervix, stomach and liver. Around a quarter of new cancer cases in developing countries are attributable to infection compared with less than 10% in developed countries⁴. The HIV epidemic exacerbates the impact of infection-attributable cancer through weakening of

the immune system of those infected, particularly in sub-Saharan Africa that is worst affected. The incidence rates of the cancers Kaposi Sarcoma and Non-Hodgkin Lymphoma, caused by infection with the herpes virus and Epstein Barr virus respectively, are higher in those living with HIV and are most prevalent in low income countries. Access to treatment for HIV and AIDS is steadily improving in many parts of the world enabling those living with HIV to survive for longer, which also means more patients are likely to develop cancer.

There remain many myths surrounding cancer which need to be dispelled. First and foremost, that it is only a problem for wealthy nations with ageing populations. Fatalism associated with cancer also needs to be challenged to mobilise the global community into action against a formidable disease against which much can be done even with

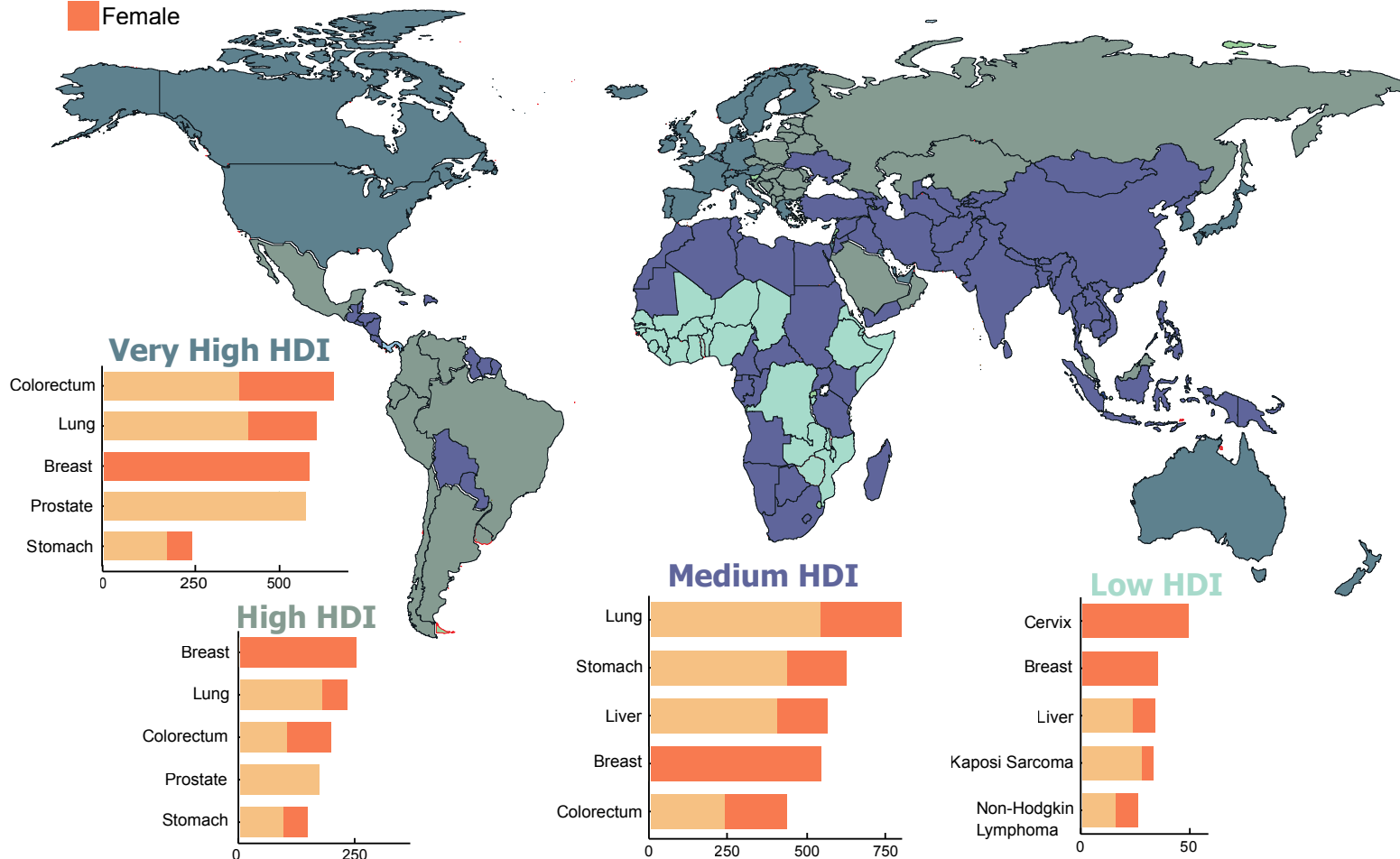
limited resources⁷. One third of all cancer cases are preventable globally, and many more can be treated effectively if detected early. As lifestyle diseases increase, a paradigm shift from health systems that not only save lives but also deliver holistic health care will be required, particularly in low resource settings. However, this will require an input of resources to match the burden of disease as currently less than 3% of development assistance for health is spent on NCDs in low and middle-income countries⁸.

Scientific research will be crucial in helping to understand the underlying mechanisms leading to development of cancer. Research has already shown that cellular mechanisms in place to prevent tumour growth can slow down the ageing process, but also progress ageing under other circumstances⁹. Cancer and ageing are two sides of the same coin, and it is a delicate balance between biological mechanisms that keeps us healthy. Further research is likely to not only aid us in controlling cancer, but also in our understanding of the ageing process, in the future¹⁰.

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New cases per 100,000 people, age standardised

Male (light orange)
Female (dark orange)



Most commonly diagnosed cancers by Human Development Index (HDI) based upon United Nations Development Programme estimates (data from 2008)⁴.

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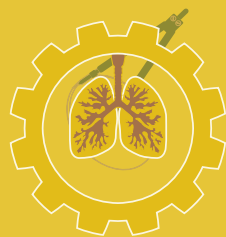
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Tailor-grown Organs: Regenerative Medicine's Auspicious Future

Stephen McCarthy, Imperial College London



The manufacture of synthetic body parts to substitute damaged organs has been the vision of generations of scientists, and we are closer than ever to realizing that dream today.

It is hoped that this could provide a promising alternative to transplantation, which suffers from two critical issues: possible rejection by the patients' immune system, and a shortage of donors.

This article surveys the historical breakthroughs made in this challenging yet fascinating field of medicine, and in particular the auspicious future of tissue engineering.

The 19th century brought many changes to the industrial landscape of Great Britain. Revolutions in the practice and scale of manufacturing fuelled the growth of an empire, and left lasting effects on Britain's economy and urban areas which are still felt today. One of the most crucial advances was the concept of replaceable parts: by designing a product such that faulty parts could be substituted rather than requiring the entire product to be replaced. This allowed for greater consistency and longer product lifetimes, and the concept is now ubiquitous in modern product design.

This development was noted with interest by the medical community of the day, and it wasn't long

before the question emerged as to whether the same principle could be applied to humans; would it be possible to manufacture body parts to replace damaged originals? The possibilities of using 'spare' body parts had long been considered: accounts of Saint Damien and Saint Cosmas claim that they replaced a patient's leg that had been lost to gangrene in the third century

A.D. Later, Mary Shelley caught the imagination of the public with her novel Frankenstein, which explored the idea of creating a new living being composed of spare body parts.

The first step towards this goal was to show that organs from a donor could be transplanted into a patient such that their function was retained in the new environment. While this had been attempted in animals and in some humans, the often fatal issue of rejection meant that this method would not become routine until the 1970s after the discovery of the immunosuppressant drug cyclosporine.

The second crucial problem of transplantation remained: for every organ recipient there must be a donor, and the shortage of willing and able donors continues even to the present day. While living donors can be used in the case of some organs (such as the kidneys or liver), many organs for transplantation must be harvested from recently deceased donors, further limiting availability. This restriction means that transplantation cannot be a widespread intervention technique for diseased organs, and waiting lists are long and dispiriting; for example, there are

currently 250,000 adults in the UK with congenital heart defects, yet only 131 heart transplants were performed in 2010/11; at an average cost to the NHS of £40,000 per transplant. Any increase in this number would also have a significant impact on public health budgets.

Body Building

The dream of manufactured body parts therefore remains a priority goal for modern medicine. Approaches based on stem cells and other 'living' materials have advanced significantly in recent years but remain far from clinical use; this is due in part to the difficulty in organising an amorphous group of cells into the higher-order structures required to form a working organ.

Bridging the gap between the micro-scale of the cell and the macro-scale of body tissue remained a thorn in the side of attempts to grow replacement organs until the early 1990s. The answer came from the decidedly inorganic field of engineering: if cells cannot organise themselves, why not guide them with a pre-organised material, like a train along tracks? By taking materials with a defined framework to act as a 'scaffold' and seeding it with cells, biological structures suitable for replacing organic tissue could be grown.

This new approach has yielded success: the first implant of artificial tissue in a human patient occurred in 1991. In this procedure, an artificial polymer scaffold was seeded with cartilage cells taken from the patient's own tissue, and successfully inserted to replace his missing sternum. With this breakthrough, similar procedures followed quickly: a new thumb constructed using a scaffold based on porous coral was implanted in 1998, and shortly afterwards, replacement pulmonary arteries were produced by researchers in Japan.

This new field of medicine was fully established, and became known as tissue engineering. Despite its successes, the scale of the challenges yet to be faced soon became apparent. The scaffold material had to be very carefully selected so as to direct cell formation correctly, and successfully growing a large number of cells from small sample sizes proved to be a significant problem. Defects in the scaffold structure or a misshapen scaffold

could lead to uneven cell growth making them unsuitable for implantation. Reliable methods for obtaining artificial tissue were (and remain) hard to come by, and the length of time taken to grow enough tissue (given that multiple attempts may be required) was a serious consideration for patients.

Even when enough suitable tissue for replacement could be produced, it was by no means guaranteed that the body would develop an adequate blood supply after implantation. And such an intensive, individual process is far from cheap; expanding its use beyond a handful of isolated cases remains problematic.

Nevertheless, the progress of tissue engineering has led to intensive research

By taking materials with a defined framework to act as a 'scaffold' and seeding it with cells, biological structures suitable for replacing organic tissue could be grown

into suitable scaffolds. The list of requirements for such materials is long: they must be non-toxic, structurally and mechanically similar to the target tissue, allow interactions with seeded cells, and, ideally, cheap to produce. Depending on the target tissue, factors such as porosity, transparency, and injectability may also be important.

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Mimicking Nature

One class of materials which have emerged as frontrunners in fulfilling these needs are synthetic polymers: plastics. They are non-toxic, have properties that can be easily tuned to the specific requirements of the implant, and are inexpensive. Indeed some polymers were already being used for other medical applications before the advent of tissue engineering, and so any effects on human tissue are well documented.



Polymers such as poly(ethylene glycol) (PEG) and poly(vinyl acetate) (PVA) have been most widely applied due to their suitable properties and characteristics. They must be modified to mimic natural biological processes of development in order to be effective. Without these modifications, they are unable to send the chemical signals that cause cells develop, and so the scaffold is ineffective for organ growth.

Similar polymers have been invaluable in the creation of replica bone. Bone has been the target of much research due to its relatively simple anatomical structure and rigidity, which can be more easily replicated by synthetic materials. It is also an important target, as bone complaints are commonplace: over 200,000 spinal fusions are performed annually in the US alone, and these require painful and expensive bone grafting. By creating a carefully-designed mixture of polymers, and incorporating proteins to promote cellular growth and biocompatibility, researchers at Nottingham were able to create an injectable substance which hardens in the body into a rigid but porous structure. This 'injectable bone' was then an excellent scaffold to promote stem cell growth into new bone in the patient.

Research carried out at Imperial College by Prof. Molly Stevens has been critical in this context. Her work focuses on developing in vivo bone tissue growth through a 'bone bioreactor'. Rather than grow the bone tissue in a laboratory and then surgically implant it, the bone bioreactor works by creating a space in the body into which regeneration of the patient's own bone is directed. The 'bioreactor space' is kept open with a biocompatible polymer gel, which dissolves to make way for the growth of the new bone. After tests in rabbits, clinical trials of the process in humans are under way, and, if equally successful, could lead to a major clinical breakthrough.

Polymers have also found applications that require biodegradability. Some plastics, mostly those linked by amide or ester bonds, are particularly susceptible to hydrolysis in the body, i.e. they are degraded and removed from the tissue site. While this would be a problem in cases where the scaffold is intended to remain part of the final structure, it is beneficial for the development of softer tissue and organs as it eliminates the need for surgical removal. The rate of degradation can be carefully designed through control of the synthesis and blending of polymer mixtures such that it neither disappears too quickly nor lingers too long in the body. The most advanced research is looking to match the rate of scaffold degradation to the rate of new tissue growth.

The Search Goes On

Despite its novelty, the potential offered by the scaffold method has led many researchers in the field to set ambitious goals. After the successful implantation of a tissue-engineered bladder by researchers in North Carolina, other soft tissues have become targets for replication: attempts to make an artificial pancreas using a scaffold of synthetic fibres and cells from the patient are underway, as are efforts towards a bioartificial liver using a collagen scaffold (intended as a short-term solution until a suitable transplant becomes available). Most recently, researchers at MIT have created a carbohydrate glass scaffold for liver tissue which also concurrently grows a network for blood supply, potentially solving a major problem in the production of large organs. Bone marrow, blood vessels and even erectile tissue are also in researchers' sights.

While the idea of organs-to-order may seem to fall under the banner of science fiction, the achievements already made by researchers in this field certainly imply that this goal may be achievable in years to come. The use of highly artificial materials such as polymers is an unexpected but beautiful example of the interaction between seemingly distant fields, and a reminder of the value of scientific collaboration in the continuing development of medicine.

Stephen McCarthy is a recent Chemistry graduate, with an interest in polymers and the medicinal applications of chemistry.

Polymers (...) must be able to mimic natural biological processes of natural development in order to be effective

The Quest for a Better Bionic Hand

Silvestro Micera, Jacopo Carpaneto & Stanisa Raspopovic, Ecole Polytechnique Federale de Lausanne & Scuola Superiore Sant'Anna

The hand is a crucial part of the body, and the desire to replace it following an amputation – with trauma or cancer being the main underlying causes – is a natural one. Existing bionic hands are already good substitutes for the natural limb yet a number of limitations prevail. These artificial limbs often present low functionality and poor aesthetic appearance and controllability, which deter many amputees from using their prosthesis. This article surveys both the progress made in the field, and the challenges that remain to be overcome.

The need or desire for the functional replacement of a missing upper limb is an ancient one: historically humans have replaced a missing limb with prosthesis for cosmetic, vocational, or personal autonomy reasons. The hand is a powerful tool and its loss causes severe physical and often mental debilitation. Together with the obvious inability to grasp and manipulate objects, an amputee loses the capability to sense and explore the surrounding world as well as the ability to use gestures to support speech and express emotions. Moreover the person may develop psychological problems and encumbrance due to physical differences compared with other people.

Nowadays prostheses are of three types, explained in more detail below: (i) myoelectric, (ii) body powered and (iii) cosmetic. The main prosthetic centre in Italy (INAIL Prosthetic Centre) fits about 100 myoelectric prostheses every year. In Sweden the incidence of upper limb amputees is 50 per year. The number in the UK is about 270 per year (UK Prosthetics Services 2006). If these data are

extrapolated to Europe the total number of traumatic upper limb amputees would be 1900 persons a year and the total European community would have approximately 94 000 upper limb amputees.

The need for a versatile prosthetic limb with intuitive motor control and realistic sensory feedback is huge and its development is a must for the near future

The most frequent causes of upper limb amputation are trauma and cancer, followed by vascular complications of disease. Transradial level amputations (below elbow) account for 57% and transhumeral (above elbow) for 23% of all arm amputations, with the right arm being more frequently involved in work-related injuries. Upper limb amputations can also be caused by diabetes or other diseases, especially in elderly people. Finally, amputees are one of the most graphic reminders of the destructiveness of war. Thus the need for a versatile prosthetic limb with intuitive motor control and realistic sensory feedback is huge, and its development is a must for the near future.

Robotic research has been transferred to industry and more functional prostheses have been recently introduced in the market (Touch Bionics, UK). Nevertheless, surveys on using such artificial hands reveal that 30% to 50% amputees do not use their prosthetic hand regularly, typically due to its low functionality, poor cosmetic appearance, and low controllability. It is therefore critical to develop prosthetics that improve the voluntarily-controlled dexterity to allow amputee to perform tasks that are necessary for activities of daily living (ADLs), but that cannot yet be done with today's state-of-the-art artificial limbs.

Myoelectric Prostheses

During the past years, hand prostheses for amputees have been mainly controlled by processing electromyographic (EMG) signals acquired by means of non-invasive surface electrodes. Now solutions are moving towards a 'pattern recognition approach': (i) signal acquisition from the brain and pre-processing; (ii) feature extraction; (iii) classification; (iv) online/online control that feeds back to improve future pattern recognition. By activating specific muscles not necessarily related to the desired task, the user can select different predefined grasping patterns. Several feature-extraction techniques and pattern-recognition algorithms have been developed to achieve high classification performances.

This approach offers advantages through its robustness, simplicity to

implement, and non-invasiveness. Nevertheless it also has several limitations. In fact, the EMG-based control is complicated by the need for coding the different actions of the artificial hand. For example, it is often necessary to control the extension of the fingers of the prosthesis by using other muscles of the upper arm or forearm. In general, it is not possible to use the homologous muscles leading to the need for a complex algorithm exploiting the potentials of advanced pattern recognition techniques. This is a significant problem for the user, who is not able control the device in a natural way.

The most important limitation of myoelectric prostheses is the difficulty of delivering any sensory feedback to the user

The most important limitation of myoelectric prostheses is the difficulty of delivering any sensory feedback to the user. These limitations are becoming even more important with the development of more advanced prosthetic arms with built-in sensors. For this reason, in the recent past, some groups have tried to develop alternative methods to restore some similarity with the natural control scheme, e.g. by implanting sensors in the muscles of the forearm or by transferring residual nerves of amputees to other muscles in or near the residual limb. These approaches are potentially very interesting and can provide very remarkable results, but some limits both for the control of the hand and for the delivery of sensory feedback remain.

Another interesting approach could be based on the use of neural interfaces able to create a direct connection with the peripheral nervous system. Despite

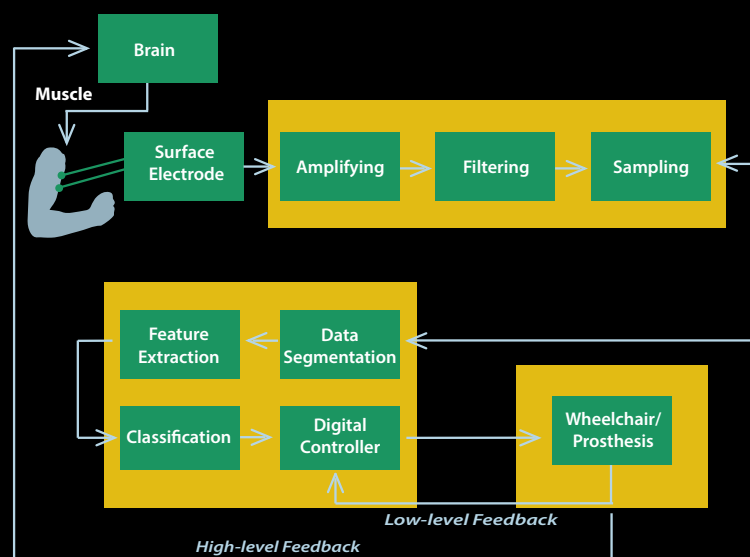
being challenging this would restore the previously existing connection between the nervous system and the artificial hand and deliver both control and sensory feedback.

Neural Interfaces

The neural interface electrode has long been the limiting technological component for achieving a successful interface to the nervous system. The adequate neural interface should be able to create a selective contact with different fascicles in the nerves in order to restore neural pathways in an effective way. Within the current state of the art, implanted interfaces for the peripheral nerve are divided into main two types: extraneural, implanted around the nerve trunk, and intraneural, which penetrate the nerve trunk.

Extraneural cuff electrodes are reliable and robust and imply a reduced invasiveness, but suffer from a limited selectivity and capability of recording neural signals. With cuff electrodes it is possible to detect the general activity of the nerve, and they have been used to switch on or off the contraction of muscle groups. To improve selectivity, intraneural electrodes (USEA, TIME), inserted into the peripheral nerve, have been developed and tested. This approach seems more promising because it combines acceptable invasiveness with good selectivity.

Schematic representation of a myoelectric control of prosthetic devices.



The four primary control signals used by myoelectric prosthetics allow movements such as flexion and extension of the elbow and hand.

For selective stimulation of peripheral nerves in the human arm, longitudinal intrafascicular electrodes (LIFE) have been applied in recent years. The thin-film LIFE (tf-LIFE) marked the development of a functional multi-channel micro-fabricated LIFE structure. This type of microelectrode consists of a polyimide loop with multiple electrode contacts. By use of a second loop with an attached tungsten needle, the tf-LIFE can be placed inside a peripheral nerve and be longitudinally drawn through an individual fascicle to achieve a very close and selective contact. The second loop with the needle is removed after implantation, and the electrode is fixed to the nerve by a suture.

The tf-LIFE has already been applied in one human trial with a bidirectional hand prosthesis. In these experiments the microelectrodes have proved to be suitable for long-term stimulation and recording in the human peripheral nervous system. In particular, the possibility of delivering sensory feedback and decoding different grasping tasks has been shown. In particular, it was shown that pressure sensations can be restored in the patients (confirming what previously achieved by Horch and colleagues), and that it was possible to modulate this feeling by changing the stimulation parameters. Moreover, by processing the

neural signals recorded, it was possible to show that it is possible to decode grasping related information which can be used for the online control of the prosthesis.

In the next few months a new clinical trial will be carried out as part of the Italian Ministry of Health's NEMESIS project, under the clinical supervision of Prof. Paolo M. Rossini (Sacred Heart University in Rome). This new trial carries this research a step further by connecting the prosthetic hand directly to the patient for the first real-time, bidirectional control using peripheral neural signals. Researchers hope to achieve further improvement in the sensory feedback and overall control of the prosthetics with this new method.

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Getting Everyone On Board To Get Women On The Board

Calypso Montouchet, Imperial College London

Increasing the involvement of women in the workforce is known to have a positive impact on economic growth. Changes to legal and corporate structures are just the first step to mending the current economic gap between men and women, which is particularly stark at the top of the private sector with only 3% female CEOs of Fortune 500 companies.

However, gender equality in both the workplace and the home can only be reached if mindsets change in parallel with the creation of new laws.

The reasons for the economic benefits of female involvement in the economy are diverse. In her opening plenary at the 2013 World Economic Forum (WEF), Christine Lagarde, Managing Director of the International Monetary Fund (IMF), suggested that by raising women's employment rates to the level of men's, gross domestic product could grow by 5% in the United States of America, 9% in Japan and 10% in South Africa by 2020¹. This would suggest that investing in, and supporting women and girls, is, in ex-US Secretary of State Hillary Clinton's own words, "not only the right, but the smart, thing to do".

At a more senior level, evidence has shown that the presence of a critical mass of women in senior jobs is positively correlated with a company's performance². Lagarde believes that women's collaborative approach to management is due to them being more attuned, and more inclined to listen, to viewpoints of minority

groups. Studies suggest that women tend to be more inclusive in their management, favouring teamwork, fostering motivation, and spurring creativity. The set of experiences acquired along women's unique career path may increase the group's range of perspectives, cognitive resources, and problem-solving abilities – all of which were associated with improved company performance. However, a threshold of 50% of women seems to be required for this collective intelligence to be effective³.

In the context of data illustrating the link between increased female participation and improved economic performance, it should be noted that correlation does not necessarily imply causation. Moreover, there is no consensus as to the exact magnitude of the impact of women's participation at the senior level – there is in fact some research suggesting that it has no impact on a company's economic performance⁴. Further research, perhaps in the form of a meta-analysis, will be necessary to support evidence-based policies.

The divide at the heart of gender economics is partially biological, as women are the ones who bear children and regularly assume the vast majority of reproductive activities such as childcare. In addition, research has shown that men often attribute their success to themselves and their skills, while women attribute it to the people who helped them along the way as well as luck. This lack of promotional confidence impacts the workplace. According to many⁵, men feel comfortable applying for

Quotas that are currently in place tend to be voluntary (...) and therefore often only suffice to maintain, rather than increase, the participation of women on boards



Facebook's Sheryl Sandberg, who has been recently at the centre of a debate over the responsibility of women to 'lean in' to career opportunities, speaks at the World Economic Forum 2013 at Davos, Switzerland.

jobs requiring skills which they have only demonstrated a few times, whereas women will wait to master those skills before applying.

Individuals' reactions to similar behaviours exhibited by men and women may further deepen the gender gap: a study by Sandler⁶ showed that what was seen as assertiveness in men was perceived as aggressiveness in women; an outburst was diagnosed as a temporary and rare loss of control when exhibited by a man, but as emotionality or a hormonal unbalance in a woman. Sheryl Sandberg, Chief Operating Officer of Facebook, also described this disparity, noting that men and women alike wanted to work with a man who negotiated for his salary, but were less positively inclined towards a woman who did the same². Furthermore, there appears to be a positive correlation between success and likeability for men, perceived by both genders, whereas women were less likely to be liked as their success grew².

Do Quotas Work?

Despite the compelling argument in favour of closing the gender gap, there is evidence that some companies have limited incentive to achieve this goal, leading many to argue that government legislation is required to increase female presence on corporate boards – a process which is further hindered by the low turnover among existing board members². Quotas that are currently in place tend to be voluntary (except in Norway, Spain, France, Iceland, the Netherlands, Italy, and Belgium⁷), and therefore often only suffice to maintain, rather than increase, the participation of women on boards.

- [1] World Economic Forum (2013). Women in Economic Decision-making. Available at: <<http://www.weforum.org/sessions/summary/women-economic-decision-making>> [Accessed: 26 Jan 2013].
- [2] Beck B. (2011) Special Report: Women and Work. Closing the Gap. *The Economist*, 26 November. Available at: <<http://www.economist.com/node/21539928>> [Accessed: 17 Feb 2013].
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- [4] Richard O.C. et al. (2004) Cultural Diversity in Management, Firm Performance, and the Moderating Role of Entrepreneurial Orientation Dimensions. *Academy of Management Journal*. **47**(2):255-266.
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- [6] Sandler B.R. (1988) The Classroom Climate: Chilly for Women? in Deneef et al., editors. *The Academic Handbook*. Durham: Duke University Press.
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Inspired by the example of France where an obligatory quota doubled the proportion of female board members (from 12% to 25%), Viviane Reding, Vice-President and Commissioner for Justice, Fundamental Rights and Citizenship of the European Commission, has been pushing for EU legislation that would set a 40% target for female board members by 2020. Were the current trend to continue, gender parity would only be reached in 2060². Reding has met fierce resistance, however, as could be expected given that a survey of company directors showed only 51% of women and 25% of men supported quotas in 2012.

It is crucial for “our boys to be as ambitious in the home as our girls are in the workplace”, and for them to feel both confident about and responsible for accomplishing their share of housework and childcare.

Reticence towards quotas often stems from a belief in the lack of qualified applicants, which would imply an obligation to hire unqualified women. However, female executives working for leading companies such as Deutsche Bank and the Boston Consulting Group have expressed their support for measures giving women a better chance to make it to board level, while acknowledging the limitations of quotas⁸. They argue that a woman (or, for that matter, a man) who is not qualified might get the job in a quota system, but would not be able to keep it. Research in Norway², which in 2003 passed mandatory quotas for gender equality in boards of publicly-listed firms, has cast doubt on the notion that quotas

favour hiring sub-standard applicants and adversely affect companies' performance.

Closing the Gender Gap

A supportive work environment is critical to increasing gender equality. This includes, for example, the presence of role models who can enable women to discuss how to juggle their professional and personal lives³. Research conducted by Deloitte³ into its pattern of attrition among the female executives showed that the company's male-oriented system of advancement (e.g. networking at gentlemen's clubs or mentoring by senior male staff) ranked ahead of both the heavy workload and the decision to start a family in explaining female departures. Changing corporate cultures may therefore be crucial in promoting a more gender-sensitive work environment.

Part-time work, which is four times as common for women as it is for men⁹, flexible working hours and the possibility to work from home are important tools in

helping working mothers to keep a foot on the corporate ladder. Sally Martin, Vice President of Commercial Services at Shell, schedules weekly phone calls with new mothers on her team to maintain a personal and professional connection, and encourages her colleagues to do the same. Working fathers would also benefit from more parent-friendly arrangements, as demonstrated by research showing that fathers who took advantage of flexible working arrangements had higher job and career satisfaction than those who did not.

Despite legislation in place to ensure equal pay for equal work, the gender pay gap averages 18% in the OECD. It should be noted that discriminatory practices account for only a third of this difference in wages, while the remainder is due to career choice, and that the younger, childless generation of women aged 22-29 is paid 3.6% more than the male equivalent in the UK¹¹. Some companies have chosen innovative means to address this challenge. For example, L'Oréal encourages women to return to work after their maternity leave by automatically granting them the average salary increase of colleagues in their age- and department-specific category.

Daddy Daycare

Closing the gender gap at the corporate level will ultimately require doing so at the household level, by addressing inequalities which persist due to traditional gender roles: in couples where both the man and the woman work full-time, women are still responsible

- [8] Lalive and Zweimuller. (2009) How does Parental Leave Affect Fertility and Return to Work? Evidence from two Natural Experiments. *Quarterly Journal of Economics*.
- [9] University of Cambridge Research News. Charting Gender's "Incomplete Revolution". Available at: <<http://www.cam.ac.uk/research/news/charting-genders-incomplete-revolution/>> [Accessed: 16 Feb 2013].
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- [13] Harrington B., Van Deusen F. and Humbert B. (2011) The New Dad: Caring, Committed and Conflicted. Available at: <www.bc.edu/content/dam/files/centers/cwf/pdf/FH-Study-Web-2.pdf> [Accessed: 17 Feb 2013].

for most of the housework, carrying out twice and thrice the amount of childcare and household chores, compared to their male partners. This is true even when women are the primary income earner. When accounting for both paid work and unpaid chores, women put in 21 more minutes than their partners into daily 'work'¹².

In addition to enrolling men's support in the workplace, therefore, it is also crucial for "our boys to be as ambitious in the home as our girls are in the workplace"¹², and for them to feel both confident about and responsible for accomplishing their share of housework and childcare. There is reason to believe that doing so could actually prove more rewarding than expected, with research conducted in Sweden, Norway, Denmark, the Netherlands, Germany, France and Britain showing that men were happier when they took on their share of household chores¹³. Unfortunately, fathers actively participating in their families' caretaking did not always find their workplace to be understanding of their choice.

Quotas may go a long way in ensuring that women make it to the upper echelons of corporations, but the path will be neither easy nor pleasant until mindsets change. Companies need to be more innovative and open-minded in granting both men and women parental leave and flexible work structures. Men need to be aware of the pressures women face in the workplace, and be more supportive both at work and in the household. Women need to be more proactive about taking chances, fighting for what they want, and respecting their peers' and partners' professional and personal choices. Only when individual attitudes and institutional policies align to promote gender equality will men and women be free to pursue success as they see fit to define it, be it by raising a family or making it to the top of the corporate ladder.

Calypso Montouchet finished her Masters in Public Health at Imperial College London in 2010. She is passionate about health economics and women's rights, and is lucky enough to have strong female role models and supportive male friends whose progressive opinions were crucial in shaping this article.

Sexual Harassment in the Workplace: Within the Spectrum of Sexual Violence

Renate van Oosten, Chatham House

The past half century has seen leaps in women's working rights, aided by policy change, media campaigns and an overall shift in the perception of working women, yet statistics show that sexual harassment, which permeates the lives of many women around the world, is still a pervasive threat in the workplace.

The concept of 'sexual harassment' was born from the civil rights movement of the United States in the 1960s^{1,2}. Initially seen as a form of sex discrimination, it was covered by the Civil Rights Act of 1964 which prohibited discrimination on the basis of race, sex, colour, nationality or religion. In the UK it was covered by the Sex Discrimination Act (SDA) of 1975.

The recognition of sex discrimination and harassment as a problem was a momentous civil rights victory. However, neither of these acts had any specific definition nor clause on sexual harassment, it was merely considered a form of discrimination, making it a difficult crime to recognize and prosecute^{1,3}. The definition of sexual harassment, and what is encompassed by this term has since then undergone an evolution.

The SDA was expanded in 1986 under pressure from the European Court of Justice to include sexual harassment³; though it wasn't until 1991 that the European Commission convened a committee on the protection of the dignity of women and men at work, to establish a definition of sexual harassment:

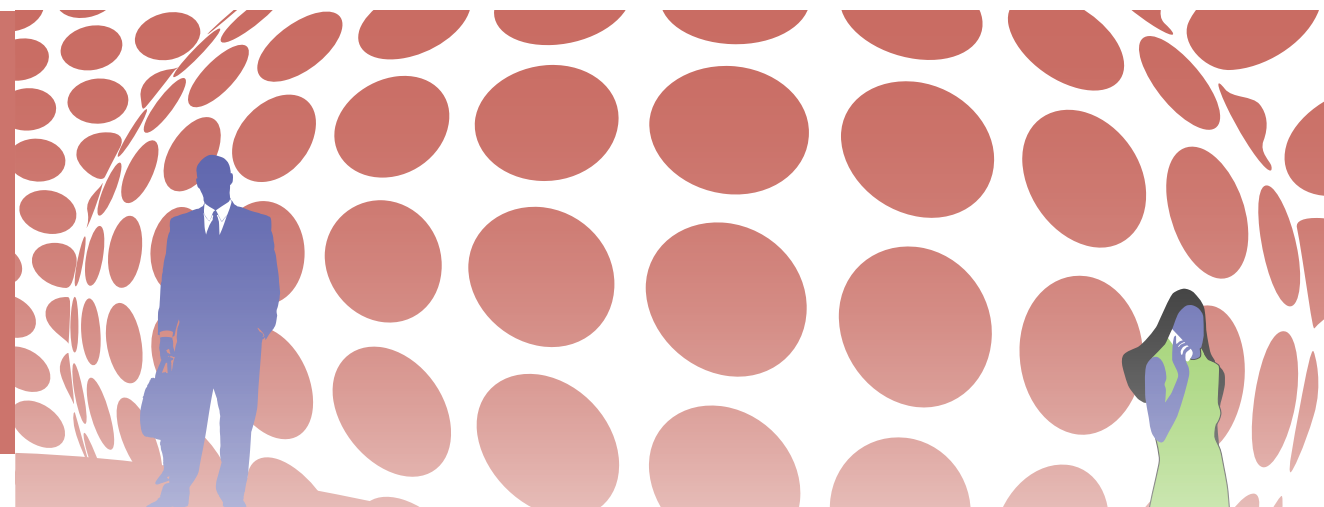
"Sexual harassment means unwanted conduct of a sexual nature, or the conduct based on sex affecting the dignity of men and women at work. This can include unwelcome physical, verbal and nonverbal conduct. Thus, a range of behaviour may be considered to constitute sexual harassment. It is unacceptable if such conduct is unwanted, unreasonable and offensive to the recipient; a person's rejection of, or submission to, such conduct on the part of the employers or workers (including superiors or colleagues) is used explicitly or implicitly as a basis for a decision which affects that person's access to vocational training or employment, continued employment, promotion, salary or any other employment decisions; and/or such conduct creates an intimidating, hostile or humiliating working environment."

Aeberhard-Hodges
1996⁴.

This definition brings sexual harassment beyond the bounds of discrimination (which it is) and sees it as an assault on a person's dignity. Most recently, the UN

Most recently, the UN Commission on the Status of Women (CSW) centred its 2013 meeting around ending all types of violence against women, and has recognized that sexual harassment (...) is a form of violence against women

- [1] MacKinnon, C.A. & Siegel, R.B. (2003) Directions in Sexual Harassment Law. Yale Press, USA.
- [2] Fitzgerald, L.F. (1993) 'Sexual Harassment: Violence Against Women in the Workplace' *American Psychologists*; **8** (10): 1070-1076.
- [3] Fitzpatrick, B. (1987) 'The Sex Discrimination Act 1986' *The Modern Law Review*; **50** (7): 934-95.
- [4] Aeberhard-Hodges (1996) 'Sexual harassment in employment: Recent judicial and arbitral trends' *International Labour Review*; **135** (5): 499-533.
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Commission on the Status of Women (CSW) centred its 2013 meeting around ending all types of violence against women, and has recognized that sexual harassment (both in the workplace and in other public spheres) is a form of violence against women.

The Spectrum of Sexual Violence

Defining Sexual Harassment as a separate crime from discrimination not only legitimizes it as the aggressive crime that it is, but also allows for legal and structural frameworks to be set up in opposition of sexual harassment. Yet there is still very little universal consensus on what sexual harassment is. Even in countries where there is a definition, and legislation in place, where women are better educated than ever before, receive more degrees and join the work force in larger numbers, sexual harassment remains a ubiquitous problem.

Statistics vary enormously, as it still one of the most underreported crimes. It is thought that anywhere between 30%-50% of women are victims of sexual harassment in the European Union, 1 in 2 in the UK, 1 in 4 in the US workplaces and 34%-78% in the US military. This speaks not just to the structure of the work place, but the entrenched culture of female objectification, which quite often paints women as mere recipients for male desire – views that are reproduced and perpetuated in a work place. Sexual harassment becomes not only a normalized form of social behaviour, but women are taught to accept and even expect this type of behaviour.

*Reports suggest that rates of sexual harassment in the workspace are lower now than they were 20 years ago; however since sexual harassment was – and still is – severely underreported, it is difficult to confirm these reports. In the US military reported sexual harassment as well as sexual assaults have actually been increasing⁵.

Prevention and Change

Combatting such a complex, entrenched problem is a formidable task, but that does not mean that there are not some measures that could alleviate and end the issue of sexual harassment in the workplace. A number of reports originating in the US have shown that the internal structure of an organization is important in reducing its incidence. Male dominated jobs tend to show higher rates of this type of violence² (the tragically classic example being the military). Workplaces with a higher proportion of women – particularly in more managerial positions – report much lower rates of sexual harassment.

More direct measures, such as requiring companies to have a clear policy against sexual violence as well as a transparent procedure to deal with it when it does occur² should be made a requirement for all organizations. Educational programs within workplaces, based around understanding what constitutes this behaviour, and how to deal with it (as a victim, witness or manager) have also been shown to make a difference in reducing its incidence in the workplace.

It is important to note that recognizing sexual harassment as a crime was the first step, and one which has made a difference in the countries where it has been recognized*. A legal framework acknowledges the right of the (primarily female) victims to dignity and an expectation of peace at work, and allows access to justice when this expectation is not met. This is a human right, and should be a requirement of all countries that have signed the Human Rights Charter.

Renate van Oosten is a recent graduate from University College London, where she got her MSc in Medical Anthropology. She is currently doing an internship at Chatham House.

Driving Growth: The Female Economy in China and India

Michael J. Silverstein, Abheek Singhi, Carol Liao and David C. Michael, The Boston Consulting Group

The increasingly affluent and powerful female consumers in China and India will stimulate extraordinary growth – and deliver growth to the companies that serve them. Understanding what Chinese and Indian women want – their devotion to their children, their desire for safe and nutritious food, their fondness for affordable luxury, their brand consciousness – will be critical to the success of companies operating in these markets.

WX Liu is a farmer in Shunhezhuang, a small village deep in China's northeastern province of Hebei. It is no rural idyll, and her calloused and muscular hands reflect a lifetime of working long hours in the fields. Now nearly 60, she has endured droughts, disappointing harvests, and unpredictable prices for her corn, and she has had only limited access to modern agricultural technology.

Yet despite her tough existence, she is cheerful and smiles often. With her own hard work, combined with the income earned by her live-in son and daughter-in-law, she is starting to fulfill some of her dreams. She lives in a two-story house that has a garage for the two cars that she still hopes to buy one day. She built her home brick by brick, having borrowed money from friends and relatives. "I am pretty satisfied with my life now," she says, in her rapid-fire, no-nonsense way. "It's so much better than it was just a few years ago."

Across the Himalayan peaks, Saumya, a 33-year-old middle-class Indian, is fulfilling a similar dream. She recently moved to an apartment on the eleventh floor of a high-rise complex in Whitefield, one of the best suburbs in Bangalore, India's third-largest city. It has everything that she and her husband, Jaideep, were looking for: landscaped gardens, children's play areas,

a clubhouse, a gym, tennis courts, and a huge shopping center. From the moment she moved in, she set about filling the apartment with beautiful things. "Ever since my childhood, I have always wanted to decorate my own house," she says. "I just thought it would be such a great feeling to live in a home that had been decorated from corner to corner by me."

Throughout China and India, there are millions of women from all walks of life who could tell similar stories. They are driving the female economy in China and India – and they are driving growth.

China's female economy is already strong – and over the next few years, we expect to see it grow even stronger. In particular, young professional women will break into middle and top management jobs and fuel the next wave of growth in the luxury business. Female earnings in China will grow from \$1.3 trillion in 2010 to \$4 trillion by 2020, up from \$680 billion in 2005 and \$350 billion in 2000. That is more than a tenfold increase in 20 years.

By contrast, India's female economy is more fragile. In the world's biggest democracy, India's voters elected a female prime minister (Indira Gandhi) and a female president (Pratibha Patil). But only the most affluent urban women have a real taste of equality. For the rest, there is significant gender discrimination, limited access to education, low formal labor-participation rates, and low wages. The female labor-force participation rate has been stuck at around 32 percent since 2000, while female wages have actually declined to 26 percent of men's wages, on average. This decline is driven by repressive, education-stunting conditions in rural areas as well as by a government unwilling to step in and end discrimination, harassment, and physical threats.

Nonetheless, the overall size of the Indian female economy is expanding fast. In 2010, some 134 million working women earned \$280 billion. By 2020, there will be 158 million working women and their earnings will have more than tripled – to some \$900 billion.

With Chinese and Indian women earning close to \$5 trillion annually by 2020, understanding what they truly want will be critical to the success of companies operating in the two countries.

What Women Want in China and India

At The Boston Consulting Group, we have been tracking the hopes, dreams, and aspirations of women around the world for nearly a decade. In our most recent poll of Chinese and Indian women, we found considerable optimism about life and future prospects.

Chinese women are more optimistic and feel more secure than women in the West. According to our research, 88 percent of Chinese women feel secure in their current financial position, whereas only 62 percent of American women feel that level of security. Eighty-seven percent of Chinese women feel secure in their current job, compared with only 44 percent in the United States.

Moreover, Chinese women have many role models of success in the business world. Seven of the top 13 richest self-made women in the world are from China. Four of the wealthiest are under the age of 50. They include property developers, a paper producer, real estate magnates, a cigarette maker, and a medical-supplies producer from Tibet with a degree in physics.

India's urban middle-class women are similarly optimistic – particularly when it comes to their political, social, economic, and professional futures. Indeed, compared with all the other women we surveyed globally, they are twice as optimistic about the future of their external world. Some 81 percent of the Indian women in our survey believe that their personal life will be better five years from now, and 86 percent – the highest of any country surveyed – believe that they will achieve more both economically and professionally in ten years.

Again, as in China, there are several standard-bearers of success. Currently, 11 percent of large-company CEOs in India are women, compared with 3 percent in the Fortune 500. The CEOs of two of the three largest private-sector banks, two of the three largest multinational banks, and four state-owned banks are women. Two of the top six executives at Hindustan Unilever are women.

But if Chinese and Indian women are optimistic, they are not without their private fears and personal insecurities. Chinese women, for instance, display a low satisfaction with their physical appearance. In our global survey, only 15 percent of Chinese women described themselves as very attractive, compared with 37 percent in the United States, 48 percent in Turkey, and 51 percent in Russia. In contrast with Chinese women, roughly half of Indian women described themselves as very attractive physi-

cally, the second-highest percentage among women from 21 countries. They also said that they are close to their ideal weight and ranked themselves very high on emotional health, second only to Russia.

But Indian women have fears, too – mainly centered on health and longevity, family well-being, and financial security. "I fear being bankrupt or sick, or losing my husband," one woman told us. In a society where the male is dominant at home, there is fear of divorce and family crisis. Indian women control less than half of household incomes.

Despite these insecurities, Indian women spend more time shopping – and shop for food and other household items more frequently – than do women in the rest of the world. Middle- and upper-class women are willing to pay top dollar in a large swath of categories, including food, clothing, apartments, hair care, restaurants, and kitchen appliances. Favorite brands include Nokia, Sony, and Levi's.

Similarly, as Chinese women garner increased spending power, they, too, want to consume brands that ensure quality – and they often choose Western brands. China's favorites include Adidas, L'Oréal, Apple, Nokia, Lancôme, Chanel, Samsung, Johnson & Johnson, and two Chinese brands: Li-Ning, a sports company, and Haier, the domestic appliance company.

It should be clear that female consumers cannot be ignored if a company hopes to succeed in China and India over the next ten years

Captivating the New Female Consumers

Chinese and Indian women put their families first – especially their children. In China, because of the one-child system, a mother's son or daughter is her hope and dream, and it is common to spend as much as 30 to 40 percent of household income on the upbringing of that child. Among India's urban middle class, in which families tend to be smaller than those of the lower and rural classes, there is a similar devotion to the next generation.

Companies that really want to succeed must understand and act upon this maternal instinct. Some have already done so. In India, for example, Maggi, a brand of instant noodles owned by Swiss food company Nestlé, has developed products that are especially responsive to the technical, functional, and emotional needs of mothers. Initially, the company targeted “two-minute convenience” positioning with quick snacks for children, but this approach did not resonate with mothers. To rethink its strategy, Nestlé engaged with mothers to determine their needs with regard to nutrition and local taste. The company then created a variety of Indian flavors and offered whole-wheat nutrition – along with vegetables, as suggested by the mothers – to make a hearty snack. Maggi is now a \$500 million brand with an 80 percent share of the instant-noodle market.

But if women put their families first, they also like to treat themselves – and we expect them to drive the luxury goods market in the years to come. Still, it is necessary to understand the subtleties of the different markets. In India, women continue to have a strong allegiance to traditional clothing: in 2010, they spent some 70 billion rupees (\$1.5 billion) on saris and other traditional wear for women, up from 45 billion rupees (\$1 billion) in 2005, or about 55 percent of the women's apparel market in India. Hermès, the French luxury company, understood this trend, and after opening the country's first stand-alone luxury retail store in Mumbai in July 2010, it unveiled its first line of Paris-manufactured saris in October.

Meanwhile, in China, women are showing a great appetite not only for cosmetics but also for cars. Maserati, the Italian sports-car brand owned by Fiat, reports that 30 percent of its buyers in China are women, compared with the 2 to 5 percent typical in the United States and Europe. For its part, L'Oréal, the French consumer giant, has seen long-term success in China. The company now

has 30,000 workers there and has built an R&D center in Pudong – one of the fashionable skyscraper districts of Shanghai. “China is a country for skin care and facial products,” says Paolo Gasparrini, head of L'Oréal China. “Chinese consumers don't want to copy the beauty products of the United States or the European Union. You need to be humble in this market. Prepare for fast change.” Chinese consumers spent \$31 billion on personal luxury goods in 2010, with \$5 billion of that amount devoted to cosmetics alone.

It should be clear that female consumers cannot be ignored if a company hopes to succeed in China and India over the next ten years. As the governments of both countries improve the lot of women – by ensuring higher literacy rates, equal access to educational offerings, a better range of jobs, a greater political voice, and overall parity both in socioeconomic opportunity and in status – there will be powerful new waves of consumer spending. The new female consumer, contributing in an unprecedented way to the rising economies of the world's most populous nations, will stimulate extraordinary growth in these two countries – and in the companies that serve them. We anticipate that annual consumer spending in China and India combined will rise to \$10 trillion by 2020 – three times the amount spent in 2010. But with a fully functioning female economy, this \$10 trillion prize could be even bigger.

As you consider the opportunities in China and India, remember Farmer Liu. She has had only three years of formal schooling – and for most of her adult life, her household income was below \$1,000. Now, with a working son and daughter-in-law living under her roof, and a higher productive yield from her small farm, her family income has skyrocketed to \$5,000 per year. She has cash in her pockets, no debt, and an aspiration to continue to trade up. She and others like her in China and India have confidence, a positive income trajectory, and a growing list of wants and needs. They are increasingly affluent and discriminating consumers with a drive to succeed and to enjoy a better life. If you embrace them, they can be your best new customers for life.

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Women's Empowerment in Kenya: Trading Fuel Briquettes

Mary Njenga, University of Nairobi & World Agroforestry Centre (ICRAF)

Fuel briquette technology is a promising alternative source of energy that could address unmet needs for cooking fuel, driven by rapid urbanisation and population growth in Kenya. Increased demand for briquettes creates a number of socio-economic opportunities, in particular for women and low-income earners. There are also favorable environmental considerations when comparing briquettes to the current most common source of fuel, charcoal.

Today, charcoal is the principal fuel source for 82% of urban and 34% of rural households¹ in Kenya. However, desperate to put food on the table for their families, women in mainly poor urban households will often also use other unhealthy fuel sources such as old shoes or used plastic containers.² Energy shortages and high costs often lead these poorer households to cook meals that require less time to prepare, irrespective of their nutritional value.

In rural areas firewood, collected mainly by women and children, is the primary source of cooking fuel. Its collection is both physically exhausting and time-consuming and in some areas, journeys can be up to a 40 km round trip. Time spent on this activity could be otherwise used more productively, e.g. in agricultural or paid labour. Firewood is also expensive: a study in three rural villages

- [1] Ministry of Energy (MoE), Government of Kenya (2002) Study on Kenya's energy demand, supply and policy strategy for households, small scale industries and service establishments, Final Report, May, KAMFOR Company Ltd.
- [2] Gathui, T., and Ngugi, W. (2010) Bioenergy and Poverty in Kenya: Attitudes, Actors and Activities. Working Paper. Practical Action Consulting.
- [3] Wamukonya L. (1994) Energy consumption in three rural Kenyan households: A survey. *Biomass and Bioenergy* 8 (6): 445-451.

in Kenya indicated that 15%-35% of a household's income is spent on fuel,³ a figure that has increased in the past few years.

In the current environment poor communities, and especially women and youth, are turning to fuel briquette making, either individually or as organised self-help groups. The market for this product is also broader than just domestic cooking fuel, as it is being used in food kiosks, hotels, and institutions such as schools, chicken hatcheries and bakeries, making it a more attractive economic opportunity for these communities.

Women Working Together

A household survey conducted in Kibera showed that all the fuel briquette producers are women. This activity is integrated in their daily schedule and gives them an opportunity to work collectively.

It also allows them to establish a traditional system of saving and lending amongst themselves, enabling independence and flexibility in their financial affairs. For example, individuals make contributions as low as Ksh10 (US \$0.1) and a member is allowed to lend as little as Ksh100 (US \$1.3). Solidarity gives them a sense of belonging that builds social capital and makes them more resilient.

In the Kibera study, households that produced briquettes for home use made savings of over 70%, while those who purchased them saved 30%. The highest savings of 82% were noted amongst the

Households that produced briquettes for home use saved over 70%, while those who purchased them saved 30%



Women in Kenya produce fuel briquettes by shaping and mounding charcoal dust mixed with soil and water.

Due to the increasing difficulty in acquiring fuel in rural areas, Milka, mother of two and member of Kahawa Soweto Youth in Action self-help group in Nairobi, makes a living by producing and transporting fuel briquettes from urban to rural areas. She sells fuel briquettes in a village 80km West of Nairobi. Women in this village are choosing to purchase fuel briquettes instead of collecting firewood, saving precious time to work in their own or neighbouring farms.

low-income households, which spent US \$40 per year on cooking fuel compared to US \$223 spent by their counterpart households not using charcoal briquettes.⁴

A related source of income for these women is training people interested in the enterprise, creating further employment opportunities for young people. This helps to address urban insecurity and crime.

Savings and direct income are then often used for food purchases, especially animal protein sources such as eggs, meat and milk, as well as the payment of school fees, rent and health care expenses.

This is in line with commonly observed household improvements as a result of female empowerment.

Environmental Impact

Briquettes are produced by compressing biomass material such as charcoal dust, sawdust and other wood residues or agricultural by-products – collected for minimal cost – into a uniform solid unit.⁵

The process is highly manual: charcoal dust is mixed with soil and water; the mixture is then shaped into briquettes using plastic containers and left to dry. Because of limited space in poor urban neighbourhoods they are often dried on rooftops and roadsides.

[4] Njenga, M., Yonemitsu, A., Karanja, N., Iiyama, M., Kithinji, J., Dubbeling M., Sundberg, C and Jamnadass, R. (2013) Implications of charcoal briquette produced by local communities on livelihoods and environment in Nairobi, Kenya. *International Journal of Renewable Energy Development (IJRED)*, 2(1): 19-29.

[5] Sotannde, O.A., Oluyeye A.O. and Abah G.B. (2010) Physical and combustion properties of charcoal briquettes from neem wood residues. *Int. Agrophysics*, 24: 189-194.

[6] ITDG-EA (2003) 'Nairobi solid waste management network' [Online], Available by WasteNet <http://www.wastenet.or.ke/> (accessed 11 February 2004).

The use of briquettes helps to lower deforestation caused by charcoal and firewood production, which is highly desirable since Kenya's forest cover levels are below 2%.

A further environmental benefit is the use of recycled materials in briquettes. Nairobi for instance, generates 2,000 tonnes of waste, only 40% of which is collected and disposed of properly.⁶ As in many cities in Sub-Saharan Africa, approximately 70% of this waste is biodegradable, presenting a huge potential for briquettes.

Promoting Briquette Business

For briquette-making communities to prosper and bring their full potential to bear, local authorities need to provide increased assistance to these small enterprises, in particular

to the construction of appropriate infrastructure such as beds for drying and selling, as well as stores. Access to water needs to be provided at a reasonable cost, acknowledging fuel briquettes as a productive commercial sector.

Despite the substantial impact of this technology, women's groups today operate primarily individually. There is a need to bring them together and better coordinate their activities so as to strengthen their voice in calling for the provision of key resources such as secure leased space. This would help to turn today's fuel briquette enterprises into full time employment opportunities and allow for better training and knowledge sharing to improve production quality and efficiency.

Mary Njenga is a doctoral research fellow in environmental science at the Department of Land Resource Management and Agricultural Technology (LARMAT) University of Nairobi, Kenya, and World Agroforestry Centre (ICRAF), where she is currently studying combustion and emission qualities of fuel briquettes and the implications of this technology on livelihoods and the environment.

For Women in Science



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The World Needs Science and Science Needs Women

Professor Pratibha L Gai & Katy Gandon, University of York and L'Oreal UK & Ireland

According to the OECD, in many countries girls have caught up with or surpassed boys in science proficiency at school. However, with research showing that a mere 32 per cent of employed scientists and engineers are women, the challenge lies in being able to retain female scientific talent and encouraging the level of participation beyond school and into the workplace.

In the UK, girls make up just over half of GCSE students studying science; yet this level of participation in science dramatically decreases as the academic levels rise, particularly when compared to their male counterparts. Today, women make up 12 per cent of all employees in Science and Engineering Technologies SET occupations in the UK, and in academia only nine per cent of all full-time professors in Science, Technology, Engineering and Mathematics (STEM) departments are women.

The L'Oréal UNESCO For Women In Science (FWIS) international programme was founded fifteen years ago by L'Oréal and UNESCO to address this imbalance, on the premise that 'the world needs science and science needs women'. The programme is designed to promote and highlight the critical importance of ensuring greater participation of women in science, by awarding promising female scientists with fellowships to help them further their research. Since the programme was founded over 1,700 women in 108 countries have been recognised for their research and received funding to further their studies.

The FWIS programme supports women at varying stages of their careers. Each year the founding 'International FWIS Laureate Awards' provides five women, one from each continent, with a prestigious laureate of up to \$100,000 for their research. Alongside this, FWIS also operates a national programme in 46 countries offering fellowships to female scientists. Since it was founded in 1998, the programme has honoured 77 Award Laureates (including two who have gone on to win the Nobel Prize), and supported more than 1,652 Fellows from around the world. Imperial college London's facility is among those who have been commended as in 2012 the university's Dr Katrina Lythgoe was awarded the UK fellowship for her work in 'multiscale evolutionary dynamics of important human diseases'.

UK Scientist Professor Pratibha Gai was this year named the 2013 European Laureate at the 15th annual L'ORÉAL-UNESCO For Women in Science Awards. Professor of Chemistry and Physics at the University of York, Professor Gai follows in the footsteps of Professor Frances Ashcroft who won the award for Europe in 2012. Professor Gai joined five other exceptional women scientists from around the world, who were recognised for their contribution to science at an awards ceremony, held at the Sorbonne in Paris, in March this year. Professor Gai was awarded for her work for ingeniously modifying her electron microscope so that she was able to observe chemical reactions occurring at surface atoms of catalysts which will help scientists in their development of new medicines or new energy sources. The awards jury was chaired by Professor Ahmed Zewail, winner of the 1999 Nobel Prize in Chemistry, and Linus Pauling, Chair Professor of Chemistry and Professor of Physics, California Institute of Technology.

The 2013 awards theme is 'Physical Sciences' with the Laureates selected through nominations by an international network of nearly 1,000 members of the international scientific community. The research of the 2013 Laureates demonstrates exceptionally original approaches to fundamental research in the Physical Sciences, from contributing to better understanding climate change to advancing research on neurodegenerative diseases and potentially uncovering new energy sources. Professor Gai is the fourth British scientist to have been selected from the whole of Europe in the 15 years of the programme's existence. This impressive achievement highlights the UK's position as an excellent incubator of scientific talent, with only France matching this total in Europe.

UNESCO Director-General Irina Bokova commented on the awards "These five outstanding women scientists have given the world a better understanding of how nature works. Their pioneering research and discoveries have changed the way we think in various areas of the physical sciences and opened new frontiers in science and technology. Such key developments have the potential to transform our society. Their work, their dedication, serves as an inspiration to us all."

A student training to become a laboratory technician at Mogadishu health centre in Somalia.



“We are very proud to have changed the face of science by supporting women in science” said Jean-Paul Agon, Chairman and CEO of L’Oréal and Chairman of L’Oréal Foundation. *“We are convinced that science and women bring hope and foster discovery, innovation and excellence. All the best talents must be called upon to accomplish this mission. L’Oréal believes in women, L’Oréal believes in science.”*

The L’Oréal-UNESCO UK & Ireland ‘For Women in Science’ National fellowships were launched in January 2007. The fellowships are run in partnership with L’Oréal and the National Commission for UNESCO, the Irish National Committee for UNESCO and the Royal Society.

Each year, four fellowships of £15,000 are offered to outstanding female postdoctoral researchers. The fellowships have been designed to provide practical help for the winners to continue in their chosen fields. Notably, there are no restrictions on what the winner can spend their prize money on. Winners may choose to spend their Fellowship on buying scientific equipment or paying for childcare costs or indeed whatever they may need to continue their research. Since the UK and Ireland FWIS programme started, L’Oréal has awarded a total of £420,000 to a network of 28 Fellows.

Dr. Emily Flashman from the University of Oxford, who was one of the winners of the fellowship for her research into the adaptation of oxygen-sensing enzymes in times of stress to help develop cancer treatments, commented: *“I spent the fellowship money on a machine that allows me to monitor how quickly my enzymes react with oxygen. It has really helped our research make progress, as well as opening up new areas of research for me through collaborations.”*

The programme not only awards promising female scientists financial support, but has evolved into an important platform for inspiring future generations of female scientists by giving women a public voice and forum to speak out for science. FWIS Fellowship events provide support, training, and vital networking opportunities for female scientists in the UK. Through such events, FWIS Fellows make valuable friendships and connections that have led to interesting collaborations, publications and wider appreciation of their work. Each year L’Oréal organises networking events for former fellows at The Royal Society in London. These events provide the opportunity for Fellows to share their experiences of working in science and share advice on a wide range of topics including how to promote their work in the media.

Dr. Heather Whitney from the University of Bristol, another fellowship winner commented: *“I’ve done things I would never have dared done before, such as speaking at the Cheltenham Science Festival, a Government Science Conference and even a TedEx. It has given me new opportunities for research, science engagement and more confidence. This led to me being offered a permanent position at Bristol”.*

The long term success of FWIS is perhaps best summed up by Soapbox Science, an annual event set up by two FWIS fellows in partnership with L’Oréal. The event is held on London’s Southbank every summer, and invites leading female scientists to speak in public about their work. Now in its fourth year, the event has received over 60 applications from female scientists wishing to take part, illustrating a new found enthusiasm for female scientists to inspire a new generation by telling their story. The event has also received widespread national media coverage helping to highlight the importance of women in science. L’Oréal’s efforts are importantly pushing the message that ‘the world needs science and science needs women’.

Professor Pratibha L Gai is Professor of Physics and Chemistry at The University of York. She has recently been awarded the European Laureate in 15th annual L’ORÉAL-UNESCO For Women in Science Awards, for creating a revolutionary electron microscope for observing atoms in action in chemical reactions. *Katy Gandon* is Head of External Affairs for L’Oréal UK & Ireland, looking after all corporate and charity partnerships for the region.



L’ORÉAL UNESCO AWARDS

*Science
needs
women*

Pratibha L. Gai, physicist, chemist and 2013 Laureate, is a professor at the University of York in the United Kingdom. She has created a revolutionary electron microscope for observing atoms in action in chemical reactions. This major innovation opens the way to the development of new medicines and environmentally respectful sources of energy.

Throughout the world, exceptional women are at the heart of major scientific advances. L’Oréal employs over 3,500 scientists worldwide, of whom over 50% are women.

For 15 years, we have been running the L’Oréal-UNESCO For Women in Science programme, honouring exceptional women scientists from around the world. Over 1,700 women from 108 countries have received our support to continue to move science forward and to inspire future generations.

For Women
in Science



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Cultural Connections at Imperial College

Jonathan Leong, Imperial College London

In mid-2011, Jonathan embarked on the first ever Imperial College - National University of Singapore (NUS) Joint PhD programme. As part of this programme he conducted research at both institutions, spending a year in the Tribology Laboratory within the Mechanical Engineering Department at Imperial College. Here he gives a first hand account of his experiences in London.

Despite the tinge of apprehension that I felt at the outset, as this was the first time that I spent an extended period of time overseas, the experience was invaluable. From the first day, it was evident that many aspects of work and life were very different in London compared to NUS back in Singapore.

At first I perceived a significant gap in the institutions' overall educational approach: whilst NUS favoured a more theoretical basis, Imperial College's 'hands-on' approach needed some adjustment. Imperial appeared to focus more on applications, while NUS spent more time on the understanding of scientific basis and theory. In the end, however, these two methods turned out to be complementary and benefitted my scientific research.

In my work on lubrication of Micro-Electrical-Mechanical Systems (MEMS), the theoretical understanding of the workings of friction at the micro- and nano-scale can only be achieved through practical experiments. This 'hands-on' approach was also suited to our aim of making MEMS devices more commercially viable.

Imperial College also seems to place a greater weight on considered reflection and academic criticism. Having been used to a culture in Singapore that ranks efficiency and speed above all else, I was challenged to develop this mind-set. It was through my time in London that I learned how to balance both scientific curiosity and a need for practical

applicability - something that I have begun to use in my everyday routine. The independent and collaborative contribution and guidance from my supervisors also spurred me on to greater heights!

Cultural Connections

The opportunity to share and learn from each other's knowledge and experiences was also invaluable. At times though I found myself caught in the middle of two worlds: the new multicultural environment in London, and the old one that I knew back home. However, I soon became accustomed to my new life in the UK: colleagues became friends and in time we began to spend many happy evenings with each other. The exposure to people from many different cultures and nationalities only served to accentuate our differences – yet never once did I feel excluded from a group.

My stay at Clayponds, one of Imperial College's postgraduate halls, was another great opportunity to mingle and experience new cultures. Living in close proximity to the College, and having well-organised activities throughout the academic year, made me feel like I was no longer in the UK but in an international microcosm.

In this sense, my education at Imperial College was not limited to academic pursuits, but there was something new to return 'home' to each day; someone with whom I could (and would) strike up a conversation, and discover a little bit more about the world – sometimes about places that I may never have had the privilege to hear of previously.

As graduation approaches, I cannot help but look back at the delightful year that I spent at Imperial College. These experiences have been unquestionably beneficial, thanks to the company of all my colleagues and friends. It is my hope that others who embark on similar journeys as academic 'explorers' will share my experience, and use it the best they can in enriching others' lives.

Jonathan Leong has just completed his PhD in Mechanical Engineering, under the Imperial-NUS Joint PhD Programme, and worked with the members of the Tribology Lab during his time at Imperial College.



