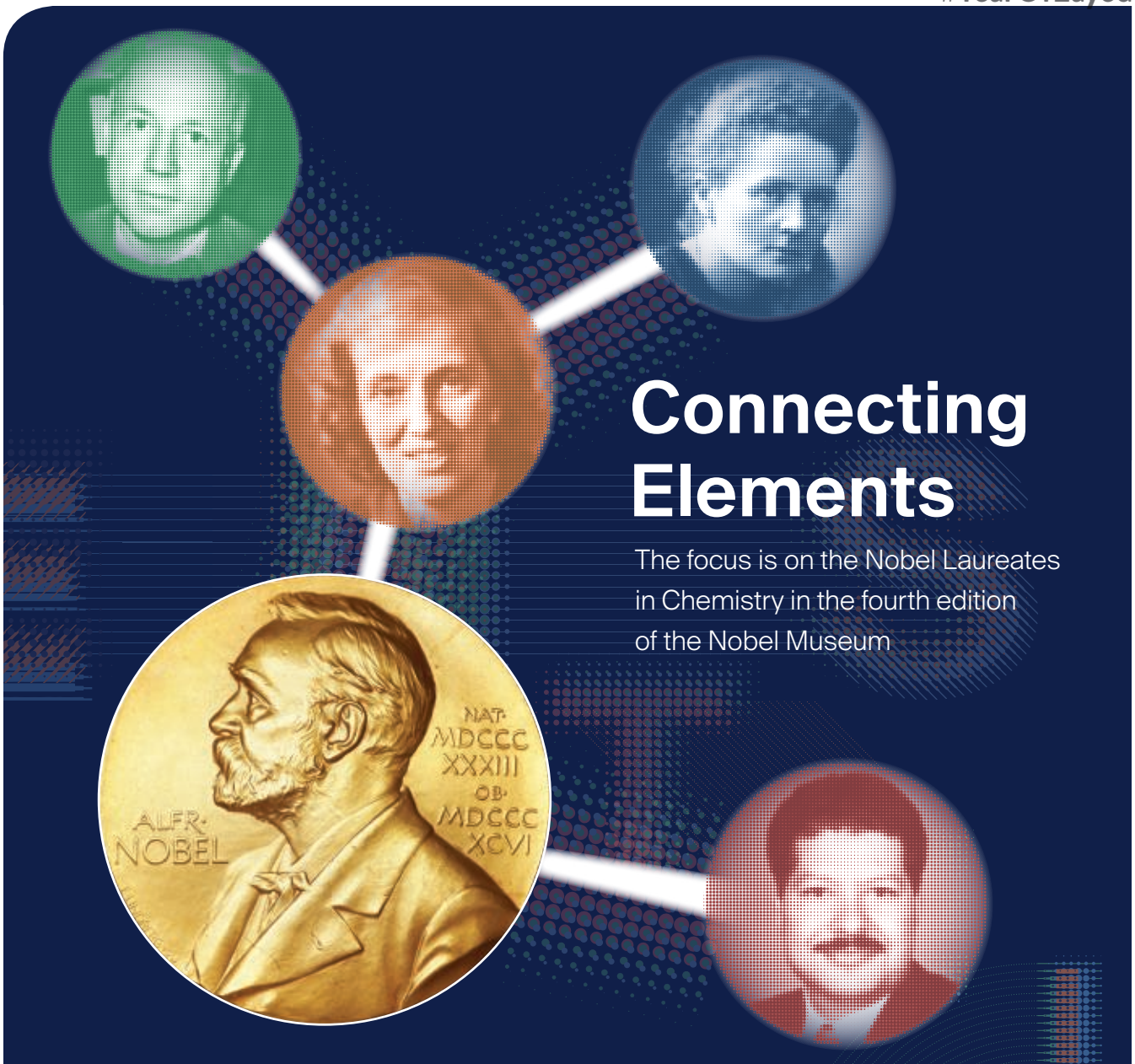
FLASHES

A MONTHLY MAGAZINE ON KNOWLEDGE AND DEVELOPMENT BY THE
MOHAMMED BIN RASHID AL MAKTOUM KNOWLEDGE FOUNDATION

FEBRUARY 2018
ISSUE 38

#YearOfZayed



Connecting Elements

The focus is on the Nobel Laureates in Chemistry in the fourth edition of the Nobel Museum

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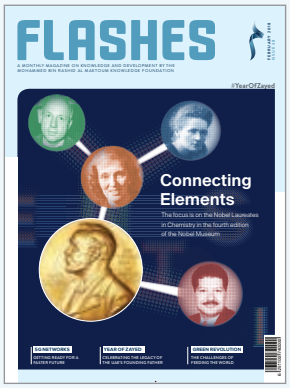

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FOREWORD

Dear readers,
It gives me great pleasure to announce the inaugural Arab Innovation Forum, which will take place on February 26-28 at the Dubai World Trade Centre.
This event, which is organised by the Mohammed Bin Rashid Al Maktoum Knowledge Foundation, is part of our remit to create projects and initiatives that help disseminate knowledge around the world.

The world today is characterised by rapid social, intellectual and economic change, which means innovation is key for governments, countries and societies to remain competitive. This is a fact that the UAE's wise leadership has long recognised, as evidenced by the launch of the UAE National Innovation Strategy in 2014. Its aim is to make the UAE one of the most innovative nations in the world within seven years through strategic initiatives. As a result, February is annually assigned as UAE Innovation Month.

The Arab Innovation Forum will play an important role in this regard by offering a platform for institutions, experts and entrepreneurs to come together, showcase their innovations, discuss topics of interest and forge professional strategic ties to strengthen the economy. The event will cover innovation in major sectors such as smart government, communication technologies, healthcare, renewable energy, transportation, and financial services.

The Forum is a multifaceted showcase for innovation by being divided into several discussion sessions, workshops, and an exhibition for international, regional and local start-ups. The event will also include the Arab Innovation Forum Award ceremony to recognise and reward original innovations from all six sectors covered by the event, as well as two additional awards for start-ups and entrepreneurs.

This month also sees the return of our popular Nobel exhibition series entitled 'The Nobel Prize in Chemistry: Connecting Elements'. This event highlights the achievements of Nobel Laureates in Chemistry and the significant contribution of Arab alchemists, such as Jābir ibn Hayyān and Muhammad ibn al-Razi, to the history and development of chemistry. This exhibition is also dedicated to another great Arab, Ahmed Zewail, who won the 1999 Nobel Prize in Chemistry for his ground-breaking work on femtochemistry.

'The Nobel Prize in Chemistry: Connecting Elements' is taking place from 4 February to 3 March at City Walk in Dubai and we hope it will continue to inspire the importance of innovation and creativity, especially among the youth.

Jamal Bin Huwaireb
CEO of Mohammed bin Rashid
Al Maktoum Knowledge Foundation

Dubai Ruler: Thank You Mohamed bin Zayed

His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, dedicated his accession day anniversary to thank His Highness Sheikh Mohamed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces, for devoting his life to serving the nation and ensuring the happiness of citizens.

"As we do every year, we issued instructions not to allocate celebratory events on the accession day anniversary that falls on January 4. We usually launch a campaign to thank those who had impact on our lives by serving the nation. Today, we urge our Emirati people to thank Sheikh Mohamed bin Zayed who devoted his life to raising the stature of the nation and ensuring the happiness of citizens," Sheikh Mohammed bin Rashid tweeted.

HH Sheikh Mohammed bin Rashid has over the past few years dedicated his accession day anniversary, which falls on January 4, to thank the community.

"As we do every year, we issued instructions not to allocate celebratory events on the accession day anniversary that falls on January 4. We usually launch a campaign to thank those who had impact on our lives by serving the nation. Today, we urge our Emirati people to thank Sheikh Mohamed bin Zayed who devoted his life to raising the stature of the nation and ensuring the happiness of citizens"

New Dubai Nature Reserve

The emirate has launched a new desert conservation reserve that spans 10 per cent of Dubai's area.

The project was launched by His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, on January 17, 2018.

"Our goal is to provide a fertile and robust environment for plants, a natural reserve for animals, and an important destination for tourists and families," HH Sheikh Mohammed said.

"Preserving and investing in the environment means preserving and investing in one of our most important assets. The Marmoom Reserve is an environmental, touristic and sporting addition to life in the UAE."

Named the Marmoon Reserve project, the unfenced desert reserve is home to 19 endangered species, as well as more than 360 native and migratory bird species, 26 reptile species, nine mammal species and 39 species of plants. It will also have 10 kilometres of lakes, including Al Qudra Lakes, and will encompass Saruq Al Hadid, an archaeological site dating back 3,000 years.

It will include observation decks, yoga areas, an outdoor theatre and cycling tracks, and will be powered using solar energy. By 2030, it will also be used to host more than 20 annual sporting, cultural and environmental events.

The reserve is a project comprised of nine government agencies: The Dubai Municipality, Dubai Sports Council, Dubai Water and Electricity Authority, Roads and Transport Authority, Media Office, Department of Tourism and Commerce Marketing, Knowledge and Human Development Authority, Dubai SME and Meraas.

Abu Dhabi Sustainability Week

His Highness Sheikh Mohammed Bin Rashid Al Maktoum, Vice President, Prime Minister of the UAE and Ruler of Dubai, visited the Abu Dhabi Sustainability Week (ADSW) 2018, the largest sustainability gathering in the Middle East.

His Highness toured various exhibition pavilions at the event, which took place at Abu Dhabi National Exhibition Centre (ADNEC), from January 13 to 20, and saw the participation of over 600 public and private sector organisations across 40 countries.

HH Sheikh Mohammed was briefed by various officials and representatives on the latest innovations and alternative solutions to generate sustainable and clean energy, as well as the latest developments on clean water innovation technologies.

During the tour, HH Sheikh Mohammed praised the great efforts and leading ideas of His Highness Sheikh Mohamed Bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces, adding that Abu Dhabi Sustainability Week is a great place for thought leaders and experts in the field to come together to discuss and develop clean and sustainable energy sources.

MBRF Marks UAE Innovation Month with 1st 'Arab Innovation Forum'

The Mohammed bin Rashid Al Maktoum Knowledge Foundation (MBRF) announced plans to organise the first-ever Arab Innovation Forum on February 26-28, 2018, at the Dubai World Trade Centre.

The Foundation revealed its plans at a press conference held on January 16, 2018 at The St. Regis Dubai hotel in Al Habtoor City and attended by MBRF's CEO His Excellency Jamal bin Huwaireb, in addition to Saif Al Mansoori, Corporate Affairs Advisor; Dr Khaled Al Wazni, Strategy and Knowledge Advisor; and Mohannad Shaheen, Project Manager.

The upcoming Forum offers a platform for institutions, experts and entrepreneurs to come together, showcase their innovations, discuss topics of interest and forge professional strategic ties to strengthen the economy. The event covers innovation in major sectors such as smart government, communication technologies, healthcare, renewable energy, transportation, and financial services.

Speaking at the conference, HE bin Huwaireb explained that MBRF is launching the Arab Innovation Forum as part of its mission to build knowledge-centred societies, embrace projects and initiatives that support ideas and innovation, and provide opportunities for young generations to learn and to create sustainable solutions for their communities.

Innovation is a key element in the development of both individuals and communities, HE added, especially with the rapid social, intellectual and economic changes taking place in the world every day. This makes it necessary for societies to promote innovation in their development plans if they want to maintain their competitiveness, he stressed, adding that the Arab Innovation Forum is in line with the aspirations of the UAE Government to place innovation at the core of all strategies and development plans.

The Forum will be divided into several sessions, starting with the opening ceremony, where entrepreneurs, creative thinkers and international experts from all around the world will discuss innovation within the various sectors covered in the Forum. The second part of the event will be the 10,000-square-metre exhibition, where more than 200 international, Arab and local start-ups are set to showcase their innovations to visitors. The Forum will also include a series of workshops on innovation, as well as topics of interest for emerging companies such as attracting investment, growth and global expansion.

The event will also include the Arab Innovation Forum Award ceremony to recognise and reward original innovations from all six sectors covered by the event, as well as two additional awards for start-ups and entrepreneurs.

The UAE launched the National Innovation Strategy, as well as the UAE Innovation Month initiative, whereby the month of February is annually dedicated to celebrating innovation and innovators across the UAE and the region. With its policies and initiatives, the UAE has established itself as the highest-ranking Arab nation on the Global Innovation Index, and a prime destination for innovation and innovators everywhere.

The Nobel Prize in Chemistry: Connecting Elements

Exhibition in memory of Ahmed Zewail

When inventor and industrialist Alfred Nobel penned his will in 1895, he laid the foundation for the world's most famous award, the Nobel Prize. It is awarded to those who confer the "greatest benefit on mankind" in physics, chemistry, physiology or medicine, literature and peace.

From 4 February to 3 March an exhibition entitled 'The Nobel Prize in Chemistry: Connecting Elements' takes place at City Walk in Dubai. The Nobel Exhibition, which is now in its fourth instalment, has been organised by the Mohammed Bin Rashid Al Maktoum Knowledge Foundation (MBRF), which has signed an exclusive agreement with the Nobel Museum.

According to HE Jamal Bin Huwaireb, CEO of MBRF, organising the Nobel Museum is part of the organisation's remit to create projects and initiatives that help disseminate knowledge around the world. The ultimate aim is to inspire the audience by allowing them to see how knowledge can be used to improve the world we live in.

The Nobel Exhibition highlights the achievements by Nobel Laureates in Chemistry such as Marie and Pierre Curie, Dorothy Hodgkin and Melvin Calvin. The Nobel Prize in Chemistry has been awarded 109 times to 178 Nobel Laureates between 1901 and 2017. The Nobel Exhibition is also being held in memory of Ahmed Zewail, an Egyptian-American scientist who was known as the "father of femtochemistry". He was awarded the 1999 Nobel Prize in Chemistry.

The exhibition also includes the significant contribution of Arab alchemists to the history of chemistry and their profound impact on its development.

The Islamic alchemists were the first to quantify and classify compounds and elements, to study the reactions between substances, and began the process of dividing organic and inorganic chemistry.

Chemistry is integral to everything in our physical world, from digesting food to creating medicines and growing plants. Chemistry examines the chemical composition of the physical world, from basic elements to the complicated molecules found in living organisms. Chemists map how different atoms bond to form molecules and the chemical reactions that take place. The chemical reactions that take place in living organisms are numerous, varied and complicated.

The Nobel Laureates and their discoveries are a gateway that allows us to see the fascinating riches of our world. The Laureates' work also demonstrates the joy of discovery, understanding and how knowledge is integral to changing the world.

COUNTRY PROFILE: SWITZERLAND

GDP US$659.83 BN **POPULATION** 8,319,769 **HDI** 0.939

SECTORIAL INDICES

PRE-UNIVERSITY EDUCATION (PUE)
RANK 12
VALUE 72

TECHNICAL VOCATIONAL EDUCATION & TRAINING (TVET)
RANK 5
VALUE 72

HIGHER EDUCATION (HE)
RANK 2
VALUE 68.5

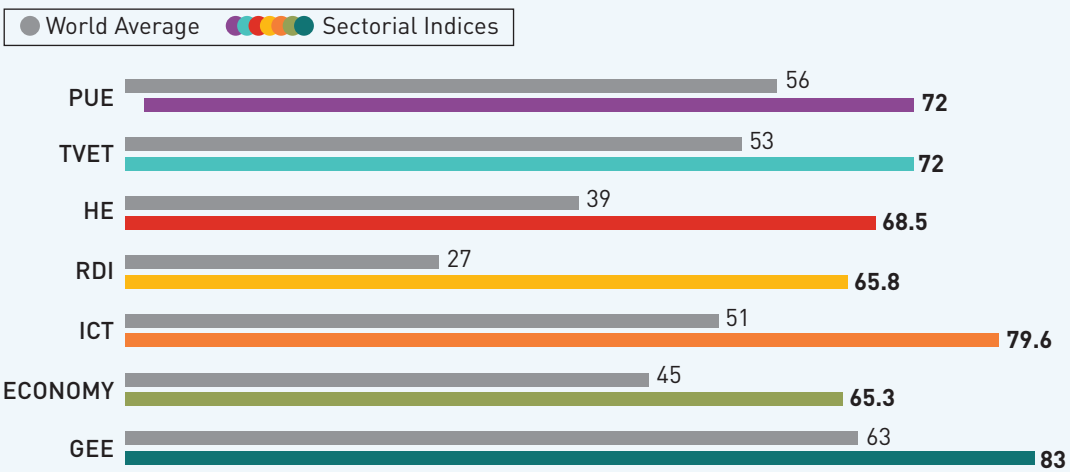
RESEARCH, DEVELOPMENT & INNOVATION (RDI)
RANK 2
VALUE 65.8

INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)
RANK 4
VALUE 79.6

ECONOMY
RANK 5
VALUE 65.3

GENERAL ENABLING ENVIRONMENT (GEE)
RANK 4
VALUE 83.2

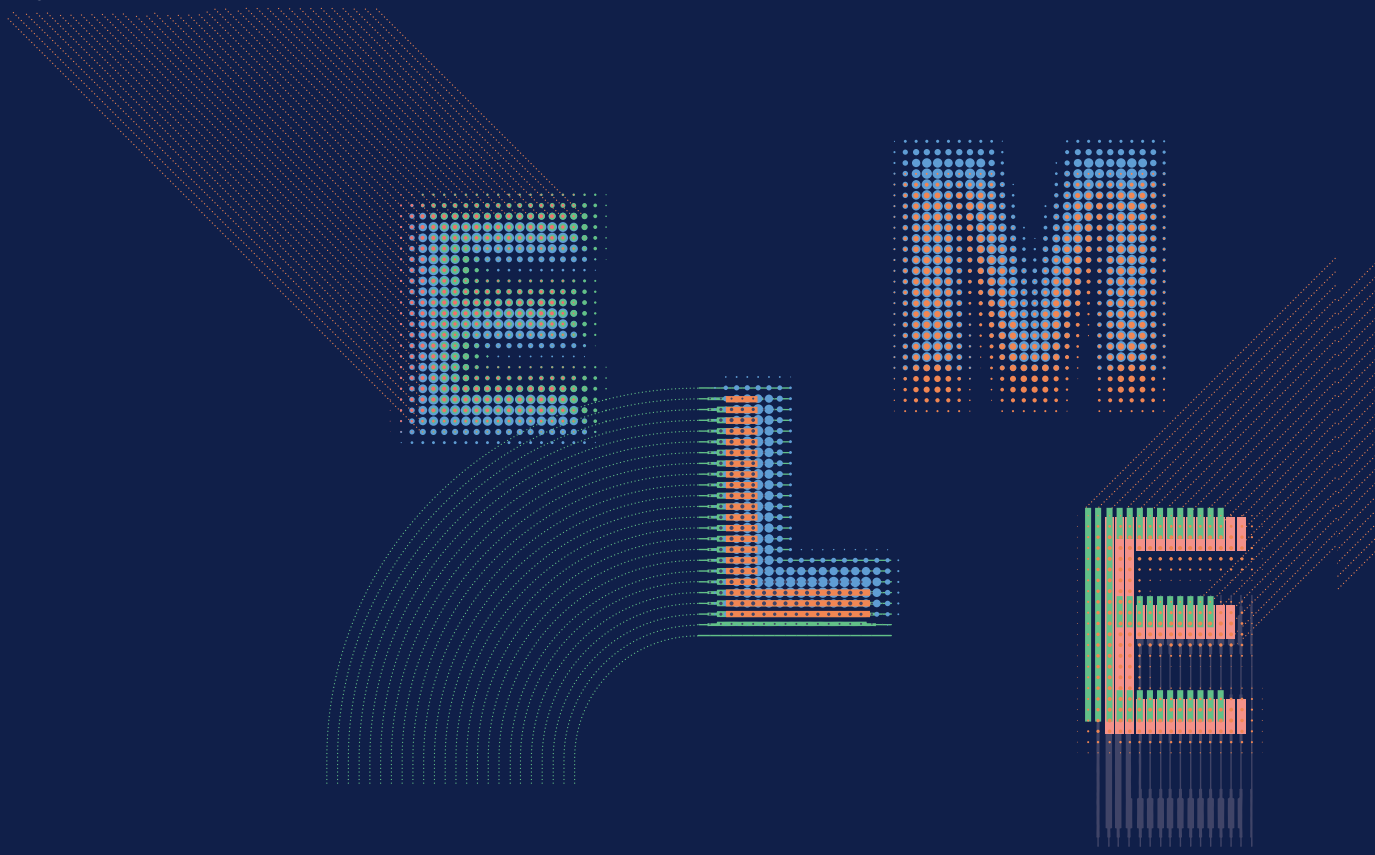
SECTORIAL INDICES IN COMPARISON WITH WORLD AVERAGE



WORLD RANK 1/131

SWITZERLAND	Singapore	Finland	Sweden	Nether-lands	US	Luxem-bourg
1	2	3	4	5	6	7

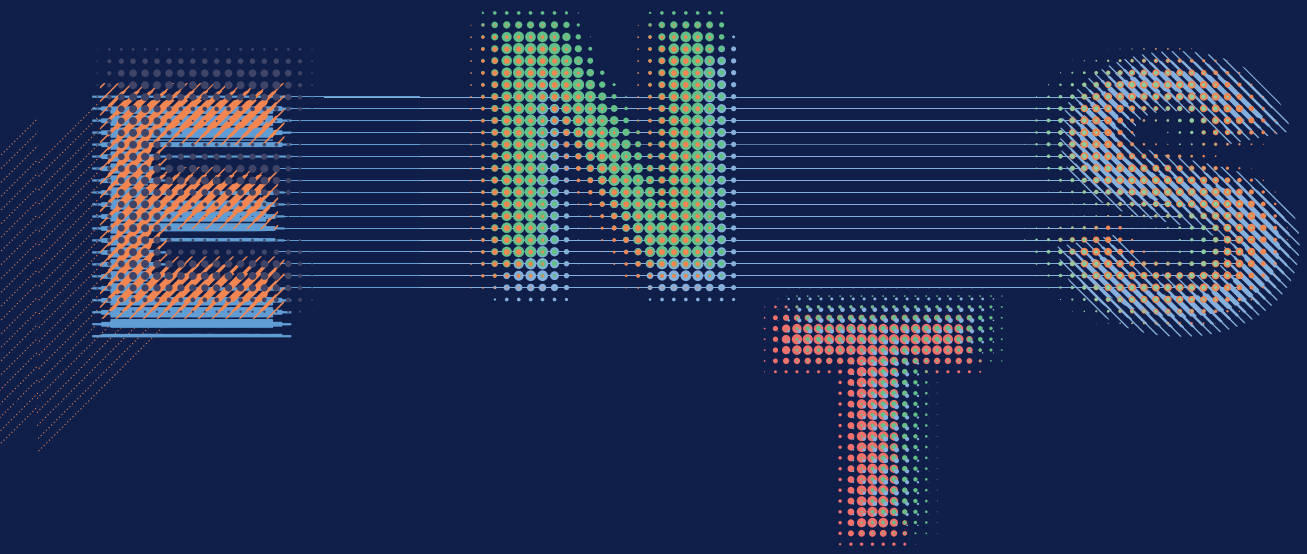
GENERAL ENABLING ENVIRONMENT	4 RANK	83 VALUE
POLITICAL AND INSTITUTIONAL	2 RANK	94 VALUE
SOCIO-ECONOMIC	6 RANK	74 VALUE
HEALTH AND ENVIRONMENT	12 RANK	85 VALUE
PRE-UNIVERSITY EDUCATION	12 RANK	72 VALUE
KNOWLEDGE CAPITAL	12 RANK	70.6 VALUE
EDUCATIONAL ENABLING ENVIRONMENT	16 RANK	74 VALUE
TECHNICAL VOCATIONAL EDUCATION AND TRAINING	5 RANK	72 VALUE
FORMATION AND PROFESSIONAL TRAINING	6 RANK	75.5 VALUE
FEATURES OF THE LABOUR MARKET	21 RANK	66.7 VALUE
HIGHER EDUCATION	2 RANK	68.5 VALUE
HIGHER EDUCATION INPUTS	1 RANK	68.1 VALUE
HIGHER EDUCATION OUTPUTS AND QUALITY	3 RANK	68.9 VALUE
RESEARCH, DEVELOPMENT AND INNOVATION	2 RANK	65.8 VALUE
RESEARCH AND DEVELOPMENT	3 RANK	68.1 VALUE
INNOVATION IN PRODUCTION	2 RANK	77.6 VALUE
SOCIAL INNOVATION	17 RANK	46.9 VALUE
INFORMATION AND COMMUNICATIONS TECHNOLOGY	4 RANK	79.6 VALUE
ICT INPUTS	3 RANK	88.7 VALUE
ICT OUTPUTS	9 RANK	75.7 VALUE
ECONOMY	5 RANK	65.3 VALUE
KNOWLEDGE COMPETITIVENESS	6 RANK	67.1 VALUE
ECONOMIC OPENNESS	16 RANK	53.1 VALUE
FINANCING AND VALUE ADDED	1 RANK	73.9 VALUE



THE NOBEL PRIZE IN CHEMISTRY

CONNECTING ELEMENTS

The fourth instalment of the Nobel Exhibition will offer exciting insights into the complex world of chemistry and the fascinating work done by Nobel Laureates.



When the chemist, engineer and inventor Alfred Nobel died in 1896 his will stipulated that 94 per cent of his considerable fortune be used to set up a series of prizes for those who confer the "greatest benefit on mankind" in physics, chemistry, physiology or medicine, literature, and peace. Today, the Nobel Prize is widely regarded as the most prestigious award available in these fields.

This legacy is being celebrated from 4 February to 3 March with an exhibition entitled 'The Nobel Prize in Chemistry: Connecting Elements', which is taking place at City Walk in Dubai. The event is also being held in memory of Ahmed Zewail, an Egyptian-American scientist, known as the "father of femtochemistry" who passed away in 2016. He was awarded the 1999 Nobel Prize in Chemistry for his work on femtochemistry and became the first Egyptian to win a Nobel Prize in a scientific field.

'The Nobel Prize in Chemistry: Connecting Elements' has been organised by the Mohammed Bin Rashid Al Maktoum Knowledge Foundation (MBRF), which has signed an exclusive agreement with the international Nobel Musium. The exhibition seeks not only to highlight the achievements by Nobel Laureates in Chemistry and inspire the UAE's youth, but also to showcase the significant contribution of Arab scientists to alchemy and their profound impact on the subsequent development of chemistry.

This is the fourth instalment of the popular Nobel Exhibition, following on from last year's focus on physics under the theme 'The Nobel Prize in Physics: Understanding Matter'. According to HE Jamal Bin Huwaireb, CEO of MBRF, organising the Nobel Exhibition is part of the organisation's remit to create projects and initiatives that help disseminate knowledge around the world.

As a result, 'The Nobel Prize in Chemistry: Connecting Elements' will also feature four workshops held by top experts in their fields, as well as numerous other events including the official opening on Sunday 4 February.

THE IMPORTANCE OF CHEMISTRY

Chemistry is integral to everything in our physical world, from digesting food to creating medicines and growing plants. Chemistry examines the chemical composition of the physical world, from simple basic elements to the complex molecules found in living organisms. Chemists map how different atoms bond to form molecules and they investigate how different substances react with one another to form new combinations. These results interact with the development of technology, medicine and everyday life. The Nobel Laureates and their discoveries are a gateway that allows us to see the fascinating riches of our world and their contributions demonstrate the possibility of using our knowledge to develop new opportunities to change our world.

But it is obviously not only the Nobel Laureates that are central to chemistry. In fact, chemistry has a long history ranging back to ancient Greek philosophers such as Aristotle, the advent of alchemy during the Islamic Golden Age and the development of modern chemistry in the 17th and 18th century.

Islamic scientists made important contributions to chemistry during the Islamic Golden Age from the

Above: Dorothy Hodgkins became the third woman to win the Nobel Prize in Chemistry in 1964.

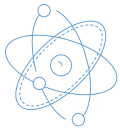
Above right: Stockholm's Nobel Museum has all the essential information about the most prestigious prize in the world, Alfred Nobel, and the Nobel Laureates.

Right: Marie Curie is the only woman to have won the Nobel Prize twice and the only person to have won it in two different fields.

8th to the 13th century. Islamic scientists were the first to identify many substances, including sulphuric acid and silver nitrate. They also discovered aqua regia, a blend of acids that can dissolve both gold and platinum.

Islamic chemists also made great contributions to developing experimental methods. They built laboratories and used a wide variety of scientific instruments, several of which they invented and that are still used today. You can read more about great Islamic scientists such as Abu Māsā Jābir ibn Hayyān and Muhammad ibn Zakariya al-Razi on page 54 of this issue of *Flashes*.

The Nobel Prize in Chemistry has been awarded 109 times to 178 Nobel Laureates between 1901 and 2017. Frederick Sanger is the only Nobel Laureate who has been awarded the Nobel Prize in Chemistry twice, in 1958 and 1980. This means that a total of 177 individuals have received the Nobel Prize in Chemistry. Below, we look at a selection of Laureates who made important breakthroughs in different fields of chemistry.

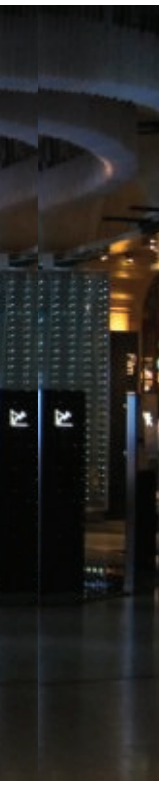


ELEMENTS

The periodic table lists 118 elements, of which the first 94 occur naturally on Earth, with the remaining 24 being synthetic elements. These chemical elements constitute all of the ordinary matter of the universe. When different elements are chemically combined, with the atoms held together by chemical bonds, they form chemical compounds.

In 1896 the French physicist Antoine Becquerel was the first person to discover evidence of radioactivity. This was followed by a period of intense research into radioactivity, especially by Marie and her husband Pierre Curie.

In 1903 the Nobel Prize in Physics was divided. Becquerel was awarded "in recognition of the extraordinary services he has rendered by his discovery of spontaneous radioactivity", while the other half was given jointly to Pierre and Marie Curie "in recognition



NOBEL EXHIBITION WORKSHOP 1: AHMED ZEWAIL – METHODS & DISCOVERIES

Professor Zewail was the sole recipient of the 1999 Nobel Prize in Chemistry for his pioneering developments in femtoscience, making possible observations of atoms in motion on the femtosecond time scale. These developments led to the establishment of the discipline of femtochemistry. Before his death in 2016, he and his group had also developed "4D" electron microscopy allowing the direct visualization in the four dimensions of space and time of materials and biological behaviours.

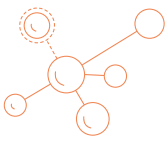
Professor Ibrahim El-Sherbiny, who specialises in nano and materials sciences, and Mohamed H. Alkordi, Associate Professor of Chemistry and Codirector of the Center for Materials Science at Zewail City of Science and Technology, will highlight Zewail's method that led him to the Nobel Prize.

of the extraordinary services they have rendered by their joint researches on the radiation phenomena discovered by Professor Henri Becquerel".

More in depth studies of radioactivity followed. In 1899 Ernest Rutherford demonstrated that there were at least two distinct types of radiation: alpha radiation and beta radiation. He further discovered that radioactive preparations gave rise to the formation of gases. Working with Frederick Soddy, Rutherford advanced the hypothesis that helium gas could be formed from radioactive substances. In 1902 they formulated a revolutionary theory: that elements could disintegrate and be transformed into other elements. For this work Rutherford was awarded the Novel Prize in Chemistry in 1908.

Marie Curie meanwhile continued her work after Pierre's death and in 1911 she won the Nobel Prize in Chemistry "in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element".

Marie Curie was the first woman to win a Nobel Prize, the first person and only woman to win twice, and the only person to win a Nobel Prize in two different sciences.



MOLECULES

A molecule is an electrically neutral group of two or more atoms held together by chemical bonds. As a result, there are an enormous number of different substances all around us as atoms can be bound together to form different molecules in extremely varied ways. Molecules can be small and simple or large and complex. How they look is crucial to the role they play in nature and in technology.

One of the forerunners in this field was Peter Debye. In 1912 he developed a method to determine how electrical charges are distributed in a molecule, which became important in the mapping of molecular structures. At the same time, X-ray radiation was becoming an important tool for mapping crystalline structures, but Debye also developed methods for using both X-rays and electron beams to map molecular structures in gases, for example. For his contribution Debye was awarded the Nobel Prize in Chemistry in 1936.

Dorothy Hodgkin advanced the technique of X-ray crystallography, a method used to determine the three-dimensional structures of crystals. Among her most influential discoveries are the confirmation of the structure of penicillin, and the structure of vitamin B12, for which she became the third woman to win the Nobel Prize in Chemistry in 1964 "for her determinations by X-ray techniques of the structures of important biochemical substances".

Left: Melvin Calvin won the Nobel Prize for Chemistry in 1961 for his important work on photosynthesis.

WORKSHOP 2: COOL ELECTRON MICROSCOPY ALLOWS IMAGING OF TINY OBJECTS IN SOLUTIONS

Since the 1930s transmission electron microscopy has been an invaluable technique for identifying the structure of materials. Over time the technique has developed to the point where it allows for increasingly advanced studies to be performed. One major breakthrough was the discovery that by rapid cooling, solutions could be imaged. This cooling has to be done in a very controlled way in order for the solution to vitrify and not crystallize and the sample has to be kept at very low temperatures during the imaging process. This technique is called cryogenic, or cryo, TEM. In 2017 the Nobel Prize in Chemistry was awarded to Jacques Dubochet, Joachin Frank and Richard Henderson for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution.

This workshop, hosted by Professor Viveka Alfredsson from Lund University. will illustrate the importance of this technique.

WORKSHOP 3: HOW TO WIN THE NOBEL PRIZE

The Nobel Prize is awarded for ideas that have changed the world, but how do the Nobel Laureates get these ideas? In this inspirational second workshop the microscope is on how Nobel Laureates are creative and how this creativity stems both from individual motivation and from working in the right environment.

Dr Anna Sjöström Douagi and Dr Gustav Källstrand will host this workshop. Dr Douagi is the head of programmes at the Nobel Centre and an expert on finding new ways to communicate and promote science. Dr Källstrand is an historian of the Nobel Prize who has interviewed several Nobel laureates about their path to recognition.

Right: German organic chemist Emil Fischer did breakthrough work in identifying purines and the actions of enzymes.

CHEMICAL REACTIONS

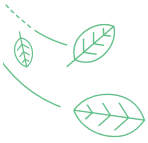
Chemical reactions in which molecules held together by atoms meet and reorganise into new compounds are one of nature's most fundamental processes. This transition from one constellation to another happens very quickly. The process is possible because the atoms inside a molecule vibrate, but the time between these vibrations is very short – 10-100 femtoseconds (A femtosecond is one quadrillionth, or .000000000000001, of a second).

Ahmed Zewail was awarded the 1999 Nobel Prize in Chemistry for his work on femtochemistry – the study of chemical reactions across femtoseconds. Using a rapid ultrafast laser technique (consisting of ultrashort laser flashes), it allows the description of reactions on very short time scales – short enough to analyse transition states in selected chemical reactions.

Femtochemistry enables us to understand why certain chemical reactions take place but not others. We can also explain why the speed and yield of reactions depend on temperature. Scientists the world over are studying processes with femtosecond spectroscopy in gases, in fluids and in solids, on surfaces and in polymers. Applications range from how catalysts function and how molecular electronic components must be designed, to the most delicate mechanisms in life processes and how the medicines of the future should be produced.

WORKSHOP 4: HOW TO SELECT A NOBEL LAUREATE (IN CHEMISTRY)

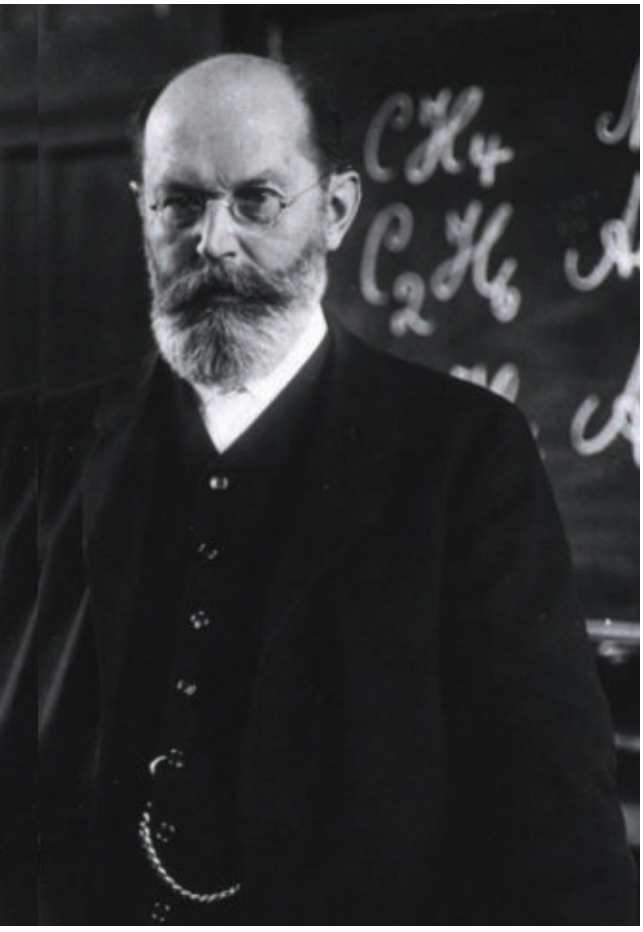
How does the Nobel Committee members select the winners? Professor Sven Lidin, former member of the Nobel Committee of Chemistry, provides insight into this process. For eight years he was one of five people responsible for awarding the Nobel Prize in Chemistry. The talk will deal with the history of the Nobel Prize and the principles of the selection process.



CHEMISTRY OF LIFE

Processes in living organisms are numerous, varied and complicated. The structure of chemical substances and their reactions are the basis for the processes. The conversion of one substance into another often involves many steps and additional substances often drive the reactions. Molecular structure and form are crucial for the role they play in the processes.

Emil Fischer, a German organic chemist, discovered caffeine and other related purines. He also studied the molecular structures of sugars and proteins. Other purines that he discovered later are important building blocks of DNA. His study of sugars led him to study their fermentation and the enzymes that cause it. In the course of this research he famously noted that the action of an enzyme is highly specific: "To make use of an image, I shall say that enzyme and glucoside [the natural precursor of glucose] must fit together like lock and key." For his work on purines and sugars, he was awarded the 1902 Nobel Prize in Chemistry.



Photosynthesis, the process used by plants, algae and certain bacteria to harness energy from sunlight and turn it into chemical energy, is the source of all life on earth. In the 1950s Melvin Calvin and his collegues Andrew Benson and James Bassham used single-cell green algae to study photosynthesis. Using the carbon-14 isotope as a tracer, they mapped the complete route that carbon travels through a plant during photosynthesis, starting from its absorption as atmospheric carbon dioxide to its conversion into carbohydrates and other organic compounds of photosynthesis. This process is known today as the Calvin-Benson-Bassham Cycle. The Nobel Prize in Chemistry was awarded to Melvin Calvin in 1961 "for his research on the carbon dioxide assimilation in plants".

The above is just a snapshot of the fascinating and diverse world of chemistry that will be more thoroughly explored by 'The Nobel Prize in Chemistry: Connecting Elements'.

SOME DISTINGUISHED NOBEL LAUREATES IN CHEMISTRY

YEAR	LAUREATE	COUNTRY	RESEARCH
1908	Sir Ernest Rutherford	Great Britain	Decay of the elements, chemistry of radioactive substances
1910	Otto Wallach	Germany	Alicyclic compounds
1911	Marie Curie	Poland-France	Discovered radium and polonium
1935	Frederic Joliot-Curie Iréne Joliot-Curie	France France	Syntheses of new radioactive elements (artificial radioactivity)
1944	Otto Hahn	Germany	Discovered nuclear fission of atoms
1954	Linus C. Pauling	United States	Studied the nature of the chemical bond (molecular structure of proteins)
1964	Dorothy Mary Crowfoot Hodgkin	Great Britain	Structure determination of biologically important substances by means of X rays
1980	Paul Berg Walter Gilbert Frederick Sanger	United States United States Great Britain	Studied the biochemistry of nucleic acids, particularly hybrid DNA (technology of gene surgery) (Berg) Determined base sequences in nucleic acids (Gilbert & Sanger)
1989	Thomas Robert Cech Sidney Altman	United States United States	Discovered the catalytic properties of ribonucleic acid (RNA)
1991	Richard R. Ernst	Switzerland	Developed high resolution nuclear magnetic resonance spectroscopy (NMR)
1995	Paul Crutzen Mario Molina F. Sherwood Rowland	Netherlands Mexico United States	Work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone
1999	Ahmed H. Zewail	Egypt - US	Studied the transition states of chemical reactions using femtosecond spectroscopy
2014	Eric Betzig, Stefan W. Hell, William E. Moerner	United States Germany United States	For the development of super-resolved fluorescence microscopy
2016	Jean-Pierre Sauvage Sir J. Fraser Stoddart Bernard L. Feringa	France United States Netherlands	For the design and synthesis of molecular machines
2017	Jacques Dubochet Joachim Frank Richard Henderson	Switzerland United States United Kingdom	For developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution

THE YEAR OF ZAYED

This year, on the centenary of the UAE's founding father's birth, the nation will celebrate and honour Sheikh Zayed bin Sultan Al Nahyan's legacy.

Sheikh Zayed bin Sultan Al Nahyan, who died in 2004, would have been 100 this year. That is why his son, UAE President HH Sheikh Khalifa bin Zayed Al Nahyan, declared last year that 2018 would be the 'Year of Zayed'. The announcement was made on August 6, the day Sheikh Zayed assumed leadership in Abu Dhabi in 1966.

Throughout this year the role of the late leader in establishing the UAE federation will be highlighted, as well as his local, regional and international achievements, with the Year of Zayed as a whole seeking to achieve several objectives.

The first will be recognising the vital role Sheikh Zayed played in establishing the UAE and consolidating its foundations of modern development. There will also be an emphasis on the nation's local, regional and global achievements, which continue to form the basis of the country's progress.

The Year of Zayed will also seek to share Sheikh Zayed's values and principles, with organisers hoping the celebration will strengthen his stature as a symbol of patriotism and love for the nation. They will draw, no doubt, on his own words.

"Our constant thinking of the past and all it has granted us, of the present and all the hopes that come with it, and of the future and all of its bright aspirations, will lead us at all times to build our country, its progress and its development," said Sheikh Zayed.

Speaking on the day the 'Year of Zayed' was announced, HH Sheikh Khalifa said: "On this day, August 6, a new era dawned upon us all when the late Sheikh Zayed assumed command of the Abu Dhabi government, and began the march towards unity, prosperity and societal development.

"The Year of Zayed is a great national occasion when we will proudly share memories of the life of the founding father, Sheikh Zayed bin Sultan Al Nahyan, and his gift to us of deeply-rooted values, principles and traditions that have become part of our Emirati identity."

The President has urged all residents of the UAE to uphold the "noble values instilled in them by the late Sheikh Zayed", including those of wisdom, respect, determination, loyalty, a sense of belonging to the nation, and a willingness to make sacrifices at whatever cost.

In response to the directive, HH Sheikh Mohammed bin Rashid Al Maktoum, the UAE's Vice President, Prime Minister and Ruler of Dubai, called for the launch of a comprehensive framework to develop an integrated and consolidated agenda that activates initiatives within all federal and local institutions.

"We celebrate the centennial anniversary of the birth of one of the greatest and most noble men who dedicated his life for the present and future of the

> *"We are inspired by the Zayed school of leadership and management. With the founding blocks of the Union State placed by the late Sheikh Zayed, from which we are all reaping the benefits, we will continue this path and look forward with optimism to the future."*

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"We are inspired by the Zayed school of leadership and management. With the founding blocks of the Union State placed by the late Sheikh Zayed, from which we are all reaping the benefits, we will con-tinue this path and look forward with optimism to the future."

Sheikh Zayed was born at Qasr al-Hosn, Abu Dhabi, in 1918, the youngest of the four sons of Sheikh Sultan bin Zayed Al Nahyan, Ruler of Abu Dhabi from 1922 to 1926. In 1946 he was chosen as Ruler's Representative in Abu Dhabi's Eastern Region, centred on Al Ain.

On August 6, 1966, he succeeded his elder brother as Ruler of Abu Dhabi. With the export of the first cargo of Abu Dhabi crude oil in 1962, Sheikh Zayed could rely on oil revenues to start an infrastructure overhaul, constructing schools, housing, hospitals and roads.

With the British announcement of the country's withdrawal from the Arabian Gulf, Sheikh Zayed took action to quickly establish closer ties with the emirates. Together with the late Ruler of Dubai, Sheikh Rashid bin Saeed Al Maktoum, Sheikh Zayed called for a federation that would include the seven emirates that made up the Trucial States.

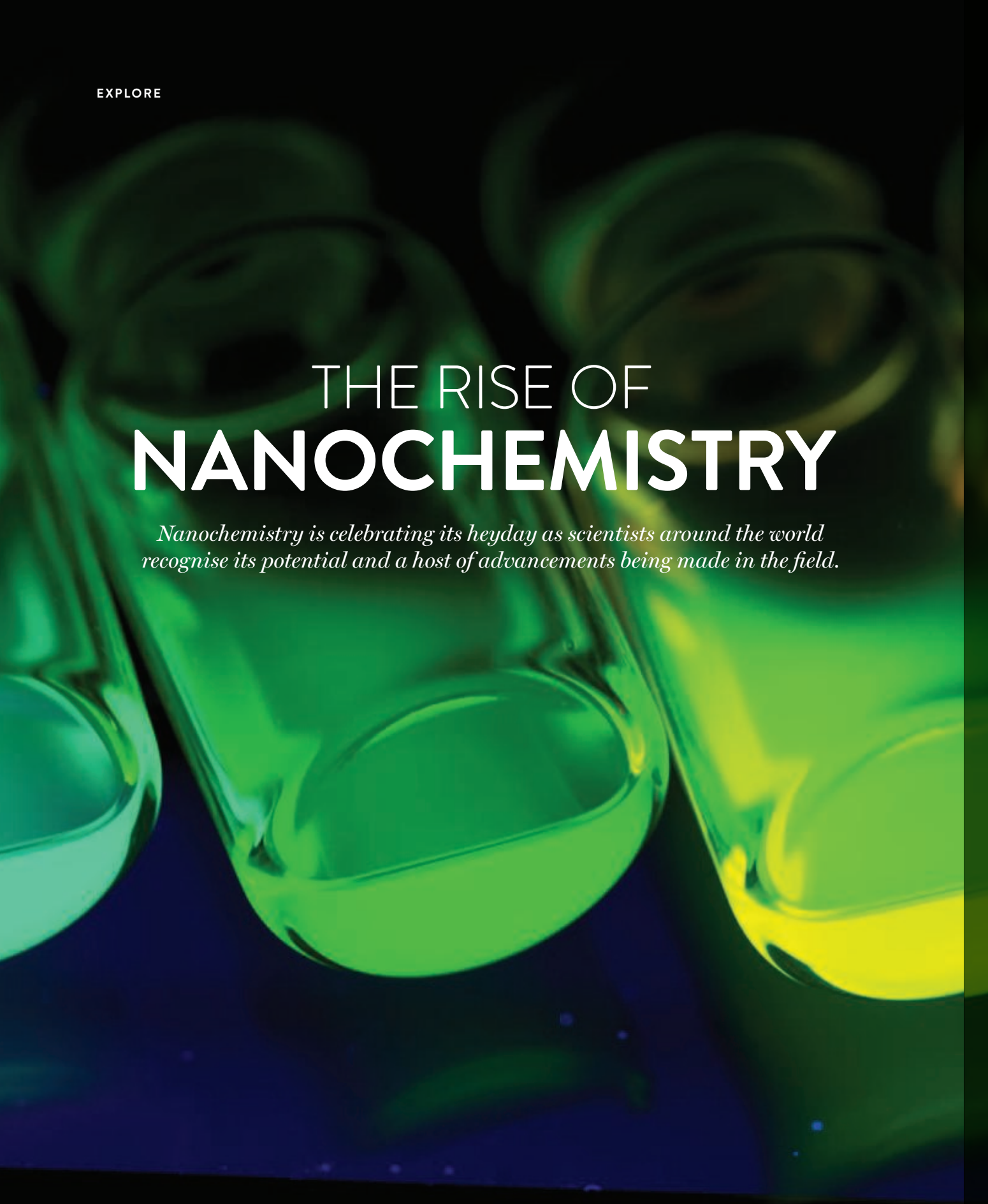
The UAE was formally established on December 2, 1971, with Sheikh Zayed serving as the first President. In 1970, recognising that Abu Dhabi was embarking on a process of rapid development, Sheikh Zayed formalised the consultation process and established the National Consultative Council, bringing together the leaders of each of the main tribes. A similar body was created in 1971 for the entire UAE: the Federal National Council, the state's parliament.

HH Sheikh Mohammed bin Zayed Al Nahyan, the Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces, said the Year of Zayed is an occasion to celebrate the achievements of the late Sheikh Zayed and their future impact. "The Emirati citizen was the most important element of development, as Sheikh Zayed's main objective was to invest in building the Emirati person, believing in his or her ability to actively participate in the building of the nation," he said.

"He has always emphasised that man is the most essential element of progress, and that the most precious wealth of this country is its people, who we must take care of well. There is no use for money without men. This is the philosophy that drives the process of comprehensive and sustainable development of this country."

HH Sheikh Mohammed added: "The best way to celebrate the Year of Zayed would be by spreading Zayed's glorious human and cultural legacy via all the people of the UAE, to continue his inspirational and noble values, and introduce these ideals to new generations."

Below: This year is dedicated to celebrating the legacy, values and principles of Sheikh Zayed, the founding father of the UAE.



THE RISE OF NANOCHEMISTRY

Nanochemistry is celebrating its heyday as scientists around the world recognise its potential and a host of advancements being made in the field.

Last year Geoffrey Ozin, distinguished Toront University Professor of Chemistry in the Faculty of Arts & Science and Canada Research Chair in nanochemistry, was named the winner of the World Technology Award. This annual award, which recognises outstanding innovators from each sector within the technology arena by the World Technology Network, both honoured Ozin and put the spotlight on nanochemistry.

"This emerging and dynamic interdisciplinary field is an essential driver of the 21st century nanotechnology revolution," said Ozin on receiving the award. Ozin believes that 'a chemical approach' to nanomaterials is not just the cornerstone of modern chemistry but also of the whole nanotechnology spectrum. He describes nanochemistry as "an emerging sub discipline of solid-state chemistry that emphasizes the synthesis rather than the engineering aspects of preparing little pieces of matter with nanometer sizes in one, two or three dimensions".

Ozin has been working with nanochemistry for almost 45 years and has seen the discipline evolve. Chemists are now working in close collaboration with other scientific and engineering disciplines, physics and biochemistry, as well as with materials scientists and industrialists. With applications in biomedical chemistry, polymer chemistry, product synthesis and a host of other areas, the gamut of nanochemistry is wide ranging.

Nanochemistry has already stepped out of labs and into our homes with many of our everyday products employing the technology. Sunscreen lotions that absorb ultraviolet light; bandages that use silver nanoparticles for antimicrobial effects; tennis rackets and bicycles built using carbon nanotubes; clear coatings for cars that protect the paint; and composites that protect airplanes from lightning strikes and keep computer circuits cool are just some of the ways in which nanochemistry has forayed into our daily lives.

NEW APPROACH TO OLD CONCEPTS

Given its growing demand, nanochemists are actively seeking to hasten traditional research, testing and development processes. Last year, researchers of the Paul Scherrer Institute PSI in Villigen and ETH Zurich developed a method for improving the precision of catalysis – the fundamental process in chemistry. Catalysts trigger or accelerate the reactions of substances and play a major role in the manufacture of synthetic materials and acids, energy storage, treatment of exhaust gases and other chemical products.

For the chemical industry, optmising catalytic processes is central to their operations and to do this, chemists need a deeper understanding of what is happening at the molecular level. The Swiss research team found a way to construct catalytic model systems accurate to one nanometre enabling them to track the chemical reactions of individual nanoparticles. This minute tracking and corresponding accurate observation of chemical reactions was not possible before. In fact the new technology helped the research team finally gain an in depth understanding of the hydrogen-spillover effect – a phenomena that had baffled chemists for over five decades. Although it was discovered in 1964, it could not be understood or visualised in detail up till now.

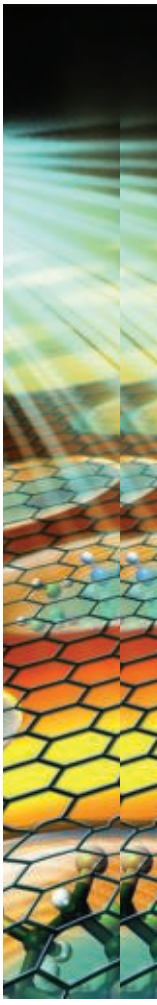
The research team believes the new nanotechnology process has the potential to enable enormous advances in chemical science overall. "With this we are opening up a whole new dimension for the investigation and understanding of catalytic processes. And with this understanding, industrial production processes can be optimised in a much more targeted way," said Jeroen van Bokhoven, Head of the Laboratory for Catalysis and Sustainable Chemistry at the PSI and Professor of Heterogeneous Catalysis at ETH Zurich, who led the study.

Identifying the ideal conditions for a catalytic reaction can be a laborious process, easily taking up to hundreds of separate experiments that involve precisely assessing continuous variables such as temperature, time and reagent concentrations. While the Swiss were developing ways to study catalytic reactions with more precision, the Americans were devising an automated system that would drastically reduce the time spent optimising reactions.

AUTOMATION FOR OPTIMISATION

Last October, a team of chemists and chemical engineers from the Massachusetts Institute of Technology developed an automated flow reactor that can respond to the results of experiments and determine the optimum conditions for catalytic reactions within a single day. The robotic system takes less than 10 minutes to identify optimum conditions within 96 experiments for a series of Suzuki-Miyaura cross-couplings (important carbon bond forming reactions) that are widely used in the chemical industry. Functioning much like a human chemist, the system conducts its own experiments, processes the data and uses the information it collects to select new experiments to optimise each reaction.

The automation is being lauded as one of the most vital contributions to both synthetic chemistry and chemical engineering. In the words of Ryan Hartman, an expert in flow chemistry and microsystems based at New York University, US, "The automation of laboratory-scale reactors is one of the most important, yet challenging chemical engineering feats that



Above: Yasin Ekinci, Waiz Karim and Jeroen van Bokhoven have developed a new, more precise method for studying catalytic processes.

could revolutionise the way we discover science in the 21st century".

In 2015, chemical researchers at the University of Illinois achieved what is often described as a 'tour de force in chemical synthesis'. They built a machine that assembles complex small molecules out of simple chemical building blocks. Automating small molecule making has the potential to quicken new drug development and other technologies that rely on small molecules – a specific class of complex, compact chemical structures.

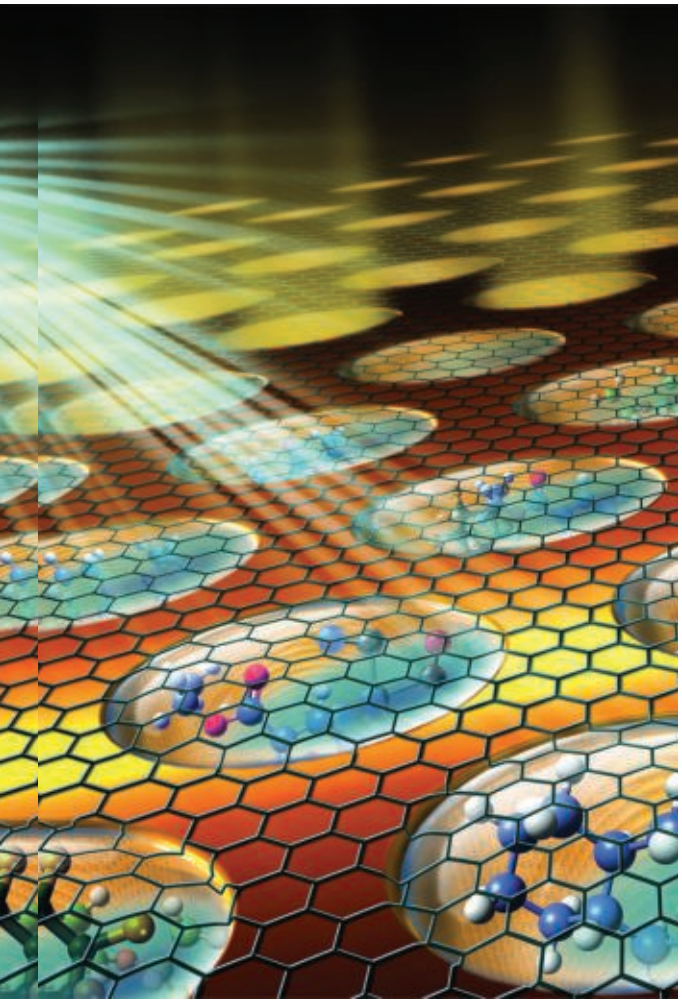
Small molecules are vital to the medical sector with most medications available in that form. They are also a key element in probes that reveal the inner workings of cells and tissues, solar cells and LED technology. But till now, small molecules were extremely difficult to make in a lab. Highly-trained chemists would take years to figure out how to make a small molecule before its functions could even be explored. The long, drawn out process was the biggest impediment in the development of small molecule based medications and technologies.

Martin Burke, Chemistry Professor at the University of Illinois, expects the technology to create new opportunities in other therapeutic areas. The industrialization of the technology will also help refine and broaden its scope and scalability.

"This work has opened up an actionable roadmap to a general and automated way to make most small molecules. If that goal can be realised, it will help shift the bottleneck from synthesis to function and bring the power of making small molecules to non-specialists," says Burke.

TAILOR-MADE PRECISION

The boundaries of nanochemistry were pushed further when a team of chemists at the Carnegie Mellon University conducted a site-specific surgery on a nanoparticle. The procedure paves the way for the precise tailoring of nanoparticles to enhance their functional properties such as catalytic activity and photoluminescence. This in turn increases their usefulness in a variety of fields such as health-care, electronics and manufacturing. While organic chemists have been able to tailor-make the functional groups of molecules for quite some time – such as tailoring penicillin for better medical functions – the 'surgery' is a first for nanochemistry. The Carnegie Mellon team performed the nano-surgery on a gold particle made up of 23 gold atoms surrounded by a protective surface of ligands. The chemists removed two of the staples from the particle's surface revealing its structural factors and increasing its photoluminescence by about 10-fold. Photoluminescence plays a critical role in biological imaging, cancer diagnosis and LED technology, among other applications. The modified particle is now poised to enhance the quality of technology in those fields.



Above: George Ozin, winner of last year's World Technology Award, believes nanochemistry is the driver of the 21st century nanotechnology revolution.

Far left: Experimental set-up shows an array of graphene-capped liquids. The caps enable the liquids to be studied using an image technique that previously was restricted to studying solid surfaces.

Left: Professor Jackie Y. Ying regards nanotechnology as a tool box with unique properties and functionalities to tackle various scientific challenges.

CHEMISTRY CALLING

Globally, the scope of nanochemistry is widening with an ever-increasing number of scientists and engineers working on nanochemistry related problems. This month, the UAE too celebrates chemistry as the Nobel Exhibition comes to town. Titled 'The Nobel Prize in Chemistry: Connecting Elements', this year's edition is dedicated to the achievements by Nobel Laureates in Chemistry.

The Nobel Museum's Chemistry edition follows on the heels of the Knowledge Summit 2017 where Jackie Y. Ying, Founding Executive Director of the Institute of Bioengineering and Nanotechnology, Singapore; and Ibrahim El-Sherbiny – Professor of Smart Nanomaterials and Nanomedicine, Founding Director of Materials and Nanoscience programmes, and Joint Director of Center for Materials Science (CMS) at Zewail City of Science and Technology – spoke extensively about chemistry, nanochemistry and their applications.

"Some of the world's greatest inventions and scientific breakthroughs that will transform our lives are being made possible by the work of chemical engineers. Chemical engineers would also contribute significantly towards the development of healthcare in the future through engineering better medicine. In the next 25 years, chemical engineering can be expected to build on current advances in energy and biomedical research through their ability to engineer at the molecular, nanoscopic, microscopic and macroscopic length scales, and integrate the complex, multiscale processes involved," said Ying.

THE GREEN

Norman Borlaug, an American agronomist and Nobel Prize laureate, helped transform global agriculture in the 1950s and 1960s. The question is whether another transformation is feasible.

The world is no stranger to concerns over hunger. Climate change, declining agricultural productivity, population growth, and alterations in diet have made the population time bomb the looming catastrophe of our time.

If you suffer from anxiety, statistics won't help. The United Nations forecasts that the world's population will grow by more than two billion people by 2050, hitting 9.8 billion and straining the world's already fragile ability to feed itself. Half of that population growth will be concentrated in just nine countries: India, Nigeria, the Democratic Republic of the Congo, Pakistan, Ethiopia, Tanzania, the US, Uganda and Indonesia. All of them (with the exception of the US) will feel the effects of climate change – drought, heat waves and extreme weather – the hardest.

Bill Marsh, writing in *The New York Times* last June, described the world's population crisis as a "slowly unfolding catastrophe", with overpopulation especially acute in Africa. All of his short but distressing article was quotable. Not only would fast-rising populations degrade economic and agricultural resiliency, but recession and drought would magnify the human consequences.

"Mass migration, starvation, civil unrest: overpopulation unites all of these," wrote Marsh. "Many nations' threadbare economies, unable to cope with soaring births, could produce even greater waves of refugees beyond the millions already on the move to neighbouring countries or the more prosperous havens of Europe."

For most of the past century humanity has managed to avoid a Malthusian catastrophe, where population growth outpaces agricultural production. But can it continue to do so? Can advances in agriculture, energy, water usage, manufacturing, disease control and transportation keep food supply ahead of the population

REVOLUTION

curve? Or is humanity doomed to be thrown back towards subsistence?

We have, of course, faced these concerns before. Paul Ehrlich, writing in his 1968 book *The Population Bomb*, predicted that famines, especially in India, would kill hundreds of millions in the 1970s and 1980s. And yet that scenario never materialised. The fact that it didn't was thanks to the Green Revolution and, in particular, the work of one man.

Norman Borlaug, an American agronomist born in Cresco, Iowa, helped transform global agriculture in the 1950s and 1960s. He did so through selective breeding and the creation of a dwarf variety of wheat that produced more grain per acre. Similar work at the International Rice Research Institute in the Philippines dramatically improved the productivity of rice.

The Green Revolution represented a steep increase in the productivity of cereal production, especially wheat, thanks to new varieties of high yielding seeds that, however, also had considerable needs in terms of irrigation and pesticides. It was a revolution that enabled the feeding of a rapidly increasing population.

In 1970, Borlaug was awarded the Nobel Peace Prize for helping to save one billion people from starvation.

Now we're facing the same situation all over again, with the UN also predicting that the world's population could hit 11.2 billion by 2100, despite previous beliefs that it would plateau at nine billion. Do we need another Green Revolution?

"I prefer to call it another 'Green Evolution', as current day choices and choices for going green have changed," replies Meis Moukayed, professor of natural sciences at the American University in Dubai. "People are becoming more aware that we need to have ethical environment-focused choices and practices to protect the planet. Governments and private stakeholders are also cognisant of the fact that we need practices and technologies that are not just sustainable and eco-friendly, but can ensure food security for everyone in the future. ›

Above: In 1970, Borlaug was awarded the Nobel Peace Prize for helping to save one billion people from starvation.

WORLD POPULATION

Projected world population until 2100

Source: UN Department of Economics and Social Affairs, Population Division

"This time the green awakening or evolution is, and will stay, different. We are using innovative technologies in farming/agriculture, irrigation, and biotechnology to make the foods more nutrient dense, safe and to ensure their sustainability. Biotechnology has allowed farmers and governments to use less chemicals and pesticides, increase nutrient value, increase crop quantities and yield, and to also reduce the carbon footprint of the production of some crops. We are using technologies that can be transferred from one country to another without the limitations of geography or climate to ensure that such improved crops can be used by everyone and are catered to different needs. This time round the choices, technologies and practices are different."

Eckart Woertz, research coordinator and senior research fellow at the Barcelona Centre for International Affairs, agrees, stating that it is not clear whether another Green Revolution is possible in an ecologically sustainable way.

"There are other ways to tackle the issue," says Woertz. "For example, reducing food waste or meat consumption. A plant-based diet is much less resource intensive than a meat-based one and about two thirds of global arable land is used for meat production, either as rangeland or to produce feedstock like corn and soybeans.

"Currently the world produces one-and-a-half times more food than is needed and it produces a lot of rubbish food that should not be consumed for health reasons. Let's be a bit less alarmist. Seventy per cent of global land is used for producing meat. If less meat were consumed, a more plant-based diet would go a long way in producing more with less. Food waste is also a huge issue. Reducing it would limit the need for production increases."

There are two competing visions of how a new Green Revolution could, or should, happen. One is high-tech, with a heavy emphasis on continuing Borlaug's work of breeding better crops, but with modern genetic techniques. The other, as Moukayed states, prefers a farming system that is much more mindful of the landscape and ecological resources.

At the heart of the former is genetic modification. That is, the modification of organisms in order to continually increase crop yields in an increasingly challenging climate. We know them primarily as genetically modified (GM) crops. Crops that are resistant to diseases, can survive in harsher climates, or produce more for the buck in the same vein as Borlaug's high yielding wheat.

There's flood-tolerant rice, water efficient maize, and cassava plants that resist the brown streak virus. The latter is especially important for farmers in Africa, where cassava is a staple for 250 million people, although the majority of African countries have banned GM crops.

In the US, around 90 per cent of the soybeans, cotton, canola, corn and sugar beets sold have been genetically engineered. Indeed, the US, Brazil and India are the world's largest growers of GM crops. But are they the answer?

"There is no indication at this stage that GMOs [genetically modified organisms] would be able

to prompt similar productivity gains as the Green Revolution did," says Woertz. "Like the Green Revolution, GMOs have ecological downsides. Much of the research by private corporations focuses on a few crops (mainly corn, soybeans and cotton) and a few traits, most notably resilience to pesticides that are sold by the same companies and have an environmental impact.

"So GMOs are not the silver bullet. If they are used there would need to be more publicly funded research that focuses on orphan crops (e.g. cassava) and traits that are currently under researched (e.g. drought resistance)."

Public concern over GM crops is a significant barrier, with media attention frequently focusing on potential health risks. However, a 2016 report from the National Academies of Sciences, Engineering and Medicine suggests there is scientific consensus that GM foods are safe.

"Biotechnology and genetically modified foods have indeed helped us around the world to increase crop yield, improve quality (from nutrient content to variety of taste), and have reduced costs for some crops and products made from them," says Moukayed. "Moreover, biotechnology has allowed us to produce crops in locations that have climate and weather challenges and areas where water might be scarce, and have allowed for the production of crops that are more resilient and resistant to pests.

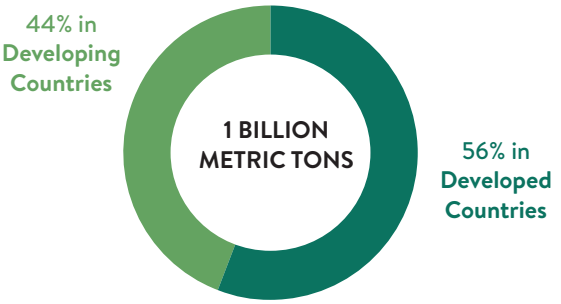
"Studies by several researchers in the field, meta-analysis of publications on GMOs and independent commissions from the World Health Organisation, the Food and Agriculture Organisation and the Food and Drug Administration in the US have identified the GMOs currently on the market are safe for consumption. There is a clear codex guide on the labelling of GMOs and their safety and risk assessment. The general public concerns are somewhat not based on science but lack of knowledge and I think therefore consumer education is important in the steps forward that we take."

Both Woertz and Moukayed believe that an alternative Green Revolution is needed, with humanity not only requiring increases in the production of crops, but the tapering of consumer behaviour and consumption. The unequal distribution of food availability, with some populations suffering from obesity epidemics and others from malnutrition, also needs to be tackled head on.

"There needs to be cooperation between all stakeholders," says Moukayed. "This is a global issue that needs public/private partnerships. We need to educate consumers about eating behaviours and food choices. We need to diversify options for food production, and start thinking innovatively in considering technologies and practices that will enable sustainable food production. Definitely, we need to have a reduction in developed populations' consumption, just as we need to educate people about the impact of their choices. Everyone needs to be mindful of the environment and savvy enough to know that our current choices eventually affect health and viability of future populations."

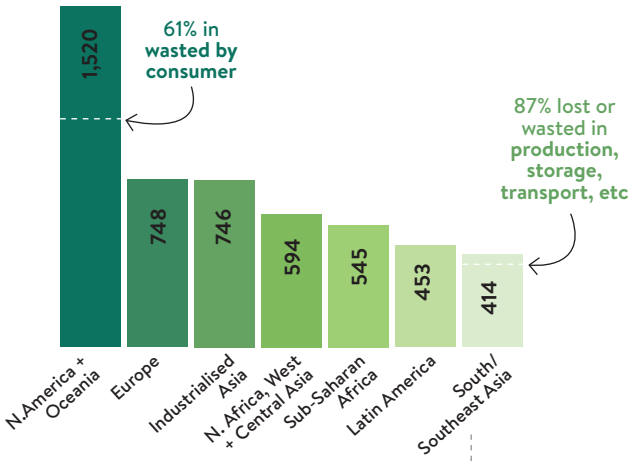
1/4 TO 1/3 OF ALL FOOD PRODUCED FOR HUMAN CONSUMPTION IS LOST OR WASTED

Source: FAO and World Resources Institute



THOSE LOST CALORIES COULD FILL HUNGER GAPS IN THE DEVELOPING WORLD

Calories **Lost or Wasted** per person, per day
(out of a recommended 2,000)



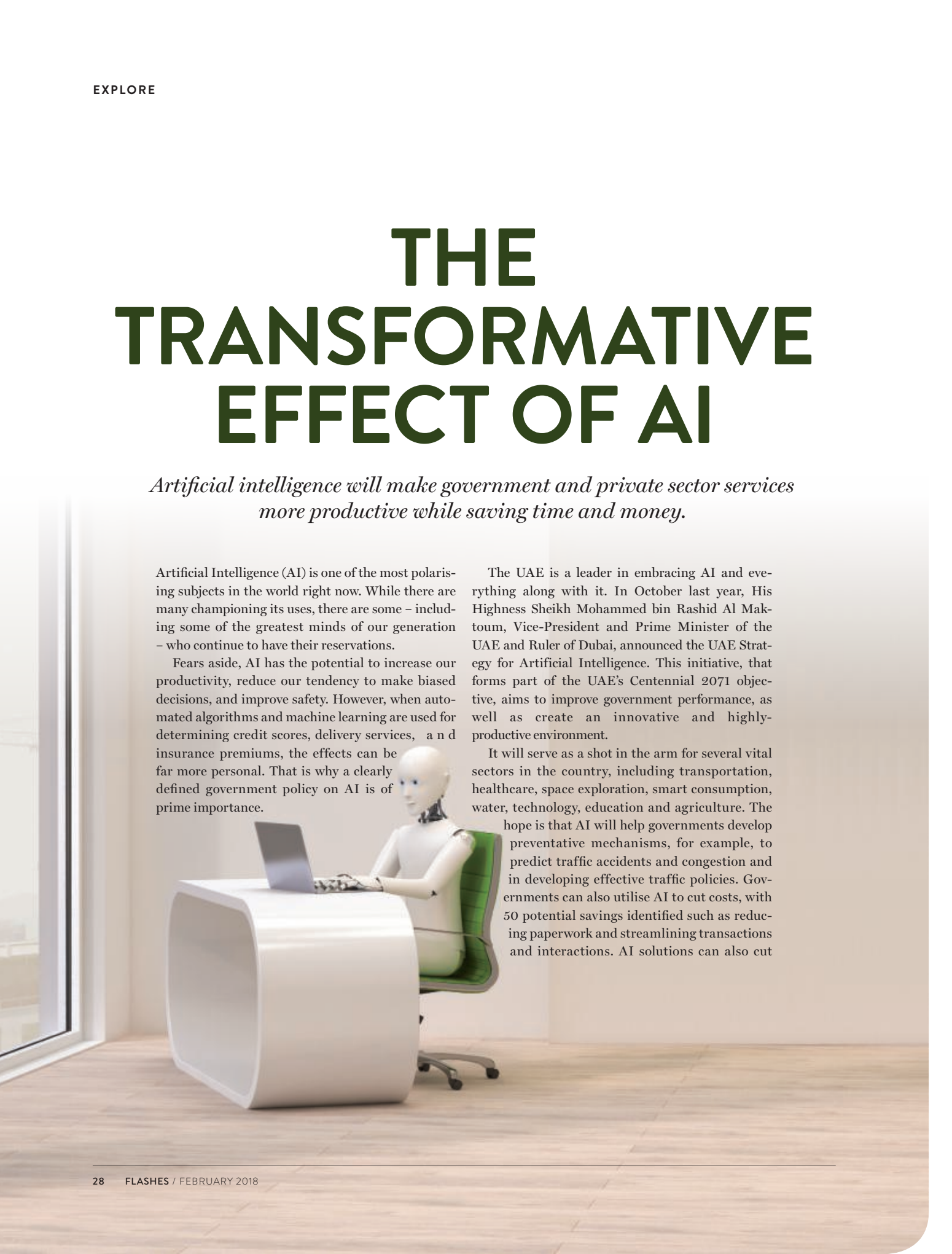
LEFT: Around 88 million tonnes of food are wasted annually in the EU, with associated costs estimated at €143 billion.

THE TRANSFORMATIVE EFFECT OF AI

Artificial intelligence will make government and private sector services more productive while saving time and money.

Artificial Intelligence (AI) is one of the most polarising subjects in the world right now. While there are many championing its uses, there are some – including some of the greatest minds of our generation – who continue to have their reservations.

Fears aside, AI has the potential to increase our productivity, reduce our tendency to make biased decisions, and improve safety. However, when automated algorithms and machine learning are used for determining credit scores, delivery services, and insurance premiums, the effects can be far more personal. That is why a clearly defined government policy on AI is of prime importance.



The UAE is a leader in embracing AI and everything along with it. In October last year, His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice-President and Prime Minister of the UAE and Ruler of Dubai, announced the UAE Strategy for Artificial Intelligence. This initiative, that forms part of the UAE's Centennial 2071 objective, aims to improve government performance, as well as create an innovative and highly-productive environment.

It will serve as a shot in the arm for several vital sectors in the country, including transportation, healthcare, space exploration, smart consumption, water, technology, education and agriculture. The hope is that AI will help governments develop preventative mechanisms, for example, to predict traffic accidents and congestion and in developing effective traffic policies. Governments can also utilise AI to cut costs, with 50 potential savings identified such as reducing paperwork and streamlining transactions and interactions. AI solutions can also cut

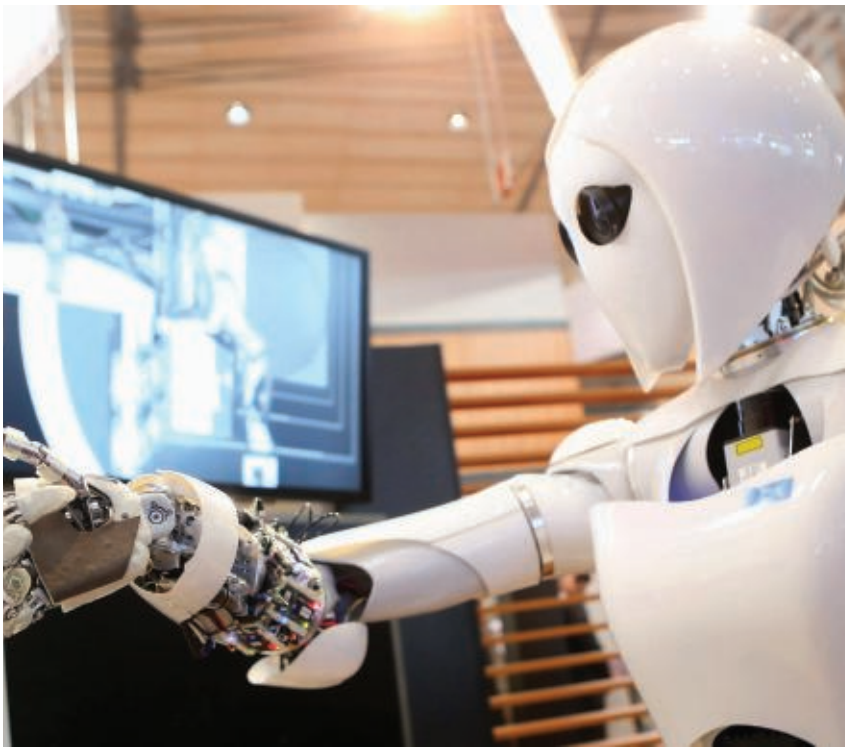
down transportation and logistics costs and make a significant contribution to GDP.

About six months before the UAE made all those announcements, a Deloitte Consulting LLP report on AI-augmented government shed light on the fact that the cognitive technologies behind artificial intelligence are already having a real impact on many people's lives and work in the United States. The analysis further found that millions of working hours each year (out of some 4.3 billion worked total) could be freed up today by automating tasks that computers already routinely do. They concluded that at the low end of the spectrum automation could save 96.7 million federal hours annually, with a potential savings of $3.3 billion; at the high end, this rises to 1.2 billion hours and potential annual saving of $41.1 billion

In the UK, a digital health company invested close to $60 million on an AI chatbot that communicates with clients via their smartphones and helps diagnose illnesses. In a 2016 study by Frost & Sullivan, the market for AI in healthcare is projected to reach $6.6 billion by 2021, a 40 per cent growth rate. The report goes on to say that clinical support from AI will strengthen medical imaging diagnosis processes and using AI solutions for hospital workflows will enhance care delivery. Frost & Sullivan also reports that AI has the potential to improve outcomes by 30 to 40 per cent while cutting the costs of treatment by as much as 50 per cent.

In the finance industry, AI financial advisors are expected to replace human advisors. The automated financial service providers consider key metrics including the client's risk appetite, financial goals, and current economic standing. According to a study by Cerulli Associates featured in a report on CNBC, robo-advisors currently account for around $60 billion in assets under management. That figure is expected to rise to $385 billion by 2021. Those though are cautious estimates – other studies expect robo-advisors to handle $2 trillion, maybe more, in assets by 2020. AI is also expected to revolutionise the insurance industry by taking away the need for claim agents. It's already begun, with companies like Progressive offering discounts if you agree to put a little monitoring device in your car that lets them know whether or not you're a safe driver.

The UAE's AI strategy consists of five interrelated core axes that serve as stages of development, research, preparation and progressive application of AI technologies in various government efforts in the country. It will focus on how AI can support employees in the public and private sectors and allow them to channel their energy into creative work. It will also develop a legal framework ensuring the safest standards for the human and machine working relationship.



Above: Artificial intelligence is expanding its reach into every sector of society, with huge impacts on government, civil society and businesses.

His Highness Sheikh Mohammed bin Rashid Al Maktoum didn't stop there. Just three days after he launched the UAE Strategy for Artificial Intelligence, he sent out a tweet announcing to the world the appointment of a new minister within the UAE government: the Minister for Artificial Intelligence. In doing so, the UAE became the first nation with a government minister dedicated to AI. The title was bestowed upon 27-year-old Omar Bin Sultan Al Olama who was one of six newly-appointed ministers – three of whom were women – as part of a cabinet reshuffle.

The UAE isn't alone in its investments in AI. According to forecasts, global spending on AI – and by association, the Fourth Industrial Revolution – will continue to see significant investment from corporates over the next few years. Estimates currently stand at a conservative compound annual growth rate (CAGR) of 54.4 per cent through 2020 when revenues will be more than $46 billion. According to market intelligence firm Tractica, consumer products, business services, advertising, finance and investment, media and entertainment, and defence applications will lead to its adoption, but AI technologies will transform almost every industry sector. Moreover, Tractica forecasts that annual worldwide AI revenue will grow from $643.7 million in 2016 to $36.8 billion by 2025.

In other words, AI is not only a sensible but also a necessary investment for the future of the UAE.

EDUCATION FOR ALL

Wendy Kopp, a winner of the Mohammed bin Rashid Al Maktoum Knowledge Award 2017, is focused on improving education around the world.

Sometimes, a simple idea mixed with faith in human nature can have a positive impact on hundreds of thousands of lives. Such is Wendy Kopp's case, founder of Teach For America and CEO and co-founder of Teach For All, which has expanded education opportunities across the world.

In November, Kopp was in Dubai to attend the Knowledge Summit 2017, organised by the Mohammed bin Rashid Al Maktoum Knowledge Foundation, as one of the three winners of the Mohammed bin Rashid Al Maktoum Knowledge Award 2017. Saudi Arabia's MiSK Foundation and renowned Japanese scientist Hiroshi Komiyama were the other two winners of this prestigious award that seeks to honour those who have made significant contributions to the regional and international knowledge industry.

There is no discussion that Kopp fits the profile of the Mohammed bin Rashid Al Maktoum Knowledge Award. In person she is energetic, enthusiastic and reflects a quiet self-belief that enabled her to get Teach For All, a US-based national teaching corps, off the ground. The organisation's motto is to "enlist, develop, and mobilize as many as possible of our nation's most promising future leaders to grow and strengthen the movement for educational equity and excellence".

So how did Kopp embark on her journey into education? "I had organised a conference alongside some other students at Princeton about improving our education system, and there were some incredible student leaders there. They said we had no idea about the need for teachers in urban and rural areas. So I had this thought of why aren't we channelling these people's energy into teaching? When I started at Princeton we were labelled the 'me generation', but I didn't believe that."

Kopp "became obsessed" with the idea that a movement could be built among the rising generation of young leaders to channel their skills into teaching at urban and rural public schools. "I thought how different would it be in our country if we had many of the most promising future leaders, instead of working on Wall Street for two years right out of college, teaching for two years in areas where they were needed?"

Above: Wendy Kopp receiving the Knowledge Award 2017 from His Highness Sheikh Hamdan bin Rashid Al Maktoum, the Crown Prince of Dubai.

Above right: Teach For All is active in 46 countries.

After researching other models such as the Peace Corps, Kopp decided to make her fledgling idea for Teach For America the subject of her 1989 thesis. As she dug deeper into the subject she realised she would need $2.5 million in funding and recruit 500 core members to get her idea of the ground. A year after handing in her thesis, Kopp had raised the money and was both delighted and shocked to have received 2,500 applications. According to Kopp this was clear proof that the 'me generation' concept was not exactly accurate.

How did Kopp manage to convince the CEOs of Fortune 500 companies to supply the funding? This question extracts a wry smile from her. "One, I just had a deep conviction in the idea that I was pursuing. Two, I really believe there's a huge power in inexperience. You just don't know what's impossible, and therefore think, 'Of course this can be done!'"

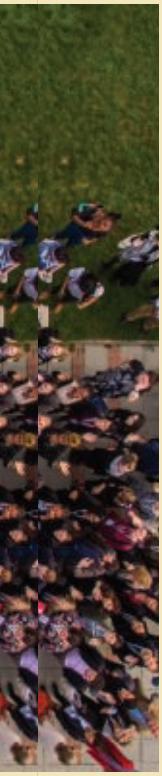
As it turned out, she was right. The successful 1990 launch of Teach For America attracted national attention, and donations poured in. In the following years, the number of areas served by the organisation expanded rapidly from the inaugural six to 53 across the US in 2016. Currently, Teach For America has 46,500 alumni, 6,900 corps members and taught in excess of 400,000 students.

In 2007, Kopp co-founded Teach For All, a global network of independent social enterprises with the ambitious aim of eliminating educational inequity around the world. According to her, global education issues are similar to the ones seen in America.

"All over we see that kids' socio-economic background predicts their educational outcomes, which have an impact on life outcomes," explains Kopp. "It's a deeply systemic problem, which exists for many reasons and to which there is no one single solution. At Teach For All, just as with Teach For America, we believe that the only thing that is fundamental to any solution is to channel the energy of our best possible human resources."

As such, the founding of Teach For All was a natural progression from the work and achievements of Teach For America. Every member organisation is locally led and funded, often through social entrepreneurs, with the mission to identifying and recruiting future leaders to first spend two years teaching in schools and areas that need them most. Standards are high, as typically only one in four applicants is accepted.

"We started Teach For All after we started meeting people from India, Chile, Lebanon and other countries who were determined to launch the Teach For America model of teaching in their own countries and were looking for help," says Kopp. "These were local social entrepreneurs who had the vision of ending educational inequities in their home countries, but needed support with regard to how to achieve their vision."



According to Kopp on a country-to-country level there are many cultural and systemic differences, yet many of the solutions are similar and shareable.

"We have learnt that the factors that make remarkable teachers are similar across countries," explains Kopp. "The challenges of developing partnerships with government agencies are also similar across countries. This fuelled our optimism that we can actually help create a network of like-minded organisations that can share and learn, and accelerate the needed changes to address the education inequities around the world."

Today, Teach For All is a network of 46 independent, locally led and governed partner organisations with the shared aim of developing collective leadership in classrooms and communities around the world. The organisation's 25-year vision is that by 2040 communities around the world will enable all of their children to have the education, support, and opportunity needed to shape a better future for themselves and the rest of the world.

Teach For All celebrated its 10th anniversary last year, so it is only fitting to ask Kopp about the organisation's main achievements.

"I think the most important thing is that between 60 and 70 per cent of the teachers across our network commit to long-term careers in education," reflects Kopp. "As a result, thousands of our teachers are inspiring students to take ownership of their education and grow their academic abilities, character strength and self-advocacy skills – opening the door to greater opportunity. Programme alumni often go on to lead the charge for educational equity in their countries, becoming veteran teachers, principals, policy makers and civic leaders."

According to Kopp the influence of alumni is of particular importance as one of the key lessons she's learned from being part of Teach For All's global network is that to truly tackle educational inequity requires many more people developing solutions across all sectors and levels.

"It doesn't start in classrooms or schools, but long before children arrive at school," she explains. "To solve this problem requires developing collective leadership – leadership across the whole ecosystem around our children and working together to effect the comprehensive changes we need to see."

This, Kopp says, is also the mainstay of Teach For All's vision for the future.

"We picture a world where Teach For All partners in virtually every country are channelling talented and committed leaders towards expanding educational opportunity. We envision these leaders innovating and spreading new solutions in their countries and sharing them across borders, thus fuelling an ever-accelerating global movement for educational excellence and equity."

This was also the principle that Kopp highlighted when she received the Mohammed bin Rashid Al Maktoum Knowledge Award 2017.

"We're grateful for this recognition from the Mohammed bin Rashid Al Maktoum Knowledge Foundation and hope this award will help raise awareness of the Teach For All network's work in disseminating knowledge of successful ideas and practices across borders to ensure all children are able to fulfil their potential."

Above: Between 60 to 70% of Teach For All's teachers commit to long-term careers in education.

The UAE is set to become one of the world's first countries to implement 5G networks.

Ever since the invention of the wheel, humans have been obsessed with going faster. One place where speed is particularly welcome is in the field of technology. Every new piece of technology boasts being smarter and faster than its predecessor. That also holds true for cellphone networks.

We're currently in the fourth generation of network technology. If you pick up your smartphone right now, on the top corner, you'll find the words 4G or 4G LTE. That's essentially the seal of approval that ensures that your phone is running on the best wireless network available in the world today. 4G was introduced to the UAE in 2011 after an AED6 billion investment in LTE and fibre-optic networks.

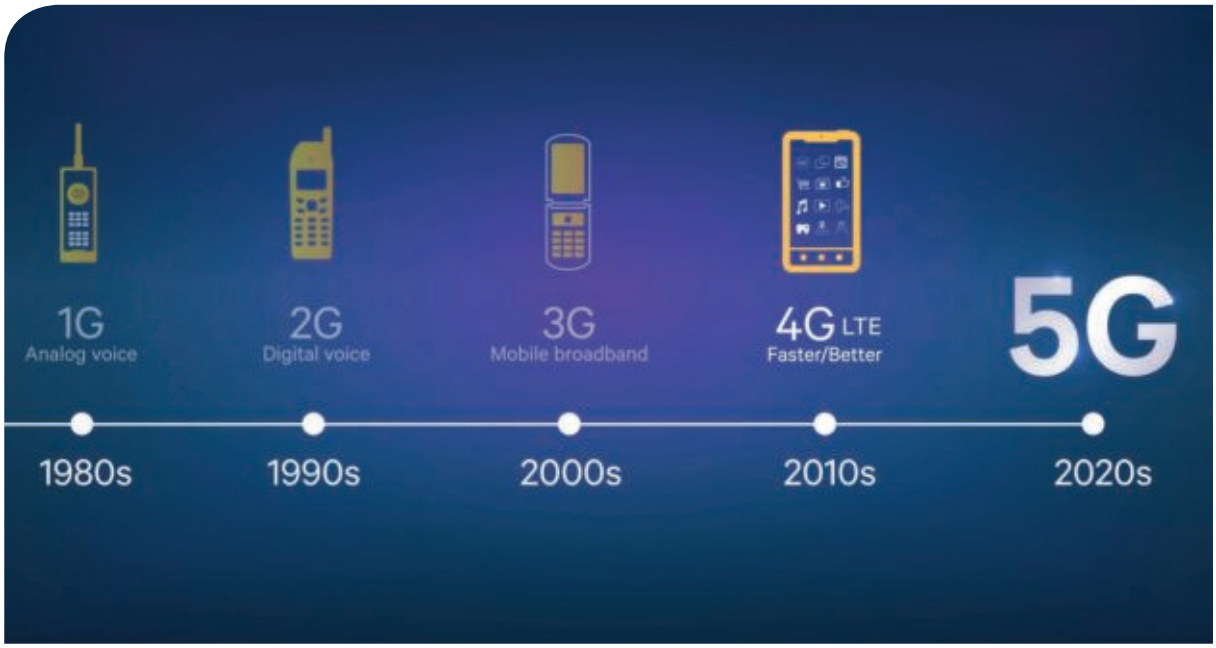
Now, the leading technology companies and minds in the world want to give you the future: 5G. The talk for the need for 5G and its implementation started in January last year at the Mobile World Congress in Barcelona, Spain but picked up steam and turned into a unanimous chant this year at the Consumer Electronics Show in Las Vegas.

Wireless technology started with 1G in the early 1990s and expanded to 2G when companies first started enabling people to send text messages

THE NEED FOR 5G

between two cellular devices. Eventually, the world moved to 3G, which gave people the ability to make phone calls, send text messages, and browse the internet. The fourth generation of wireless technology didn't reinvent the wheel as much as it perfected it. People could browse the web, send text messages, make phone calls and even download and upload large video files without any issues. Then – only a few years ago – came 4G Long Term Evolution (LTE). LTE simply perfected everything the fourth generation of technology built on and today is the industry standard of wireless technology. LTE helped 4G get faster and, in turn, helped in the creation and sustainability of streaming services. To put it in simple terms, your Netflix subscription wouldn't work if it wasn't for 4G LTE.

Never one to fall behind on the technology trends sweeping the world, the UAE jumped onto the 5G wagon early. In October last year – in the lead up to 5G deployment in the UAE by 2020 – telecom provider Etisalat announced its fastest 5G live trial reaching 71Gbps, setting a global record in the industry. Building on that success, by December, the country's Telecommunications Regulatory Authority (TRA)



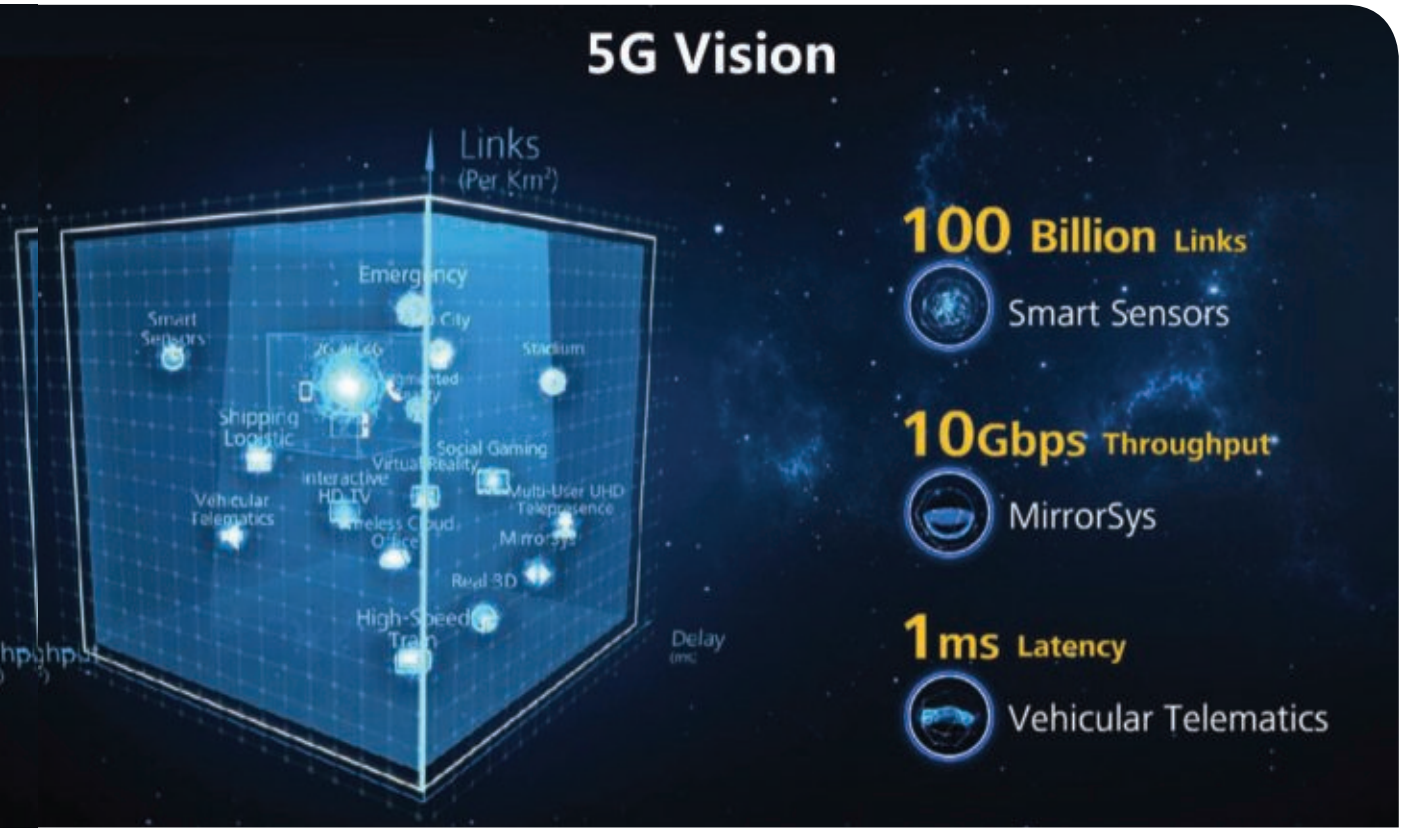
Above: The buzz at this year's Consumer Electronics Show in Las Vegas was about the implementation of 5G.

announced the launch of 5G technology, with mobile operators in the country expected to start deploying 5G networks from early 2018.

At the time, Etisalat led the 5G charge by confirming that it would be rolling out 5G technology, but du said it would only commence advanced field trials of the technology in the first quarter of 2018. However, Etisalat did note that no mobile device currently available on the market supports 5G and that it will be up to phone manufacturers to come up with updates or new devices to support the 5G technology.

With that announcement, the UAE is set to become one of the first countries to get 5G networks. Being the early bird in that race matters. Countries around the world are racing to reap the economic and civic rewards of being the first to deploy the service. The USA learned about the drawbacks of not leading the pack the hard way. After missing the memo and trailing its European counterparts in the roll-out of third-generation mobile services, the US was first to deploy the next generation 4G. That leadership paid dividends. Today, with only five per cent of the world's population, the US makes up 15 per cent of global 4G connections. Its companies run the operating systems on nine out of 10 smartphones worldwide and its wireless services generate $400 billion in annual economic activity. In short, its economy benefitted immensely. Being one of the leaders won't be a cakewalk though.

The fifth generation of wireless technology won't simply build and perfect everything that was a result of the fourth generation. In some ways, it'll be exactly what you're expecting: faster speeds than 4G that will give users the power to download 4K movie content in a matter of seconds. Problem is, that's easier said than done. Typically, when a new mobile wireless technology such as 5G comes along, it's assigned a higher radio frequency. New wireless technologies use higher frequencies as those frequencies typically aren't in use and move information at a much faster speed. Therein lies the catch. While higher frequencies increase speeds and reduce latency issues of the previous wireless generation, they can't travel as far as lower frequencies. Obstacles such as walls become a problem, which is why multiple input and output



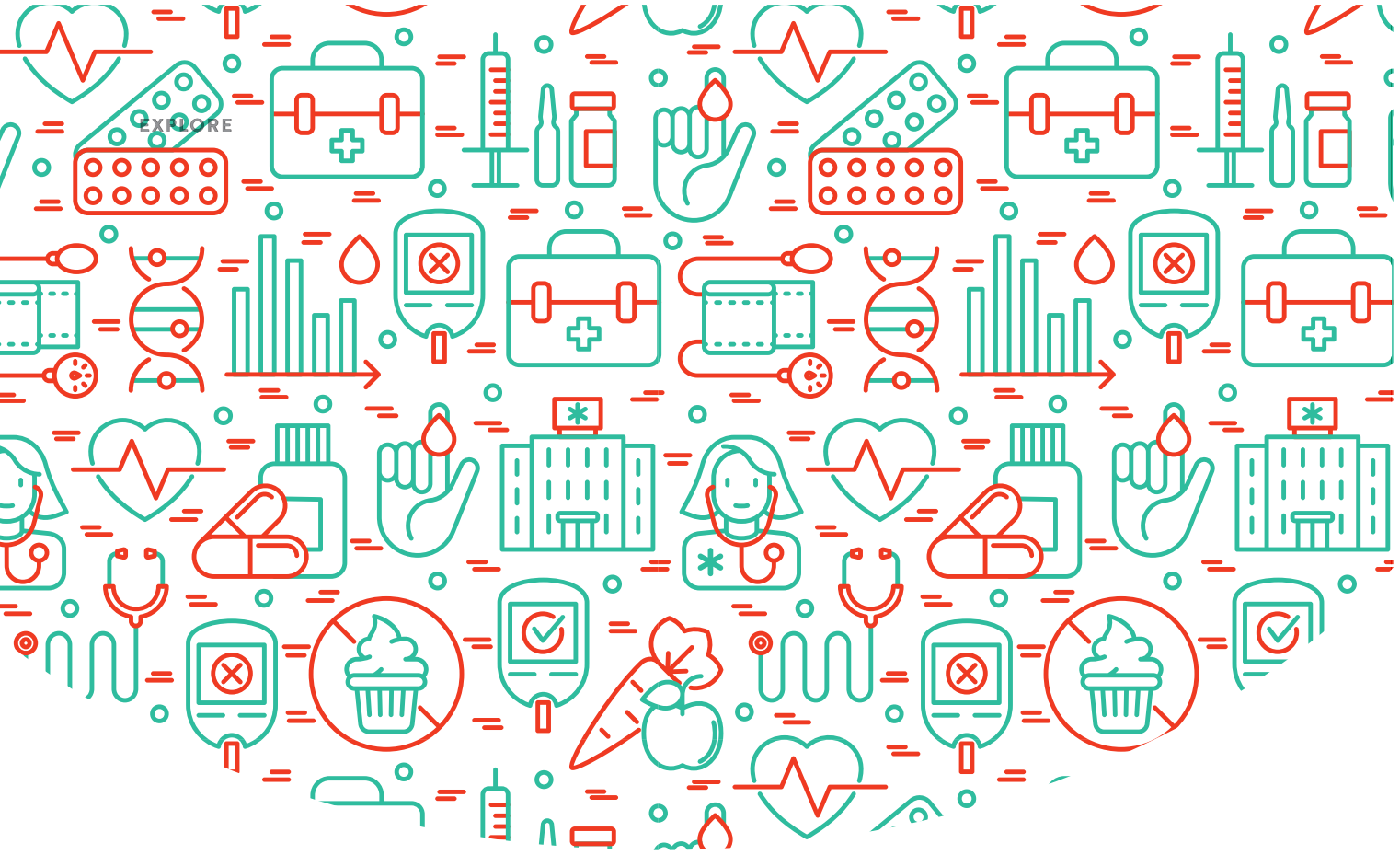
antennas (MIMOs) will probably be used to boost signals anywhere 5G is offered. Basically, you'll see mini antennas everywhere. Then there's the problem of implementation.

The number of connected mobile devices in the world surpassed the number of human beings back in 2014. Getting all those devices and users onto the 5G standard won't be an easy task. Despite the official worldwide 5G standards being approved in December 2017, there is still a lot of work to be done on behalf of cities, device manufacturers, and the carriers themselves.

Despite the loopholes, 5G is a must. It will drive the evolution of the internet itself. Experts believe it could mark the birth of a smart network. Since it's designed for a world in which tens of billions of gadgets depend on constant connectivity, 5G networks will be engineered to adapt to the needs of each individual device. For example, if you're streaming 4K video to a big-screen TV, it may prioritize sheer data throughput, but if it's serving as the connection between a controller and a drone, it may prioritize a quick response.

In the smartphone universe, 5G will supposedly fix many of the problems with 4G and existing wireless technologies. It'll be designed to support many more concurrent users and devices, serving them all at higher speeds than 4G. The days of your data speeds slowing down because you're at a crowded event are numbered. It will also be the bridge we need to finally delve into Virtual and Augmented reality, which opens up a whole host of new possibilities that have yet to even be imagined.

Above: : UAE telecom provider Etisalat reached a 5G speed of 71Gbps, which is a global record.



THE FUTURE OF DIABETES TREATMENT

Diabetes is also among the top 10 leading causes of death worldwide. Although the statistics are grim, medical breakthroughs are showing there's hope on the horizon.

With one in 12 people globally suffering from diabetes, the disease is finally being recognised as an epidemic with the potential to cause a worldwide healthcare crisis. A 1997 World Health Organisation report stated that 299 million people would be affected by diabetes by 2025. But current estimates suggest that over 400 million already have diabetes.

The Middle East is not immune. According to the World Health Organisation diabetes rates in the region have reached a record high of about 43 million cases, accounting for almost 14 per cent of its adults. Governments and healthcare providers are well aware of this problem. Back in 2009, the UAE government declared an "Anti-Diabetes Year," which involved rolling out a ten-year plan to fight the disease including increased diabetes research, public awareness campaigns, and updated medical facilities.

Yet on the global scale the disease is growing faster than predicted leaving healthcare specialists worried.

Life for a diabetic is a constant balancing act – keeping track of their carbohydrate intake, continual blood-sugar level checks and punctilious insulin injections. Managing diabetes is a grueling, never-ending cycle to stay healthy. But now advances in engineering are offering diabetic patients disease-management solutions that could help make life easier.

AUTOMATING CARE

In 2016, the US Food and Drug Administration (FDA) approved the use of artificial pancreases for patients over the age of 14. The device is designed to automatically monitor and inject insulin into patients. The technology was hailed as a breakthrough for patients with Type 1 diabetes. Prior to this, patients with Type 1 diabetes had to manually monitor their blood sugar levels and then administer insulin. The artificial pancreas combines the two procedures into a 'closed-loop system'. A glucose monitor is placed along with an insulin pump under the patient's skin. Once fitted, the system automatically controls glucose levels.

Artificial pancreases have demonstrated great accuracy in maintaining a patient's blood sugar levels. They also removed the need for constant monitoring. But the system did have a shortcoming – there would be a delay, sometimes of up to two hours, between the injection of insulin and it reaching a peak level in the blood stream. A research team at Harvard proffered a solution. They adopted a computative approach to the problem. Instead of trying to maintain the body's blood sugar at a specific level, they used a model-predictive control algorithm to keep the patient's glucose levels to within a broad range.

Last year, the Harvard team took the technology another step ahead. The artificial pancreas now connects to a patient's smartphone and keeps track of their activity cycles such as sleep, meal times, physical activity and metabolism. The system is able to predict any major glucose changes making the device more proactive than previous pancreas models.

AN ORAL SOLUTION

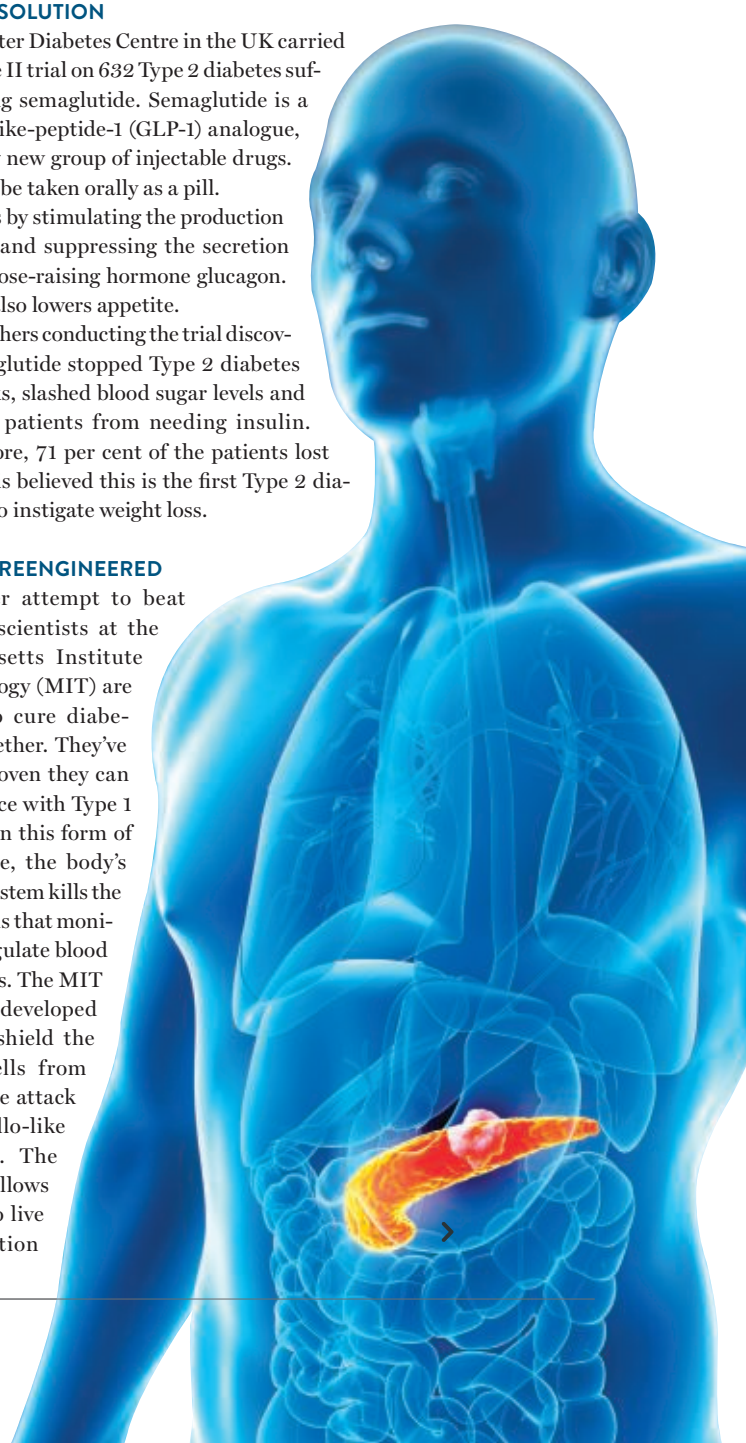
The Leicester Diabetes Centre in the UK carried out a phase II trial on 632 Type 2 diabetes sufferers using semaglutide. Semaglutide is a glucagon-like-peptide-1 (GLP-1) analogue, a relatively new group of injectable drugs. It can also be taken orally as a pill.

It works by stimulating the production of insulin and suppressing the secretion of the glucose-raising hormone glucagon. The drug also lowers appetite.

Researchers conducting the trial discovered semaglutide stopped Type 2 diabetes in its tracks, slashed blood sugar levels and prevented patients from needing insulin. Furthermore, 71 per cent of the patients lost weight. It is believed this is the first Type 2 diabetes pill to instigate weight loss.

BIOLOGY REENGINEERED

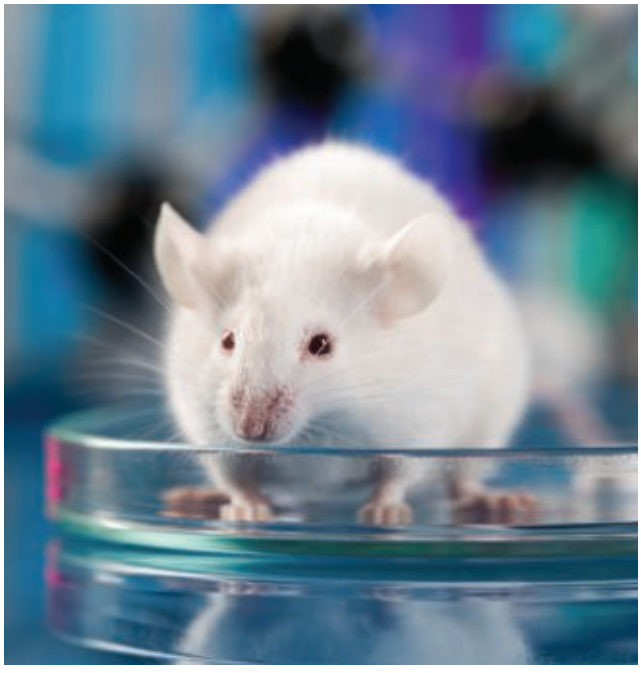
In another attempt to beat diabetes, scientists at the Massachusetts Institute of Technology (MIT) are seeking to cure diabetes all together. They've already proven they can do it in mice with Type 1 diabetes. In this form of the disease, the body's immune system kills the insulin cells that monitor and regulate blood sugar levels. The MIT team has developed a way to shield the insulin cells from an immune attack using a jello-like substance. The material allows the cells to live and function



Above: Diabetes necessitates continual monitoring of blood sugar levels.

normally but protects them from the immune system. The procedure has been successful in curing diabetes in mice for months. However, it is yet to be tested in human beings and it may be years before a human trial even takes place.

Scientists at the University of North Carolina and NC State have also demonstrated a technique to eliminate diabetes. They want to use artificial beta cells to mimic the behaviour of natural beta cells that secrete insulin. To do this, they produced artificial cells containing insulin-stuffed vesicles. The vesicless' coating is able to identify high glucose levels and subsequently release the load of insulin into the surrounding bloodstream. Again, the procedure has shown success in diabetic lab mice. Within an hour of the injection the mice displayed normal



blood glucose levels, which remained steady for up to five days following a single dose of the synthetic cells. The researchers are now seeking to test this in human subjects.

ENGINEERING STEM CELLS

Although scientists previously managed to produce insulin-producing cells from human stem cells, they lacked many of the functional characteristics of pancreatic beta cells. However, a new technique pioneered by Harvard scientists allowed the team to produce hundreds of millions of mature beta cells from stem cells. These are remarkably similar to adult beta cells in that they respond to glucose and secrete insulin in quantities comparable to normal functioning cells.

The Harvard researchers tested out the cells both in dishes and in mice and found that they responded appropriately to challenges with glucose. Furthermore, they relieved diabetic mice of hyperglycemia after transplantation. The transplanted mice have been monitored for several months now, and so far the cells have resisted immune attack and are still producing insulin. The Harvard team is currently continuing tests in both rodents and non-human primates, and they hope to move towards human trials within a few years.

It marks the culmination of 23-years of research for Harvard professor Doug Melton who has been trying to find a cure for the disease since his son Sam was diagnosed with Type 1 diabetes as a baby.

"We are now just one pre-clinical step away from the finish line," said Professor Melton.

A recent *Lancet* study found that diabetics are living longer than a quarter of a century ago, due to better drugs for both the disease and its complications. Whether it's with artificial organs, cell treatments or chemical engineering, the battle against diabetes is gaining pace and it is just a matter of time before human intelligence conquers the disease.

Above: Advanced algorithms now allow artificial pancreases to function more effectively.

Above left: The national health agenda goal is to reduce the prevalence of diabetes from 19.3 per cent in 2015 to 16.28 per cent by 2021 in line with the UAE 2021 Vision.

Left: Harvard scientists have successfully engineered human stem cells that have relieved diabetic mice of hyperglycemia.

CONNECTING PEOPLE FROM SPACE

The race to launch satellites that will provide internet services is gathering momentum this year.

In 2015, Farooq Khan, head of Samsung Research America, published a paper titled *Mobile Internet from the Heavens* in which he described a vision of "Internet services available to everyone in the world via low-cost micro-satellites." He outlined the idea of using a cluster of about 4,000-odd small low earth orbit (LEO) satellites to provide high-speed internet all over the planet.

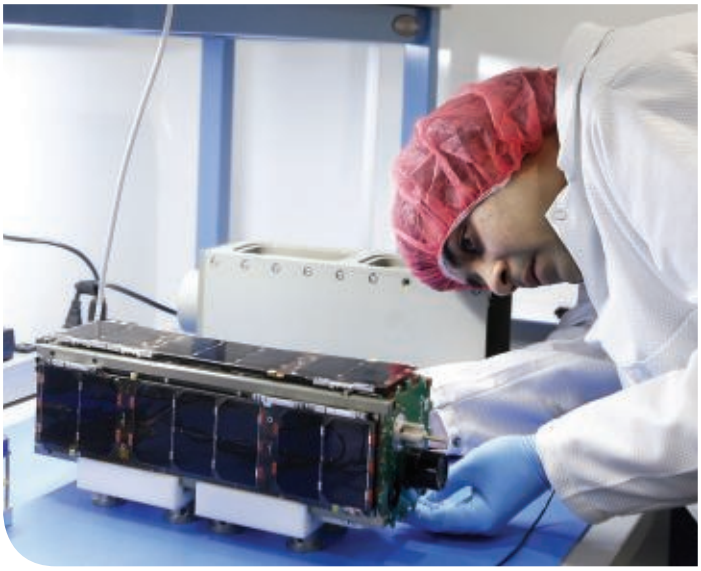
Satellite internet is in no way a new phenomenon, the idea has been around for years and it has at times been thought to be a pipe dream by many experts. Traditionally, satellite internet providers share one common problem: Latency. The time gap between a satellite receiving a request and responding to said request is not feasible in this age of instant gratification. The lag would be impractical for social media platforms such as Snapchat or telecommunication apps like BOTIM – the UAE's answer to Skype. Bringing a larger cluster of cheaper satellites closer to earth like Farooq Khan elucidates, could potentially cut latency from 500 milliseconds to 20 milliseconds.

While that sounds exciting, a mere 4,000 satellites aren't enough to cover the whole planet and adequately match the earth's rotation to ensure seamless internet experiences. That essentially means companies will have to launch a lot more satellites to make up for the variables. Khan's paper hinted that Samsung would be looking to make that kind of internet utopia a reality. Other ones in the race includes heavyweights such as Elon Musk's SpaceX, which is backed by Google, and a company called OneWeb, which is backed by The Virgin Group – whose founder is Richard Branson.

There are other, smaller companies in this race as well but, in all reality, they have a slim chance against the aforementioned big guns. SpaceX's advantage – aside from Elon Musk's deep pockets – is that it has its own rockets from which to launch the satellites. OneWeb – in spite of The Virgin Group's involvement – was initially considered a fledgling company. That changed with the company's deal with Jeff Bezos' Blue Origin. As if to prove that it shouldn't be taken lightly, OneWeb became the first company to receive FCC permission to actually build a next-generation satellite internet service that targets US customers.

Some experts believe that space internet technology is a farfetched dream. However, according to Forbes' 2017 list, Jeff Bezos is worth $72.8 billion, Musk is worth $13.9 billion and Branson is worth $5 billion. Men like those – smart and super rich – don't simply jump onto bandwagons. They kick-start revolutions. In fact, the richest and brightest among them, Bill Gates – worth $86 billion – was one of the first people in the world to get the space internet ball rolling. Back then Gates, along with Craig McCaw and Saudi Prince Alwaleed bin Talal, funded Teledesic. The company had hoped to launch an 840-satellite constellation but couldn't get the project off the ground and shut shop in 2002.

So why exactly do the rich care about this space internet marvel? Money. Obviously, that was the answer. All these guys are vying for the chance to sell high-speed satellite internet connections to the billions of people throughout the world who don't yet have access – and in the process become the largest global telecommunications company. SpaceX's eccentric CEO, Musk, is thinking further ahead than



Top and above: Constellations of smaller and cheaper satellites are being proposed by companies such as SpaceX and OneWeb to provide global internet services.

everyone else in the game though. Since this form of the internet is funnelled through space, he believes there's a good chance he could leverage this company to become the first internet provider for humans after they successfully colonise Mars.

The companies will, however, need to act fast. While the small satellites that SpaceX and OneWeb plan to use to create satellite constellations are far cheaper than they were back when Gates tried his hand at the task, these companies still need above 4,000 of them. The total cost will be anything but cheap. Add to that the fact that those companies are going after developing countries, everything from subscription costs to the satellite dishes must be cheap. Then there's the problem with wired internet connections and wireless mobile data plans reaching everyone in the world a lot faster than first anticipated. At last count, about 51 per cent of the world has access to the internet. As you can imagine, it's hard to convince people to pay for internet if they already have it, especially if they're set in their ways.

Another point to consider is that the United States of America obviously isn't alone in its quest to give internet access to the millions around the world. While companies in the United States take the limelight, smaller companies such as the Abu Dhabi-based satellite operator, Yahsat, is going about silently occupying smaller markets. A unit of Abu Dhabi strategic firm Mubadala Investment Company, Yahsat, launched its third satellite into orbit last month. The Al Yah 3 satellite expanded the company's coverage to 19 markets in Africa and also marked its entry into Brazil. The launch of Al Yah 3 means Yahsat's satellites, which include Al Yah 1 (2011) and Al Yah 2 (2012), cover 140 countries across the Middle East, Africa, Europe and central and south-east Asia while the company's broadband service, YahClick, covers 28 countries in Africa, central and south-west Asia and the Middle East.

And finally, there's the problem with space junk. To keep it simple, more satellites equals more collisions and more collisions equals more debris, which in turn equals more space junk. The space internet race is only going to fuel those fires. In 2018 alone, eight new constellations of internet satellites will begin deployment to LEO and Medium-Earth Orbit (MEO). And that's just the beginning, SpaceX plans to send up nearly 12,000 small internet-beaming satellites over time while OneWeb is plotting its numbers around the 700 mark. It is about to get crowded up there.

Above: Boeing plans to launch a 2,956 satellite constellation.

Left: The UAE's Al Yah 3 satellite extend's Yahsat's coverage to 140 countries.

THE PLAYERS

- SpaceX will be launching a prototype internet satellite this year, the first of a planned constellation of 4,425 satellites that will make up its Starlink Service.
- Samsung is deploying an internet satellite this year, the first in a plan to begin deploying 4,600 satellites to LEO by 2028.
- Boeing has also announced a launch. The aerospace giant has plans for a 2,956 satellite constellation that will provide enhanced broadband.
- Others companies that are getting in on the ground floor of the space-based internet trend include OneWeb, Telesat LEO, SES O3B, Iridium Next and LeoSat. Each of them has plans to send between a few dozen and a few hundred satellites to LEO to enhance global bandwidth, starting this year.
- In conjunction with Thales and Boeing, SES 03b plans to use its proposed constellation of 27 satellites to bridge the global digital divide.

FASHION VICTIM

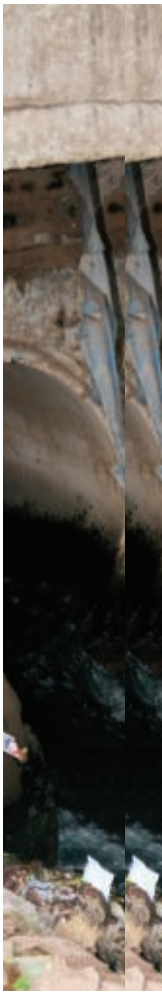
Keeping up with rapidly changing fashion trends isn't just monetarily draining, it's also damaging the planet.

"The clothing industry is the second largest polluter in the world ... second only to oil," said clothing magnate Eileen Fisher recently. Traditionally, pollution is associated with fossil fuels, industry, transport, agriculture and mining. With the majority of environmental awareness campaigns revolving around these industries, the fact that our clothes are damaging the planet is little known. Too what extent remains open to debate.

Although there is no doubt that the fashion carbon footprint is large, its actual extent is hard to determine. The business involves long and varied supply chains of production, raw material, textile manufacture, clothing construction, shipping, retail, use and ultimately disposal of the garment. Then pollutants such as pesticides used in the farming process, toxic dyes and the huge amounts of waste generated in both cloth production and its subsequent discard have to be taken into account along with the extravagant amount of natural resources used to get the garment from raw material to ramp. What is known is that the fashion industry globally generates $620 billion in revenue, which is about equal to the combined revenues of the top three global automotive manufacturers.

While the environmental outlook for the fashion industry is negative, it is being further compounded by 'fast fashion'. Fast fashion refers to the speed at which clothes are consumed and disposed of. The number of Fashion Weeks has risen to over 100 annually, without factoring in local events, haute couture and resort shows. Large fashion houses such as Zara, H&M and Forever21 release as many as 18 collections a year easily luring consumers into constantly renewing their wardrobes to match the latest runway trends. An overpowering consumer culture breeds the incessant craving for novelty, which fashion houses feed by offering continuous supply at affordable prices. To cater to the never-ending demand, production standards are lowered, compromising on sustainability standards.

The damage starts right from the raw material stage – not just bringing them together but their very production. Take for instance the production of cotton and leather. Forty per cent of all clothing includes cotton, which requires vast amounts of resources for cultivation. The production of a single shirt can require up to 2,700 litres of water. The environmental hazard of the cotton industry is already visible in ›



Top: Both natural and artificial fibres find their way into the earth's food chain.

Above: Most fast fashion is produced in developing countries, leading to long supply chains.

Uzbekistan. Its Aral Sea was once the fourth largest lake in the world and the main source of water for 1.47 million hectares of agricultural land used for cotton production. Now it is just a dried up pit of toxic material leaking carcinogens into the air, slowly killing the communities that live near it.

"Conventional cotton (as opposed to organic cotton) has to be one of the most unsustainable fibres in the world. Conventional cotton uses a huge amount of water and also huge amounts of pesticides which cause 350,000 farmer deaths a year [in Uzbekistan] and a million hospitalisation," says fashion designer Katharine Hamnett.

Fashion demands vibrancy and colour and production houses are dulling the planet for it. The chemical wastes produced from textile dyeing practices are the next biggest environmental pollutants of the fashion industry. Indonesia's Citarum River has suffered greatly due to the textile boom that took place there. Its waters are now contaminated with toxins such as mercury, lead and arsenic. The water remains untreated, thereby killing or damaging aquatic life as it flows into the ocean.

Almost every aspect of garment manufacture has an adverse environmental effect. Greenhouse gases released into the atmosphere during the production of polyester and nylon contribute to global warming 300 times more than carbon dioxide. The microfibers that come loose when these garments are washed end up in oceans and streams and are ingested by fish and other marine life. These make their way up the food chain to our own plates.

The damage to the earth continues even after the garment has been produced. It is mostly developing countries that serve as production centres for fashion houses due to cheaply available labour. The garments then have to be shipped from these countries to large markets. The shipping industry makes its own pollution contribution – it is estimated a single large ship can emit as much sulphur in one year as 50 million cars. Leading environmental news site, Ecowatch claims that the low-grade bunker fuel burned by ships is 1,000 times dirtier than highway diesel used in the trucking industry. However, there are still no measures in place in the shipping industry to account for the damage it causes to the atmosphere and oceans.

Brands such as Patagonia, Noah, Organic Threads, Symbology, and Krochet Kids Intl. are some of the businesses that practice ethical and sustainable business models, which include the use of organic or recycled raw materials and fair wages to labourers. Educating oneself on which shops offer quality items and choosing to invest in those instead of cheap, short-lived alternatives is a meaningful way not only to claim personal responsibility but also to combat the climate threat fast fashion is posing.

Above and left: Synthetic dyes, when released into rivers without water treatment, are toxic to the environment.

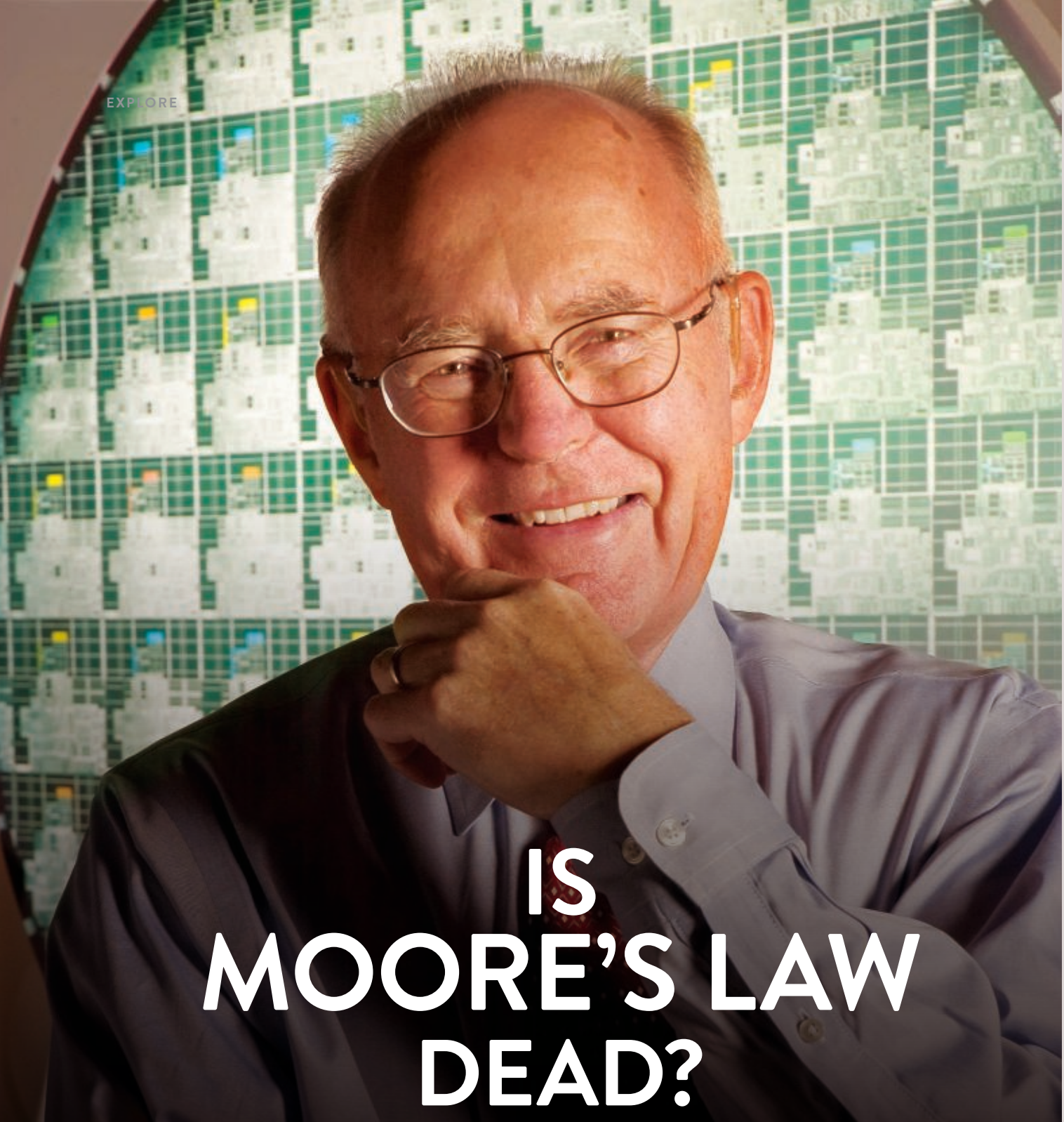
Textile waste is another consequence of fast fashion. People are buying more and more clothes but not keeping them as long as they used to. Rapidly expanding fast fashion retailers aggravate the problem on a global scale. Clothing has become more 'disposable'. Increasing disposable income levels, busy lifestyles and loss of mending and sewing skills have contributed to reducing the need to 'make do and mend'. It is easier and more convenient for people to buy new clothing than repair it.

CULTIVATING A SARTORIAL SENSE

The first step to mitigating the effects of fast fashion is to cultivate a more sustainable sartorial sense in the form of quantity, as well as quality of purchased clothing. In both movements, central power lies in the hand of the consumer. Buyers need to limit the quantity of clothing they buy as well as ensure to invest only in high-quality timeless items of clothing. The next step would be for fashion retailers to adopt greener production processes and business models.

DID YOU KNOW?

- Over two billion pairs of jeans are produced each year with a typical pair taking 7,000 litres of water to produce.
- Around 400 billion square metres of textiles are produced each year, of which 60 billion square metres will become factory waste. Only one fourth of this is likely to be recycled.



IS MOORE'S LAW DEAD?

A true pioneer of Silicon Valley, Gordon Moore predicted in 1965 that computing would dramatically increase in power, and decrease in relative cost, at an exponential pace. It has held true ever since but are the brakes finally coming on?

The American businessman Gordon Earle Moore has a beaming smile that lights up his eyes in an almost mischievous manner. The Co-founder and Chairman Emeritus of Intel Corporation has many good reasons to grin. Aside from an immense fortune, his net worth being $8.4 billion, he has the unusual pleasure of being constantly proved right about a prediction he made more than half a century ago.

In 1965, Moore was described as "One of the new breed of electronic engineers, schooled in the physical sciences rather than in electronics". In that same year, Moore wrote a now legendary article entitled *Cramming More Components Onto Integrated Circuits*. This insightful paper was the groundbreaking basis for Moore's Law – which is the observation that the number of transistors on integrated circuits will double every year.

Moore's Law isn't a fixed law of physics – the time period for the doubling of transistors has been revised a few times, from every year to every two years or 18 months – but Moore's Law was an incredibly prescient and well educated hunch that the chip and computer manufacturing industry has kept proving correct.

There are now claims that Moore's iconic prediction that computer processing power would double every year is finally slowing down. This has often occurred over the decades but somehow the electronics industry has always ended up corroborating it. Moore's insight has been like a golden rule and a precursor to boundless innovation.

In that 1965 *Cramming More Components*... article written for *Electronics* magazine, Moore wrote, "With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip." There were just 60 transistors on a chip when he wrote that. Today, our ubiquitous and ever-multiplying devices carry between one and two billion transistors on a single chip.

Moore also predicted the types of devices we would be using in that paper. "The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas. Integrated circuits will lead to such wonders as home computers – or at least terminals connected to a central computer – automatic controls for automobiles, and personal portable communications equipment."

In that one paragraph alone Moore outlines the arrival of personal computers, mobile phones and loosely, driver-less cars. The article also states, "The electronic wristwatch needs only a display to be feasible today... In telephone communications, integrated circuits in digital filters will separate channels on multiplex equipment. They will also switch telephone circuits and perform data processing," thereby adding big data, iPads and smartwatches to his list. Moore co-founded Intel three years later in 1968 and paved the way for the arrival of smaller, faster, cheaper transistors.

The integrated circuit, or chips, that Moore mentions were the path to cheaper electronics. Transistors are the tiny switches that control the flow of an electrical current on an integrated circuit. As the number of transistors doubled and the cost halved, the exponential growth brought about the massive advances in computing that permeates modern life in such an all-encompassing way.

The transistors essentially give our devices computing power and determine how many operations your computer, tablet or phone can perform. That's the technology behind the videos on your screens to the more complex calculations carried out in the workplace.

Moore, who is from San Francisco, California, and turned 89 in January, is still witnessing the lasting impact and benefits of his work and the company he helped to establish. The economic impact is seen everywhere as processing power and energy efficiency increases and access to life-changing electronic devices is spread around the world. Almost all levels of society can access mobile phones today and whole new industries have been forged through cheap and powerful computing.

The technological impact of Moore's observation has transformed computing from an expensive venture only accessible to elites, into an affordable luxury, if not necessity. 'What did we do before mobile phones?' is a fairly common ›

Above: Greg Yeric, Director of Future Silicon for ARM Research, believes time may be running out for Moore's law.

Below: Moore's lawn continues today, but the technological challenges are mounting.

refrain we hear these days. The societal impact has fundamentally changed how people work, and on a vast scale the nature of entertainment and communication. Without the force of change predicted by Moore's Law and the pioneering developments in modern cities, transportation, healthcare, education, and energy production, it's hard to imagine what modern life would be like.

Intel does concede however, that it is getting more difficult to roll out smaller transistors at an affordable cost in that two-year time frame that has held true for over 50 years. Greg Yeric, the Director of Future Silicon Technology for ARM Research, said in an interview for *Engineering and Technology* magazine last year, "I don't think anyone could confidently tell you that they have a plan for 15 more years of Moore's law."

Yeric's focus is on analysing future technology trends, including Design-Technology Co-Optimization with industrial and academic partners, as well as technology incubation and predicting effects on future ARM products. Based in Cambridge, UK, ARM is the world's leading semiconductor intellectual property supplier and the technology the company designs is used in a colossal number of electronic products. In one year ARM's customers delivered 15 billion processors.

"I do think we are approaching the limits of conventional scaling with silicon," Yeric says, adding, "the 'end of Moore's Law' is more of a 'tailing off of the historic Moore's Law curve'. How far off of the 50 per cent transistor cost every two years do we go until it is 'the end'?"

MOORE'S LAW IS NOT AT ALL DEAD...

INTEL PROCESS TECHNOLOGY CAPABILITIES

High Volume Manufacturing	2004	2006	2008	2010	2012	2014	2016	2018
Feature Size	90nm	65nm	45nm	32nm	22nm	16nm	11nm	8nm
Integration Capacity) (Billions of Transistors)	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**

Transistor for 90Nm process
Source Intel

Influenza Virus
Source: CDC

In basic terms a processor is comprised of a silicon wafer capped with a photoresist layer. The challenge facing processor manufacturers is the miniaturisation of crucial light patterns that are applied to the photoresist layer. Essentially, the most advanced processors available today use a 10 nanometre (nm) process to form the circuit pattern, but the beam of light used to create processors has been around 190nm since the mid 90s. Making 10nm processors with lasers that are almost twenty times thicker is becoming a prohibitive process. At the same time, the global demand for the latest in computing technology rages on, driving traditional fabrication plants to their limits.

Yeric says bluntly, "This is not a sustainable paradigm." He believes a new technology called extreme ultraviolet lithography (EUV) will be the next innovation to sustain development, as this technology can produce light as thin as 13nm in width. The pace may be slow and steady though, as EUV is profoundly intricate.

"Making this 13nm light is one of the most complicated engineering feats of modern technology," Yeric states. "I'm talking about everything including space exploration. The technology for EUV is mind-bogglingly complex."

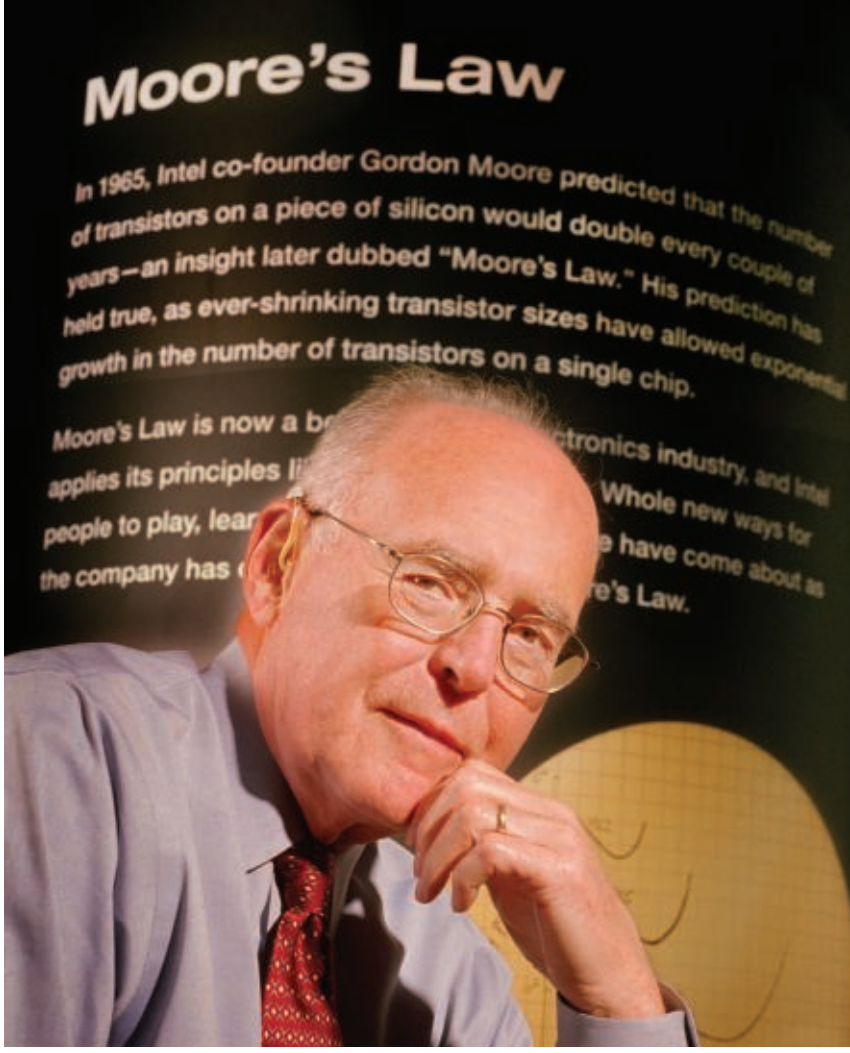
Returning back to the subject of Moore's Law, Yeric says, "There is no shortage of new approaches in the design realm that could realise more performance… it's just that past progress in Moore's law has been achieved by implementing the easy ones. Now we are faced with more difficult choices."

To power the next generation of electronics the possibilities include quantum computing and neuromorphic computing – which are essentially computer chips modelled after human brains, capable of learning and remembering at rapid pace.

These computing components emulate connections among neurons in the brain, mimicking the way calcium ions behave at a human synapse. The world's first self-learning neuromorphic chip has so far been shown to have the capability of self-learning and demonstrated the ability to compose music.

In a short film by Silicon Valley company ASML, Moore, aged 86, says about his eponymous law, "Rather than becoming something that chronicled the progress of the industry, Moore's Law became something that drove the industry. A tremendous amount of engineering and commitment has been required to make that happen, but the industry has been able to keep up with the projection." With a warm smile Moore adds, "I'm amazed at the things we can make now."

There have been a variety of potential barriers over the years that looked set to finally halt Moore's Law, but the engineering and technology always got around them. Moore says, "There have been predictions for the end of Moore's Law for the last 30 years I think."



Above: Gordon Moore, a Co-founder of Intel, made his famous prediction known as Moore's law in an article he wrote in 1965.

In a televised interview with the *New York Times* journalist Thomas L. Friedman in May 2015, Moore responded to the question of whether he was surprised by how long he has been proved basically correct, saying, "Oh, I'm amazed. The original prediction was to look at 10 years, which I thought was a stretch. This was going from about 60 elements on an integrated circuit to 60,000 — a thousand-fold extrapolation over 10 years. I thought that was pretty wild. The fact that something similar is going on for 50 years is truly amazing. You know, there were all kinds of barriers we could always see that [were] going to prevent taking the next step, and somehow or other, as we got closer, the engineers had figured out ways around these. But someday it has to stop. No exponential like this goes on forever."

It may not last forever but it remains fascinating to observe for how long this Silicon Valley pioneer's prediction holds true.

Moore's Law and related innovations have merged computing with our daily lives to the point where technology is ever-present. An interconnected future is inevitable, and although privacy and security are serious and persistent concerns, there is hope in the promise of the benefits of technology.

FROM ALCHEMY TO CHEMISTRY

Arab and Muslim scientists played a major role in the history of chemistry by creating the earliest know forms of scientific experimentation.

"Logic must be learned from the ancient masters, regardless of the fact that they were not Muslims," is a famous quote attributed to Ibn Rushd, often referred to by his Latinized name of Averroes. Ibn Rushd was a medieval Andalusian polymath who wrote on logic, Aristotelian and Islamic philosophy, Islamic theology, physics, medicine and mathematics to name just a few.

Ibn Rushd was just one of the many enlightened thinkers that characterised the Golden Age of Islam from the 8th to the 13th century. During this period, artists, engineers, scholars, poets, philosophers, geographers and traders in the Islamic world contributed to numerous fields such as economics, law, literature, astronomy, philosophy, and technology, both by preserving earlier traditions and by adding inventions and innovations of their own. Also at that time the Muslim world became a major intellectual centre for science, medicine and education.

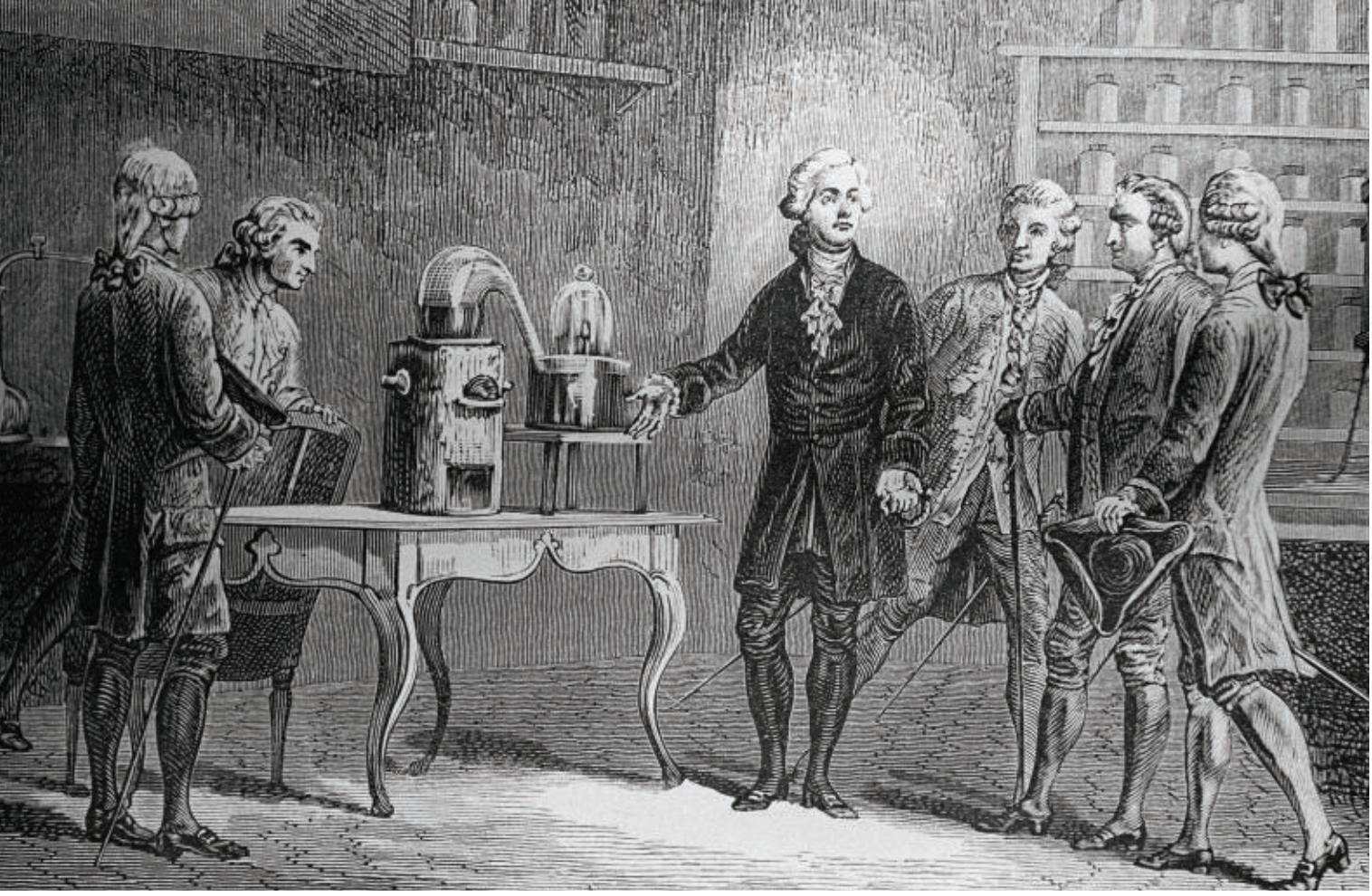
Islamic scientific achievements encompassed a wide range of subject areas, especially astronomy, mathematics, and medicine. Other subjects of scientific inquiry included alchemy and chemistry, botany, geography and cartography, ophthalmology, pharmacology, physics, and zoology.

THE CONTRIBUTION OF ISLAMIC SCIENTISTS TO CHEMISTRY

The history of chemistry is not without controversy, with the contribution of Islamic scientists often receiving scant attention or being ignored. Yet it is indisputable that they made a significant contribution to the field. Islamic scientists ensured that knowledge from Greece, Egypt, India, and further afield was preserved for the later European scholars and underpinned the development of the proto-scientific approach to alchemy that would be adopted by the Renaissance scholars.

The Islamic alchemists were the first to quantify and classify compounds and elements, to study the reactions between substances, and began the process of dividing organic and inorganic chemistry.

What is the difference between alchemy and chemistry? Chemistry, simply defined, is the branch of science concerned with the substances of which matter is composed, the investigation of their properties and reactions, and the use of such reactions to form new substances.



Above: Antoine-Laurent de Lavoisier, a French nobleman and chemist, is widely considered in popular literature as the "father of modern chemistry". However, Maslama Al-Majriti is regarded as the first to prove the principle of conservation of mass.

The precursor of chemistry, alchemy, was unsuccessful in explaining the nature of matter and its transformations. However, by performing experiments and recording the results, alchemists set the stage for modern chemistry. The distinction began to emerge when Robert Boyle made a clear differentiation between chemistry and alchemy in his work *The Sceptical Chymist* (1661). While both alchemy and chemistry are concerned with matter and its transformations, chemists are seen as applying scientific method to their work while alchemists took a more mythical approach. According to most modern interpretations, chemistry as a science dates back from around the 17th and 18th centuries. Compared to today's standards, chemistry would not be practiced in a scientific way before then.

The defining characteristic of modern chemistry is experimentation according to the scientific method. The ancient Greeks championed speculation and metaphysical analysis about chemical processes, and it is this approach that informed early Muslim scientists. However, Muslim scientists soon realised the shortcomings of the Greek heritage in the field of chemistry and introduced the vital concept of experimentation. The three Islamic scientists who stand out in this field are, in chronological order, Abu Musā Jābir Ibn Hayyān (722-815CE), Muhammad ibn Zakariyya al-Razi (854-925CE), and the Spanish Muslim court scientist Maslama al-Majriti (950-1007CE).

ABU MUSĀ JĀBIR IBN HAYYĀN

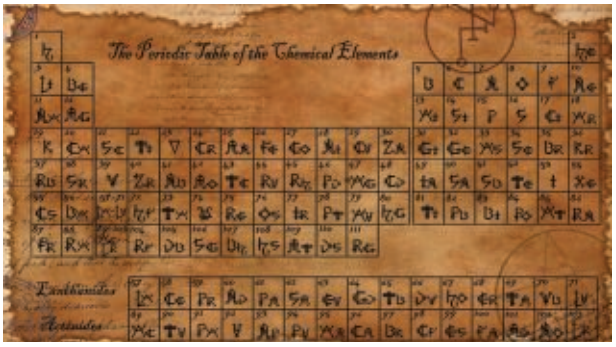
Abu Musā Jābir Ibn Hayyān, who is also known by his Latinized name Gerber, is without doubt one of the greatest Muslim scientists and has been described as the father of early chemistry. He emphasised the importance of experimenting by writing: "The most essential in alchemy is that you should perform practical work and conduct experiments, for he who performs not practical work nor makes experiments will never attain the least degree of mastery."

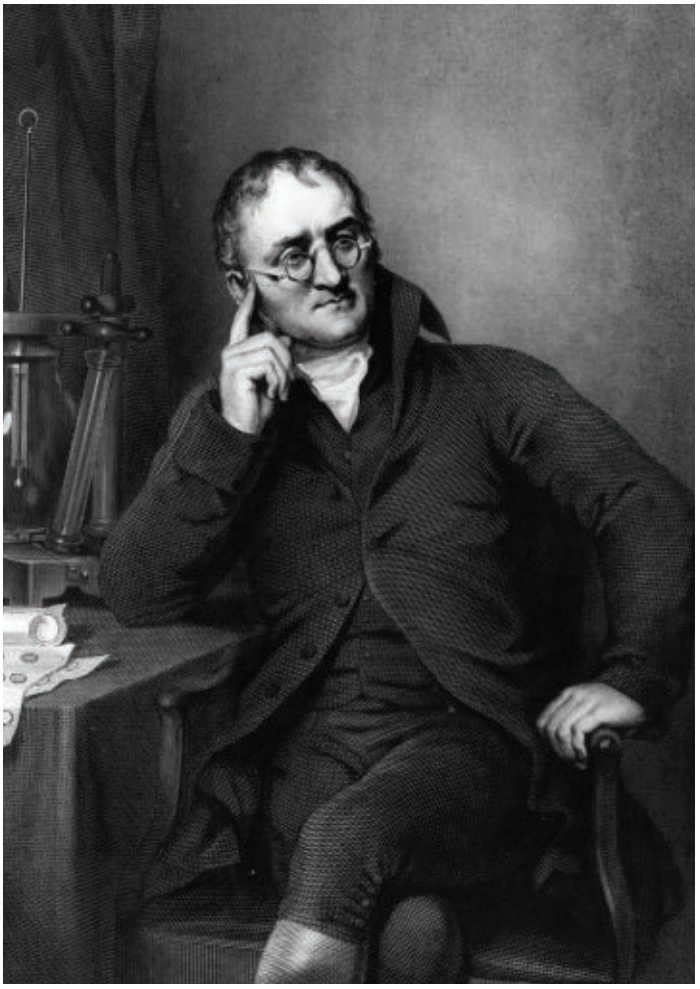
Ibn Hayyān set up a three-step process that still underlies chemistry today. The first is that the chemist has to set an assumption through his observations so as to explain the phenomenon he wants to explain.

The second is to deduce conclusions based theoretically on his assumptions.

The third is to to take these conclusions back to nature and see whether it will support his new findings or not. If they proved to be true, the hypothesis changes into a scientific law that can be relied upon in detecting how nature will react under certain circumstances.

Ibn Hayyān conducted numerous laboratory experiments, some of which were already known before his time and some of which were new experiments. Among the methods that he used were evaporation, distillation, crystallisation, sublimation, filtration, melting, condensation, and dissolution. He studied the properties of some





elements accurately and thus discovered the complex silver ammonium ion.

Ibn Hayyān's attention to precision led him to create scales that could weigh with an accuracy of 1/6 of a gram. In order to perform his experiments accurately, he designed different kinds of new vessels such as the retort. His experiments with various chemical processes allowed him to trigger reactions like reduction (a reaction that involves the gaining of electrons), calcination (oxidation through heating, e.g. the burning of chalk) and perhaps the most important: distillation. The traditional image of his 'alchemist's workplace looked a lot like a chemistry laboratory does today.

He is credited with identifying and producing many new substances. These include alkalines, acids, salts, paints and greases. He prepared sulphuric acid, nitro-hydrochloric acid (used to dissolve some metals), caustic soda and a multitude of salts such as sulphates, nitrates, and potassium and sodium carbonates. Ibn Hayyān's work with metals and salts subsequently helped develop foundry techniques and glazing processes for tiles and other ceramics.

These discoveries are of great significance to modern chemistry, and an essential part of the chemical industry.

The preceding work would already be enough to elevate Ibn Hayyān to the canon of the world's greatest scientific minds. However, he is credited with two other great contributions. Ten centuries before John Dalton (a British physicist and chemist who became known through his atom and molecule theory), Ibn Hayyān created the image of chemical bonds as a link between elements, in fact small particles invisible to the naked eye.

Last but not least: Ibn Hayyān also laid the groundwork for what is known today as Mendeleev's periodic table of elements. Ibn Hayyān's classification of elements into metals and non-metals laid the foundation for chemical naming systems today. He divided substances into three categories: 'spirits' that turn to vapour when heated; 'metals', such as iron,

Clockwise from top: Jābir Ibn Hayyān identified the need for experimentation and came up with the first theory of atomic bonds; John Dalton is credited with proposing atomic theory; Islamic scholars were the first to lay the groundwork for today's periodic table of elements.

Above: Islamic scientists designed a lot of the equipment that is still found in modern laboratories.

copper, silver, gold, zinc, mercury, and lead; and 'stones' or minerals that can be pounded into powdery form and used in many chemical reactions.

MUHAMMAD IBN ZAKARIYYA AL-RAZI

Al-Razi was a Persian polymath whose interests covered fields as diverse as music, medicine, chemistry, philosophy, logic and astronomy. Razi is primarily known for his contribution to medicine, but he is also an important figure in the history of chemistry.

One of the defining characteristics of Razi is that he was a pure rationalist, who only believed in experimentation and concrete evidence. Razi eliminated the symbolic, occult aspects that plagued alchemy, and thereby created the firm foundations of modern chemistry. He, most of all, set up the laboratory in the modern sense, designing, describing and using more than 20 instruments. He developed apparatus such as mortars, flasks, spatulas and phials, which were used in pharmacies until the early twentieth century. He also discovered several chemicals including alcohol and kerosene.

In his work *Secret of Secrets,* he made an influential contribution to chemistry through his classification of all the chemical substances he knew. This is the first written record of such an attempt at classification. Razi divided these substances into four main groups: vegetable, animal, derivative, and mineral.

He went further in the cataloguing and description of his experiments, describing first the materials he used, then the apparatus and methods, and the conditions of his experiments. This is another prerequisite of the scientific method, describing experiments in such detail that they can be replicated by other scientists. In the *Secret of Secrets,* he describes in great detail the chemical processes which he performed, and that have their modern equivalent in the form of distillation, calcination and crystallisation.

MASLAMA AL-MAJRITI

The last Muslim scientist with a major contribution to alchemy is Maslama al-Majriti, another gifted polymath who worked at the court of Islamic Spain. He was particularly noted for his work *Rutbat Al-Hakim (The Rank of the Wise),* which amongst other things gives formulae and instructions for purification of precious metals. It was collected and put together in the year 1009, two years after his death. In this work, Al-Majriti also wrote about inferences from his experiment on mercury that proves that he was alert to the almost non-existent change in the weight of the mass after the reaction. As such, he is regarded as the first to prove the principle of conservation of mass, credited eight centuries later to Antoine Lavoisier. Ironically, Lavoisier is regarded as the father of modern chemistry.

A LASTING LEAGACY

"Science in the early Muslim period is largely forgotten today in the Western world, or relegated to pseudoscience," Benjamin Huddle, Ph.D., declared in a report presented at the 238th National Meeting of the American Chemical Society. "We are rediscovering the fact that from 750 to 1258 CE the best science in the world was being done by Arabic-speaking peoples."

In his book *The Civilisation of Islam*, author Jean Mathe summarises the achievements of Muslim alchemists. They discovered alcohol, nitric and sulphuric acids, silver nitrate and potassium. They also determined the weight of many bodies and mastered the technique of sublimation, crystallization and distillation. Muslim chemistry also took many industrial uses, including tinctures and their applications in tanning and textiles; distillation of plants and flowers, the making of perfumes and therapeutic pharmacy.

In *Makers of Chemistry* Eric John Holmyard, a famous historian and chemist, traces the evolution of chemistry from the very beginning until modern times. In this work he states that Islamic alchemy is in fact a base for modern chemistry.

The Nobel Prize in Chemistry has been awarded 109 times to 178 Nobel Laureates between 1901 and 2017. Frederick Sanger is the only Nobel Laureate who has been awarded the Nobel Prize in Chemistry twice, in 1958 and 1980.

If there had been the equivalent of a Nobel Prize in Chemistry in Ibn Hayyān and Al-Razi's time, these gifted scientists might also have been two-time winners.

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