Science, Technology and Innovation Under Ever Changing Global Events

Conference Proceedings

Adnan Badran
Najwa Daghestani
Editors

Published by
Islamic World Academy of Sciences
Amman - Jordan

بسم الله الرحمن الرحيم

SCIENCE, TECHNOLOGY AND INNOVATION UNDER EVER CHANGING GLOBAL EVENTS

Proceedings of the 23rd IAS Science Conference on
Science, Technology and Innovation Under Ever Changing Global Events

Organized in Rabat - Morocco
18-19 October 2022

Edited by

ADNAN BADRAN
NAJWA DAGHESTANI

Published by

ISLAMIC WORLD ACADEMY OF SCIENCES (IAS)
AMMAN, JORDAN.

Conference sponsored by

Kingdom of Morocco

Hassan II Academy of Science and Technology
Rabat, Morocco

The Higher Council for Science and Technology (HCST)
Amman, Jordan

Kuwait Foundation for the Advancement of Sciences (KFAS)
Kuwait, State of Kuwait

OIC Standing Ministerial Committee on Scientific and Technological Co-operation (COMSTECH)
Islamabad, Pakistan

First published in 2023 by
Islamic World Academy of Sciences (IAS)
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Amman 11183 – Jordan.

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Type-setting at the Secretariat of the Islamic World Academy of Sciences, Amman, Jordan.

Jordan National Library Classification Deposit Number: 2023/11/6176
Descriptors: /Technology//Innovations/World Events/

ISBN 978-9957-412-31-9 (ردمك)

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Najwa F. Daghestani is currently the Programs Manager at the Islamic World Academy of Sciences (IAS). She earned her Master of Business Administration (MBA) from the German Jordanian University, Jordan, and her BSc in Computer Science from Princess Sumayya University, Jordan.

She works on organizing conferences and workshops, editing proceedings, newsletters and various papers and documents and acts as a liaison with international and national organizations and institutions.

She previously worked at the Royal Scientific Society as an Applications Programmer.

ISBN 978-9957-412-31-9

PREFACE

The Organization of Islamic Co-operation (OIC) was founded in 1969 as an organization grouping Islamic countries. In 1981, the heads of state of the OIC decided to establish a number of specialized organs to enhance co-operation between the OIC-Member countries in the fields of culture, trade and science and technology. The science and technology role was assigned to the Islamabad-based COMSTECH; the Ministerial Standing Committee on Scientific and Technological Co-operation. In 1984, the heads of state of the OIC approved the launch of the Islamic World Academy of Sciences (IAS) as an independent autonomous S&T Think Tank of the OIC to be based in Amman, Jordan. Of the issues that the IAS has been concerned with since its launch has been bridging the divide that has historically existed between the science community and the decision-making community in OIC-Member countries. Moreover, as an advocate for science, the IAS has always viewed science and technology – including the history of science – as an enterprise that can contribute to bridging divides between cultures and civilizations and has established itself as an active and vibrant player in the domain of science and technology promoting the values of science across the Islamic world. It executes its mission through programs that emphasize knowledge sharing, networking and capacity building, while also sustaining stakeholder engagement. In this respect, the Academy advocates the scientific community's points of view in all facets of developmental processes. Its contribution is communicated to decision-making bodies at OIC, national or international levels. Among its many objectives, the IAS strives to fulfill its mission through many activities and initiatives such as conferences, webinars and workshops.

Under the High patronage of His Majesty King Mohammed VI, King of Morocco the IAS convened its 23rd international scientific Conference in Rabat, Morocco during 18-19 October 2022 in collaboration with Hassan II Academy for Science and Technology, Rabat, Morocco. The title of the conference was *Science, Technology and Innovation Under Ever Changing Global Events.*

The conference was held at the headquarters of the Academy of the Kingdom of Morocco and was attended by Fellows of the Islamic World Academy of Sciences, as well as world-renowned lecturers and experts.

This publication includes the majority of the papers that were presented at the conference that aimed to address several topics, including new diagnostic approaches to cancer treatment, bionanotechnologies used in agriculture, and water resource management. The participants in this two-day conference also discussed education

issues after the Corona pandemic, energy security, the vaccine industry in OIC countries and the role of antioxidants in promoting health.

Around 90 participants attended the conference including IAS Fellows, invited speakers, academics, decision-makers, scientists, researchers as well as presidents/representatives of academies of sciences from different countries in the world.

Adnan Badran
Najwa F. Daghestani

ACKNOWLEDGMENTS

The Islamic World Academy of Sciences (IAS) is grateful to His Majesty King Mohammed VI, King of Morocco for his high patronage and support of the conference.

We thank Hassan II Academy of Science and Technology, Rabat, Morocco for hosting the conference and for their grand hospitality, organization, and attention to all the details.

We would also like to thank all the organizations that have sponsored the conference including The Higher Council for Science and Technology (HCST), Amman, Jordan; Kuwait Foundation for the Advancement of Sciences (KFAS), Kuwait and the OIC Standing Ministerial Committee on Scientific and Technological Co-operation (COMSTECH), Islamabad, Pakistan.

The dedicated staff of the IAS in Amman including Ms. Taghreed Saqer, all deserve our thanks and appreciation.

Adnan Badran
Najwa Daghestani

SPONSORS OF THE IAS 2022 CONFERENCE

Islamic World Academy of Sciences (IAS)
Amman - Jordan
www.iasworld.org

The nascent idea of establishing the Islamic World Academy of Sciences (IAS) first appeared in the plan of action developed by the OIC Standing Committee for Scientific and Technological Cooperation (COMSTECH). Upon the invitation of Jordan, the Founding Conference of the Academy was held in Amman (Jordan) in October 1986. IAS came into being as an independent, non-political, non-governmental and non-profit organization of distinguished scientists dedicated to the promotion of all aspects of science and technology in the Islamic world.

The IAS seeks to act as functional platform for improving, facilitating and nurturing interaction, collaboration, networking and enhancing knowledge sharing in a bet to address pressing challenges facing socio-economic development in OIC member states.

The IAS aspires to avail its capacity and capability to serve as Islamic Brain Think Tank and to respond effectively and timely to current and futuristic needs for advancing and promoting developmental goals and objectives to realize aspirations of the Ummah.

Main objectives of the Academy are:
1. Enabling inter-Islamic world connections among scientists and academies to advance STI.
2. Acting as legitimate, scientifically-based voice for the cause of STI on behalf of scientists in the Islamic World.
3. Promoting the development of ecosystem that nurtures science and values education and research as a vehicle for socioeconomic transformation in the Islamic World.
4. Providing science-informed advice and recommendations through its various activities to local, regional and international levels.

Kingdom of Morocco

Hassan II Academy of Science and Technology
Rabat – Morocco
www.academiesciences.ma

According to the wishes of His Majesty the King Hassan II, blessed be his soul, the Hassan-II Academy of Science and Technology is a place of high thinking, where men and women whose talent, enlightenment and wisdom have earned them a prominent standing within the international scientific community work to foster moral serenity in society and to achieve the material prosperity of the nation as well as its intellectual advancement by pondering on how to provide mankind with enlightenment and guidance in its effort to usher in a new era. The Academy Hassan II of Science and technology was founded by His Majesty the King, Mohammed VI, on May 18th, 2006.The fact that mastering sciences is nowadays an essential complement to national sovereignty, the Academy lies within a strong conviction that: **I)** creativity and innovation in science and technology have a significant impact on social and economic developments in modern nations; **II)** the scientific research policies have to be reshaped and attuned to human needs, and their technical applications have to be kept within overriding ethical boundaries. Placed under the guardian protection of His Majesty the King Mohammed VI, the Hassan-II Academy of Science and Technology has the mission of promoting and developing the scientific and technical research, contributing at setting the general orientations for the scientific and technological development, making pertinent recommendations regarding the national priorities in terms of research, evaluating the research programs and ensuring their grants and contributing at integrating the Moroccan scientific and technical research activities within the national and international socio-economical environments. The academy is composed of 90 members. 30 of them are national members holding resident status, 30 are foreigners' scientists and are qualified as associates and 30 corresponding members composed by both national and foreigner scientific personalities.

The Academy's motto is "***To serve the country and contribute to the advancement of universal science***" which is extracted from the inaugural speech of the installation of the Academy on May 18th, 2006, by His Majesty the King, Mohammed VI Tutor of the Academy.

The Higher Council for Science and Technology (HCST)
Amman – Jordan
www.hcst.gov.jo

The Higher Council for Science and Technology was established in 1987 as a public independent institution and acts as a national umbrella for all science & technology (S&T) activities in Jordan.

The objective of the Higher Council is to build a national science and technology base to contribute to the achievement of development goals, through increasing awareness of the significance of scientific research and development, granting the necessary funding and directing scientific and research activities, within national priorities, in line with development orientations.

The Higher Council was also entrusted with the establishment of specialized centers for R&D activities, the support of innovation and entrepreneurship to contribute to commercialize scientific and technological ideas into products and businesses, the conclusion of agreements relating to cooperation with Arab, regional and international parties, the representation of the Kingdom in scientific and technological activities, at the Arab, regional and international levels.

The Higher Council is chaired by HRH Prince El Hassan Bin Talal, who has been instrumental to the progress of science and technology in Jordan from the beginning.

Kuwait Foundation for the Advancement of Sciences (KFAS)
Kuwait - State of Kuwait
www.kfas.org

The Kuwait Foundation for the Advancement of Sciences (KFAS), a private non-profit organization, continues on its 40-year journey to harness science, technology and innovation in Kuwait, as well as to promote modernization, a better quality of life and a sustainable future for the Kuwaiti people. In line with the long-term vision of the late Amir Sheikh Jaber Al Ahmad Al Jaber Al Sabah and supported by leaders in the private sector, an Amiri Decree was issued in 1976 for the establishment of the Foundation, with a focus on advancing and integrating science, technology and innovation (STI) throughout the country.

The Foundation's efforts toward fostering STI to address national challenges first began through the pledge made by the private sector shareholding companies to fund the Foundation based on a set percentage of their annual profits — currently at one percent — as well as through the incorporation of a unique governance modality, in which the Board of Directors is chaired and appointed by the Amir of the State of Kuwait. Today, KFAS's impact is prominently embedded within the country's scientific and technological accomplishments and advancements.

OIC Standing Ministerial Committee on Scientific and Technological Co-operation (COMSTECH)
Islamabad - Pakistan
www.comstech.org.pk

COMSTECH the Ministerial Standing Committee on Scientific and Technological Cooperation of the OIC (Organization of Islamic Cooperation) was established by the Third Islamic Summit of OIC held at Makkah, Saudi Arabia in January 1981. The President of Pakistan is Chairman of COMSTECH. The core mandate of COMSTECH is to strengthen cooperation among OIC Member States in science and technology (S&T), and enhance their capabilities through training in emerging areas, undertake follow-up-actions and implementation of the resolutions of the OIC, and to draw up programs and submit proposals designed to increase the capability of the Muslim countries in science and technology (S&T). The ultimate aim is to build and nourish a scientific culture in addition to using S&T as a major contributor to socio-economic development and rapid industrialization.

The objectives of COMSTECH include

1. Assessment of human and material resources of Member States and identification of scientific and technological needs and requirements of the Ummah,
2. Building indigenous capabilities of Member States in the fields of science and technology through cooperation and mutual assistance,
3. Enhancement of cooperation and coordination in scientific and technological fields amongst the OIC member states with a view to achieving collective competence in science and technology for solution of the problems of the OIC member states,
4. Creation of an effective institutional structure for planning, research, development and monitoring of scientific and technological activities at national, regional, and international levels.

COMSTECH works in close collaboration with various Standing Committees and other organs of the OIC, Member States of the OIC and their major Scientific and Technological Institutions, in addition to some international organizations. The latter include The World Academy of Sciences (TWAS), Islamic Scientific, Educational and Cultural Organization (ISESCO), Islamic World Academy of Sciences (IAS), Islamic Development Bank (IDB), Global Environment Facility (GEF), United Nations Environment Program (UNEP), United Nations Development Program (UNDP), International Foundation for Science, Stockholm (IFS), Eastern Mediterranean Regional Office of the World Health Organization (WHO–EMRO). In addition, protocols are being prepared for collaboration with the Lindau Council and IIASA in the EU.

23rd Islamic World Academy of Sciences Conference
on

"Science, Technology and Innovation (STI) Under Ever Changing Global Events."

Conference Declaration

Adopted at Rabat, Morocco
on
19 October 2022

Firstly, the Islamic World Academy of Sciences and the Hassan II Academy of Science and Technology extend their appreciation and gratitude to His Majesty King Mohammad VI of the Kingdom of Morocco for his patronage of the 23rd IAS scientific conference. A letter of appreciation and gratitude will be dispatched to His Majesty for patronizing the conference on behalf of the conference participants.

1) Whereas Islamic teachings and values encourage pursuit of knowledge and upheld it as an obligation for Muslims.
2) Whereas knowledge is assimilated from data generated from observation and research output.
3) Whereas research and development output could flourish and generate technology and incite innovation under viable science, technology and innovation (STI) ecosystem.
4) Whereas STI is a major instrument capable of inducing positive change on social well-being augmenting human, environmental and economical dimensions.
5) Whereas most of OIC member states do not have delineated STI framework and agenda to consolidate their scientific base contribution to development efforts.
6) Whereas OIC member states in their declared vision 1441 recognized the importance of education, science and technology as a vehicle for socio-economic transformation. A stance that had been reiterated in the 2021 O1C Summit Conference.
7) Whereas the adoption of STI policy and implementing articulated action plan within sound environmental context or activation of these instruments can increase productivity and sustain ecosystem ability to provide vital provisional, aesthetic and regulatory services.

8) Whereas freely accessible data of research output, production practices and inputs across the food supply chain can help in networking, symmetry of information dissemination, job creation and sustainable production.
9) Whereas OIC member states and humanity in general are faced with cross-border challenges in food and health security, climate change and biodiversity loss.
10) Whereas OIC member states exhibit variable levels in STI capacity and capability.
11) Whereas the sudden emergence of COVID 19 presents harsh realities specially with regard to disparity in vaccine roll-out between developed and developing countries due to insufficient vaccine supply or inadequate financial resource at the disposition of most developing countries.

We the Fellows of the IAS and participants in the IAS 23rd Conference entitled *"Science, Technology and Innovation (STI) Under Ever Changing Global Events"* held in Rabat during 18-19 October 2022 in partnership with Hassan II Academy of Science and Technology herein:

1) Call for OIC member states to introduce into their educational curricula principles of critical thinking that can nurture curiosity.
2) Urge our governments to increase allocations for research funding in their annual budget to arrive to tangible ratio of at least 1% of their GDP.
3) Urge OIC member states with no STI policy to draft such a policy that can identify national priorities, and orchestrate physical, human and financial resources as part of a master developmental plan.
4) Urge OIC governments to enact legislation outlining STI management structure supported by advisory body and empowered to perform its duties that can coordinate, streamline national resources and support to sustain research output and achieve smooth transition from research into technology and innovation into commercialization.
5) We emphasize the importance of creating and adopting an effective functional STI ecosystem that sustains and improves human resource, research and educational institutions, establishes science parks and incubators and provides funding. Of particular importance, the system should induce networking and outreach activities that aim at creating a vibrant scientific community.
6) Acknowledge the vital role the private sector can play in the transition pathway from research to commercialization. Governments are to entice and incentivize its involvement and participation in the process.
7) Emphasize the importance of government commitment to improve education system, provide pertinent infrastructure and build capacity and enhance capability of their country's STI domain.
8) We call for OIC Secretariat to form intergovernmental scientific panels to deal with cross-border challenges of interest to OIC member states and humanity in general.

9) We call for OIC member states to adopt a framework enabling mobility of science across member states. Such mobility schemes will facilitate knowledge sharing, networking and technology transfer. In this context, we commend COMSTECH and IAS for their joint initiative that intends to provide small mobility grant that enable scientists from least developed countries to do research in predetermined centers of excellence in the Muslim world.
10) Acknowledge that the OIC member states collectively have scientific, financial and economy of scale, we call upon them to embark on establishing a joint enterprise for developing and manufacturing vaccines for recurrent and emerging diseases.

LASTLY, THE ISLAMIC WORLD ACADEMY OF SCIENCES (IAS):

Extends its appreciation and gratitude to all organizations and institutes the extended sponsorship for this conference, these are; Hassan II Academy of Science and Technology (Morocco), Kuwait Foundation for the Advancement of Science (KFAS) (Kuwait), Higher Council for Sciences and Technology (HCST) (Jordan) and OIC Standing Committee on Scientific and Technological Cooperation (COMSTECH) (Pakistan).

23rd Islamic World Academy of Sciences Conference
on

Science, Technology and Innovation Under Ever Changing Global Events

CONFERENCE REPORT

18-19 October 2022

Under the high patronage of His Majesty King Mohammed VI, King of Morocco, the IAS convened its 23rd international scientific conference in Rabat, Morocco during 18-19 October 2022 in collaboration with Hassan II Academy for Science and Technology, Rabat, Morocco. The theme of the conference was Science, *Technology and Innovation Under Ever Changing Global Events.*

The venue of the conference was the Academy of the Kingdom of Morocco in Rabat. The IAS Conference was an open activity in which around 100 local and international participants attended from 15 countries. Among the participants were Fellows of the IAS and local scientists from various universities and institutions. After the conference, the 24th meeting of the General Assembly of the IAS as well as the 44th meeting of the IAS Council were convened.

The conference was co-sponsored by; The Higher Council for Science and Technology (HCST), Amman, Jordan; Kuwait Foundation for the Advancement of Sciences (KFAS), Kuwait; and OIC Standing Ministerial Committee on Scientific and Technological Co-operation (COMSTECH), Islamabad, Pakistan.

The inaugural ceremony of the conference included an address by Prof. Omar Fassi-Fehri, Permanent Secretary, Hassan II Academy of Science and Technology, Rabat, Morocco; who expressed his pleasure for the presence of eminent professors who came from different regions and from all scientific disciplines to exchange views and to share their knowledge that will contribute to the Sustainable Development Goals. Prof. Fassi-Fehri highlighted that, in light of the accelerating transformations the world is experiencing, mastery of science, technology and innovation has become one of the most important elements of the economy and cultural power of nations and peoples, and an essential bet for exercising effective sovereignty at the level of societal choices.

Following was the Minister of Higher Education, Scientific Research and Innovation, Mr. Abdellatif Mirawi, who said that this world, which is going through multi-dimensional crises, is the scene of devastating transformations that question our abilities to anticipate and adapt, both of which are necessary to secure

development paths in our countries. He also pointed out that this changing context clearly highlights the central role of science and technology as powerful levers to enhance the resilience of our economies and societies, by shaping the foundations of sovereignty in a plurality of vital areas, such as health, water, food security and energy.

A message from HE Prof. Abdel Salam Majali, President, IAS, Jordan was delivered by Prof. Abdullah Al Musa, Director General, IAS where he highlighted that the changes that will be the focus of the discussions of this conference are very clear and focus on a number of topics of interest to societies in the Arab-Islamic region.

The message of the President of Pakistan, Dr. Arif Alvi, IAS Patron was delivered by HE Prof. Iqbal Choudhary, Coordinator General, COMSTECH, Pakistan, who joined the conference virtually via ZOOM. He stressed the importance of cooperation in the development of Islamic societies, pointing out that good cooperation in scientific and technological fields would enhance the living framework of citizens. He also expressed his desire for this conference to culminate with recommendations that would have an impact on the lives of citizens of Islamic countries.

His Royal Highness Prince El-Hassan bin Talal, Founding Patron of the IAS sent a message to address the conference participants and was delivered by HE Prof. Adnan Badran, Treasurer, IAS. In his message, HRH pointed to the most important challenges facing humanity according to the World Economic Forum 2021 in the next decade; Human-induced environmental damage including loss of biodiversity and spread of infectious virus, Poverty, human displacement and widening gap between rich and poor, Cyber security and Digital inequality. These issues were considered the most pressing issues. Prince El-Hassan emphasized the importance of responsibility and participatory approach in governance across different societal institutions and organizations. HRH also upholds the Paris Agreement to reduce CO_2 emissions but unfortunately, its targets seemed to be out of reach as indicated by research and studies presented in COP26.

The inaugural session concluded with a recorded message from Sir Peter Gluckman, President of the International Science Council (ISC).

After the inaugural session, newly elected IAS Fellows were inducted.

The first academic session of the conference included keynote presentations starting with a presentation by **Prof. Bulent Aydogan**, Associate Professor and Director of Medical Physics at the University of Chicago Pritzker School of Medicine, USA entitled *Novel Theragnostic Approaches for Personalized Cancer Care;* a presentation by **Prof**. **Irfan Ahmad**, Executive Director for Interdisciplinary Initiatives at the Grainger College of Engineering; and Executive Director for the Health Maker Lab

at the Carle Illinois College of Medicine, University of Illinois at Urbana-Champaign, USA on *Bionanotechnology toward Environment-friendly Agriculture*; followed by a presentation by **Prof. Munir Nayfeh** FIAS, Professor, Department of Physics, University of Illinois at Urbana-Champaign, USA on *Energy Security between Nuclear, Renewable and Nanotechnologies*. The keynote session was concluded with a presentation on *Bricklaying at Nanoscale* by **Prof. Mostapha Bousmina**, President, Euromed University of Fes and Chancellor, Hassan II Academy of Science and Technology, Rabat, Morocco.

The second working session of the conference included two presentations; *Water for Development and Development for Water: Realizing the Sustainable Development Goals (SDGs) Vision* by **Prof. Mohamed Aït Kadi**, President of the General Council of Agricultural Development and Resident Member of Academy Hassan II of Science and Technology, Rabat, Morocco, and a presentation by **Prof. Adnan Badran** FIAS, Chancellor of the University of Petra and the Chairman of the Board of Trustees of the University of Jordan, on *Post-COVID Higher Education: Lessons from a Pandemic.*

The last session started with a presentation by **Prof. Abdullah Al Musa**, Director General, Islamic World Academy of Sciences (IAS), Jordan, on *Joint Vaccines Development and Manufacturing Potential in OIC Countries* followed by a presentation by **Prof. Elmostafa El Fahime**, Professor at National Center for Scientific and Technical Research (CNRST) and Head of Functional Genomic platform, Rabat, Morocco on *Genomic Surveillance of SARS-CoV2 in Morocco: A Major Component of the Integrative Approach Adopted by the Hassan 2 Academy of Sciences and Techniques to Support Biomedical Research on COVID-19*. **Prof. Mohammad Abdollahi** FIAS, Faculty of Pharmacy and the Pharmaceutical Sciences Research Center (PSRC), Tehran University of Medical Sciences, Iran, through a prerecorded video presented a paper on *On the Epigenetics as a Toxicological Mechanism Causing Human Degenerative Diseases.* Last in the session, **Prof. Ali A. Moosavi-Movahedi** FIAS, Institute of Biochemistry and Biophysics, University of Tehran, Iran joined virtually via ZOOM and presented a paper on *The Role of Antioxidants and Nutraceuticals in Promotion of Lifestyle and Health.*

At the conclusion of the Conference, Prof. Hamza Kettani made some closing remarks and read the adopted IAS 2022 Rabat Declaration on *Science, Technology and Innovation (STI) Under Ever Changing Global Events*.

The declaration of the conference (approved by the Fellows of the IAS and participants in the IAS 23rd Conference) called for OIC member states to introduce into their educational curricula principles of critical thinking that can nurture curiosity.

Urged governments to increase allocations for research funding in their annual budget to arrive to a tangible ratio of at least 1% of their GDP.

Urged OIC member states with no STI policy to draft such a policy that can identify national priorities, and orchestrate physical, human and financial resources as part of a master developmental plan.

Urged OIC governments to enact legislation outlining STI management structure supported by an advisory body and empowered to perform its duties that can coordinate, streamline national resources and support to sustain research output and achieve a smooth transition from research into technology and innovation into commercialization.

Emphasized the importance of creating and adopting an effective functional STI ecosystem that sustains and improves human resource, research and educational institutions, establishes science parks and incubators and provides funding. Of particular importance, the system should induce networking and outreach activities that aim at creating a vibrant scientific community.

Acknowledged the vital role the private sector can play in the transition pathway from research to commercialization. Governments are to entice and incentivize their involvement and participation in the process.

Emphasized the importance of government commitment to improve the education system, provide pertinent infrastructure and build capacity and enhance the capability of their country's STI domain.

Called for OIC Secretariat to form intergovernmental scientific panels to deal with cross-border challenges of interest to OIC member states and humanity in general.

Called for OIC member states to adopt a framework enabling mobility of science across member states. Such mobility schemes will facilitate knowledge sharing, networking and technology transfer. In this context, COMSTECH and IAS were commended for their joint initiative that intends to provide small mobility grants that enable scientists from least developed countries to do research in predetermined centers of excellence in the Muslim world.

Acknowledged that the OIC member states collectively have scientific, financial and economy of scale, we call upon them to embark on establishing a joint enterprise for developing and manufacturing vaccines for recurrent and emerging diseases.

Lastly, the IAS through its declaration extended its appreciation and gratitude to His Majesty King Mohammed VI of the Kingdom of Morocco for his patronage of the 23rd IAS scientific conference and to all organizations and institutions that extended sponsorship for this conference, these are; Hassan II Academy of Science and Technology, Morocco, Kuwait Foundation for the Advancement of Science

(KFAS), Kuwait, Higher Council for Sciences and Technology (HCST), Jordan and OIC Standing Committee on Scientific and Technological Cooperation (COMSTECH), Pakistan.

As part of the follow-up action to the conference, the Academy will circulate the IAS 2022 Rabat Declaration to concerned individuals and relevant agencies throughout OIC and developing countries, so that measures are taken to put into action the ideas proposed at the conference.

The presentations delivered at this conference are published on YouTube;
https://www.youtube.com/@academiehassaniidesscience2443/streams

The IAS will also publish the complete proceedings of the conference online and will be distributed internationally.

MESSAGE* OF
HIS EXCELLENCY PROF. ABDEL SALAM MAJALI FIAS
PRESIDENT OF THE
ISLAMIC WORLD ACADEMY OF SCIENCES (IAS)

بسم الله الرحمن الرحيم

السلام عليكم ورحمة الله وبركاته، و بعد،،،

Your Excellency Mr. Abdellatif Miraoui, Minister of Higher Education, Scientific Research and Innovation

Prof. Omar Fassi-Fehri, Permanent Secretary, Hassan II Academy of Science and Technology

Fellows of the IAS

Members of the Hassan II Academy of Science and Technology
Excellencies

Ladies and Gentlemen

Dear friends

It is my pleasure and indeed a privilege to welcome you all this morning and to greet you and communicate my deep appreciation for your interest in this conference which hopefully will outline the Science, Technology and Innovation under Ever Changing Global Events.

Science, technology and innovation is of paramount importance in driving socioeconomic development for our nations. For this trio to be effective, a total national STI capacity trifecta should be achieved namely: a government commitment to providing STI physical and soft infrastructure, a vibrant, ethical scientific community with enabled and efficient governance, and a private sector capable and willing to invest in product development.

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* *Presented by Dr. Abdullah Al Musa, Director General, Islamic World Academy of Sciences (IAS), Rabat - Morocco, 18 October 2022.*

The efficacy of this STI ecosystem is dependent on the intricate and smooth interactions among all stakeholders in the state and a functional international outreach. An effort that should be culminated in a solid STI policy entailing an action plan to galvanize the efforts and delineate priorities.

The Islamic World of Sciences (IAS) is holding its 23 conference to provide a platform for fruitful discussions and deliberations and enhance networking and exchange of STI experience in OIC Countries, especially with regard to proper governance, partnership framework that accommodate all STI Stakeholders.

We at the IAS are grateful and honored to His Majesty King Mohammed VI for patronizing the IAS 23rd Scientific Conference in Rabat.

I take this opportunity to extend appreciation and gratitude to Hassan II Academy of Science and Technology for hosting and organizing this conference and to all organizations, institutions that extend or pledged sponsorship for this conference including Kuwait Foundation for the Advancement of Science (KFAS), the Higher Council for Sciences and Technology (HCST), The Ministerial Standing Committee on Scientific and Technological Cooperation of the OIC (COMSTECH), and Pakistan Academy of Sciences (PAS).

Thanks are also extended to the speakers who did spare no effort to put forward their contributions in this scientific activity.

Thank you

Message from Dr Arif Alvi
President of the Islamic Republic of Pakistan

On the occasion of the 23rd International Scientific Conference on Science, Technology, and Innovation (STI)

***

It is a matter of great satisfaction that the Organization of Islamic Cooperation Standing Committee on Scientific and Technological Cooperation (COMSTECH) and the Islamic World Academy of Sciences (IAS) are organizing the 23rd International Scientific Conference on the rapidly changing ecosystem of Science Technology and Innovation (STI) at the global scale. The exponential nature of changes happening in this field has put tremendous pressure on governments and society everywhere. All these developments are profoundly affecting our collective as well as our personal lives and pose multifarious challenges for governments, academia, and industry. I am glad that IAS is organizing this conference to deliberate on the implications of these rapid changes, devise mechanisms and come up with recommendations for the leadership of the Muslim Ummah to effectively harness the potential of science and technology for the benefit of the entire Muslim Ummah.

I note with great satisfaction that COMSTECH, after careful consideration, has figured out that the solution to this issue is to set aside a minimum level of resources by the member states to spur the development of STI in Islamic countries and to have a permanent set up within the OIC system to effectively deal with the rapidly changing scenario of STI. COMSTECH has rightly conceived the idea of the Science Technology and Innovation Organization (STIO) to contemplate the ever-changing frontiers of STI development. Its core concept is "member states, money for member states, development of STI infrastructure'. I am glad that eighteen founding member states joined the STIO and four member states made a commitment to contribute USD 20 million to make it operational. I would urge the Fellows of the IAS to deliberate on its revival strategy and formulate recommendations for making it functional. Another important suggestion from COMSTECH was the creation of a Pan-Islamic Fund to strongly push the agenda of STI forward to make meaningful progress under the current circumstances.

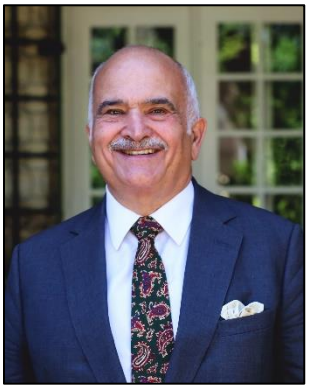
Both these concepts require the establishment of a body to regularly meet, analyze and set directions in the rapidly changing environment of the STI infrastructure development of the OIC countries. Fortunately, Kazakhstan has already proposed the formation of such a body under the name "OIC-15". The Fellows may also look into it during this meeting and propose a set of rules to make it operational.

In the end, I would also like to wish unbound success to your deliberations and wholeheartedly thank His Majesty King Mahammad VI of Morocco for his patronage, and to His Majesty's government for hosting the 23rd International Scientific Conference of the Islamic World Academy of Sciences in Rabat.

***

STI for Digital Transformation Toward Sustainable Human Development in an Ever-Changing World[1]

Statement by
His Royal Highness Prince El-Hasan bin Talal
at the
23rd Conference of the Islamic World Academy of Sciences (IAS)
"Science, Technology and Innovation Under the Changing Global Events"
18-19 October 2022
Rabat-Morocco



My thanks and gratitude to His Majesty King Mohammed VI, King of Morocco for his high patronage of this conference.

May I thank the Hassan II Academy of Sciences and Technology for organizing this conference.

Also, I wish to thank sponsors: the Islamic World Academy of Sciences (IAS), the Higher Council for Science and Technology (HCST) in Jordan, The Kuwait Foundation for the advancement of Sciences (KFAS), the OIC and COMSTECH in Islamabad.

According to the World Economic Forum 2021, Humanity is facing the following risks in the next decade:

1. Human-induced environmental damage including loss of biodiversity and spread of infectious virus.
2. Poverty, human displacement and widening gap between rich and poor, 1% of the world population has 50% of world wealth.
3. Cyber security.
4. Digital inequality.

These risks create further challenge in an ever-changing world by 2050, of food security, water scarcity, biodiversity, energy, environmental imbalance and degradation, and human health.
We're facing globally, natural disasters and climate change and turmoil of man-made disasters. By 2050, we have to feed 9 billion people with 60% increase of access to food. The question here, can our planet resources carry out such **responsibility**. Do we have the space for sustainable environment?

[1] *Presented by Prof. Adnan Badran, Treasurer, IAS.*

Talking about **responsibility**, it was Edward Gibbon, who once said that Athenians called for all forms of freedom, but when Athenians chose freedom from responsibility, Athenians ceased **to be free**.

Developing critical thinking and logics among ***the free*** in our learning institutions to educate the ***Liber*** to share **responsibility** and **participatory** in governance and private sectors and civil society have to meet the challenges to future crisis, to give solutions that matters, to save humanity on our planet and develop a culture of peace and coexistence among all.

I do not represent government, nor do I do business, but being an NGO "humane" I was associated in 1988 with *independent commission on International Humanitarian Issues* in calling on the UN general assembly for the *New International Humanitarian Order* and I thanked Sweden for appealing for the creation of *Fundamental Rights of Humanity*. In Dennis Meadow, the club of Rome which I was associated with, *thirty years update of limits to Growth*, we were told that humanity today is burdening the "carrying capacity" of Mother Earth by the factor of 1.2. Also, 85% of consumption and depletion of natural capital is caused by the "rich minority" of the 20% of the world population.

Climate change (Paris agreement and COP26) is a serious threat to our planet which may cause of 1 billion refugees leaving their livelihood by 2050, and malnutrition of 2 billion people.
Global energy demand is expected to increase 56%. Nowadays, we see countries are back to burning coal to meet their energy crisis, because of conflicts affecting the chain of energy supplies. So, reducing emission targets of the Paris agreement is already evaporating. Soil, the world largest carbon-sink due to climate heterotopic change is becoming an emitter of carbon due to respiration. So, we are witnessing frequent hurricanes, flood, tornados, heat waves and droughts affecting millions to become homeless. Science, technology and innovation, (STI) are crucial in decarbonizing the economy and removing excess CO2 from the atmosphere.

When Al Gore and I, together with five others received the UNEP prize, Al Gore spoke of **global warming** and I spoke of **human warning**. The problem is not with the imprisonment of heat but in the imprisonment of thought.

The crisis today in our region is the sectarian fragmentation, unemployment and conflict, between the rich and the poor.

The challenge for us today, do we meet the SDGs (the UN sustainable development goals) by 2030 and leave our conflicts and differences aside, to cooperate and share on our **global commons**: world hunger, access to clean water, economic deprivation, resource depletion, species loss, global warming, pollution, cross-cultural conflicts, terrorism, weapons trading, conflicts and wars.

The report on "*winning the human race"* is a global common of how to put human well-being at the center of our policy-making. I always ask "**In the modern economic, social and political environment, is it possible for human beings to become more humane**". How we strike a balance in the framework of globalization for a **social civil contract vs economic development contract.**
At this juncture, how STI, would become the main driving force in achieving the SDGs 17.

It is becoming clear, that the specific goals, we are pursuing-whether they involve food, water, clean air, environmental protection, energy, free flow of information, human rights, indigenous people rights, or other social concern are essentially **global common goods**, which cannot be allocated optimally as long as they remain enclosed, overused, or degraded.

People around the world are realizing that our common goods is not a matter of sovereign claims or private ownership, but a matter of survival. Our common resources should sustain local population and ensure human security.

Therefore, the challenge is not whether the SDGs are realistic targets but the challenge is whether the public-private framework itself is the most realistic way of meeting the SDGs.

It should be no surprise, them, that national expenditures for global common goods are not at the level needed to meet our SDG targets by 2030. I would like at the UN to see **a synergy** between a regional ECOSOC, to think and act, regionally and globally.

We need urgently, to enter a new era of multilateralism by building a cooperative framework across borders for the governance of our commons, where most of the SDG will ultimately be realized.

At the 36th session of the UN assembly in 1981, I stated that an examination of the current world situation clearly demonstrates a divergence between the **commonly shared aspiration** for a world ruled by peace and justice and **the existing reality**, where power rules and the politics of "fait accompli" dominate. The world clearly needs new ways of thinking about old problems. I do hope that we foresee the SDGs as a mean to end our global problems, rather than an end in themselves.

Dear colleagues, Fellows of the academy.

Science, Technology and Innovation (STI) are crucial for managing our natural resources and building our human capital of rich human resources, and move forward into the digital economy, for self-reliance and a sustainable productive quality of life for

all citizens. The Islamic world needs to join forces in building peace and justice, and create an inducing environment for releasing the potential of the minds of men and women for enquiry and research oriented to solve our problems and diversify our industry, and increase productivity and convert scientific research toward technology, innovation and startups companies, to generate jobs and wealth. The gap between academia and industry is widening. We have to bridge the gap between teaching, training, research with academia for economic and social development. The ivory tower of university concept is no more acceptable. We have to bridge higher education and research delivery with the marketplace, and with the needs of the community.

Where do we start:

1st from education: we start from early childhood to build an enquiry-based education to develop the mind of logics, the analytical mind who is able to investigate, analyze and solve problems. This is where we plant the seeds of building ethics, thinking skills, and creativity. Teaching less but learning more. This is where we create smart schools and induce, love to teamwork, and learning how to live with others and respect other values and traditions and appreciate other cultures and diversity.

2nd we have to modernize our overall education to develop thinking skills, for new knowledge to meet the emerging needs of an-everchanging world. We have to reeducate our teachers through life-long education, out-service and in-service training, and the use of modern packages of smart materials to upgrade technical training. We have to divert our schools and class-rooms from to modern learning sites, environmentally friendly campus.

3rd our universities should adapt quickly to fast changing world with new demands in providing frontier areas of disciplines, and interdisciplins to be able to deliver graduates, to meet the challenges of climate change, water scarcity, energy, food security, artificial intelligence (AI), digital economy, health care, unemployment and poverty, and modern infrastructure. Universities have to be resilient and flexible in teaching and research to undertake a change. Our campuses should be an inviting place for learners. Our method of teaching should shift to blended learning, to produce the critical thinkers and problem-solvers.

Research should not end up only in peer-reviewed journals. This is not enough. Research outputs should be incubated to new technology and innovation. Therefore, incubators should be provided in departments and faculties, to turn research outputs, into business science parks for startup companies.

Universities and research centers should be pioneers in graduating startups, in addition to graduating students. This way we will lead in the Islamic world in building innovation

and entrepreneurship by translating knowledge into business to produce employment and wealth.

For South-South scientific cooperation, we should try to create a network among higher learning institutions in the Islamic world to cooperate in research and exchange of knowledge and information.

In addition of bridging our higher learning institutions and research centers, we should bridge it also, with industry, to close the gap between academia and society.

At the end, I wish to add little humor to you fellows as scientists of the academy.

A Princeton plasma physicist, at a sandbeach, discovers an ancient oil lantern (Aladdin lamp), he started to rub it clean, when a giant genie pops out, the genie *granted the physicist one wish to realize*, the physicist runs to his car, brining the map of the world and circles the Middle East, asking the genie *to bring peace to the region*, the genie looked "*oh, Gee, this is so much complexed issue there*, *with Iraq, Syria, Lebanon, Yemen, Libya, Iran, the Israel-Palestinian conflict and others"*, then the genie asked the physicist "*could you have please, another wish"*. "*Ok fine"*, said the physicist, my other wish is that the "*Princeton Tokamak when would achieve scientific fusion energy breaking*", after few minutes of silence, the genie asked the physicist "*Sir, could I see the map again*".

If the wish was given to me, I will ask the genie "*can we create a fusion of ideas to serve human dignity*".

Thank you, Fellow members, thank you ladies and gentlemen.

NOVEL THERAGNOSTIC APPROACHES FOR PERSONALIZED CANCER CARE

BULENT AYDOGAN
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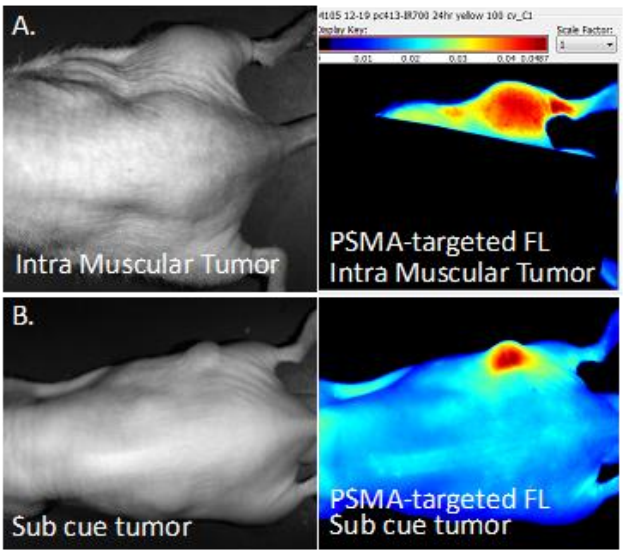
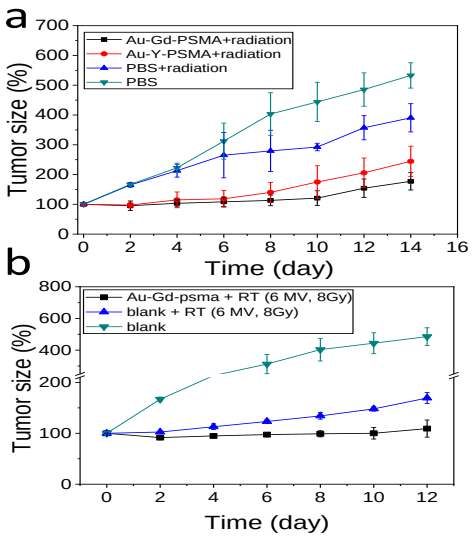
University of Chicago, USA

ABSTRACT

Despite extraordinary advances in medicine and cancer therapy, the number of cancer cases continue to surge, making it one of the top leading causes of death across the world. As a result, early detection is one of the key aspects in our battle against this disease. Screening and early diagnosis play a crucial role for effective treatment and to lower the cancer mortality rate. Cancer nanotechnology is a relatively recent advance in science that provides a new hope in our fight against cancer. This novel approach aims to integrate the advancements made in the fabrication of nanoscale devices with cellular and molecular components associated with cancer diagnosis and therapy. Understanding these new technologies ad challenges is crucial to translate these approaches from bench to bed and integrate in clinical settings. Recent advance has facilitated the conjugation of nanoscale devices with agents such as tumor-specific ligands, antibodies, imaging probes and therapeutic opportunities. Coupling nanoparticles with targeting molecules enables an efficient interaction between biological systems with extraordinary accuracy. The development and progress associated with nanoscale devices with regard to theragnostic applications will be discussed with two examples from my lab including 1) patented deoxyglucose conjugated nanogold (AuNp-DG) and 2) PSMA-1-AuNP-Gd(III) nanoplatforms. Furthermore, we will summarize how nanoparticles take advantage of the tumor microenvironment for targeting cancer cells with examples. A review of drawbacks, challenges, and future opportunities as effective strategies to replace current clinical trends will be presented.



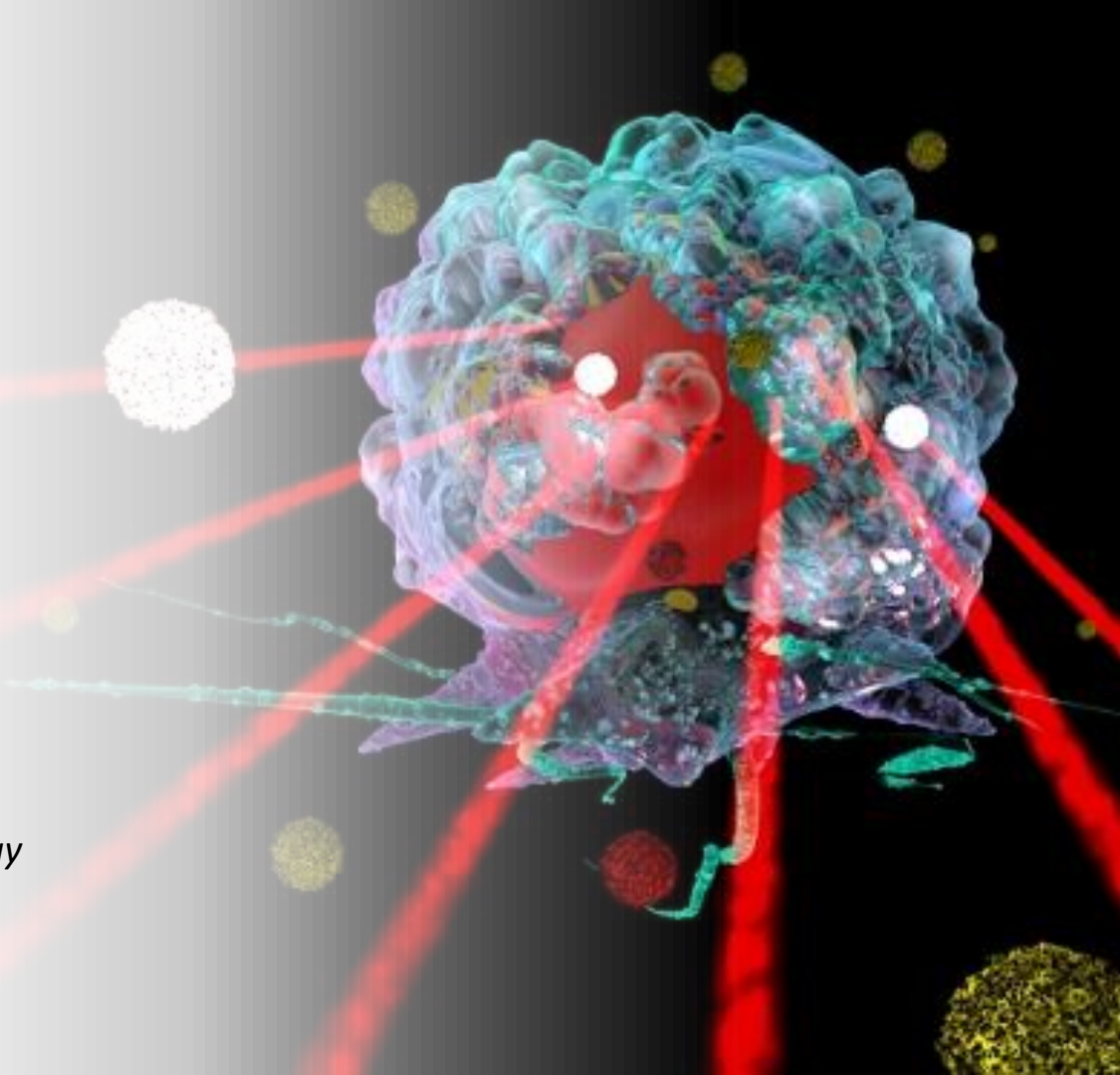
PSMA targeting of (A) IM tumor implantation (upper) showing offshoot growth at tumor edge; and (B) Sub cue tumor implantation (lower)



Comparison of tumor control with (a) Cs-137- 0.667 MV vs. (b) clinical 6 MV therapy. Clearly demonstrating the improved tumor control with PSMA-1-AuNP-Gd(III)

1. Funding: American Cancer Society.
2. Funding: National Institute of health.

Novel Theragnostic Approaches for Personalized Cancer Care



Bulent Aydogan, PhD

Professor of Radiation and Cellular Oncology

Director of Medical Physics

Director of Small Animal Irradiation Center

Director of Clinical Oximetry Center

Theranostic or TheraGnostic

Therapy-diagnosis

Springer Link

Letter to the Editor | Published: 06 November 2018

Why should we be concerned about a “g”?

Savvas Frangos & John R. Buscombe

European Journal of Nuclear Medicine and Molecular Imaging **46**, 519 (2019)

5906 Accesses | **21** Citations | **13** Altmetric | Metrics

Thera (Santorini)

The God of War

Thera - nostic

- **Thera:** by itself does not refer to therapy
  - Mytology: God of War, Lava
  - Biblical Greek: the hunt
  - It is the name of **a Greek island**
- **Nostic:** refer more to the disease than diagnostics.

- **Ther-agnostic** - lack of knowledge

Thera - gnostic

Linguistically the better approach is a synergy of the two words: ***Therapo-gnostics:***

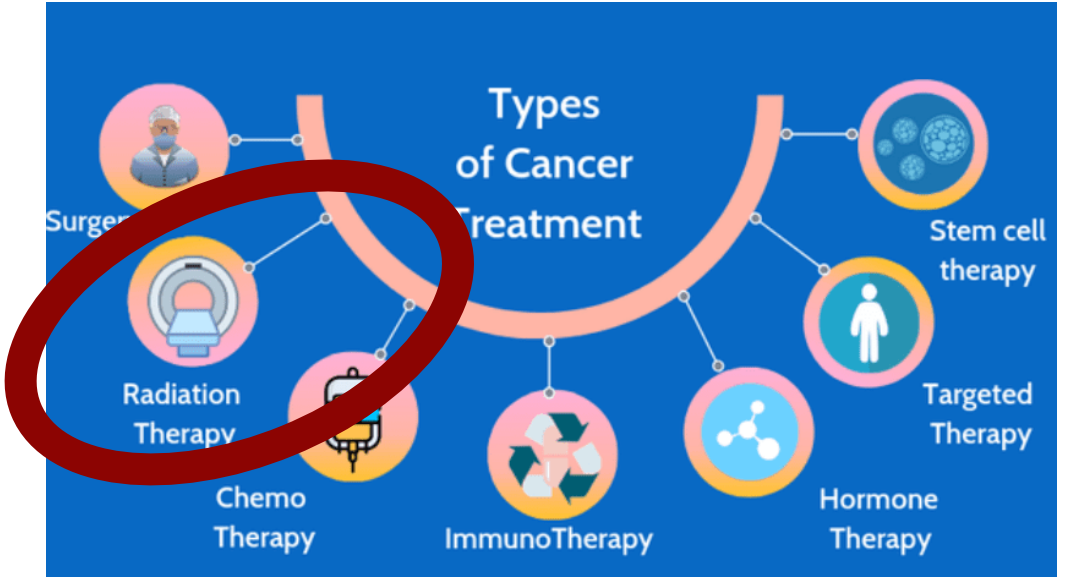
- **Gnosis:** Knowledge

- Nanotechnology has the potential to provide **knowledge-based precision medicine** through combination of molecular imaging and molecular radiotherapy.

Cancer Therapy

Cancer is one of the leading causes of death and morbidity with a complex pathophysiology.

Precision Medicine



was a dream 10 yrs ago!

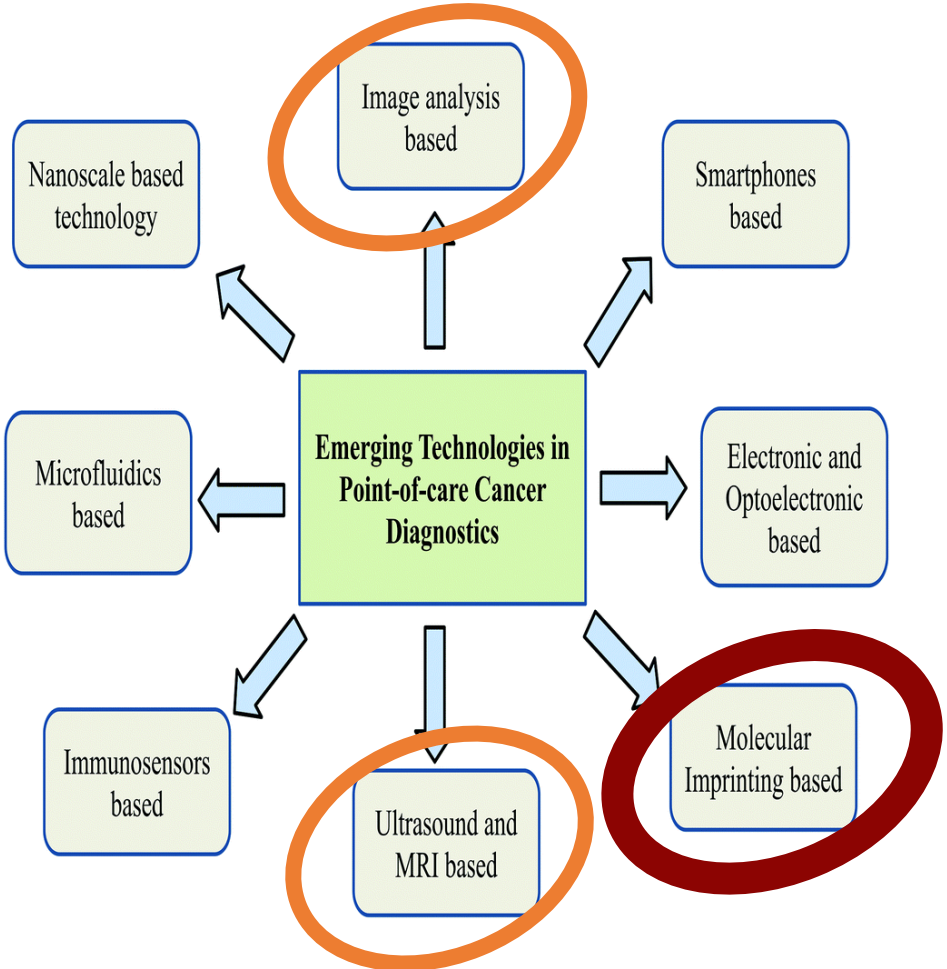
1st pillar of Precision Medicine

Early diagnosis is still the most important weapon against CA

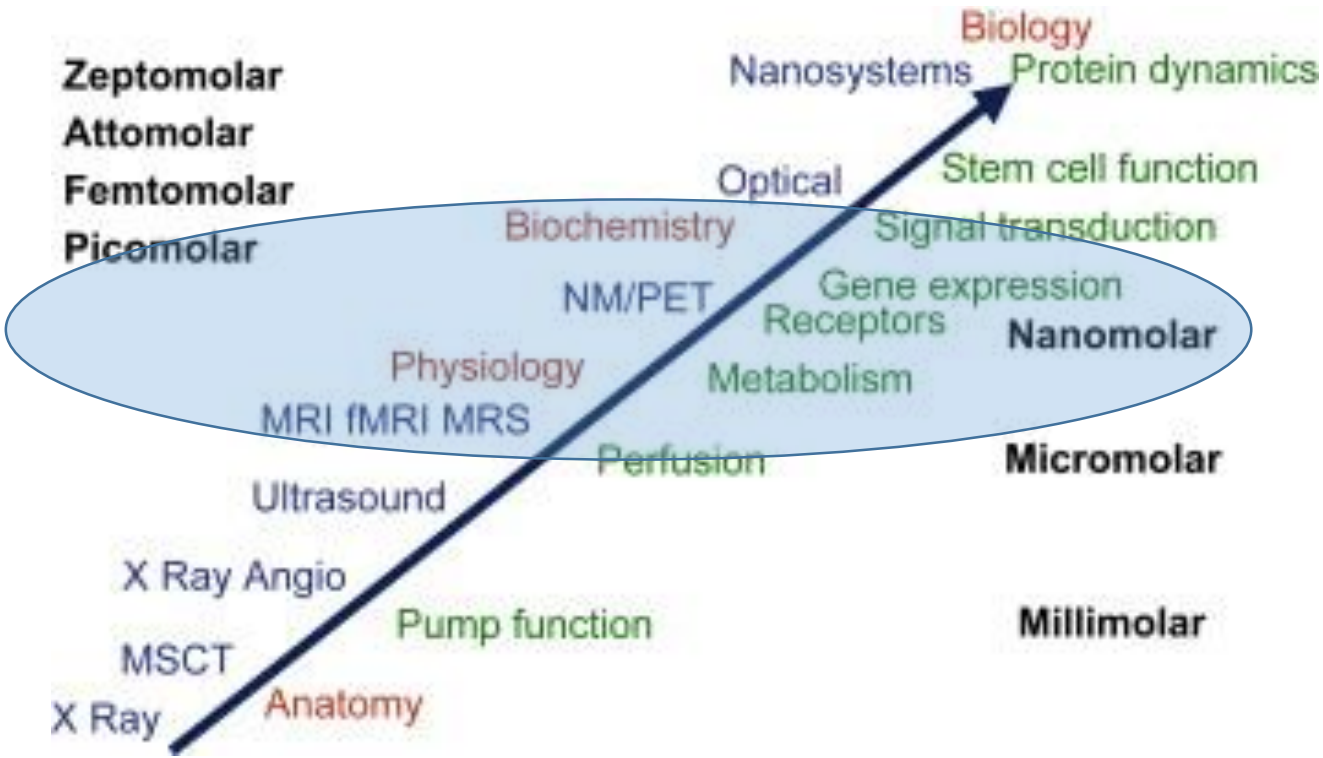
Imaging to identify not only location but also other attributes

Limitations

- lack of specificity
- Resolution
- how early is early ?

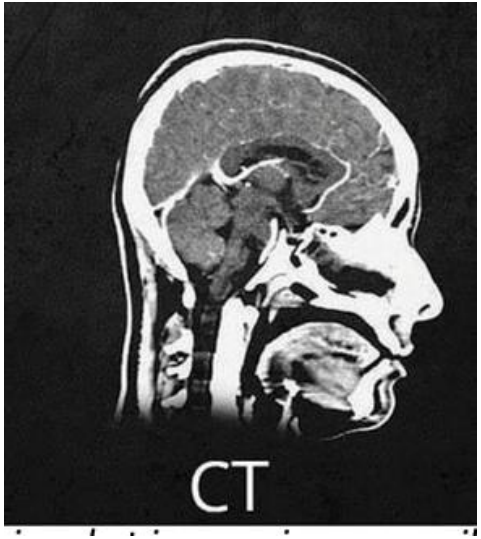


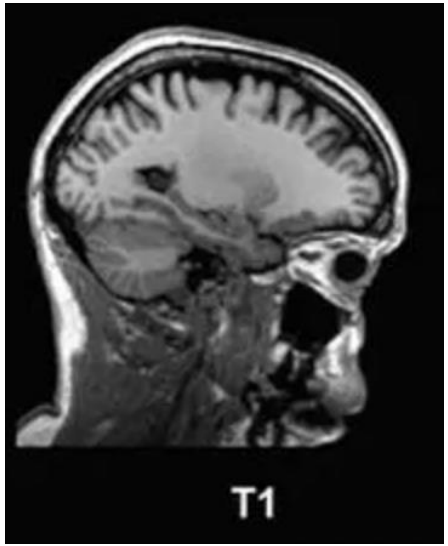
Relative sensitivity of different imaging technologies.

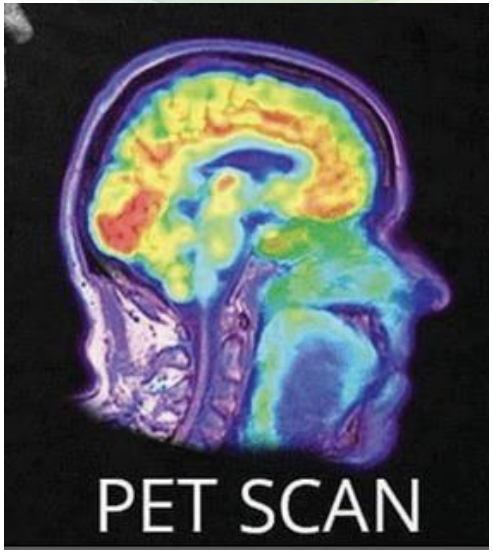


- Imaging systems vary in physical properties including sensitivity, temporal and spatial resolution.

Healthy human brain, PET, MRI, CT



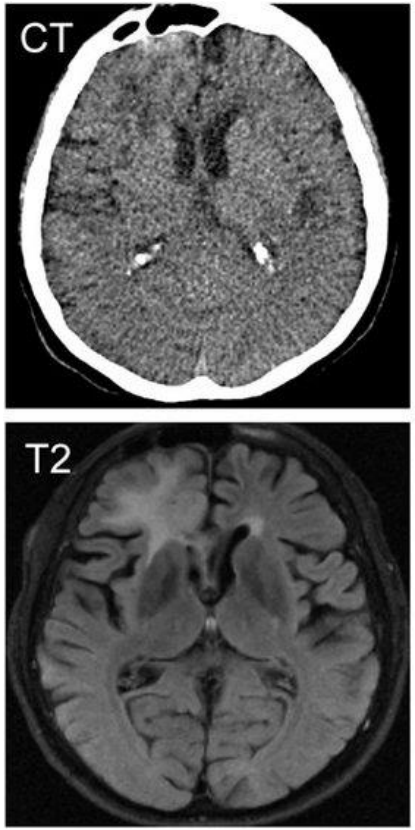




- *https://www.kcl.ac.uk/news/new-database-of-healthy-adult-human-brain-pet-mri-and-ct-images-is-now-available-for-research*

CT- PET- MRI comparison

56-y-old patient with glioblastoma multiforme



Boss A, Hybrid PET/MRI of intracranial masses: Initial experiences and comparison to PET/CT JNM 51(8):1198-205, 2010

Challenges in imaging technology for cancer *diagnosis and localization*

- Current modalities are not specific enough to differentiate tumor from surrounding tissues
  - *Need contrast agents*

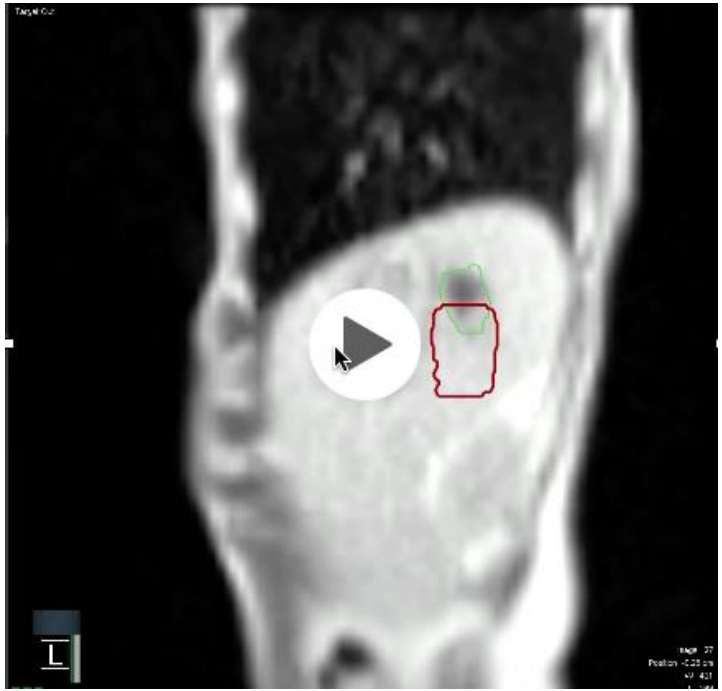
- Resolution is not optimal to differentiate tumor below certain size.
  - *PET is worse ~0.6 cm vs. CT @ 0.1*

- Considering even one mutated cell can trigger a tumor formation we need to develop better imaging tools

Challenges in cancer therapy

Imaging is the Key technology in cancer therapy

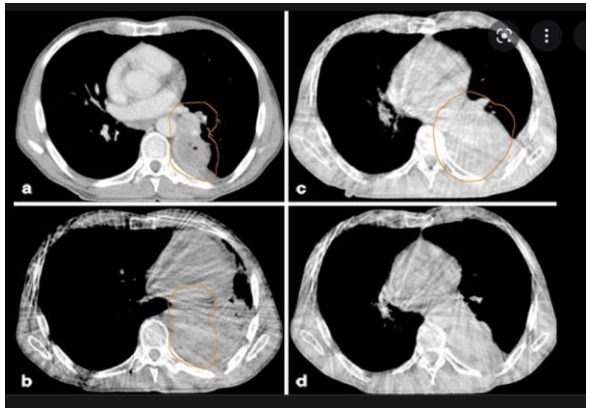
Tumor moves

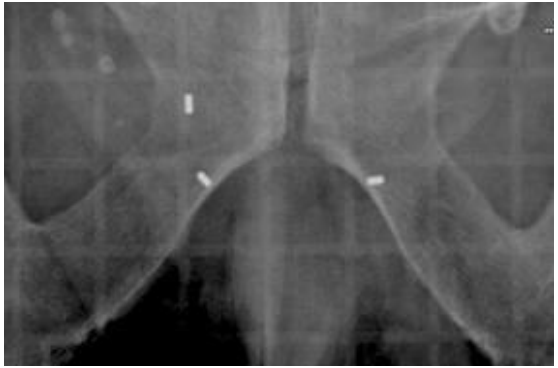


Radiation Therapy of Cancer

Currently no real-time nor functional imaging for tumor targeting is available in Treatment room

We use fiducials





IT'S ALL ABOUT PROPER TARGETING

IMAGE AND MORE IMAGE

Project 1: Statement of the Problem

CT is used for treatment while PET(MRI) is used to identify tumor.

CT can only provide anatomic information w/ high spatial resolution

No functional imaging currently available in the treatment room to see and target tumor.

A PET like CT tracer is urgently needed

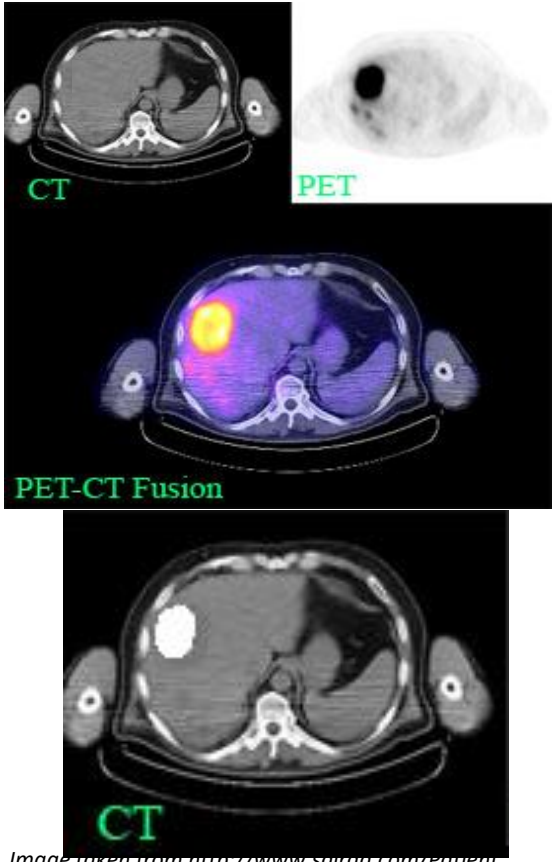
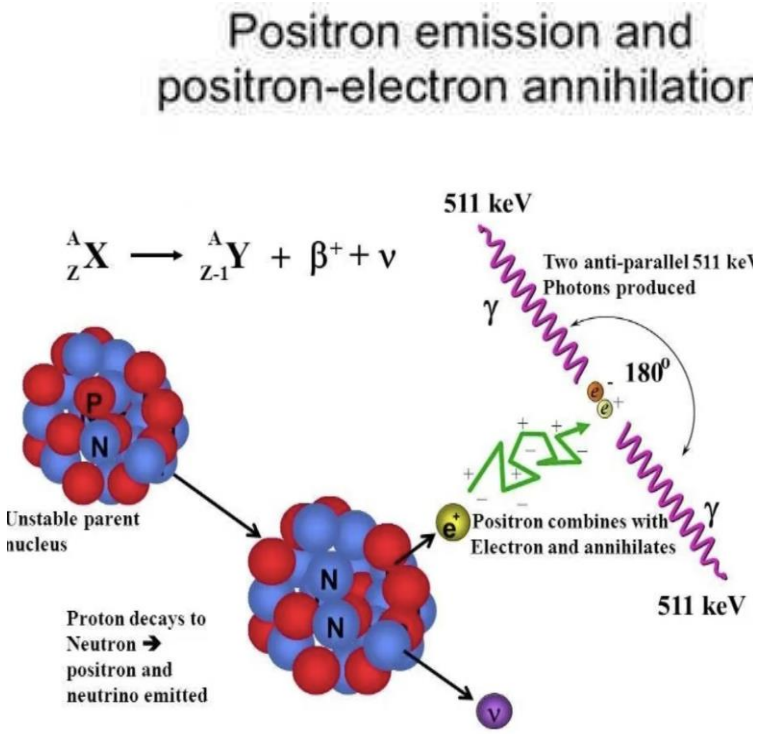


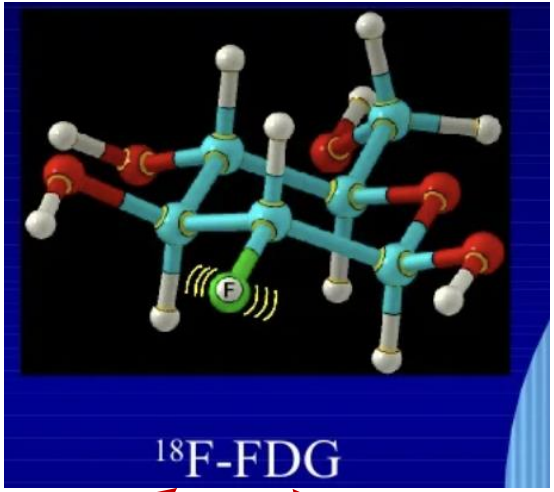
Image taken from http://www.sulrad.com/Patient Info/pt_pet.htm

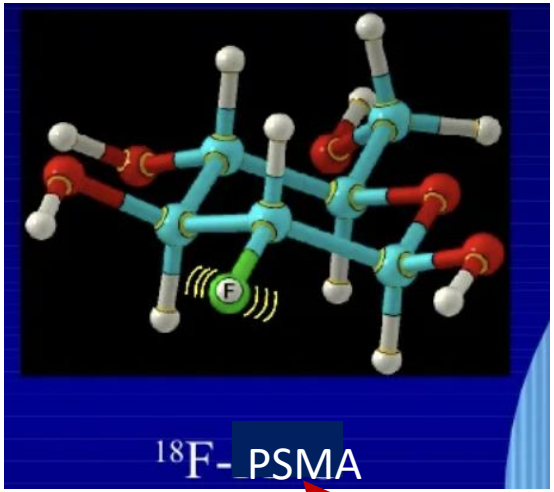
PET: Positron Emission Tomography



Finding tumors: Radiotracers

Tagging with compound specific to physiology/metabolism





Positron emitting Radioisotope

Sugar Metabolism

Prostate Specific Membrane Antigen

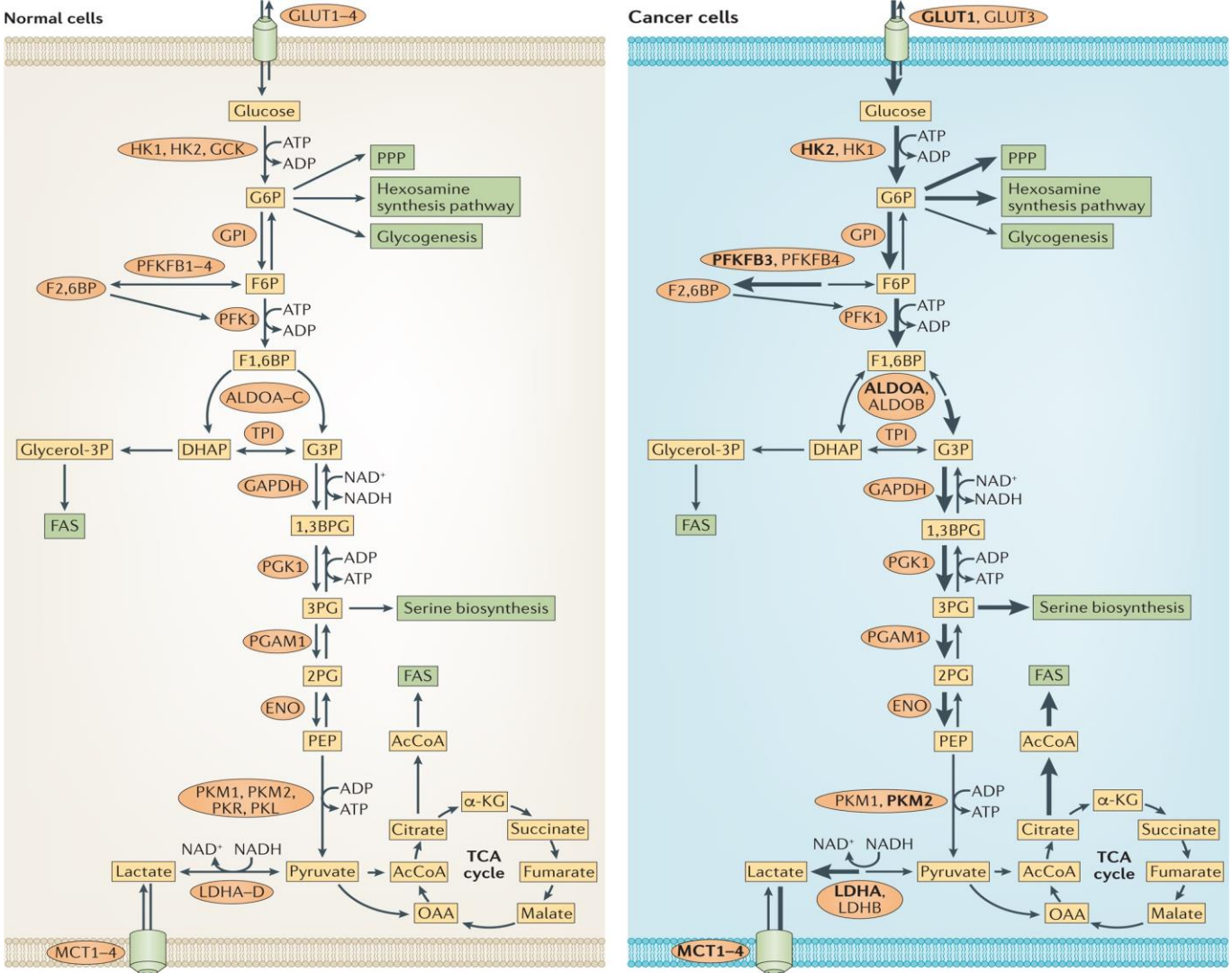
PET imaging

- short half life (< 6 hours)
- Short blood retention
- Complexity of synthesis: cyclotron/radiochemistry lab : *Cost & Availability*
- *Radioactive*
- *Require Expensive technology and operation*
- *Limited availability*
- **Tumor-specific targeting ability*

CT imaging with AuNp

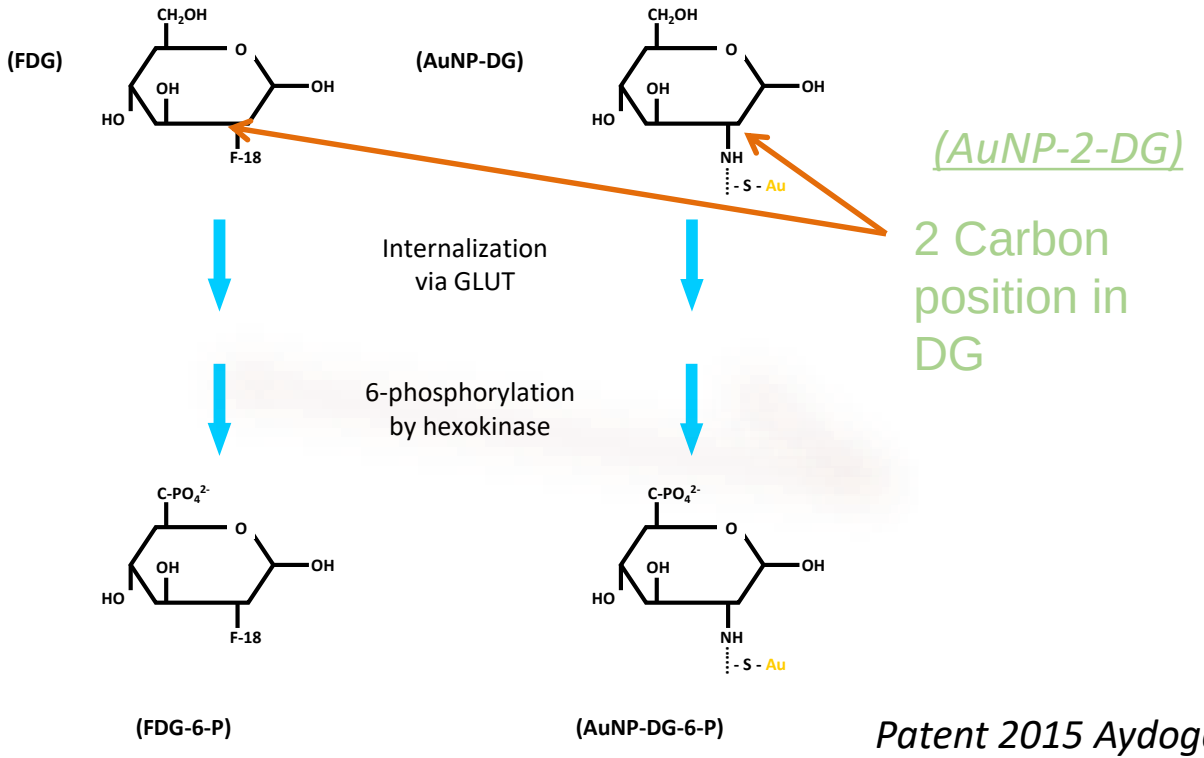
- Longer blood retention due to large molecular weight
- Easier to synthesize: wet chemistry lab
- Stable and long shelf life
- Non-radioactive
- EPR-effect
- **Tumor-specific targeting*
- *Toxicity?*

- **Tumor-specific targeting only with tagging.*


Normal cells
GLUT1–4
Glucose
HK1, HK2, GCK
ATP
ADP
PPP
G6P
Hexosamine synthesis pathway
Glycogenesis
GPI
PFKFB1–4
F2,6BP
F6P
PFK1
ATP
ADP
F1,6BP
ALDOA–C
TPI
Glycerol-3P
DHAP
G3P
GAPDH
NAD+
NADH
FAS
1,3BPG
PGK1
ADP
ATP
3PG
Serine biosynthesis
PGAM1
2PG
FAS
ENO
PEP
AcCoA
PKM1, PKM2, PKR, PKL
ADP
ATP
α-KG
Citrate
Succinate
NAD+
NADH
Lactate
Pyruvate
AcCoA
TCA cycle
Fumarate
LDHA–D
OAA
Malate
MCT1–4
Cancer cells
GLUT1, GLUT3
Glucose
HK2, HK1
ATP
ADP
PPP
G6P
Hexosamine synthesis pathway
Glycogenesis
GPI
PFKFB3, PFKFB4
F2,6BP
F6P
PFK1
ATP
ADP
F1,6BP
ALDOA, ALDOB
TPI
Glycerol-3P
DHAP
G3P
GAPDH
NAD+
NADH
FAS
1,3BPG
PGK1
ADP
ATP
3PG
Serine biosynthesis
PGAM1
2PG
FAS
ENO
PEP
AcCoA
PKM1, PKM2
ADP
ATP
α-KG
Citrate
Succinate
NAD+
NADH
Lactate
Pyruvate
AcCoA
TCA cycle
Fumarate
LDHA, LDHB
OAA
Malate
MCT1–4

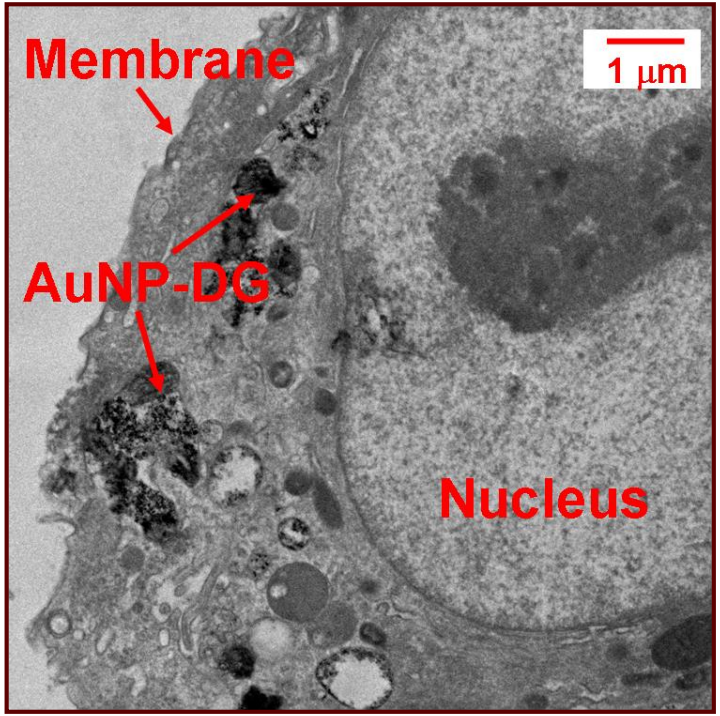
AuNP-DG

Uptake/entrapment of AuNP-DG are similar to FDG



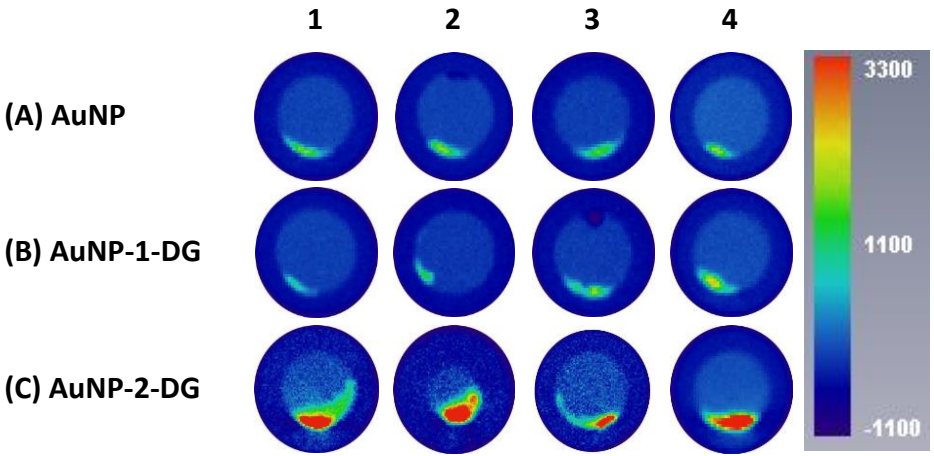
Patent 2015 Aydogan and Rajh

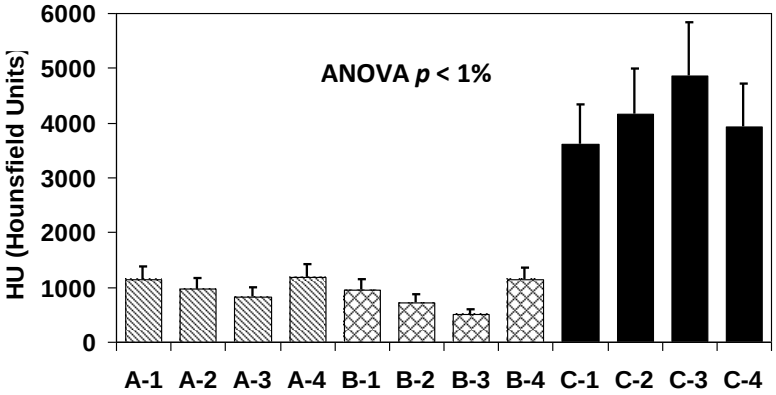
TEM imaging



intracellular localization of the AuNP-DG

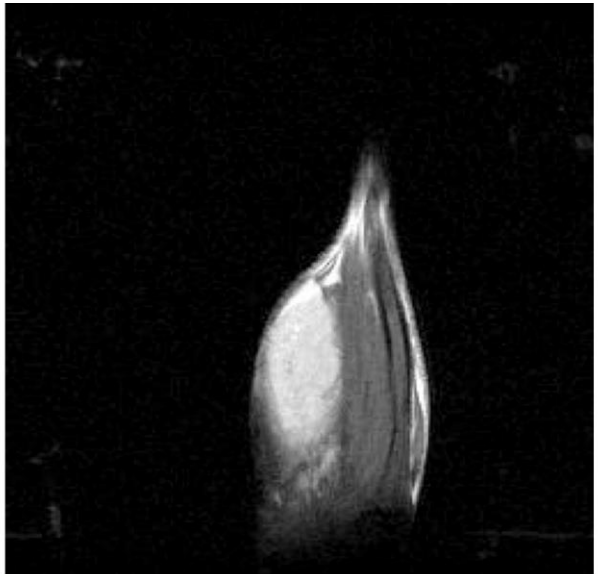
Results



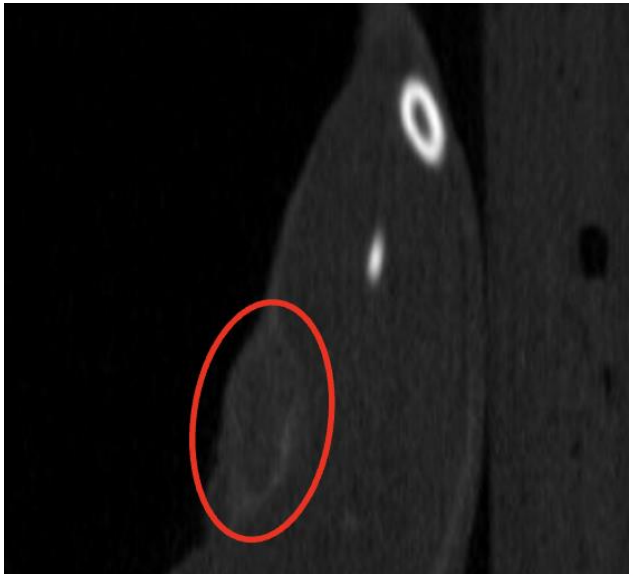


Aydogan et al. Phys Med Biol. 2010 Aug 7;55(15):4389-97. Epub 2010 Jul 20.

MR vs CT vs CT with AuNP-DG



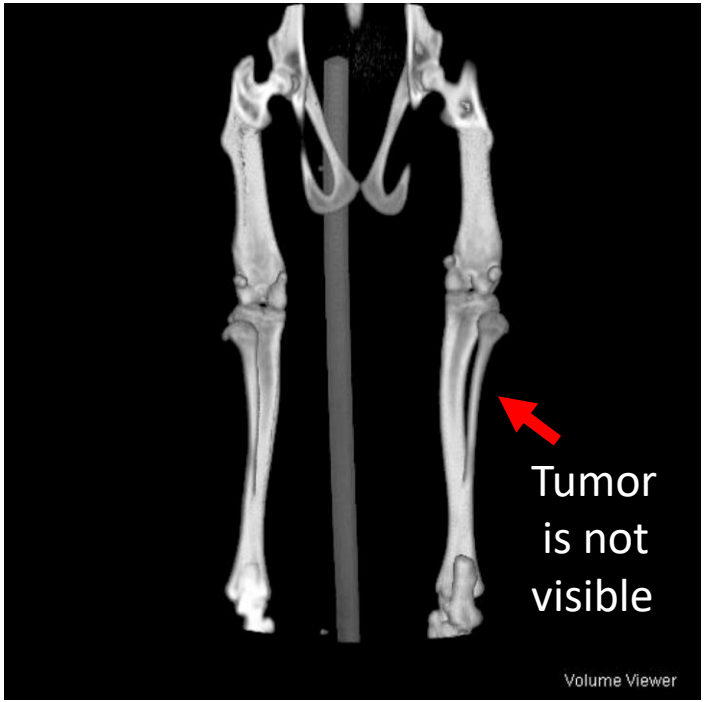
MRI

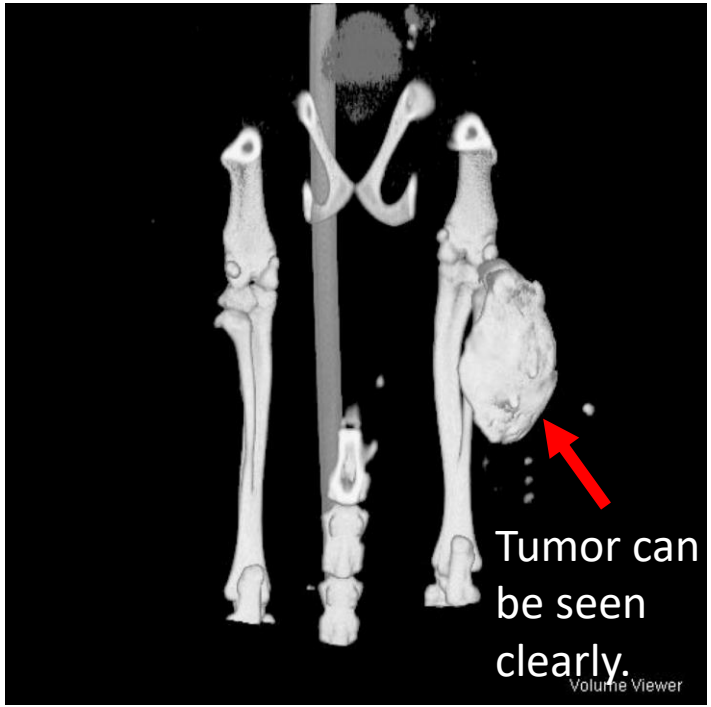


CT with AuNP-DG

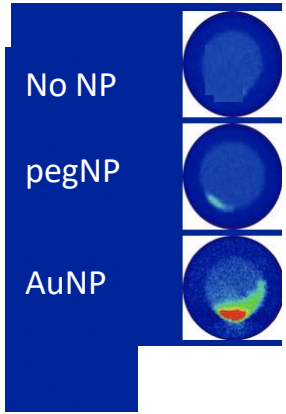
Animal Imaging

3D rendering of the same mouse after 1 hour post injection.

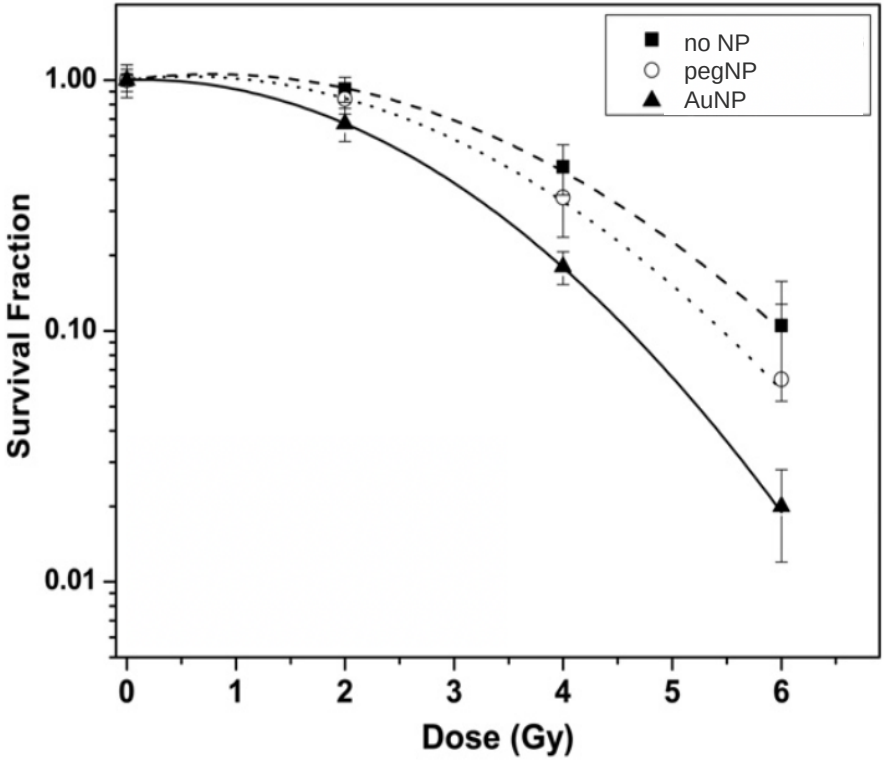




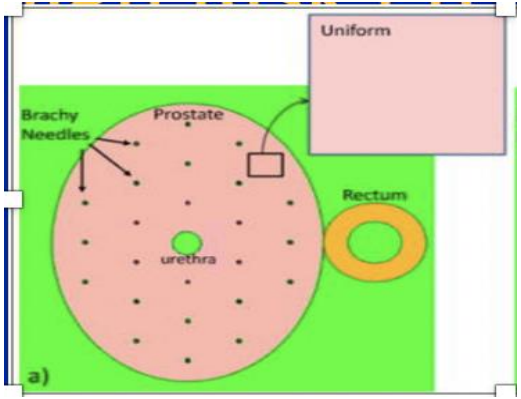
Theranostic application of AuNP

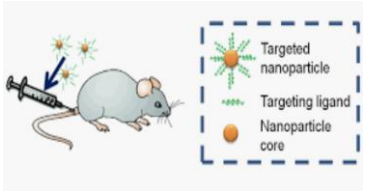


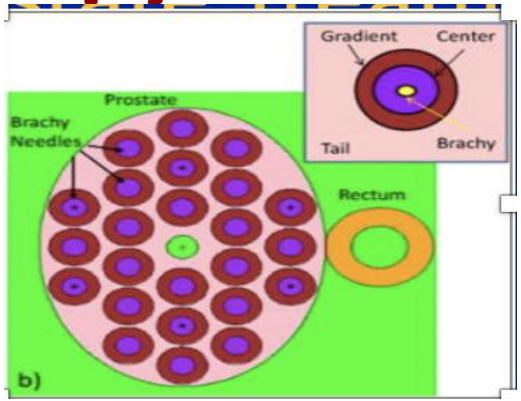
6MV Treatment

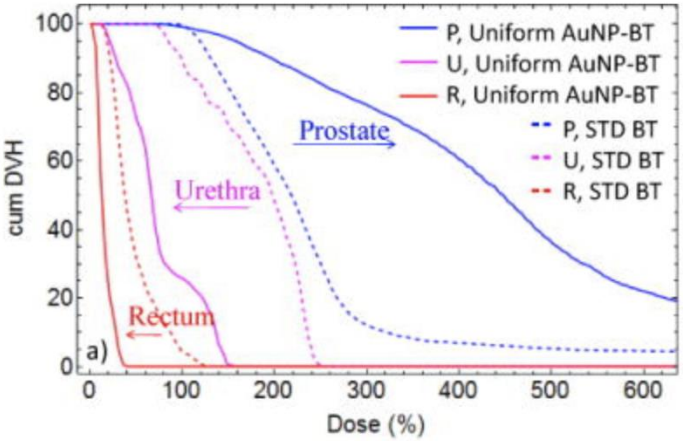


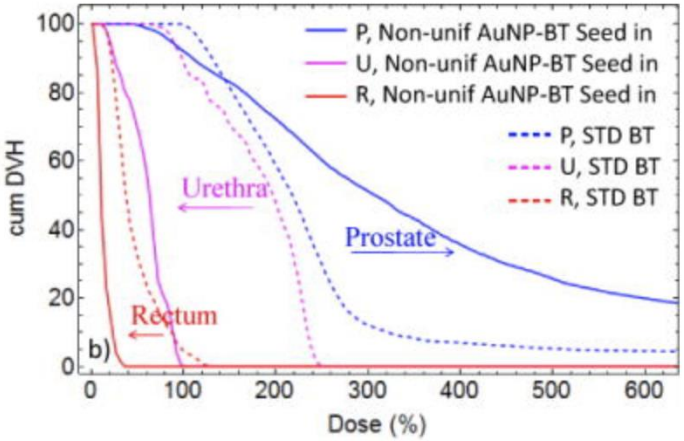
Clinical Applications 1
Nano Enhanced Brachytherapy



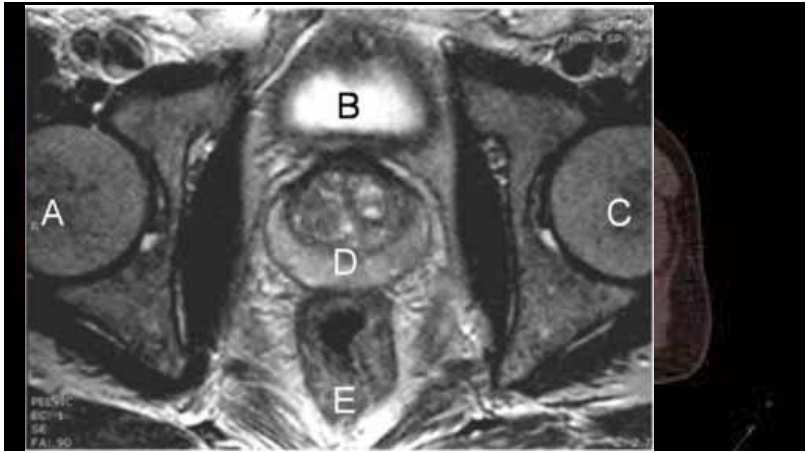


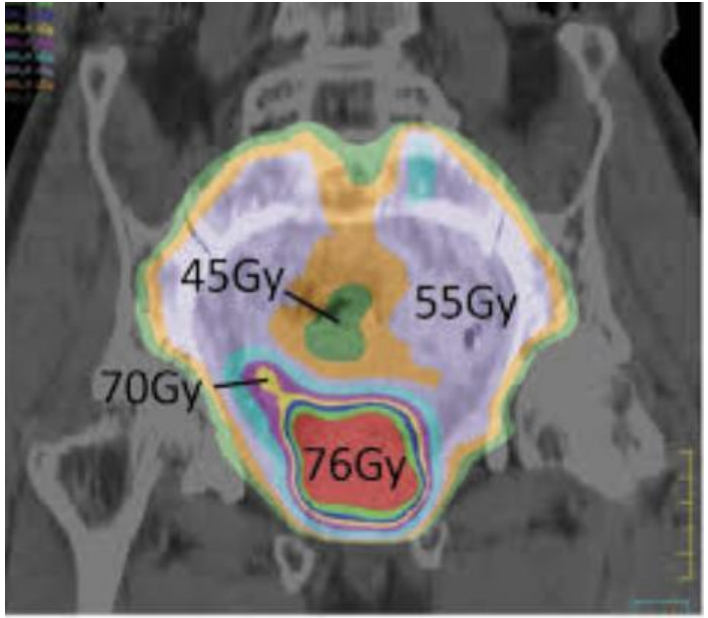






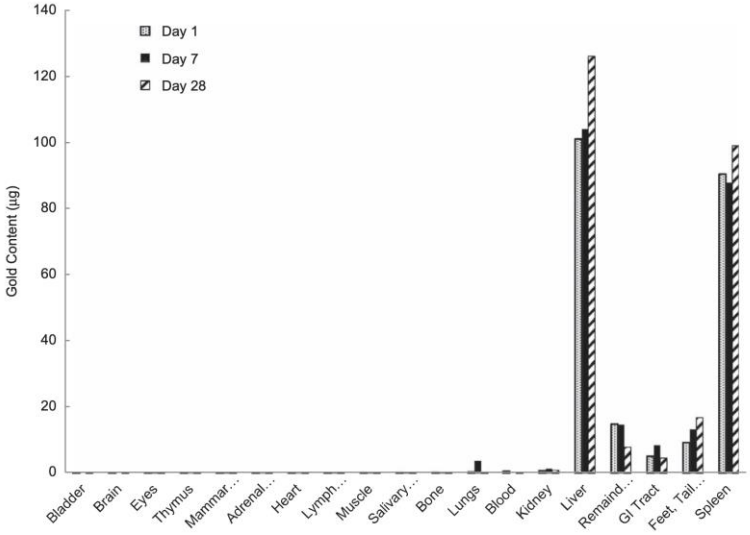
Clinical Applications 2
Personalized Prostate Treatment



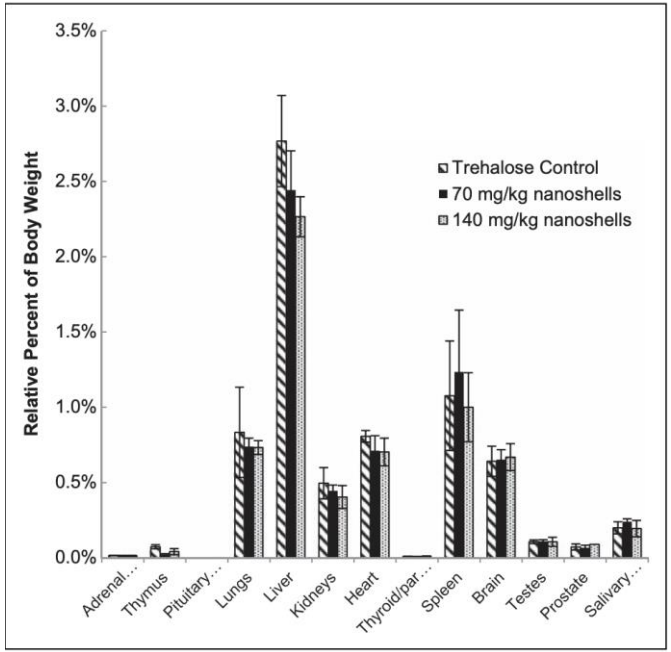


Toxicity

Mice



Dogs 10 months



Toxicity

Table 2. Histopathological Findings From 10-Month Chronic Dog Study.

			Incidences		
		Dose group	Control	70 mg/kg	140 mg/kg
		Number of animals	4	4	4
Tissue	Lesion type	Severity			
Heart (3)	Infiltrate	Minimal			1
	Inflammation	Minimal	1		
	NSF		11	12	11
Lung	Hemorrhage	Mild			1
	Histiocytosis	Minimal	1		
	Infiltrate	Minimal		2	1
	Inflammation	Minimal	1		
	Inflammation	Mild	1		
	NSF		5	6	6
Liver	Pigment, exogenous	Mild		7	1
	Pigment, exogenous	Moderate		1	7
Spleen	Congestion	Minimal			1
	Congestion	Mild	1	2	1
	Congestion	Moderate	3	2	
	Pigment, exogenous	Minimal		2	
	Pigment, exogenous	Mild		1	
	Pigment, exogenous	Moderate			4
Left kidney	Infiltrate	Minimal	1		
	Mineralization, pelvic	Minimal	3	4	4
	NSF		1		
Right kidney	Mineralization, pelvic	Minimal	3	4	3
	Nephropathy	Minimal	1		
	NSF		1		1

The thorough evaluation conducted on the gold nanoshell at the extensive exposure levels evaluated here identified no indication of toxicity, lack of tolerance, or immunological effects.

Gad et al. Int. J. of Toxicology, 2012

Project 2: Precision Treatment for Prostate Cancer

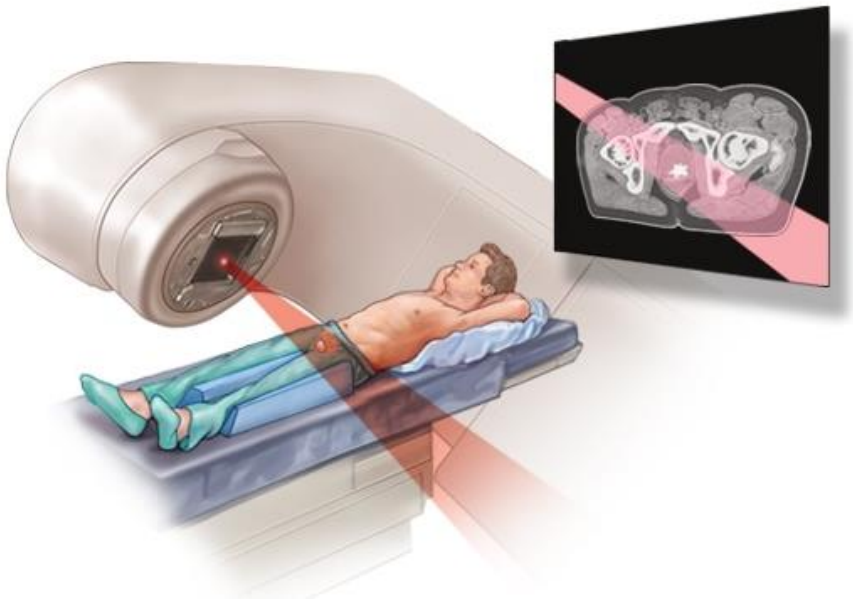
1 in **9** American men will have prostate cancer during his life

No.1 most commonly diagnosed cancer for men (268, 490 estimated new cases in 2022)

nearly **3.1** million American men living with prostate cancer

No.2 #2 leading cause of cancer death among American men (34, 500 estimated death in 2022)

Radiation therapy for prostate cancer



Radiation therapy (RT)
Intensive energy beam: X-rays, protons

Potential side effects of RT for prostate cancer:

- Frequent urination
- Difficult or painful urination
- Blood in the urine
- Urinary leakage
- Abdominal cramping
- Diarrhea
- Painful bowel movements
- Rectal bleeding
- Rectal leaking
- Fatigue
- Sexual dysfunction, including diminished erectile function or decrease in the volume of semen
- Skin reactions (similar to a sunburn)
- Secondary cancers in the region of the radiation

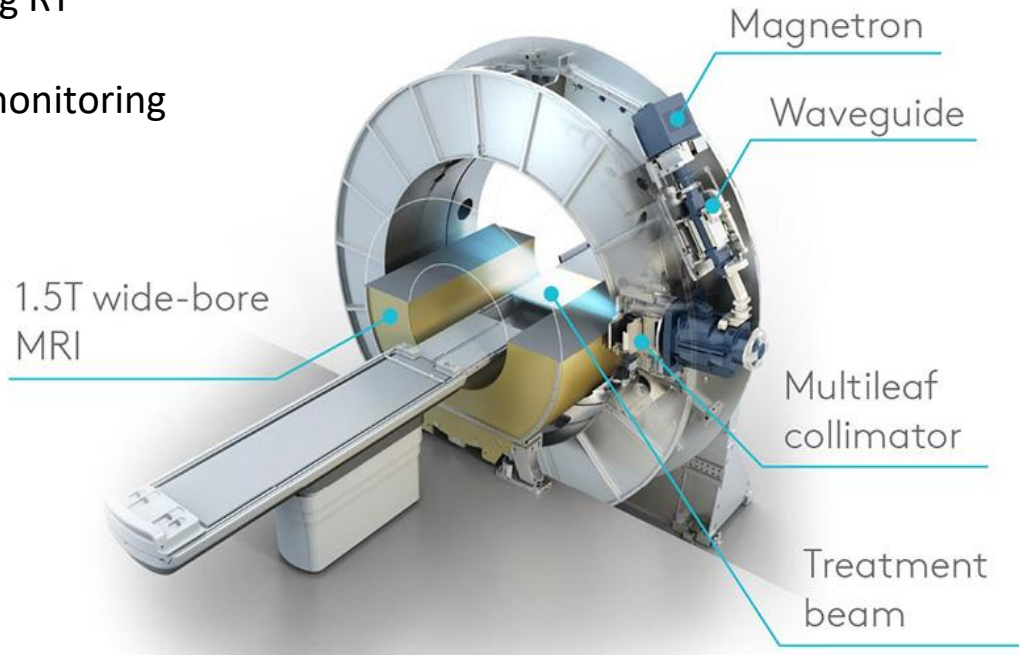
MRI-guided Radiation therapy

Image-Guided Radiation Therapy (IGRT)

- Incorporates imaging techniques during RT
- Accurate and precise
- Improved definition, localization and monitoring of tumor position, size and shape
- Decrease normal tissue damage

MRI-Guided Radiation Therapy

- Excellent soft tissue contrast
- Real time volumetric tracking
- No ionizing radiation for imaging



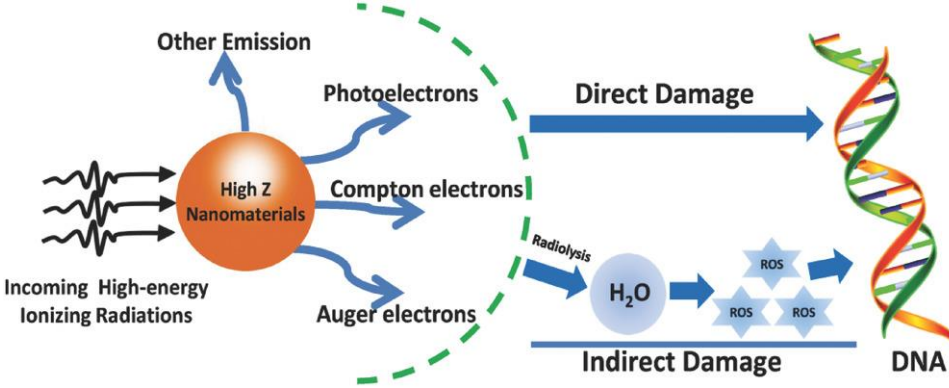
Elekta Unity High-Field MRI/Linac System

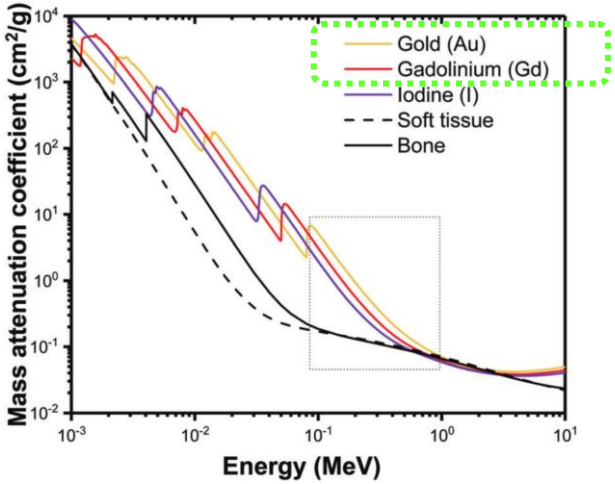
Radiosensitizers

Radiosensitizer: compounds that increase the cytotoxicity of ionizing radiation

Heavy-metal nanomaterials with high atomic number (Z) values

absorb, scatter, and emit radiation energy





Goswami, N. et al. *Mater. Horiz.* 2017, 4, 817-831

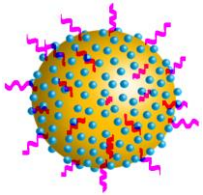
Need to deposit the High Z nanomaterials efficiently to tumor !

Targeting

Xie, J. et al. *Adv. Mater.* 2019, 31, 1802244

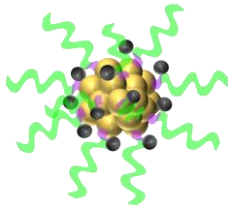
Project 3 : Hafnium Nanostructures as Radiosensitizers

Au-Gd-PSMA NPs :



- High relaxivity (sensitivity)
- Selectively targeting to prostate cancer
- Synergetic sensitizing effect of Au and Gd

Au-Gd-PSMA NCs :

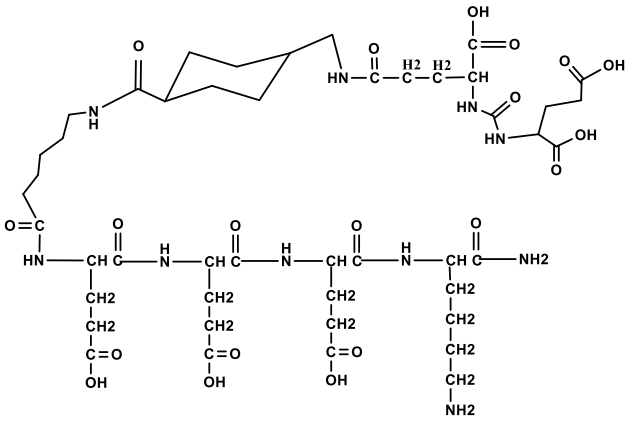


- MR/FL imaging
- Selectively targeting to prostate cancer

Radiation therapy of prostate cancer:

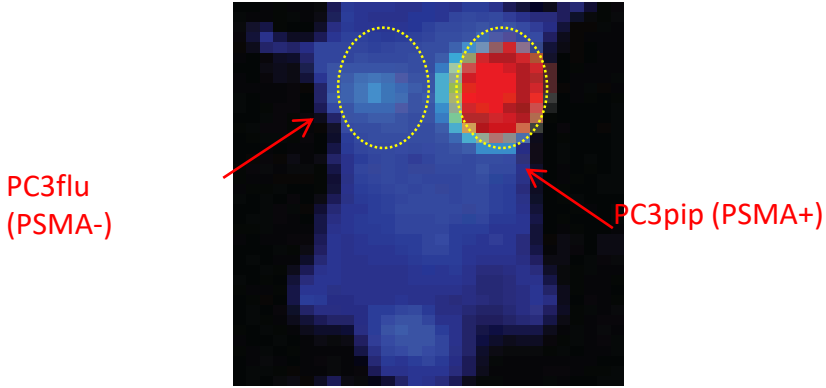
- Selective accumulation of NPs at prostate tumor
- Precise tumor localization by MRI
- Radiosensitizing enhancement and tumor inhibition by both Au and Gd
- Potentially used for MRI guided radiation therapy in other tumor models
- Can be combined with other chemotherapy/radiosensitizers

PSMA targeted ligand



PSMA-1

IC_{50}=2.30 nM



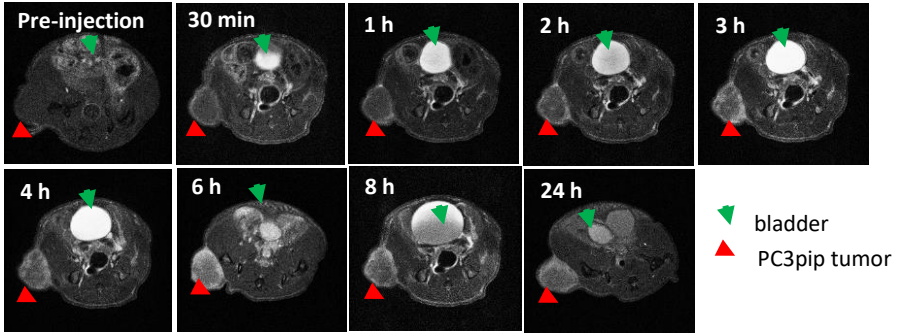
PSMA-1-Cy5.5

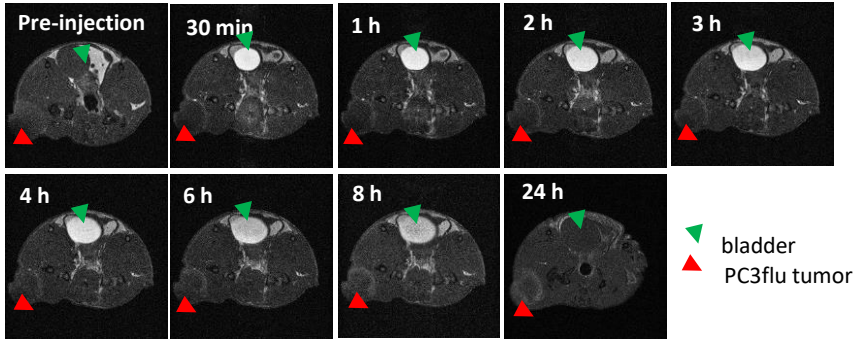
Wang X., et al. *Mol Cancer Ther*, 2014, 13, 2595.

is **a far-red (and near-infrared) emitting dye**

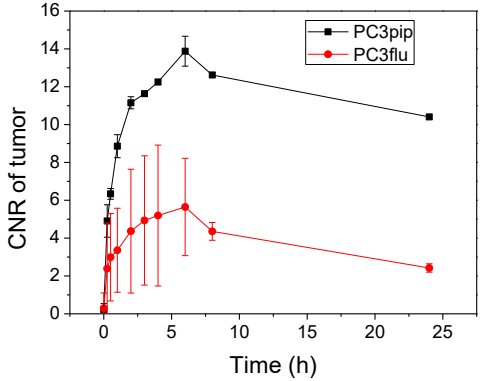
In vivo MR imaging of prostate cancer

T1-weighted spin echo axial images
Injecting dose 60 umol/kg Gd

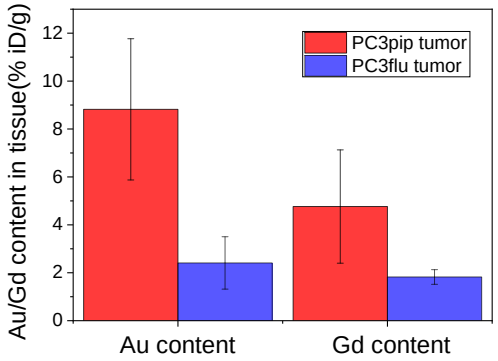




Tumor CNR

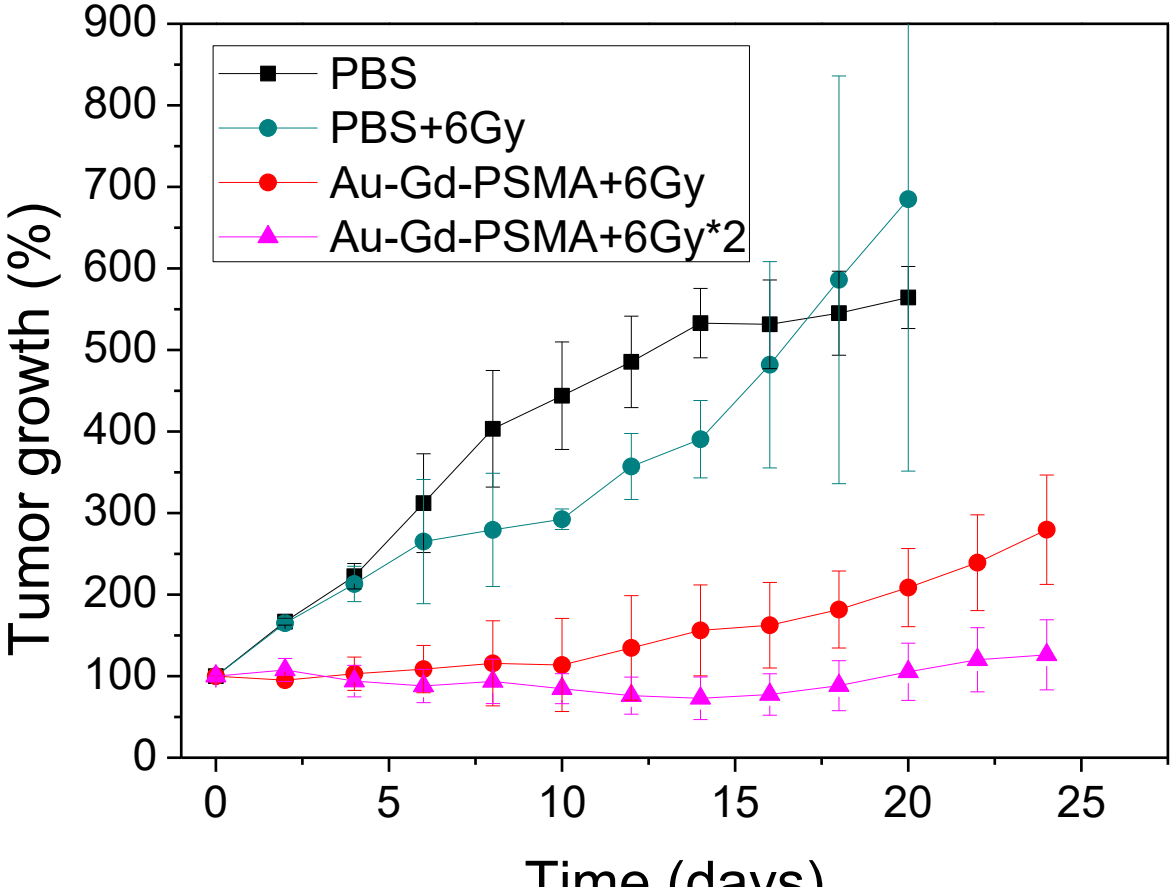


Au and Gd content in tumor

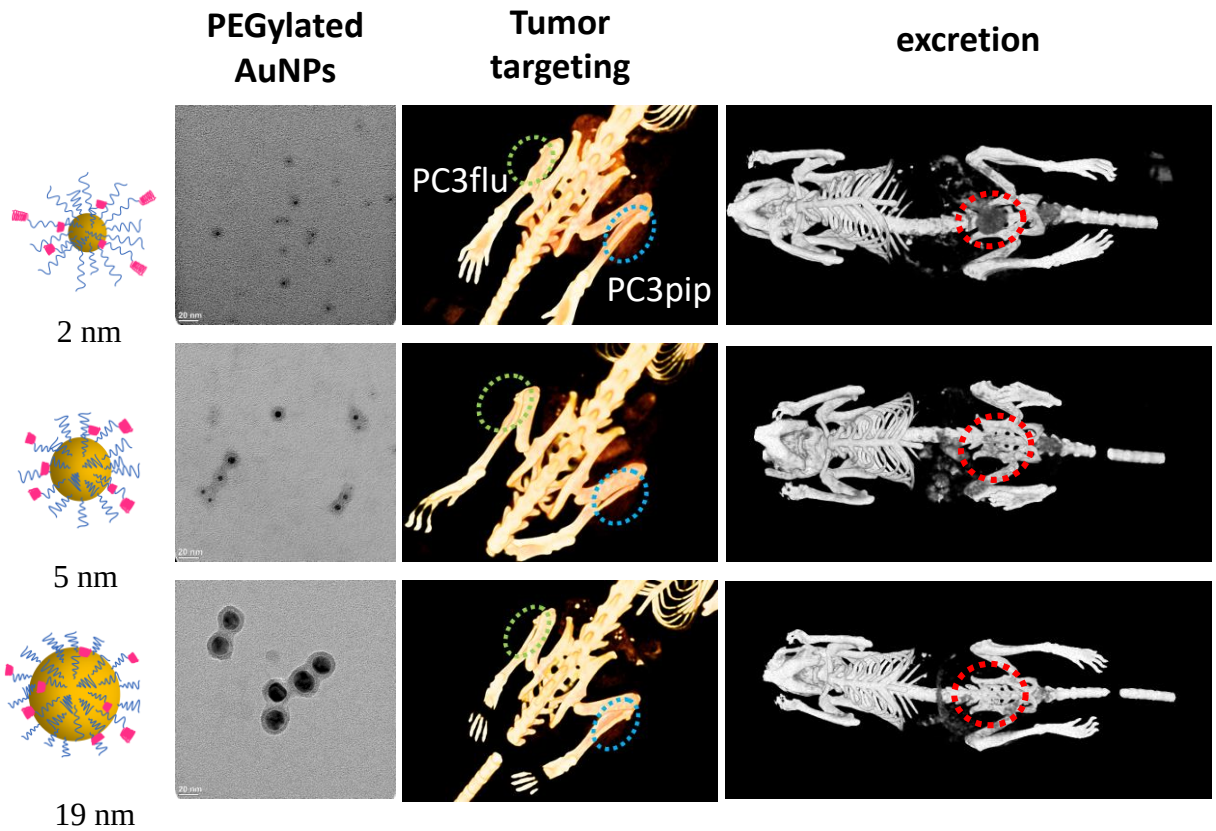


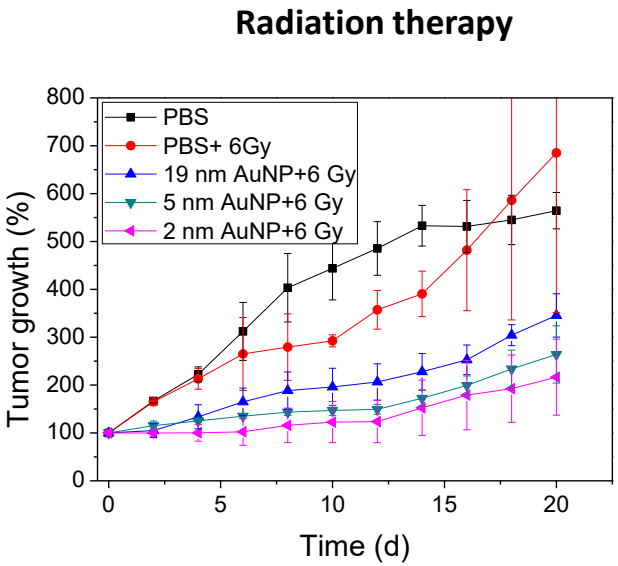
Radiation therapy for prostate cancer

Irradiation doses,
6 Gy x1
vs
6 Gy x2
4h & 24h



PSMA targeted AuNPs and size

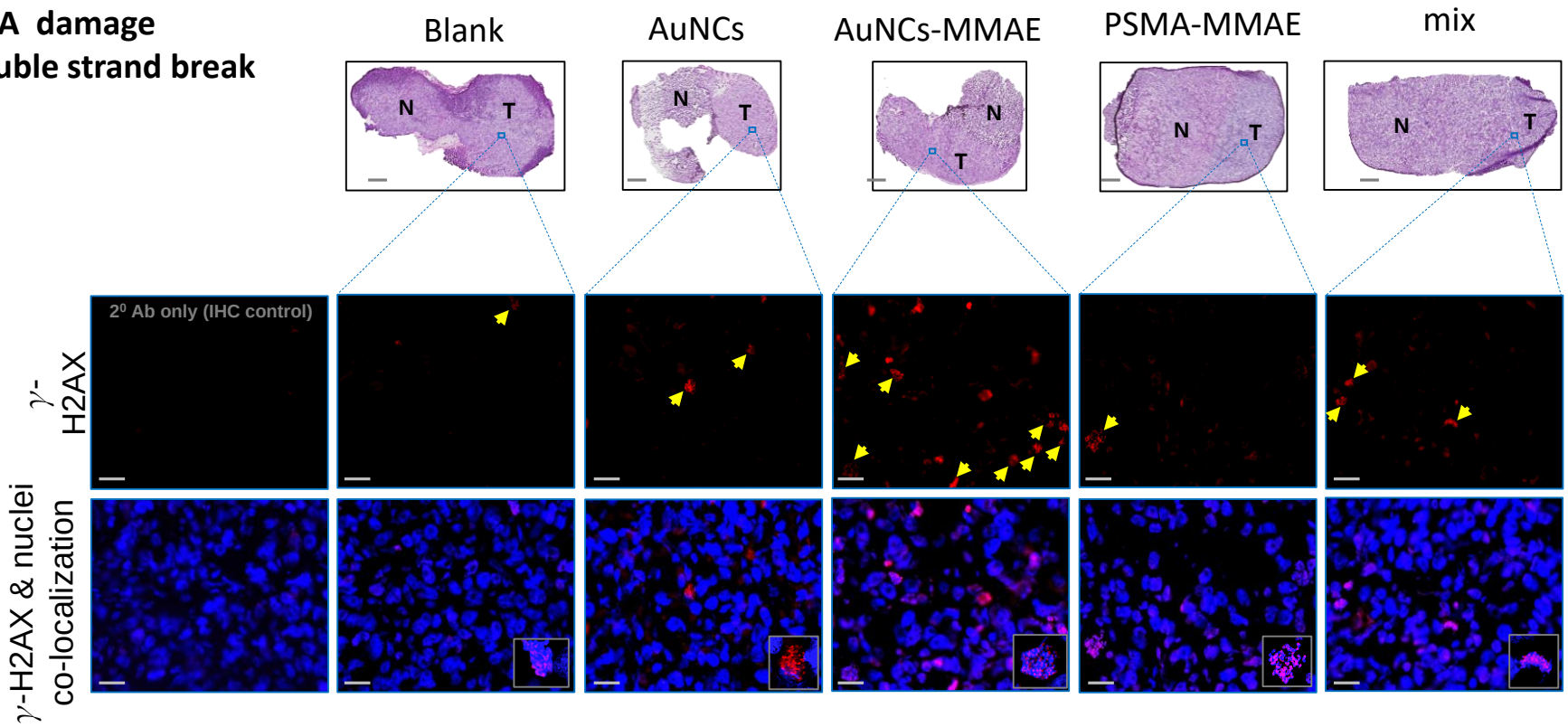




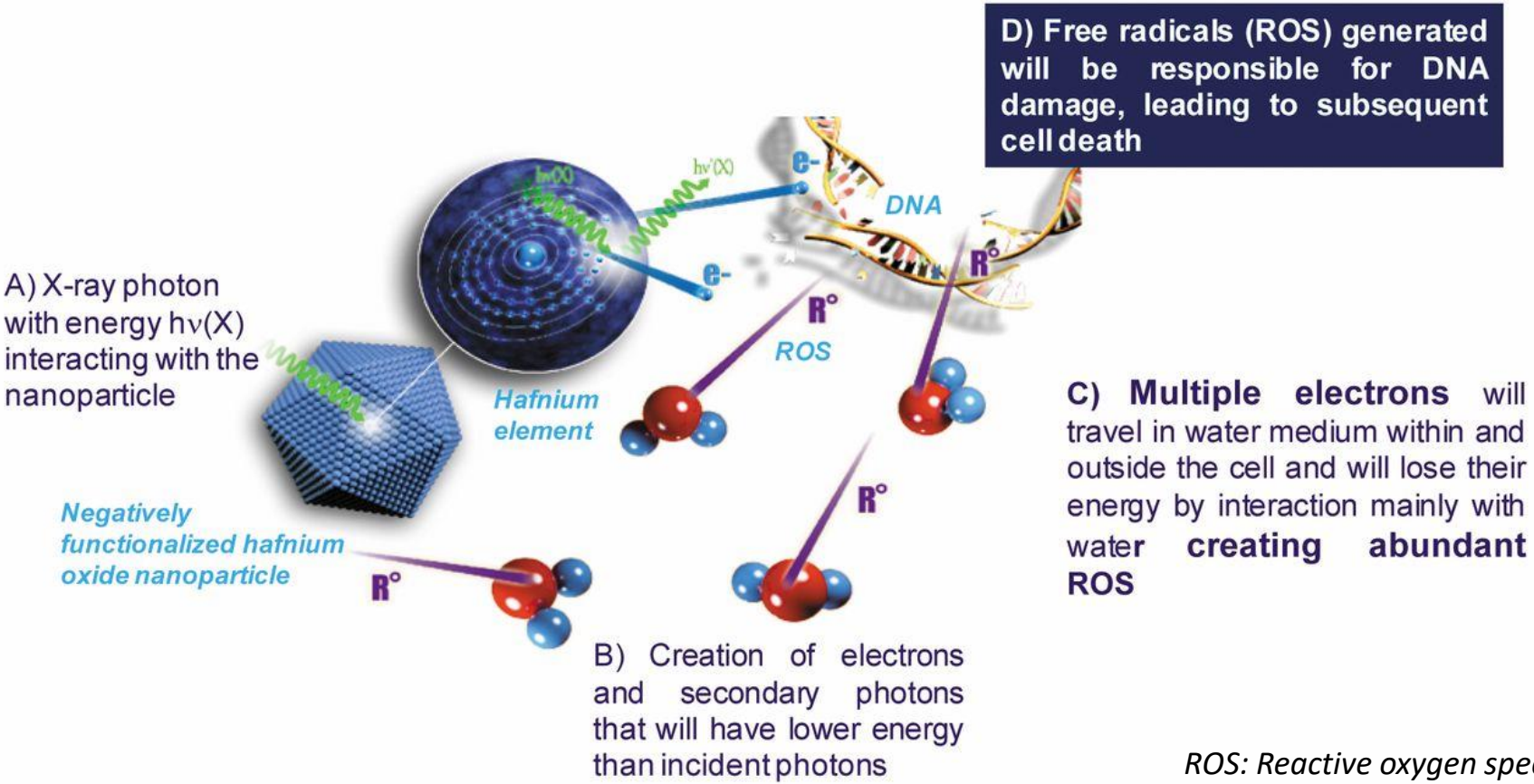
Luo, D., et al. *Chem. Sci.*, 2019

Tumor staining – with radiation

DNA damage
Double strand break

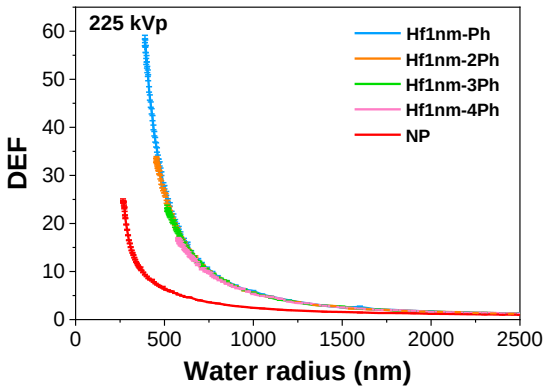


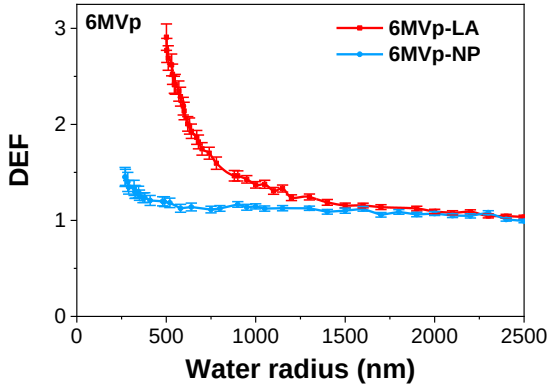
Project 3 : Hafnium Nanostructures as Radiosensitizers

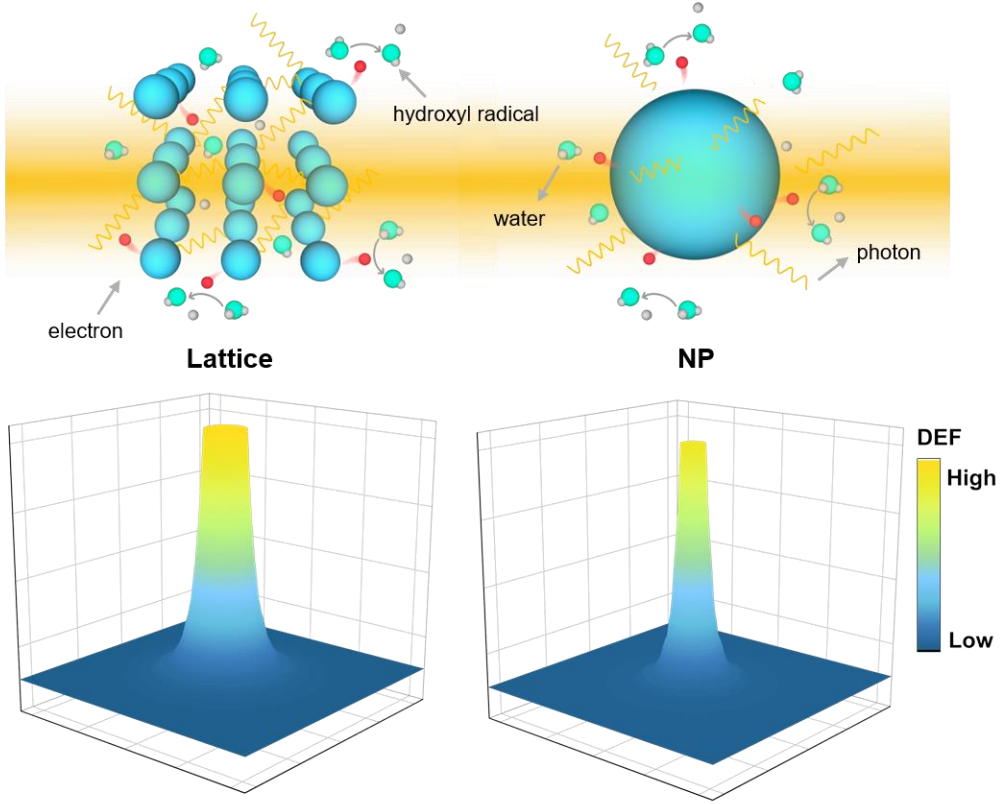


ROS: Reactive oxygen species

Monte Carlo Simulations Confirm Superior Radioenhancement by Nanoscale Metal-Organic Frameworks (nMOF)

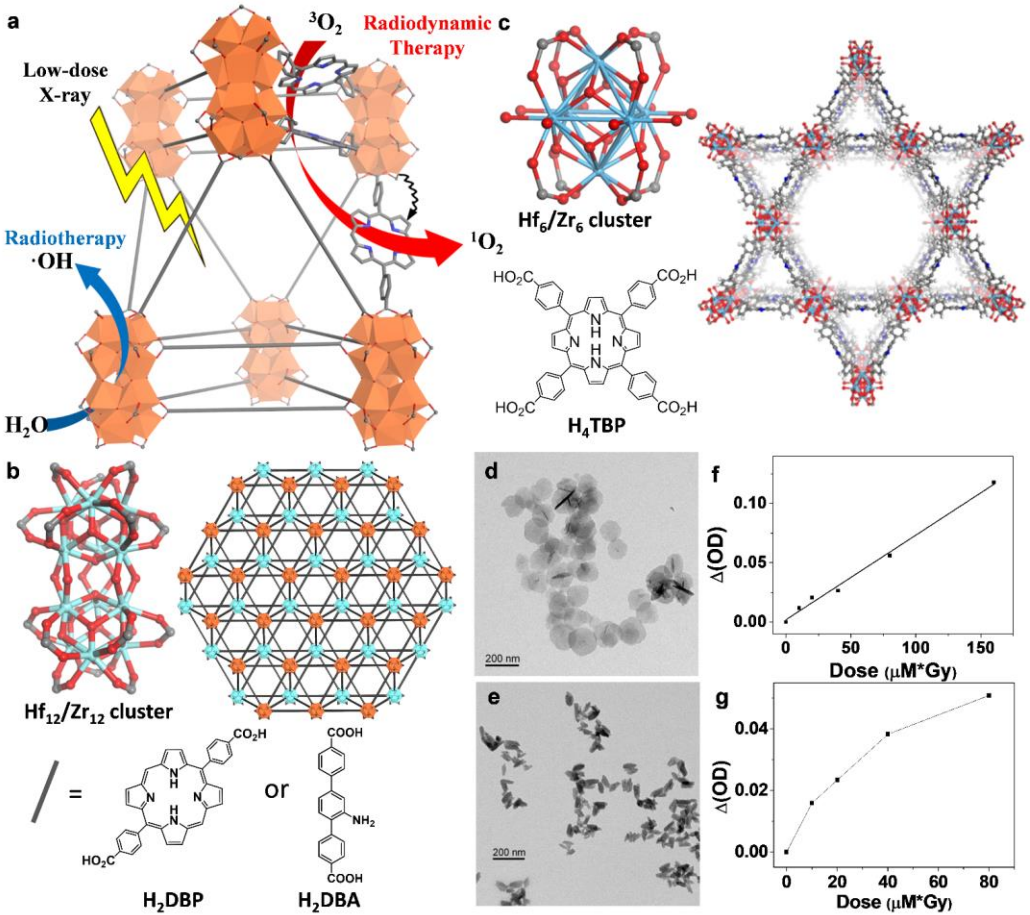






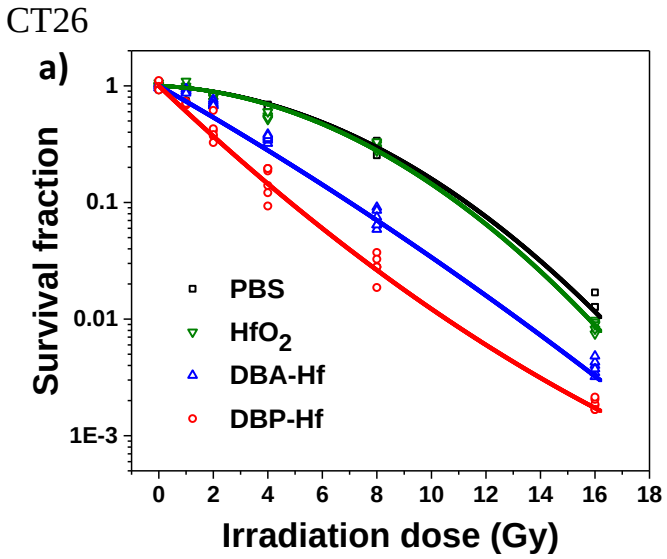
Xu, Z. et al. *Adv. Matter.* **2021**, *33*, e2104249.

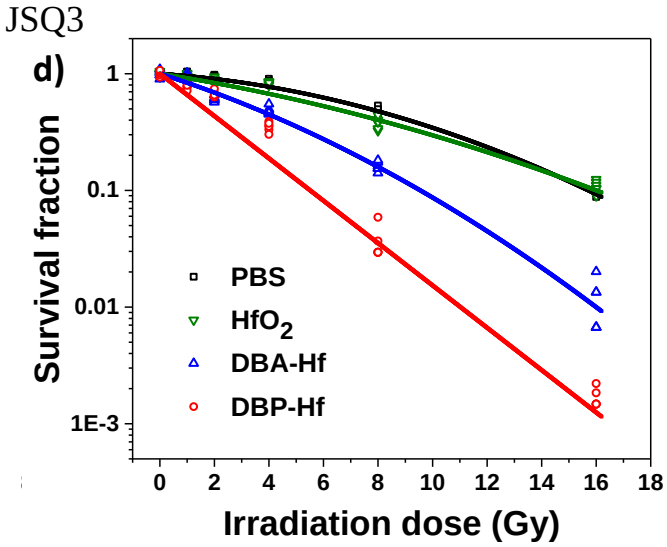
nMOFs Enable Low-dose X-ray Radiotherapy-Radiodynamic Therapy (RT-RDT)



Nat. Biomed. Eng. **2018**, 2: 1899.

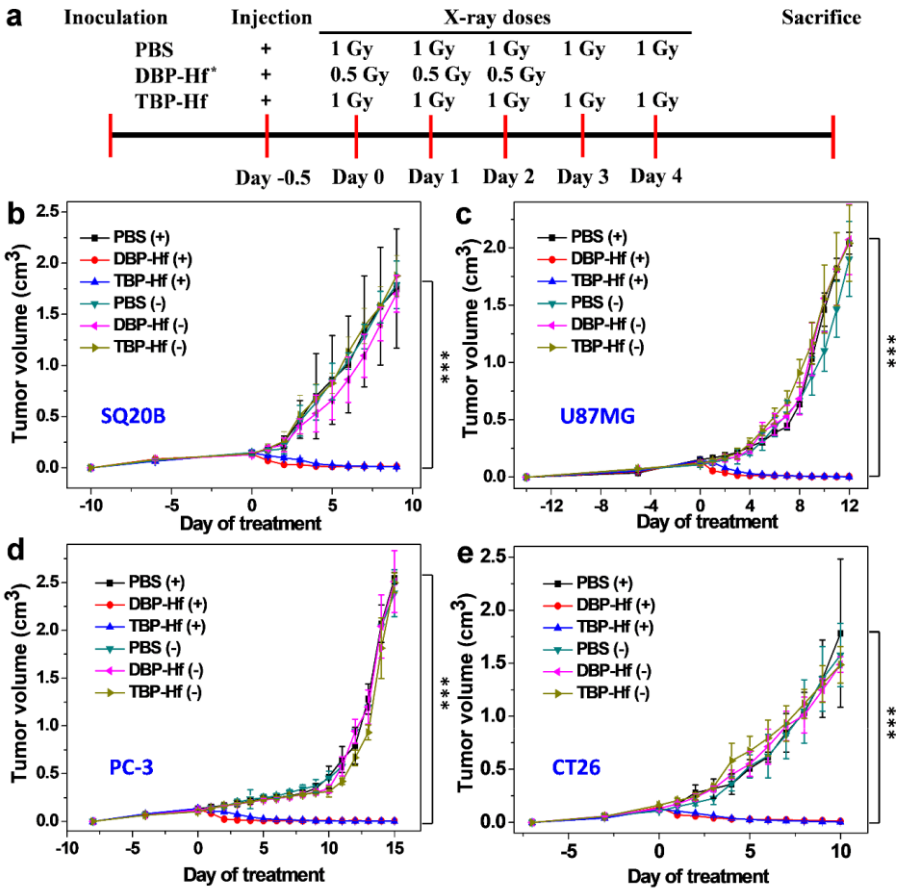
nMOF Radioenhancement Effects

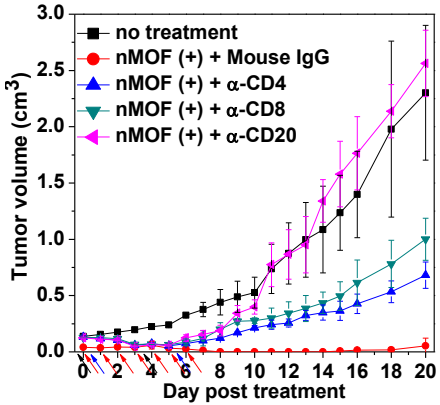




REF at 10% Survival (6 MeV LINAC)	CT26	4T1	Hela	JSQ3	SQ20B	TUBO
HfO_2	1.01	1.09	1	1.13	1.04	1.09
DBP-Hf	2.15	3.29	2.16	1.88	1.93	2.97

nMOFs Enable Low-Dose X-Ray Radiotherapy-Radiodynamic Therapy (RT-RDT)





Antibody blocking experiments

RiMO-301 in phase 1 clinical trial

NCT03444714: Phase I Study of RiMO-301 with Radiation in Advanced Tumors

RiMO-301, courtesy of RiMO Therapeutics, Inc.

- ✓ Phase 1 Principal Investigator: Steven J. Chmura, MD, PhD and B. Aydogan, PhD
- ✓ 25 patients treated
- ✓ No systemic toxicity
- ✓ Promising efficacy with local PR and CR

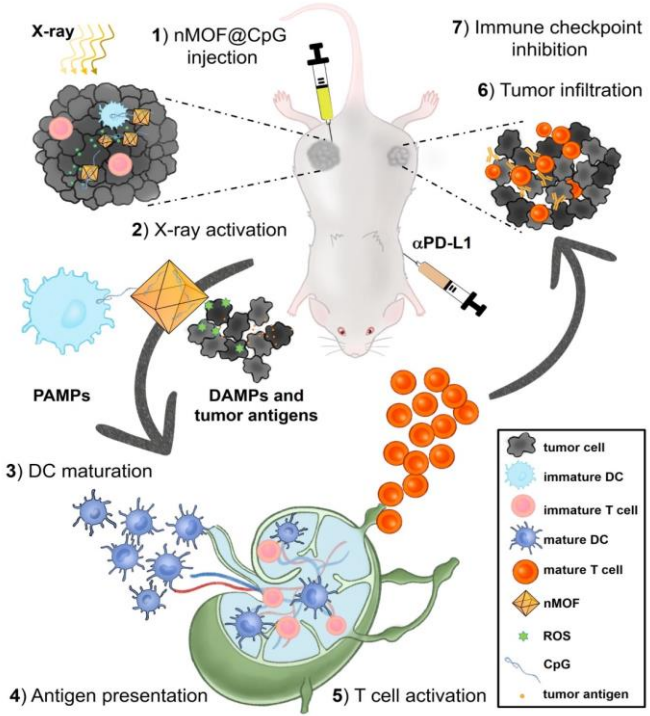
<u>Primary Objectives:</u>

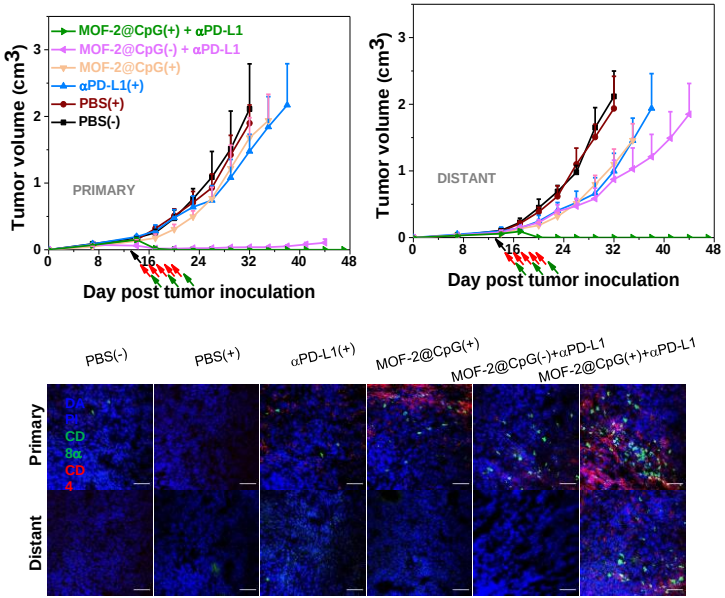
- The primary objective is to determine the maximum tolerated dose (MTD) of RiMO-301 as determined by toxicity observed in patients treated with palliative radiation doses

<u>Secondary Objectives:</u>

- To determine clinical response after RiMO-301 and radiotherapy as assessed by clinical response rate using clinical evaluation, imaging and/or symptom relief
- To characterize adverse events of RiMO-301 in patients with advanced cancers
- To evaluate the pharmacokinetics (PK) of RiMO-301 with radiation

nMOFs for X-ray activated *in situ* cancer vaccination





Ni, K.; Lan, G.; Guo, N.; Culbert, A,; Luo, T.; Wu, T.; Weichselbaum, R.R.; Lin, W. *Sci. Adv.* **2020**, *6*: eabb5223.

Acknowledgement

Thanks to Aydogan Lab!

Dr. Erik Pearson
Dr. Ji Li
Daniela Oliverda
Prof Chin-tu Chen

Thanks Basilion Lab!

Prof James P. Basilion
Prof Xinning Wang
Prof Ethan Walker
Dr. Dong Luo

Thanks Meade Group!

Prof Thomas J. Meade
Dr. Matthew Bailey
Andrew Johnson

Thanks Argonne Lab

Dr. Tijana Raj

Thanks to Lin Lab

Prof Wenbin Lin
Prof R Weicselbaum
Prof S Chmura

Thanks ACS for funding!

Thanks NIH for RO1 funding!

BIONANOTECHNOLOGY TOWARD ENVIRONMENT-FRIENDLY AGRICULTURE

IRFAN S. AHMAD
Holonyak Micro and Nanotechnology Laboratory; Grainger College of Engineering and College of Agricultural, Consumer, and Environmental Sciences
University of Illinois at Urbana-Champaign, USA

ABSTRACT

The global challenge is to feed 9 billion people by 2050 with a 60% increase in food availability. The agricultural and food sectors are confronted with such large issues as- climate change, urbanization, sustainable use of resources, and environmental issues like run-off and accumulation of pesticides and fertilizers. Bionanotechnology can address such impacts as damage to the ecosystem with toxin-release due to the over application of fungicides, insecticides, pesticides, and fertilizers. Bionanotechnology can contribute to the potential increase in crop production, food security, and sustainability. Fundamental and innovative research is needed to address these challenges for improved biodiversity, productivity, nutrition, and quality. This entails understanding the mechanisms of host-parasite interactions at the molecular level, development of new generation of pesticides and their transport mechanisms, preservation, and packaging of food. The talk will focus on research efforts toward environment-friendly agriculture through the development of liposomes as a novel carrier for designing slow-release formulations of commercially available nematicides, the use of CuO nanoparticles for disease management and plant health improvement, and the sensing of soil nitrates.

Keywords: Cellular biology, Copper oxide, Antifungal, Targeted delivery, Micro and Nanotechnology, Nanoparticles, Pesticides.

Irfan S. Ahmad

Bionanotechnology Research toward Environment-Friendly Agriculture

October 18-19, 2022
Islamic World Academy of Sciences
Rabat, Morocco

ILLINOIS
Holonyak Micro &
Nanotechnology Laboratory
GRAINGER COLLEGE OF ENGINEERING

Remembering

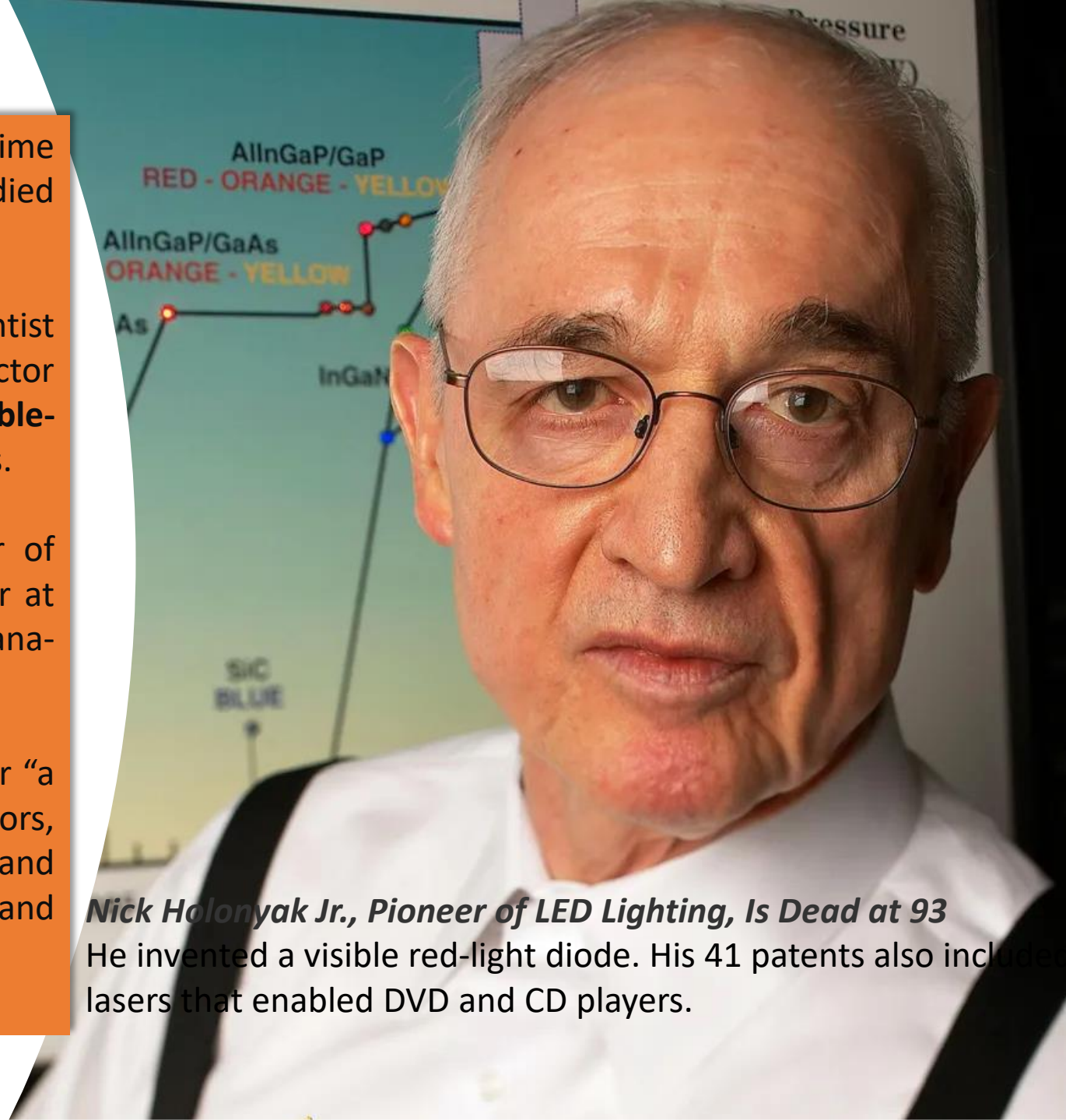
A giant and a colleague at HMNTL

Nick Holonyak Jr., a prolific inventor and longtime professor of electrical engineering and computing, died on 17 September at the age of 93.

In 1962, while working as a consulting scientist at General Electric's Advanced Semiconductor Laboratory, **he invented the first practical visible-spectrum LED**. It is now used in light bulbs and lasers.

Holonyak left GE in 1963 to become a professor of electrical and computer engineering and researcher at his alma mater, the University of Illinois Urbana-Champaign. He retired from the university in 2013.

Holonyak received the 2003 IEEE Medal of Honor for "a career of pioneering contributions to semiconductors, including the growth of semiconductor alloys and heterojunctions, and to visible light-emitting diodes and injection lasers."



Nick Holonyak Jr., Pioneer of LED Lighting, Is Dead at 93
He invented a visible red-light diode. His 41 patents also include lasers that enabled DVD and CD players.

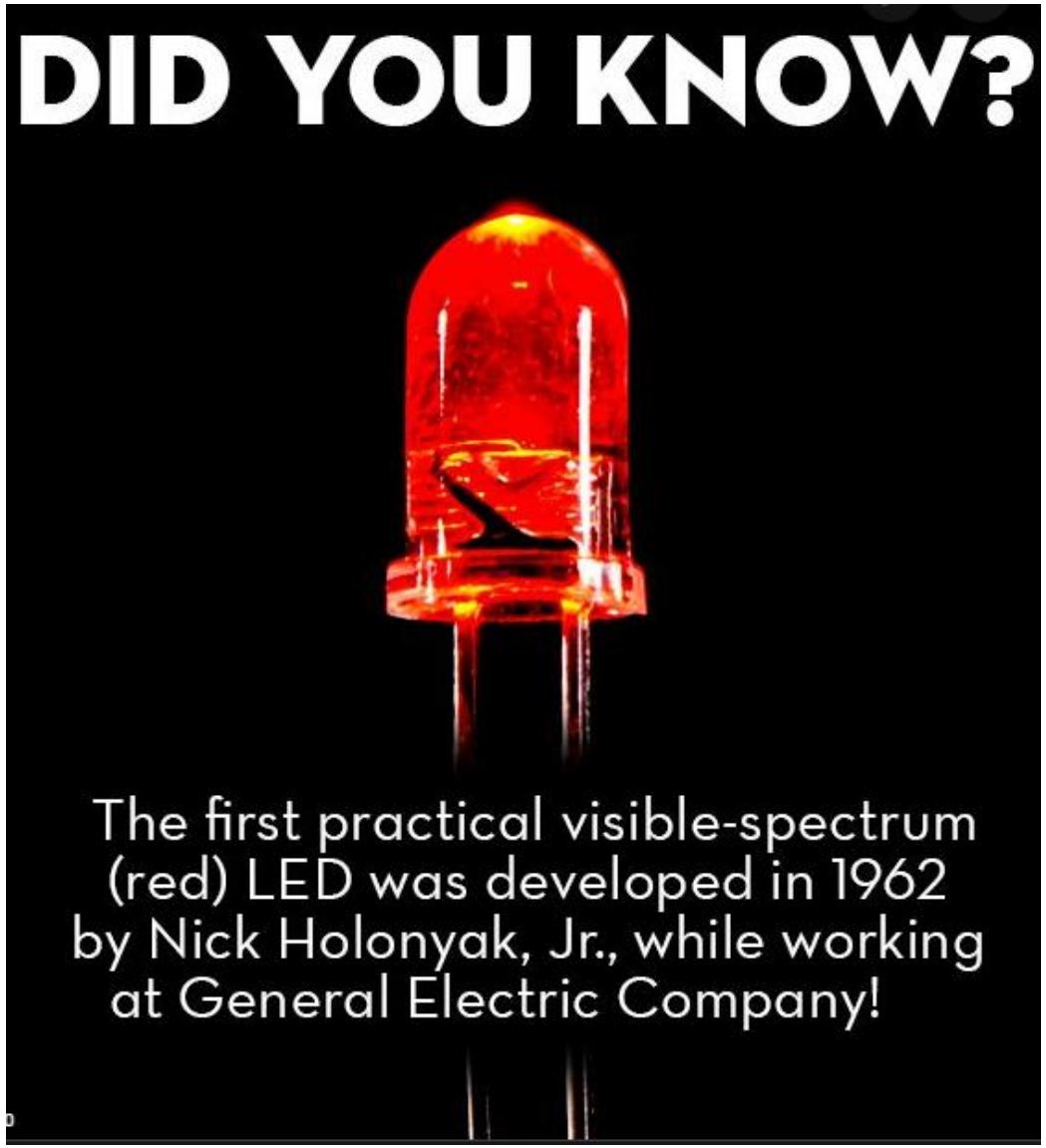
The Telegraph News Sport Business Opinion

Queen lights up LED inventor's day with honour after Nobel Prize snub

Prof Nick Holonyak, the man behind the red LED light, receives engineering award years after being overlooked by Nobel committee

By Hannah Furness, ROYAL CORRESPONDENT
8 December 2021 • 4:45pm

Prof Nick Holonyak, pictured with one of his inventions, said it was a 'great honour' to receive the Queen Elizabeth Prize for Engineering | CREDIT: Chris Jackson/Getty Images/Ralf-Finn Hestoft/Corbis via Getty Images



The New York Times

Nick Holonyak Jr., Pioneer of LED Lighting, Is Dead at 93

He invented a visible red-light diode. His 41 patents also included lasers that enabled DVD and CD players.

Willis Tower, Chicago, and State Farm Center, Urbana glowed red in honor of Nick Holonyak Jr.

https://www.nytimes.com/2022/09/30/science/nick-holonyak-jr-dead.html

Presentation Outline

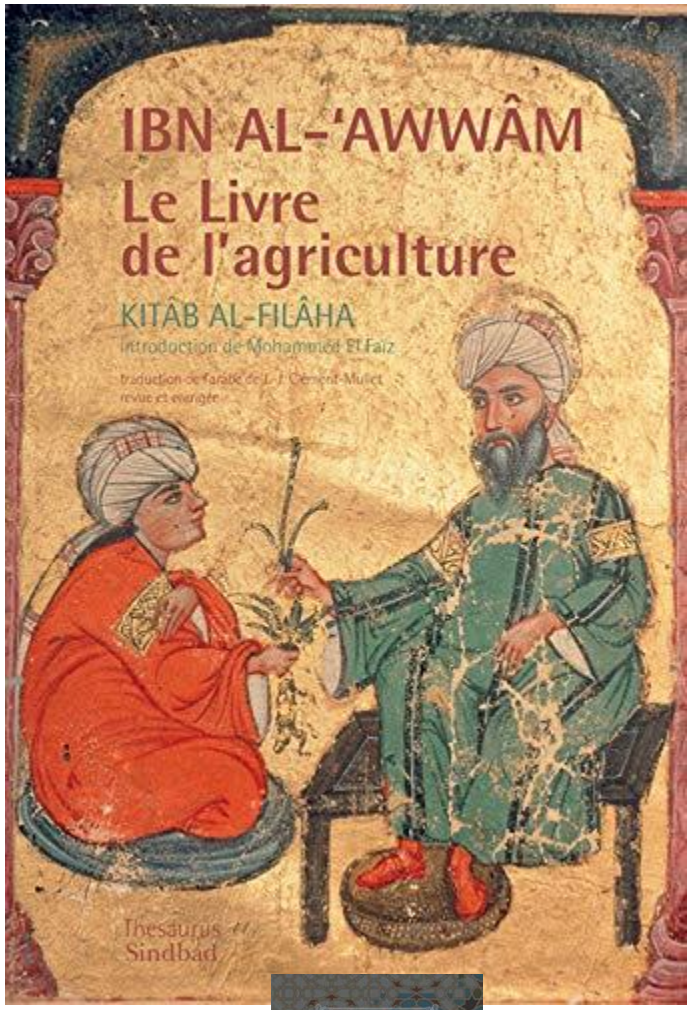
- Perspective
- About Bionanotechnology
- Projects
  - Digital Agriculture
  - CuO NP for Agriculture
  - Liposome Technology
  - Pathogenesis of fungi using NEMS
  - Rapid Testing of Nitrates in Soil
  - Plant Extracts for Cancer Nanomedicine
- Summary and Conclusions
- Acknowledgments

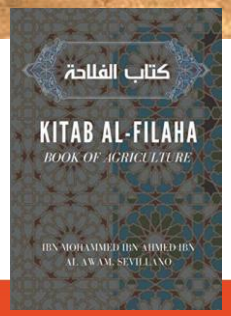
A Broad Perspective

https://www.ecomena.org/sustainability-islam/

Agricultural Practices in Islam

"land cultivation means fixing the land, planting trees, growing cereals and grains, and taking care of the same, in addition to a good knowledge of the fertile, semi-fertile, and useless land. Further, the knowledge of each kind of tree and plant to be planted on given earth, and the choice of the best kind and proper time, water, insecticides, and fertilizer for each kind of plant and tree are essential. How to store the production is also included."- Ibn al-Awwam





Ibn al-Awwam, *Kitab al-Filaha al-Andalusiyyah*, manuscript in the British Museum, p. 3.

Is there a Better Way to Feed the World?

Sound.ag

Sound.ag

BBC


SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

UN, 2015

UN Sustainable Development Goals: 2 and 6

- The main goal of the United Nations' 17 Sustainable Development Goals is to **eliminate hunger by 2030**.

- > Billion people suffer from malnutrition.

- Rising population and climate change continue to stress the food production and distribution stakeholders.

UN.org

Relationship between Agriculture, Food Security, and Climate Change

Climate variability impact on Agriculture

- *Large temperature variations- extremes*
- *Excessive rainfall*
- *Droughts and Famine*
- *Changes in diseases and pests*
- *Changes in atmospheric CO2*
- *Rising sea levels*
  - *reducing agricultural land*
  - *reduction in the variety of crops and pasture lands*

Agriculture's Impact on the Environment

- Soil chemical pollution
- Soil erosion
- Greenhouse gas emissions
  - deforestation
  - methane emissions from rice cultivation
  - nitrogen emissions from fertilizers

Food Security and Safety

- *To achieve sustainable food production capable of feeding the future population, resources must be used in a sustainable manner.*
- *Current agricultural practices that emerged during the green revolution are no longer viable. Nanomaterials may play an important role in the future of agriculture and food production in the recent era of evolving precision farming/site-specific crops.*
- *The most promising application of nanotechnology is in smart crop and food production processes.*

Challenges

- Climate Change
- Rapidly growing Population
- Urbanization
- Sustainability of Natural Resources


Interpress Service


Middle East Eye


BBC.com

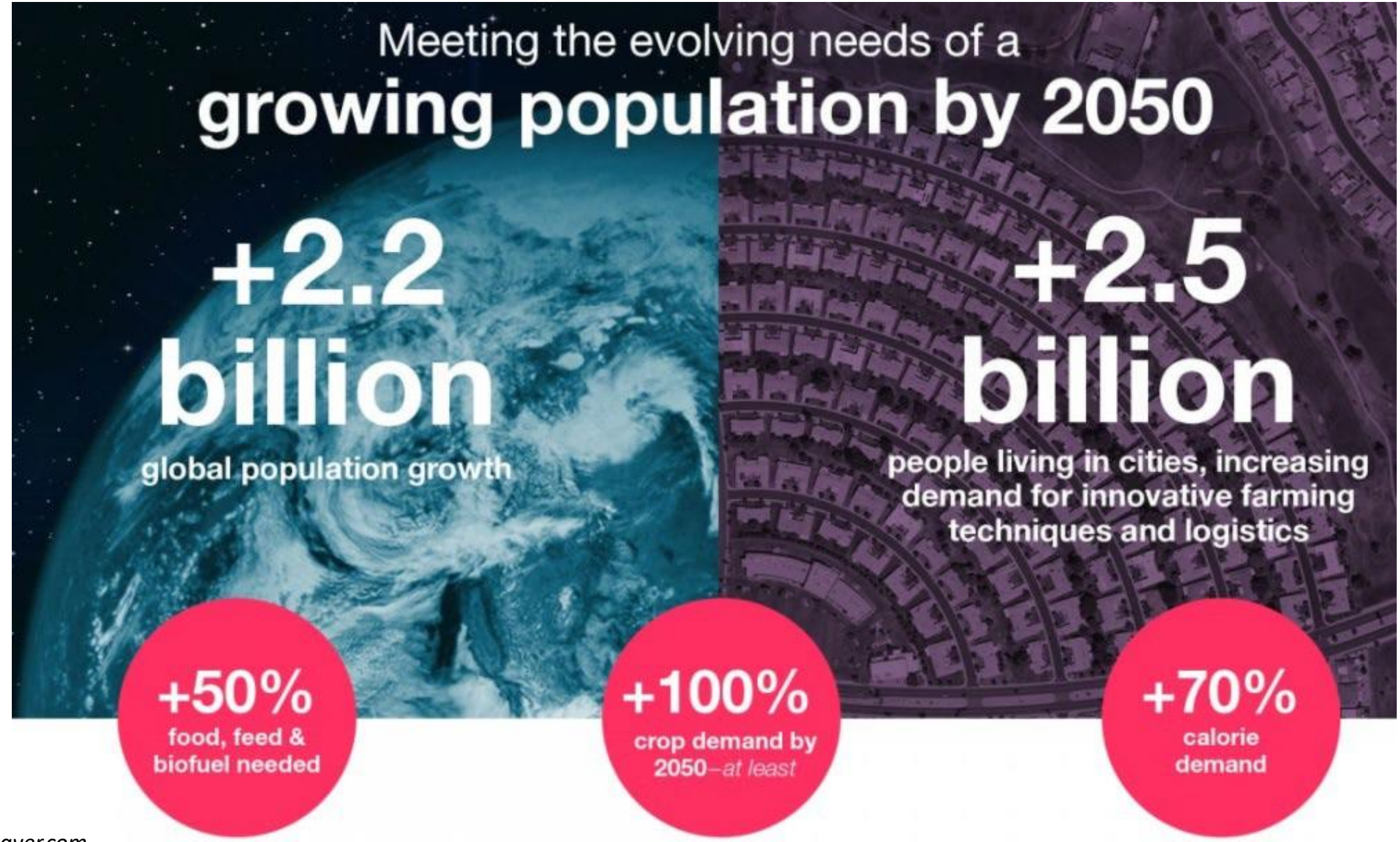


Image: Bayer.com

Bionanotechnology

Nanotechnology through *Time*

1959 Richard Feynman gives a speech at annual meeting of American Physical Society which predicted physicists could manipulate matter at the molecular level

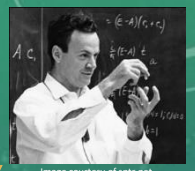
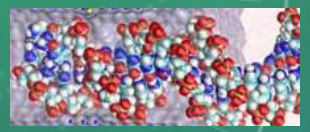


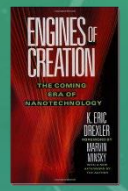
Image courtesy of sptr.net

1980 IBM scientists use a scanning tunneling microscope to directly image individual atoms for first time



1986

Word "nanotechnology" publicly used in Eric Drexler's book



Binnig and Rohrer won Noble Prize in Physics for inventing scanning tunneling microscope

1996 Kroto, Smalley, and Curl's "buckyballs" earn them a Nobel Prize in Physics

Image courtesy of Google Images

1998 US government organized Interagency Working Group on Nanotechnology

2000

$270 million for funding initiation of multi-agency NNI

NSF sponsored "Societal Implications of Nanoscience and Nanotechnology" workshop

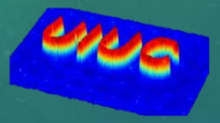
2004

NSF initiates competition for "Center for Nanotechnology in Society" funded at $2.6 million

US Congress passes "21st Century Nanotechnology Research and Development Act"

NCI applies nanotechnology and research for early cancer detection

2014 UI researchers study behavior of nanomembranes associated with transient electronics



2013 Stanford develops first carbon nanotube computer

Image Courtesy of MIT Technology Review

1970 **1980** **1990** **2000** **2010** **2021**

1974 Japanese engineer Norio Taniguchi used the word "nanotechnology"

Image courtesy of shutterstock.com

1985 Physicists Kroto, Smalley, and Curl discover carbon exposed to high temp form spherical molecules called "buckyballs"

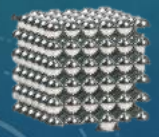


Image courtesy of Google Images

1990 Scientists at IBM manipulate individual Xenon atoms to write their company logo

Image courtesy of ibm.com

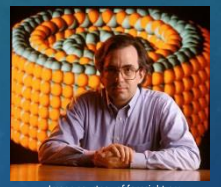


Image courtesy of foresight.org

Eric Drexler held first doctoral degree in molecular nanotechnology

In US, NSF funded $6 million to begin first program devoted to NSE

1991

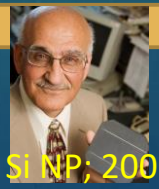
1999 Mihail Roco proposed National Nanotechnology Initiative (NNI) to the White House

Nano.gov National Nanotechnology Initiative

2001 2 academic papers published that analyzed role of nanotechnology in science fiction

2003 NSF supports 2 major projects at $1.5 million over 5 years along with 600 grants including "nano"

2004 *Bulletin of Science, Technology, and Society* devote issue to societal implications



Si NP; 2002

2009 NYU researchers create DNA-like robotic nanoscale assembly devices

Image courtesy of thatsreallypossible.com

2010 Harvard demonstrates nanowire transistor that measures electrical activity in heart cells

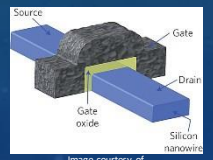


Image courtesy of nature.com

NPs for vaccination, theranostics CoV infections

nano@illinois CNST University of Illinois Center for Nanoscale Science and Technology

Designed by Mariam Saadah


Societal Implications of Nanotechnology
INNOVATION
Computation
Agriculture and Food
Advanced Manufacturing
nano@illlinois
Center for Nanoscale Science and Technology
Atmosphere, Environment and Energy
Medicine and Pharma
Communications and Electronics
ENTREPRENEURSHIP
Economic • Environmental • Ethical • Global • Healthcare • Legal • Policy • Social

Micro/Nano Solutions

- Engineered Nanomaterials
- Targeted delivery of Fertilizer, Herbicide, Pesticide, and Weedicide
- Water sustainability through nanopolymers hydrogels
- Enhancing seed germination through metal oxide nanoparticles
    - Higher yields and vitamin content
    - Drought resistant

Nanocarriers with smart delivery systems can enhance crop productivity and reduce operations costs

AgBots

https://www.youtube.com/watch?v=GK5ncp82je4

https://www.youtube.com/watch?v=9LbbMWzfabQ

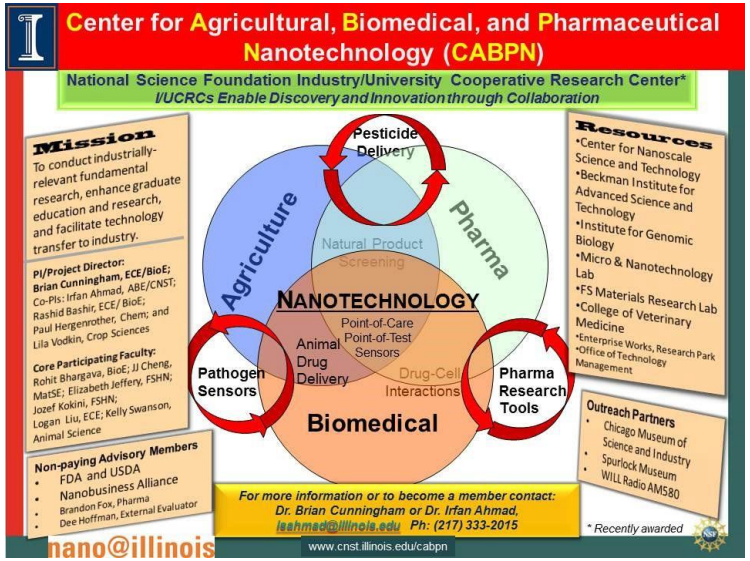
The Grainger Engineering researchers are focused on the mechanisms to increase the levels of autonomy in agbots while enabling interaction with humans / stakeholders, are testing their robots in the Illinois Autonomous Farm testbed. Katherine Rose Driggs-Campbell and Girish Chowdhary. **Center for Digital Agriculture**


EARTHSENSE
Agricultural Intelligence for a Sustainable Planet

AI-FARMS

- The Artificial Intelligence for Future Agricultural Resilience, Management, and Sustainability Institute serves as a nexus for multidisciplinary research teams that advance foundational AI and use these advances to address important challenges facing world agriculture.
- It focuses on technologies that impact production practices, on developing a diverse technically skilled workforce in digital agriculture, and on supporting women and minority farmers.

Coordinated Science Laboratory, UI



CiiT Recently completed

CiiT Industry / University Cooperative Research Center
Center for Innovative Instrumentation Technology

What is an Industry/University Cooperative Research Center?

- **NSF funds operations,** IAB members fund research areas of their interest
- **Industry Advisory Board Members** pay **$50k** annually at **10%** overhead
- Over **1000** I/UCRC memberships across ~**70** centers
- Level of Interest and Feedback Evaluation (**LIFE**) Process
- NSF I/UCRC Program has been running for **40 years**

Sensor Platforms

- Optical Chem/Biosensors
- Microelectronic Sensors
- Imaging Modalities
- Smartphone-Based
- Micro/Nanofluidics

Nanosensors

- Diagnostics
- Food Safety
- Process Analytical
- Pharma Screening
- Point of Use/care
- Agricultural Sensors

Applications

- Life Science Tools
- Agricultural Systems
- Food Safety Sensors
- Mobile Systems
- Water Quality Monitoring

instrumentation.illinois.edu

CiiT

Industry / University Cooperative Research Center

Center for Innovative Instrumentation Technology

Facilities

Micro and Nanotechnology Lab

Beckman Institute for Advanced Science and Technology

Veterinary Medicine small and large animal clinics

Frederick Seitz Materials Research Lab

College of ACES

Institute for Genomic Biology

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Members

Baxter
Abbott — A Promise for Life
Dow AgroSciences
Daktari
Kraft
MONSANTO
MOXTEK — INNOVATING SOLUTIONS
US Army Corps of Engineers — Engineer Research and Development Center
Illinois Soybean Association
Elanco — Animal Health
Our Soy Checkoff
TATRC — Telemedicine & Advanced Technology Research Center

Converting Desert to Farmland with Clay

Clay in Soil in the right proportion provides fertility and resiliency

UAE converted in 40 days a barren plot of sand into an arable plot with sweet watermelons

Smart Sensing Technologies for AgBioFood Research Group

Irfan S. Ahmad

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isahmad@illinois.edu

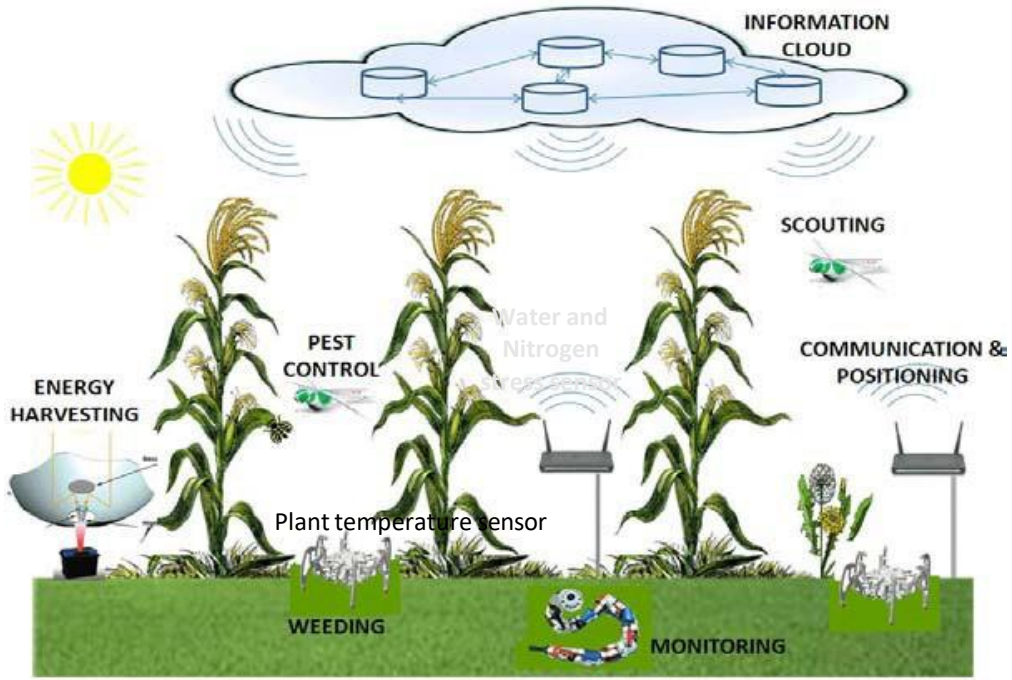
August 8, 2018, rev. 10/18/22

Research Faculty, Agricultural & Biological Engineering;

Holonyak Micro and Nanotechnology Lab.; and Biomedical and Translational Sciences

Research Interests

- Biological Engineering
- Off-Road Equipment Engineering
- Nanomedicine



Current Projects

- QNRF: A Novel Microchip based Spatial Gene Expression Analysis Assay for Breast & Prostate Cancer
- USDA: Innovative Food Dehydration Technologies for Improving Product Quality, Energy Efficiency, Sustainability
- NSF NCN: Hierarchical nanoManufacturing Node (https://nanohub.org/groups/nanoMFG)
- NSF I/UCRC: Center for Advanced Research in Drying (CARD) (Dryingresearch.org)
- DOD: Mechanism of Fungal Degradation in Military Aircraft Coatings - completed
- Dudley Smith Initiative: Reducing Insecticide Resistance: Development of Unique Liposomes Pest Control System (LPCS)- completed

Interest areas for collaboration/future work
Advanced manufacturing, Digital agriculture, Food safety, Smart sensing technologies

Keywords: Bionanotechnology, Crop, Imaging, Sensors, Nanomedicine, Pathogenesis, Soil

Collaborators and Group Members*

Irfan Ahmad
ABE/CNST/HMNTL /CIMED

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Plant Pathology/HMNTL

Joseph Spencer
PRI/Crop Sciences/ Entomology

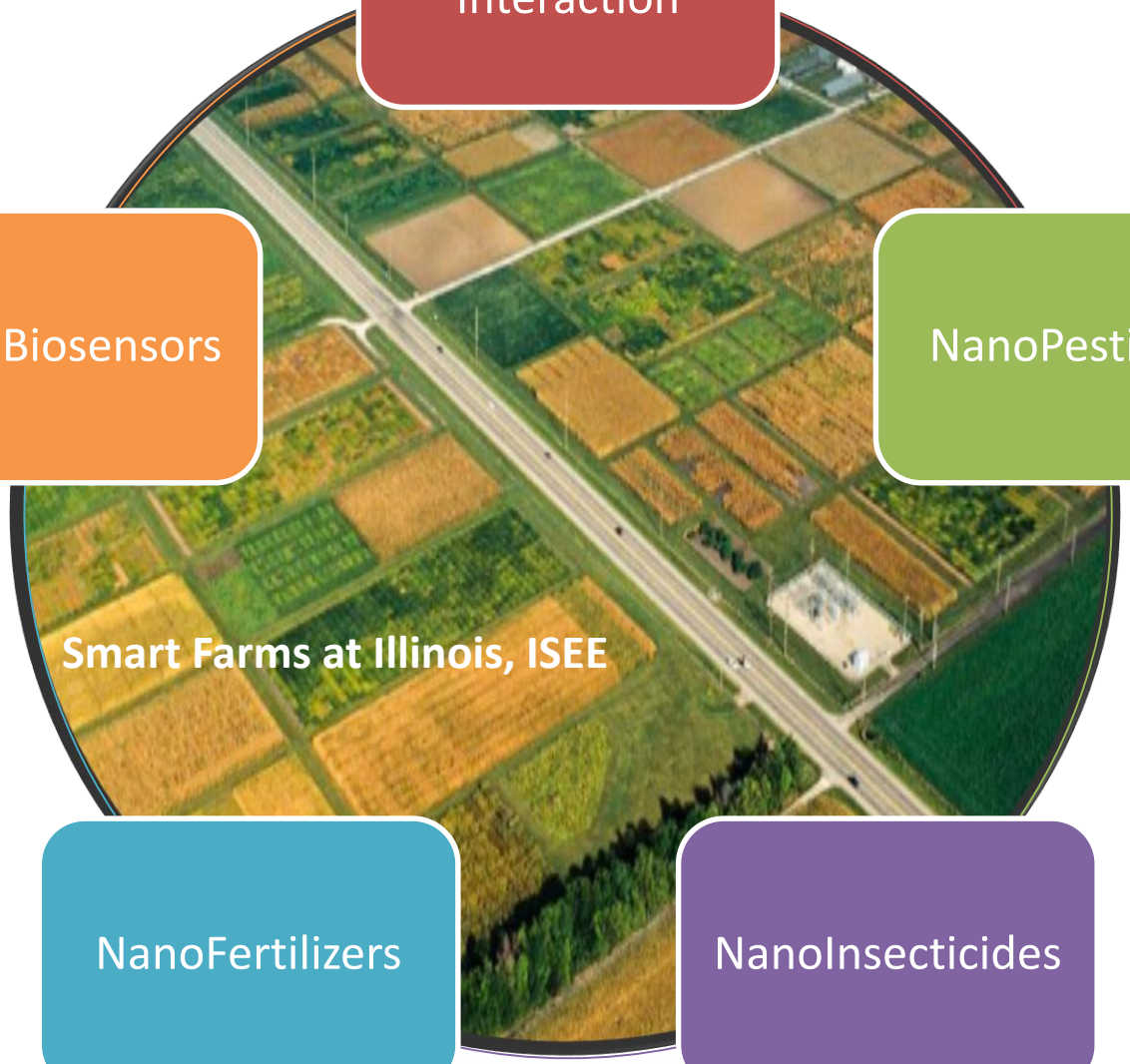
Joseph Irudayaraj
BioE/HMNTL/IGB/CIMED

G. Logan Liu
Formerly at ECE/BioE/HMNTL

- Rashid Ahmed, visiting researcher
- Hina Ashraf, visiting graduate student
- Postdoctoral research associate: Ezzeddine
- Niknaz; Economu; Roveiza Irfan: undergraduates

** Former and current*

ABE: Agricultural and Biological Engineering
BioE: Bioengineering
CIMED: Carle Illinois College of Medicine
CNST: Center for Nanoscale Science & Technology
ECE: Electrical and Computer Engineering
HMNTL: Holonyak Micro and Nanotechnology Laboratory
IGB: Institute for Genomic Biology
PRI: Prairie Research Institute



Plant-Soil Interaction

Nano Biosensors

NanoPesticides

NanoFertilizers

NanoInsecticides

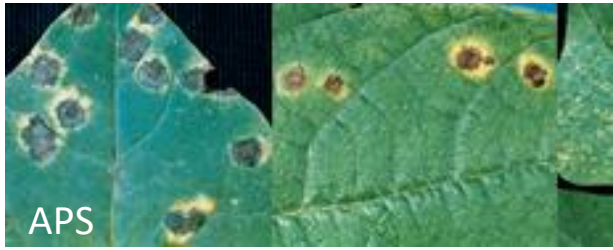
Key Motivations: Bionanotechnology toward Environment-friendly Agriculture

- The global challenge is to feed 9 billion people by 2050 with a 60% increase in food availability.
- The agricultural and food sectors are confronted with such large issues as climate change, urbanization, sustainable use of resources, and environmental issues like run-off and accumulation of pesticides and fertilizers.
- Bionanotechnology can address such impacts as damage to the ecosystem with toxin release due to the overapplication of fungicides, insecticides, pesticides, and fertilizers.
- Bionanotechnology can contribute to the potential increase in crop production, food security, and sustainability. Fundamental and innovative research is needed to address these challenges for improved biodiversity, productivity, nutrition, and quality.
- Understanding the mechanisms of host-parasite interactions at the molecular level, developing a new generation of pesticides and their transport mechanisms, preservation, and packaging of food.
- Focus on research efforts toward environment-friendly agriculture through the development of liposomes as a novel carrier for designing slow-release formulations of commercially available nematicides, the use of CuO nanoparticles for disease management and plant health improvement, and the sensing of soil nitrates.

Barriers to Overcome: Bionano in Agriculture

- Determination and minimization of toxicity levels- risk assessment
- Bionano Regulatory Framework
- Global adoption of new Agricultural Protocols
  (through the UN FAO, the USDA, FDA, WFP)

Detection of Plant Disease



- Early detection of the disease is key to higher yields
- Enables the reduced use of pesticides and fungicides
- Contributes to decreased toxicity for a greener environment
- Bionano Sensing of pathogens in a site-specific manner
- Targeted Delivery of nanoencapsulated pesticides

CuO Nanoparticles for Boosting Crop Growth

Hina Ashraf, Tehmina Anjum, Saira Riaz, Irfan S. Ahmad, Joseph Irudayaraj, Sidra Javed, Uzma Qaiser, Shahzad Naseem

Ashraf, H., et al., 2021. Environmental Science Nano.
DOI: 10.1039/d0en01281e

Environmental Significance

- Positive correlation between green synthesized nanoparticles and plants contributing to plant growth parameters concurrently minimizing the environmental contamination of conventional fungicides due to their specific physio-chemical properties.

- Antifungal behavior of CuO nanoparticles showed spore and mycelial inhibition. Improvement in tomato growth parameters and fruit quality also indicated the positive impact of these miniature particles.

- Nanoscale particles have the ability to boost the defense and growth responses in tomatoes; therefore, they can be utilized both as nano-fungicide and nano-fertilizer, thus playing a crucial role in the agriculture- specifically for crop improvement.

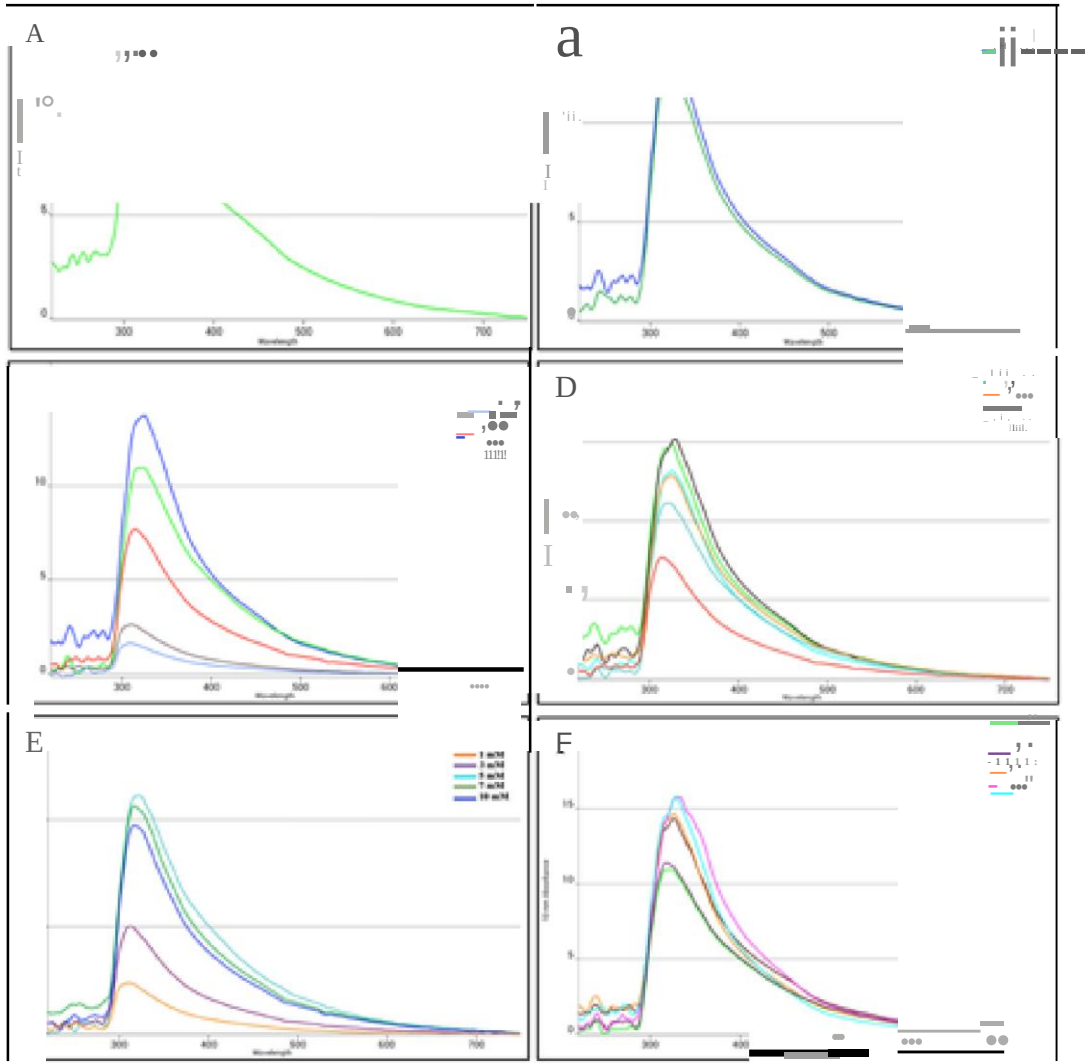
Synthesis and Characterization of CuO-CF NPs*

- *Fusarium oxysporum f.sp. Lycopersici* strain was put on PDA

In vitro and *in vivo* anti-fungal activity of CuO-CF NPs

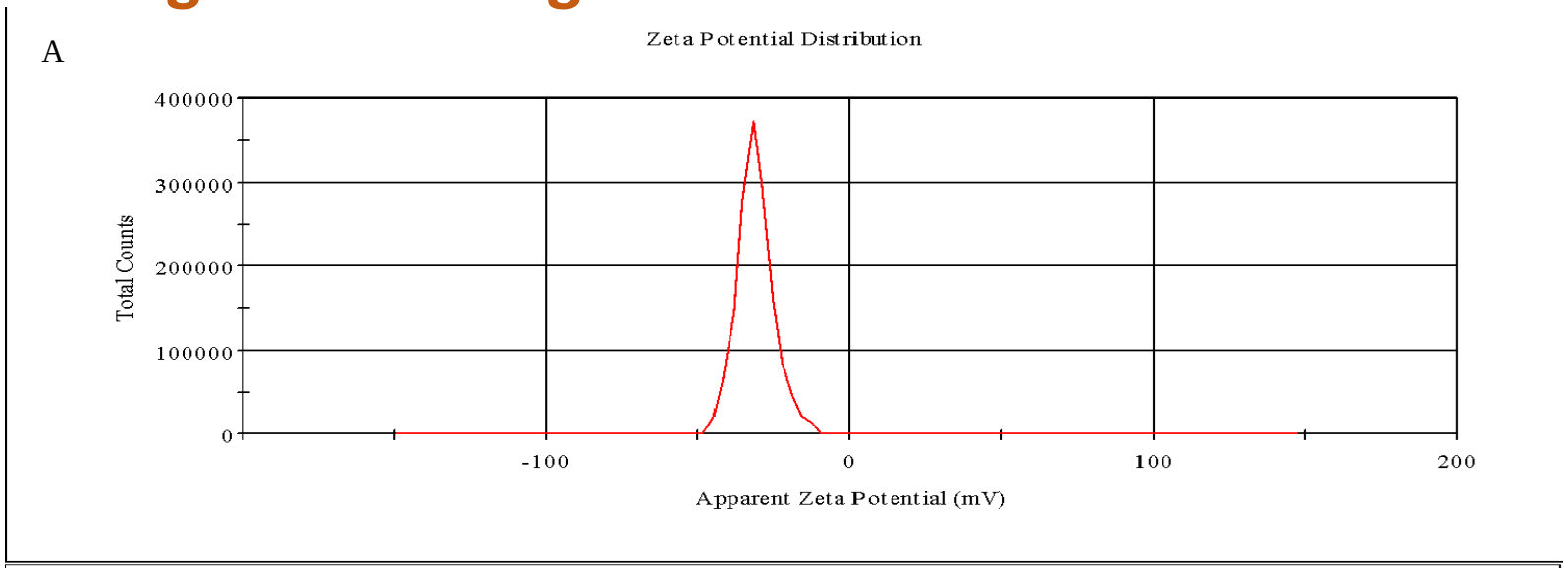
- Concentrations 5-350 ug/mL

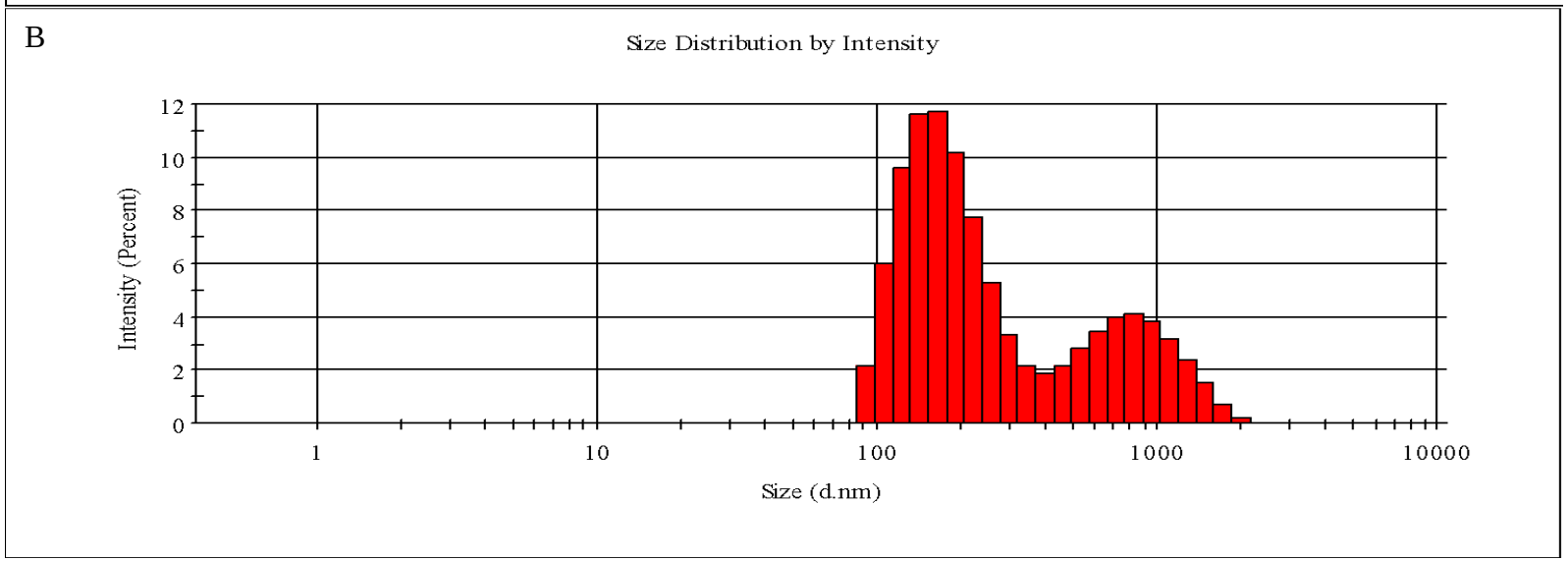
CF: *Cassia fistula* plant extract



Fii.i::.: UV-visible abmliJ)1ion spectra of g.mcn. symhesiz:oo CuO-CFNPs at best optimization conditions:.. 1 N - . isible specl!l'iUill under cllifrerenl oplimizathm eonditions during ynthesis. wer.e doommmted as a func1ion of: (A), UV-visili!e afo;o:rplion . ctr:a of OuO–CFNPs.. Stabiility o.f c:o;pp1.roxide nuoparticles (lWmins-funont!h)·(B) pH (9);{C) Amomd o.fCIF lwextract(Sm.L); ([)) (,oppcr sulphat ocmcc:nrtration (SmM){6) T,cm,-pcra.t'Jllra(8WC),

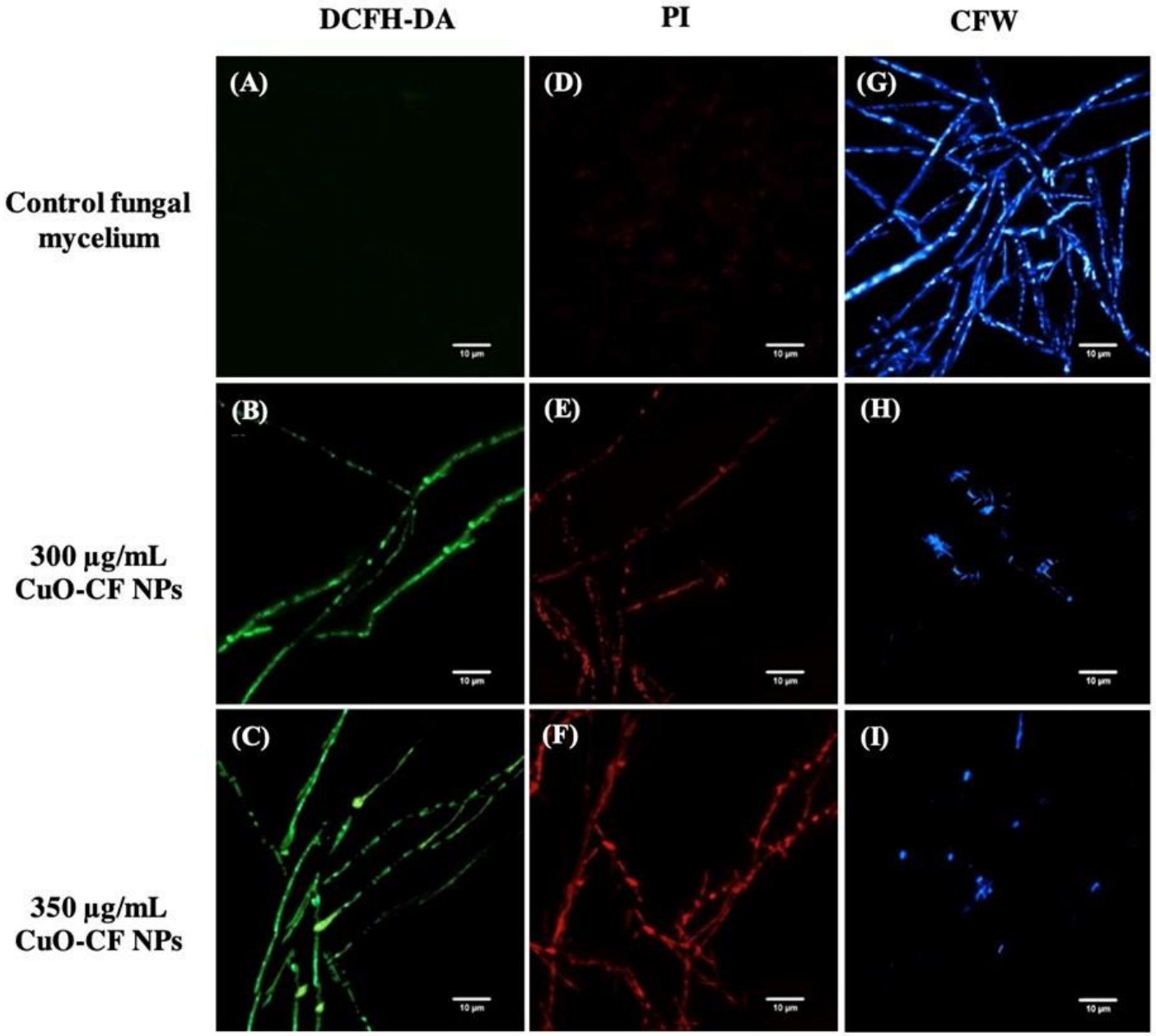
Size distribution intensity and zeta potential distribution of CuO-CFNPs (A&B) - Dynamic light scattering

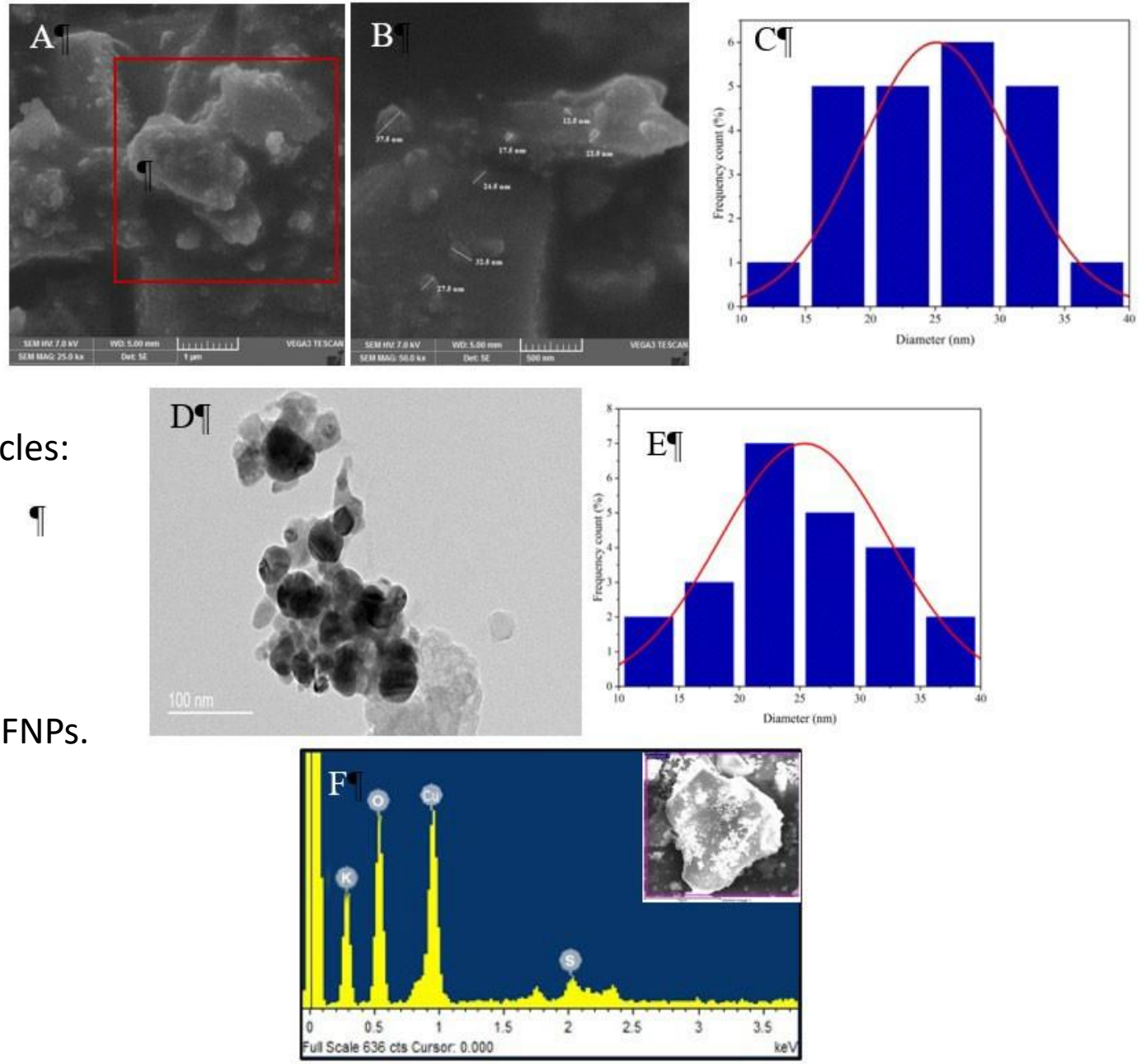




•**Figure.** Fluorescence microscopy of *F. oxysporum* mycelium treated with different concentrations of CuO-CF nanoparticles (300 µg/mL & 350 µg/mL) and control (sterile water). **A-C:** represents accumulation of reactive oxygen species (ROS) in hyphal cells of *F. oxysporum* stained with DCFH-DA (dichloro-dihydro-fluorescein diacetate) staining, **D-F:** fungal hyphal cells with damaged cell-membrane show red fluorescence in contrast to control after staining with Propidium iodide (PI), **G-I:** representative fluorescence micrograph of hyphal cells stained with Calcofluor white (CFW) indicating low glucan and chitin content in fungal cell-wall treated with nanoparticles. Scale bar: 10µm.

•





- Size analysis of green-synthesized CuO-CF nanoparticles:
  (A) SEM Image (Scale bar of 1µm),
  (B) Magnified view of SEM (Scale bar of 500 nm),
  (C) Size distribution analysis of SEM image,
  (D) TEM image (scale bar indicates 100 nm),
  (E) Histogram of size distribution of TEM image,
  (F) Energy Dispersive X-ray (EDX) spectrum of CuO-CFNPs.

METHODOLOGY

Synthesis and Characterization of CuO-CF NPs

- All chemicals used in this study were of analytical grade, used in pure form. A strain of *Fusarium oxysporum* f.sp. *lycopersici* (IAGS-1322) was maintained on PDA. Fresh leaves of *Cassia fistula* (CF) were boiled in de-ionized water for 30 minutes. The plant extract was allowed to cool and filtered with Whatman filter paper at room temperature. The CuO-CFNPs were synthesized as follows: 45 mL of 5mM $CuSO_4.5H_2O$ solution prepared in de-ionized water was reduced stepwise by addition of 5 mL of *C. fistula* extract in 100ml flask. Optimization of reaction condition for CF-CuO NPs were achieved by adjusting pH, amount of CF-leaf extract, $CuSO_4.5H_2O$ concentration and stirring temperature. The biosynthesized copper oxide - *Cassia fistula* nanoparticles (CuO-CFNPs) were characterized by UV-visible, FTIR, XRD, DLS, TEM, and SEM with EDX.

In-vitro and In-vivo antifungal activity of CuO-CF NPs

- *In-vitro* antifungal activity of CuO-CFNPs, against *F. oxysporum,* was evaluated at different concentrations of of CuO-CFNPs, i.e., 5, 25, 50, 100, 150, 200, 250, 300, and 350 μg / mL. Media plates treated with distilled water and fungicide served as positive and negative control respectively. The potential of CuO-CFNPs to damage fungal membrane, ROS induction, and loss of cell viability in *F. oxysporum* was investigated by following the protocols described by Wei et al. [1].
- *In-vivo* efficacy of CuO-CFNPs was evaluated under greenhouse conditions using tomato as model plant. Growth parameters such as length (root + shoot), biomass weight (fresh + dry), and percentage disease incidence (DI) and severity (DS) was recorded after 45 days. Photosynthetic pigments, phenolic content and stress / antioxidant enzymatic compounds were estimated in tomato plants (roots and shoot) after treatment with various concentrations of CuO-CFNPs. Similarly, accumulation of bioactive compounds such as vitamin C, lycopene and flavonoids in tomato fruit were determined at end of field experiment (145th day).
- Histochemical analysis performed to evaluate the production of defense compound in roots and shoots of treated and control plants. Moreover, Cu-content in tomato plants (roots and shoots) was measured by Atomic absorption spectrophotometer.

Statistical Analysis

- Statistical analysis was performed by employing Graph-pad-prism (8.4.3) software (CA, United States) and Statistic 8.1.

RESULTS

Synthesis and Characterization

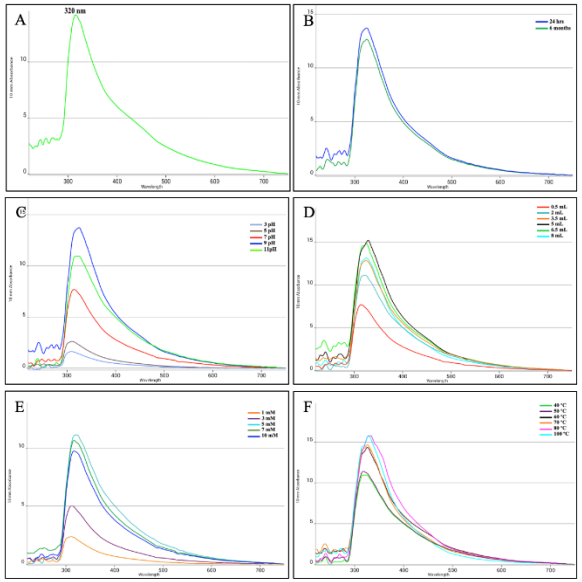


Fig: UV-visible absorption spectra of green synthesized CuO-CFNPs at best optimization conditions. UV-visible spectrum under different optimization conditions during synthesis were documented as a function of: (A) UV-visible absorption spectra of CuO-CFNPs. Stability of copper oxide nanoparticles (150mins-6months); (B) pH (9); (C) Amount of CF leaf extract (5mL): (D) copper sulphate concentration (5mM) (E) Temperature (80°C).

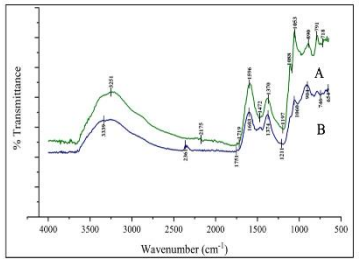


Fig. FTIR spectra of synthesized CuO-CFNPs: (A) Spectra of CF-Extract alone. (B) Spectra of CuO-CFNPs.

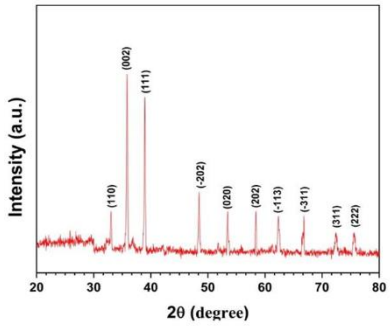


Fig. X-ray Diffraction (XRD) Pattern of CuO-CFNPs

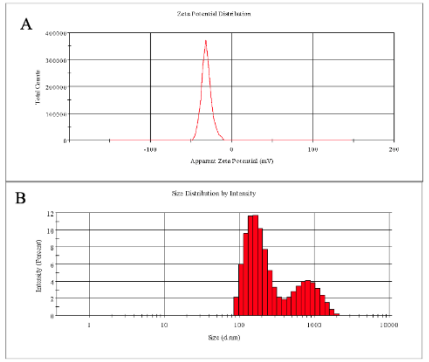


Fig. Size distribution intensity and zeta potential distribution of CuO-CFNPs (A&B) as revealed by Dynamic light scattering.

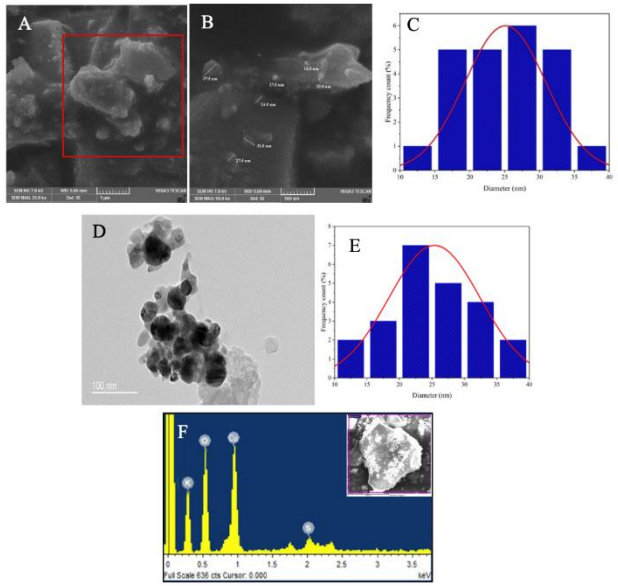


Fig. Size analysis of green-synthesized CuO-CF nanoparticles, (A) SEM Image (Scale bar of 1μm), (B) Magnified view of SEM (Scale bar of 500 nm), (C) Size distribution analysis of SEM image, (D) TEM image (scale bar indicates 100 nm), (E) Histogram of size distribution of TEM image, (F) Energy Dispersive X-ray (EDX) spectrum of CuO-CFNPs.

In-vitro & In-vivo Bioassays

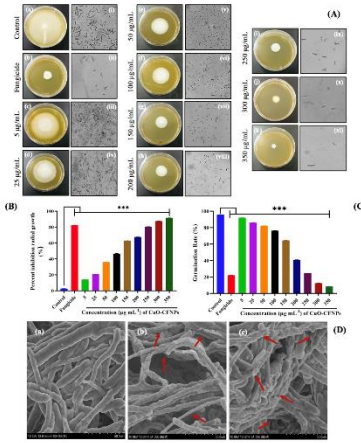


Fig. A: Photomicrographs of *invitro* antifungal activity of CuO-CF nanoparticles on mycelium radia growth (a-k) and spore germination (10x magnification) (i-n) of *F. oxysporum* after exposure to differen concentrations (5-350μg/mL) along with control and fungicide, **B:** Percent inhibition (%) by copper oxid nanoparticles on *F. oxysporum* mycelial growth after 7 days of incubation at 28°C on PDA plates, **C:** *F. oxysporum* conidia were germinated on cover slips for 6 hours at 28°C without (control + fungicide) an with CuO-NPs at various concentrations, **D:** SEM micrographs of *F. oxysporum* hyphae after treatmen with (a) water (b), 300 μg/mL and (c) 350 μg/mL of CuO-CF NPs, red arrows indicate th morphological deformations in fungal hyphae after treatment, Scale bar: 50μm. Data signifies as a mean ± SEM of three-replicates (n=3) denotes substantial difference (***p<0.001) in parallel to control by One Way-Anova (p<0.05) and Tukey's-multiple comparison analysis using Graph-pad prism.

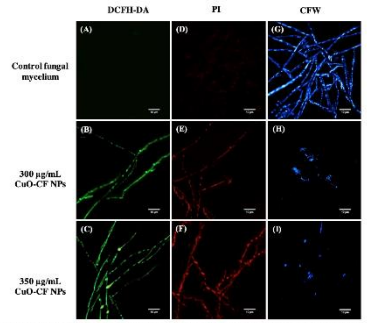


Fig. Fluorescence microscopy of *F. oxysporum* mycelium treated with different concentrations of CuO-CF nanoparticles (300 μg/mL & 350 μg/mL) and control (sterile water). **A-C:** represents accumulation of reactive oxygen species (ROS) in hyphal cells of *F. oxysporum* stained with DCFH-DA (dichloro-dihydro-fluorescein diacetate) staining. **D-F:** fungal hyphal cells with damaged cell-membrane show red fluorescence in contrast to control after staining with Propidium iodide (PI). **G-I:** representative fluorescence micrograph of hyphal cells stained with Calcofluor white (CFW) indicating low glucan and chitin content in fungal cell-wall treated with nanoparticles. Scale bar: 10μm.

Fig 3. A: Exposure by dipping of 25-30 days old tomato seedlings in different concentrations (5-350μg/mL) of CuO-CFNPs for 2 hours, **B:** transplantation of treated seedling in pots infected with inoculum of *F. oxysporum*, **C:** tomato plants after application of two foliar sprays of nanoparticles, **D:** flower and fruit formation in tomato plants after two months of transplanting, **E:** Control treatment, **F:** pot with best concentration of CuO-CFNPs (300 μg/mL), **G:** fruit from control group (infected with *F. oxysporum* only), **H:** fruit from treatment group (NP treated).

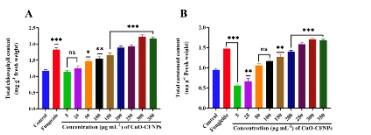


Fig. Effect of various concentrations of CuO-CFNPs on photosynthetic pigments: chlorophyll content (**A**) and carotenoid content (**B**) in tomato leaves infected with *Fusarium oxysporum* under green-house conditions. Data signifies as a mean + SEM of three-replicates (n=3) denoting substantial difference (*p<0.05, **p<0.01, ***p<0.001: ns: non-significant) in parallel to control by One-Way-Anova (p<0.05) and Tukey's-multiple comparison analysis using Graph-pad prism.

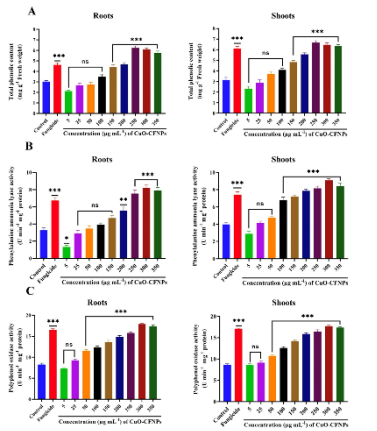


Fig. Effect of various concentrations of CuO-CFNPs on secondary metabolite activity: total phenolic content (**A**) and stress-related enzymes: PAL (**B**), and PPO (**C**) in the roots and shoots of tomato plants infected with *Fusarium oxysporum* under green-house conditions. Data signifies as a mean + SEM of three-replicates (n=3) showing substantial difference (*p<0.05, **p<0.01, ***p<0.001: ns: non-significant) in parallel to control by One-Way-Anova (p<0.05) and Tukey's-multiple comparison analysis using Graph-pad prism.

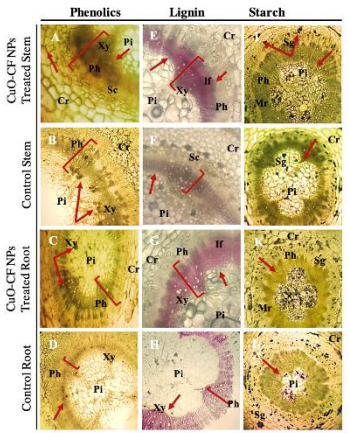


Fig. Histochemical analysis of transverse section of tomato root and stem treated with CuO-CFNPs for localization of phenolic (A-D), lignin (E-H) and starch(I-L) at 40x magnification under light-microscope. Cr: Cortex, Pi: Pith, Xy: Xylem, Ph: Phloem, If: Interfascicular-fibers, Mr: Medullary ray, Sg: Starch grains, Sc: Sclerenchyma.

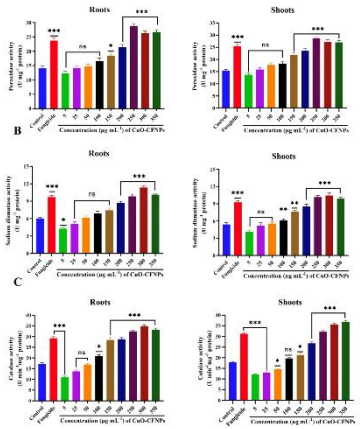


Fig. Effect of various concentrations of CuO-CFNPs on enzymatic antioxidant compounds: POD (**A**), SOD (**B**), and CAT (**C**) in the roots and shoots of tomato plants infected with *Fusarium oxysporum* under green-house conditions. Data signifies as a mean + SEM of three-replicates (n=3) shows substantial difference (*p<0.05, **p<0.01, ***p<0.001: ns: non-significant) in parallel to control by One-Way-Anova (p<0.05) and Tukey's-multiple comparison analysis using Graph-pad prism.

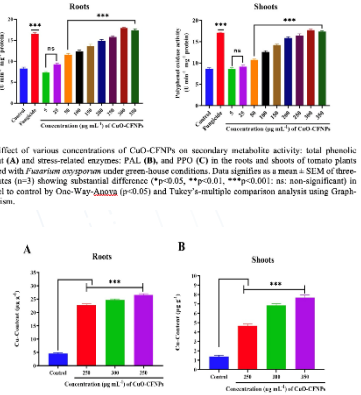


Fig. Effect of various concentration of CuO-CFNPs (250-350 μg/mL) on copper content in the roots and shoots of tomato plants infected with *Fusarium oxysporum* under green-house conditions. Data signifies as a mean + SEM of three-replicates (n=3) showing substantial difference (*p<0.05, **p<0.01, ***p<0.001: ns: non-significant) in parallel to control by One-Way-Anova (p<0.05) and Tukey's-multiple comparison analysis using Graph-pad prism.

Table 2: Potential of CuO-CFNPs on average weight, number, proteins and non-enzymatic-antioxidant compounds in tomato fruits infected with Fusarium wilt under greenhouse conditions

Treatment	Average Fruit weight (g)	Fruits Number	Lycopene (mg 100 g^{-1} FW)	Flavonoids (mg 100 g^{-1} FW)	Vitamin C (mg 100 g^{-1} FW)	Protein (U/min/ mg)
Control	59.61^{j}	21.53^{g}	2.16^{e}	14.12^{b}	15.82^{e}	5.26^{e}
Fungicide	87.42^{b}	30.12^{d}	3.42^{b-d}	20.42^{a}	17.42^{c}	8.92^{b}
5 μg/mL CuO-CFNPs	52.34^{i}	18.28^{f}	1.97^{e}	14.32^{b}	15.69^{e}	5.09^{e}
25 μg/mL CuO-CFNPs	65.14^{h}	20.56^{b}	2.07^{e}	15.23^{g}	15.94^{e}	5.17^{e}
50 μg/mL CuO-CFNPs	69.51^{g}	21.77^{e}	2.28^{e}	16.85^{f}	16.18^{de}	5.28^{e}
100 μg/mL CuO-CFNPs	72.37^{f}	23.52^{f}	2.89^{d}	17.19^{f}	16.79^{cd}	5.39^{e}
150 μg/mL CuO-CFNPs	77.26^{e}	25.17^{e}	3.28^{cd}	17.89^{e}	17.38^{c}	5.83^{c}
200 μg/mL CuO-CFNPs	82.59^{d}	29.63^{d}	3.47^{bc}	19.63^{d}	18.27^{b}	8.87^{b}
250 μg/mL CuO-CFNPs	86.32^{bc}	31.48^{c}	3.86^{ab}	21.49^{b}	19.66^{a}	9.46^{ab}
300 μg/mL CuO-CFNPs	90.14^{a}	34.25^{a}	4.05^{a}	22.38^{a}	20.04^{a}	9.75^{a}
350 μg/mL CuO-CFNPs	85.75^{c}	32.19^{b}	3.49^{a-c}	21.81^{ab}	19.49^{a}	9.19^{ab}
CV (%)	1.11	1.50	11.24	2.07	2.62	6.21

*Different letters per column indicate significant differences (P≤0.05) among treatments, determined by LSD Fisher test. Each value of data is the average of three replicates. CV represents coefficient of variation.

Table 1: Potential of CuO-CFNPs on growth variables and disease attributes in tomatoes infected with Fusarium wilt under greenhouse conditions.

Treatment	Plant Height (cm)	Total Length (cm)		Total Biomass (g)		Disease Incidence (%)	Disease Reduction (%)	Disease severity (%)
		Root	Shoot	Fresh	Dry			
Control	27.5^{k}	12.7^{i}	14.8^{j}	8.76^{e}	1.54^{e}	100^{a}	0.03^{k}	96.6^{a}
Fungicide	41.6^{d}	19.5^{d}	22.1^{d}	12.6^{c}	1.98^{ab}	43.3^{h}	56.7^{d}	55^{d}
5 μg/mL CuO-CFNPs	27.8^{j}	12.9^{i}	14.9^{i}	7.43^{g}	1.61^{d}	93.3^{b}	6.7^{l}	87.7^{b}
25 μg/mL CuO-CFNPs	28.9^{i}	13.7^{h}	15.2^{h}	9.78^{f}	1.64^{cd}	86.7^{c}	13.4^{j}	83.3^{b}
50 μg/mL CuO-CFNPs	30.5^{h}	14.8^{g}	15.7^{g}	10.5^{e}	1.73^{bc}	73.3^{d}	26.7^{h}	75^{c}
100 μg/mL CuO-CFNPs	34.1^{g}	15.4^{f}	18.7^{f}	11.4^{d}	1.84^{ab}	66.7^{e}	33.3^{i}	63.9^{d}
150 μg/mL CuO-CFNPs	39.5^{f}	18.7^{e}	20.8^{e}	11.9^{d}	1.87^{ab}	53.3^{f}	46.7^{f}	56.1^{d}
200 μg/mL CuO-CFNPs	42.4^{c}	19.8^{c}	22.6^{d}	12.5^{c}	1.92^{ab}	46.6^{g}	53.4^{e}	43.3^{ef}
250 μg/mL CuO-CFNPs	48.4^{b}	22.7^{b}	25.7^{b}	13.7^{b}	2.09^{a}	36.7^{i}	63.4^{c}	32.2^{g}
300 μg/mL CuO-CFNPs	51.9^{a}	23.4^{a}	28.5^{a}	14.5^{a}	2.17^{a}	26.7^{k}	73.3^{a}	31.1^{f}
350 μg/mL CuO-CFNPs	45.1^{e}	21.3^{a}	23.8^{c}	13.4^{b}	2.06^{a}	33.3^{j}	66.7^{b}	33.3^{ef}
CV (%)	0.96	1.55	1.45	2.95	6.32	0.79	0.69	10.7

*Different letters per column indicate significant differences (P≤0.05) among treatments, determined by LSD Fisher test. Each value of data is the average of three replicates. CV represents coefficient of variation.

Future prospects

Nanotechnology has shown promising potential to promote sustainable agriculture. It has many applications in the agricultural sector including nanofertilizers, nanopesticides, nanobiosensors or as bioremediation agents. However, a better understanding of nanomaterials' fate and their eco-impacts remains a major challenge in agricultural and environmental sciences. Combined research among institutes exploring different uses of nanomaterials would be crucial to develop efficient, multifunctional, stable, cost -effective and environment -friendly nanomaterials.

Application of nanomaterials may assist in improving the growth and yield of crop plants, but response may alter as per plant species. Thus, commercial use of nanomaterials requires comprehensive investigations into screening and optimization of the nanomaterials for different plant species.

Efficiency and behavior of nanomaterials can be tailored by tuning the properties and stability of nanomaterials. Therefore, further progress in the development of innovative and improved synthesis methods with precise control over product composition will be highly useful to improve their efficiency.

Moreover, most of the studies on nano -assisted agriculture rely on experiments performed under controlled conditions while limited data is available regarding their field application. More knowledge at field level would be highly useful for large -scale implementation of nano -based strategies.

Summary

- CuO NPs synthesis and characterization aided in tomato growth
- Eco-friendly CuO NPs showed potent activity against fungal pathogens
- Continued research is needed to show the promise of CuO NP toward sustainable agriculture for food security

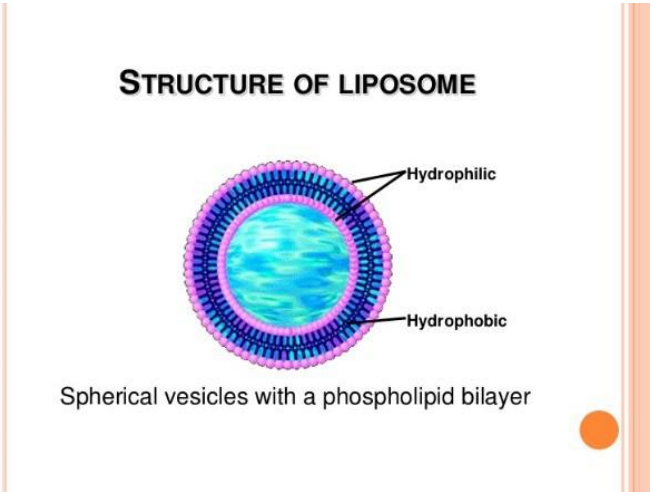
Liposome Technology for Environment Friendly Agriculture

Liposome Technology for Pest Management

- **Rationale:** It is estimated that approximately 50 million acres of U.S. corn production faces pressure from corn rootworms.
- The total external cost attributed to pesticide resistance is estimated at 10 and 25% of current pesticide treatment costs, or more than $1.5 billion each year in the United States.
- The experiments focus on the development and testing of an innovative approach to sustainable CRW management.

Short term objectives:

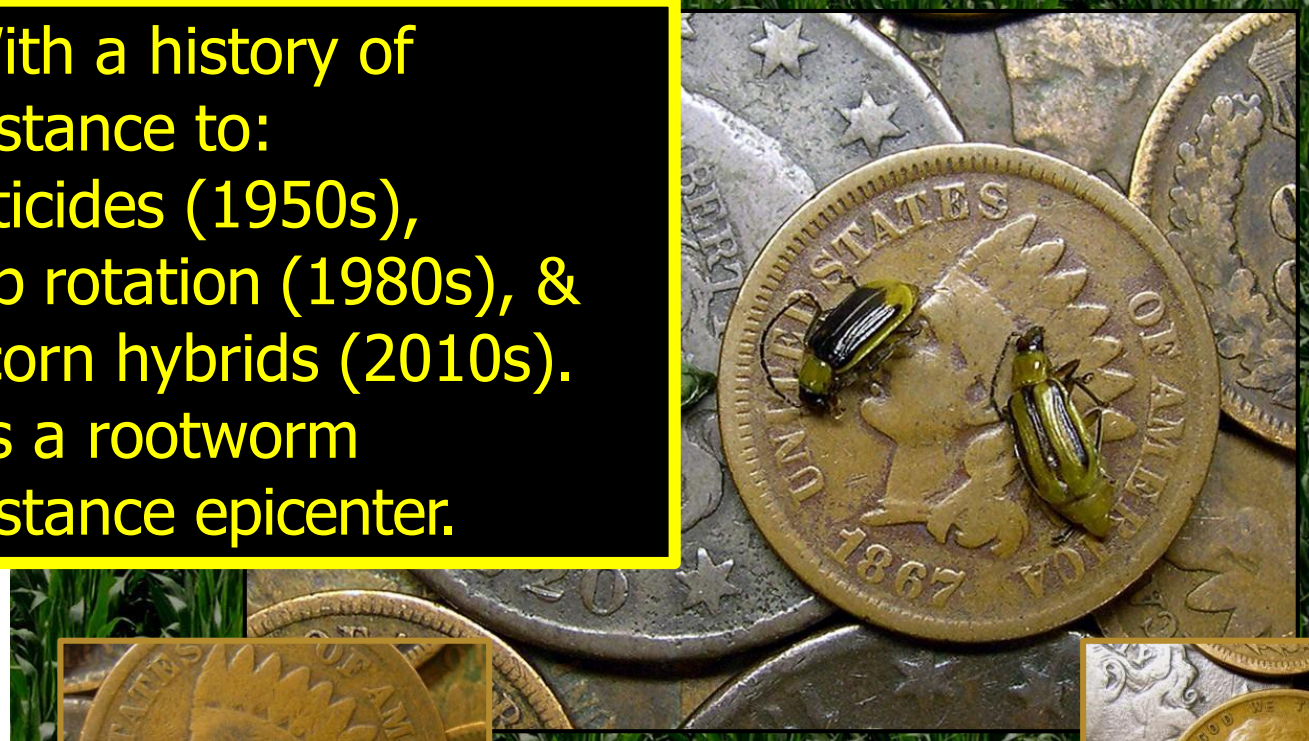
1) Develop and use liposomes as new carriers for slow or delayed release formulations of commercially available insecticides; and
2) Evaluate insecticide-liposome complexes for management of CRW in the greenhouse and small field trials.




Diabrotica virgifera

Corn Rootworms are Historic Pests

…With a history of resistance to:
Pesticides (1950s),
Crop rotation (1980s), &
Bt corn hybrids (2010s).
IL is a rootworm resistance epicenter.



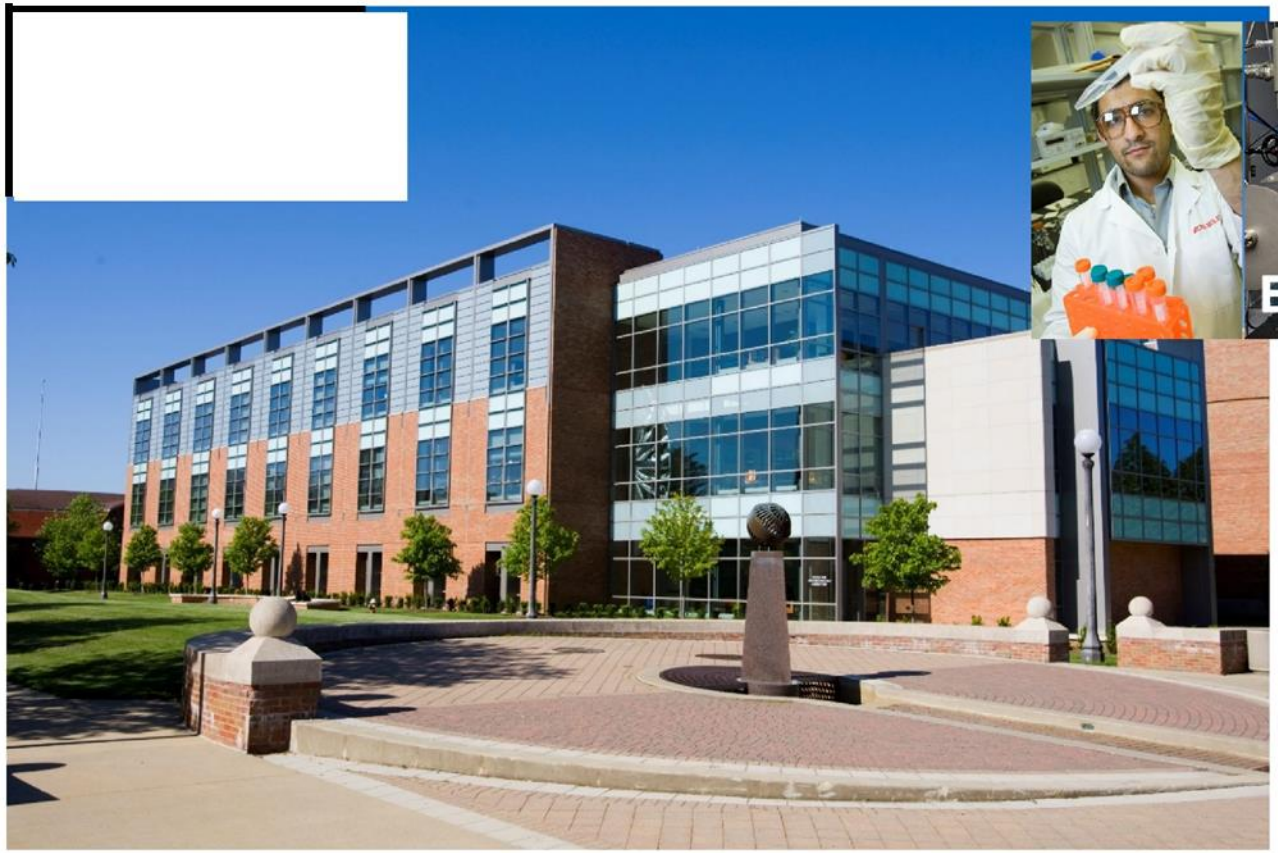
‘Billion Dollar Insects’

‘Northern’, NCR

‘Western’, WCR

Western Corn Rootworm (WCR) Lifecycle

Climatic Factors play a significant role in the Life Cycle of WCR




EXPERIMNTL

Goals

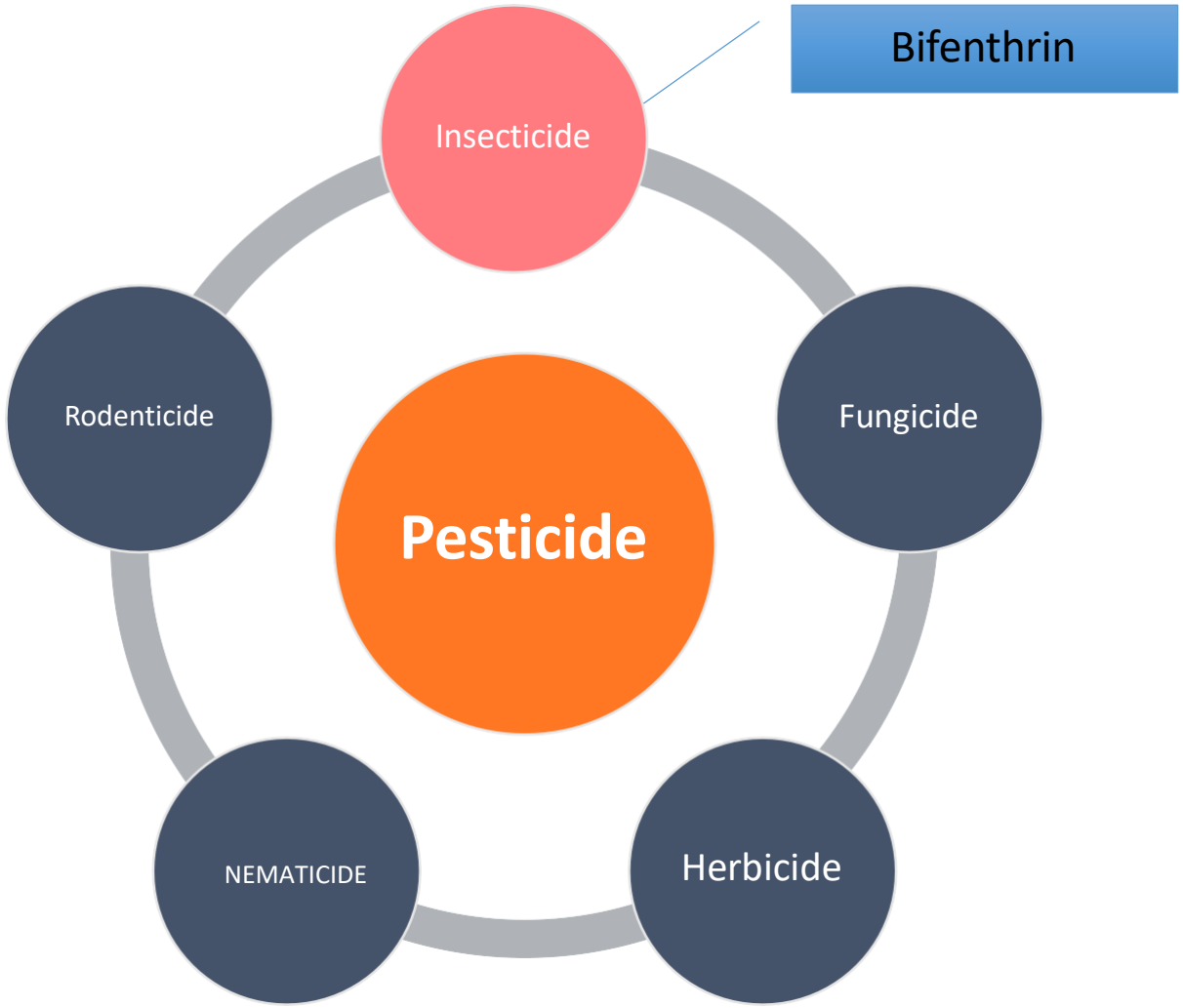
Long-term

- To use liposomes as a new tool for designing slow-release formulations of insecticides (conventional, plant-derived, and microbial)
- To maximize their efficiency in controlling Corn Root Worm for improved crop production

1. Preparation of Liposomes using the thin-film dehydration-rehydration method obtaining, multilamellar vesicles (MLVs) and small unilamellar vesicles (SUVs)

2. Conducting Bioassays with different concentrations of commercial insecticides and insecticide-liposome formulations applied to corn plants grown in the greenhouse and field plots

Potential outcome:
This project leads to the development of new, environmentally safe formulations of insecticides useful for CRW management.


Bifenthrin
Insecticide
Rodenticide
Fungicide
Pesticide
NEMATICIDE
Herbicide

10mg/plant

(recommended)

~5ug/plant

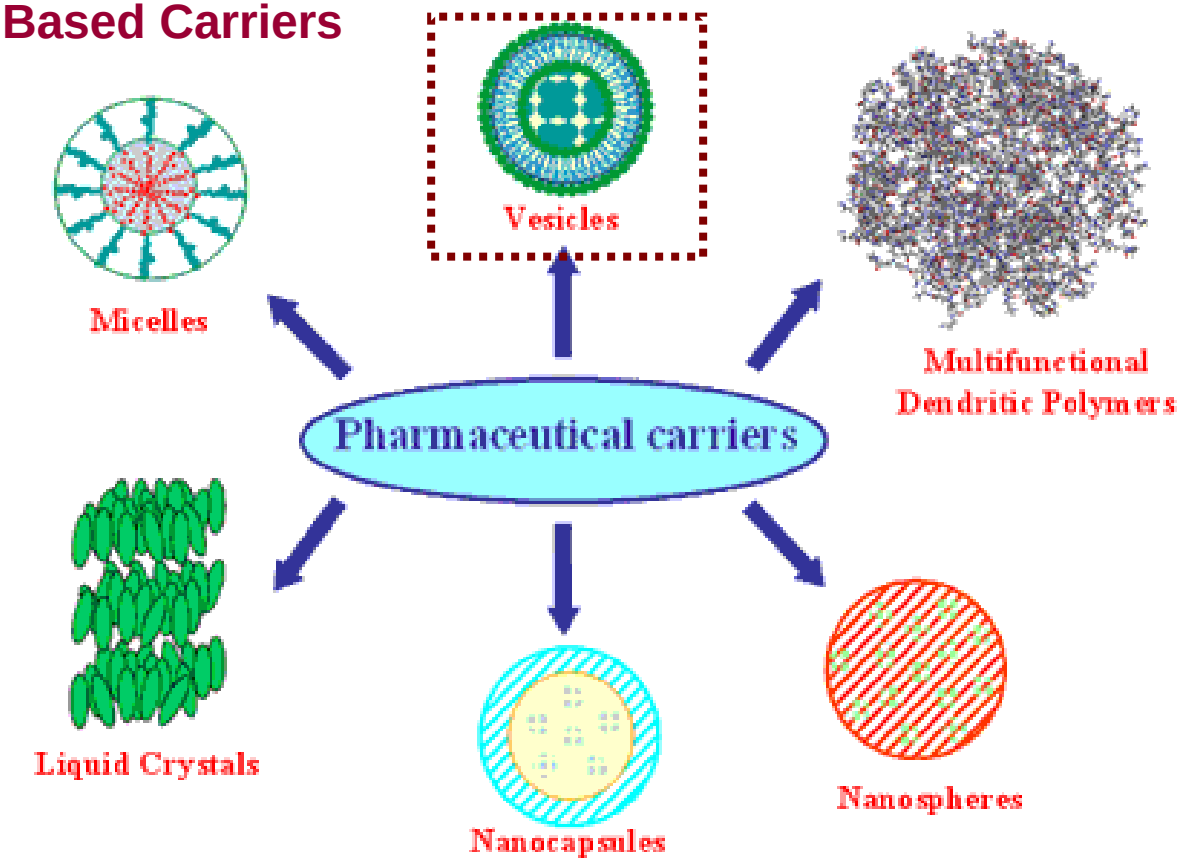
(targeted)

- Stability profile of insecticide liposomal formulation developed and used as a calibration metric
- Stability tested over discrete time intervals of two weeks to six months
- Slow release of insecticide from liposome in soil(s) (e.g. ~0.01 mg/ml over four weeks) monitored under varying watering conditions
- Analyze data from different locations in Illinois, to study the effects of insecticide formulation on corn

Lessons from Biomedical Sciences

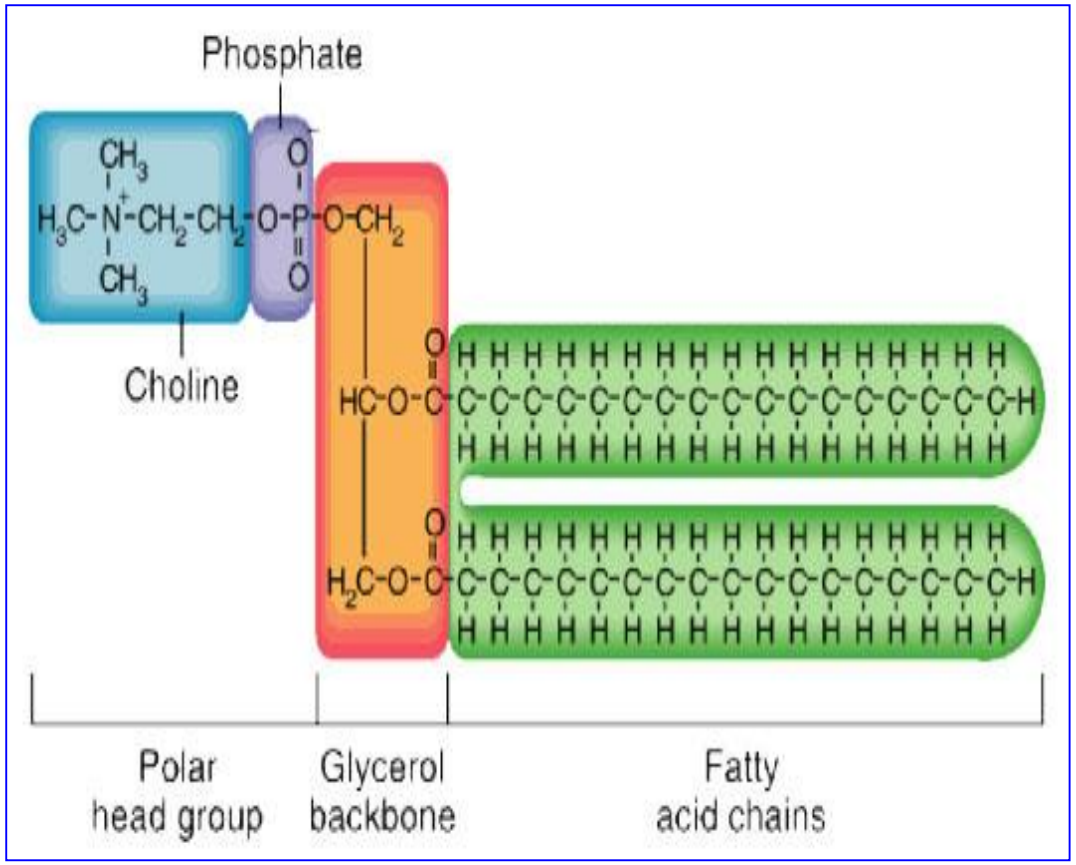
A CARRIER for insecticide: Biocompatible substances that can carry a drug

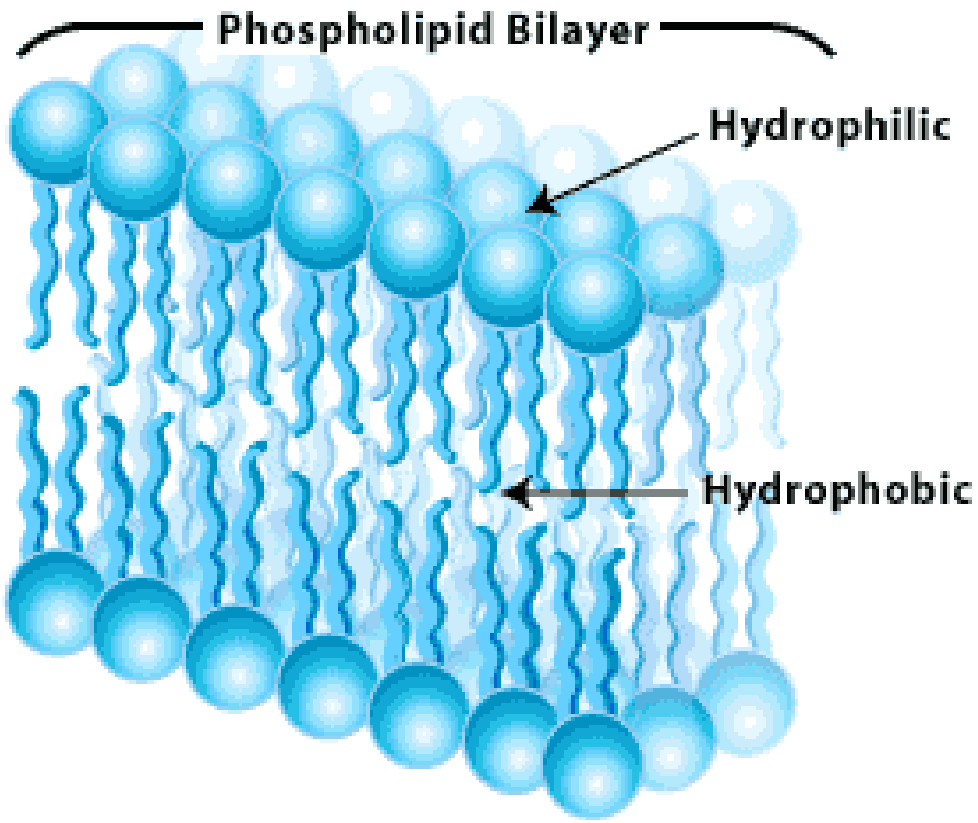
Lipid Based Carriers



Phospholipids

Major Structural lipid in cell membranes





Lipid Vesicles

- In an aqueous environment
  - **Hydrophilic heads assemble together**
  - **Lipophilic tails align away from water**
- They form spherical structures called **liposomes**

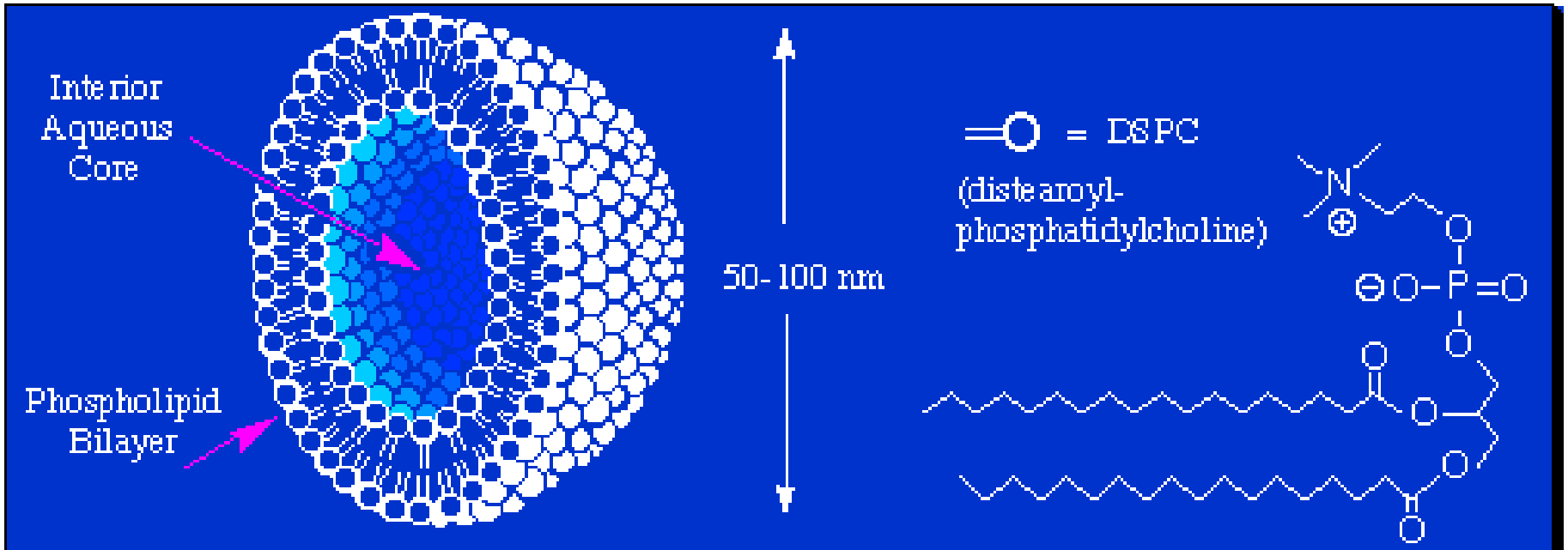
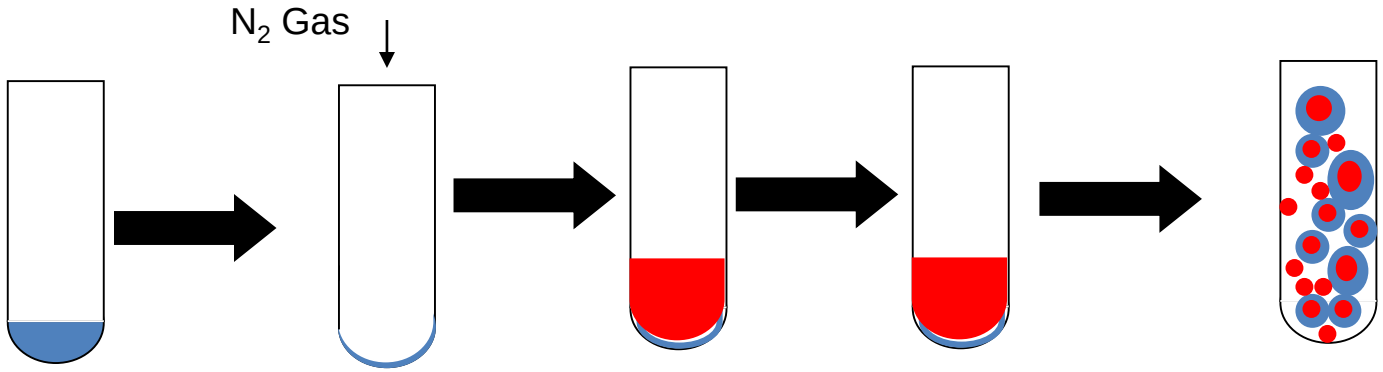


Figure 1. Cross-sectional view of a small unilamellar liposome.

Liposomes are generally relatively small (~50nm in ϕ) in aqueous compartments that are surrounded by a phospholipid bilayer membrane). In our case we are using 1µ sized liposome

Hydration-Sonication Method



Lipids dissolved in $CHCl_3$

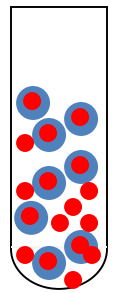
Uniform Lipid Film

Add Insecticide

(Bifenthrin)

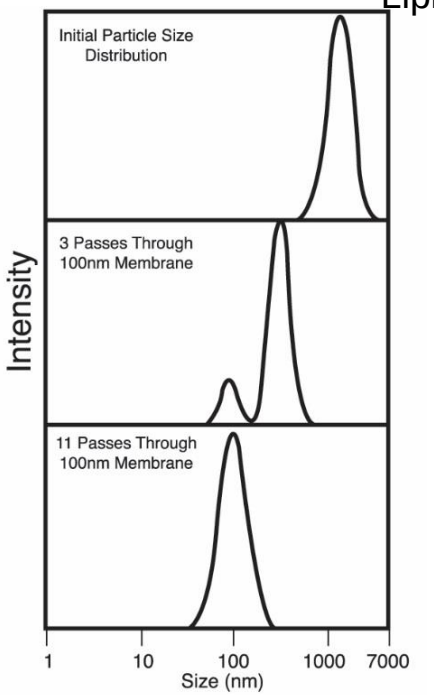
Immerse in Water Bath

Lipid Film swells to form vesicles with insecticide inside



Extrusion for right sizing

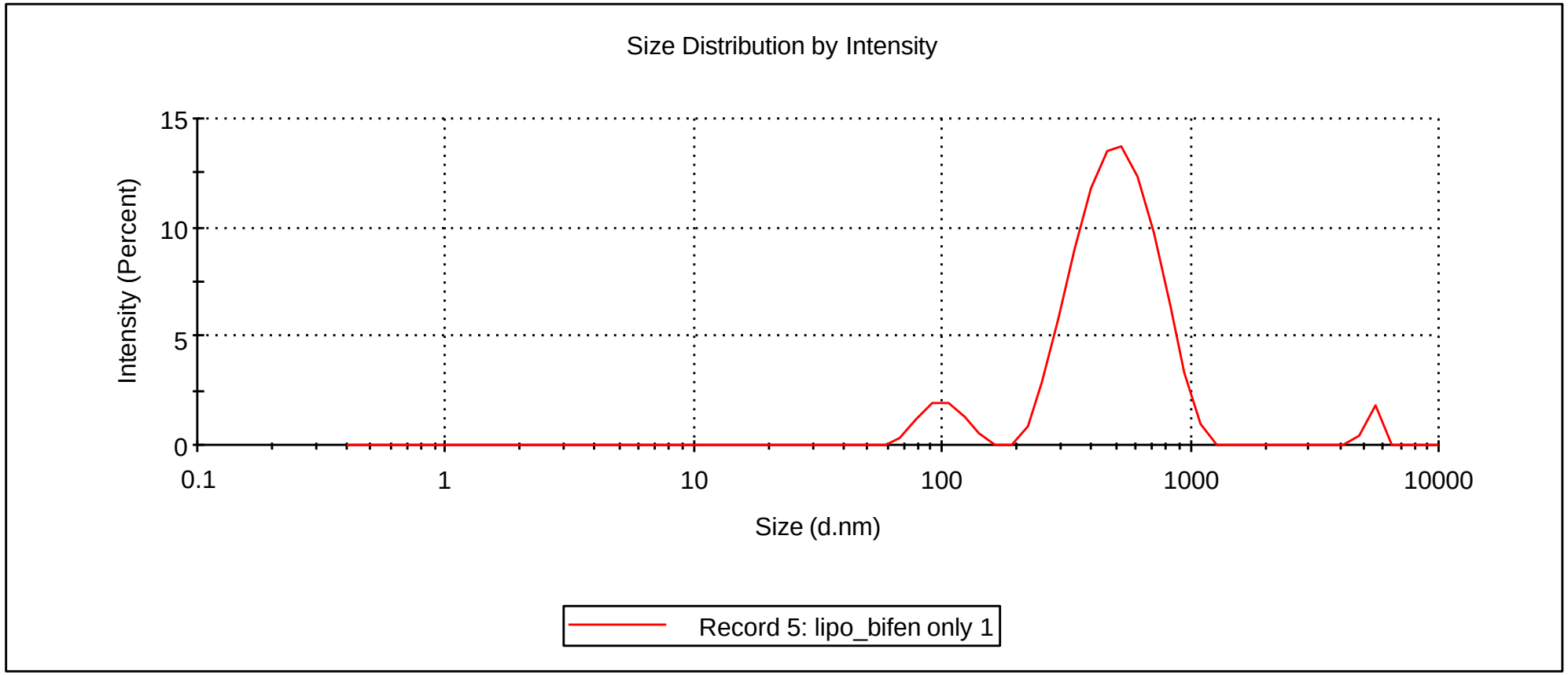
Mean particle size also is based on lipid composition and is quite reproducible from batch to batch.



The energy from the sound waves in sonication process results in a homogeneous population of liposomes

Lasic, D. 1997. Gene Delivery. CRC Press.

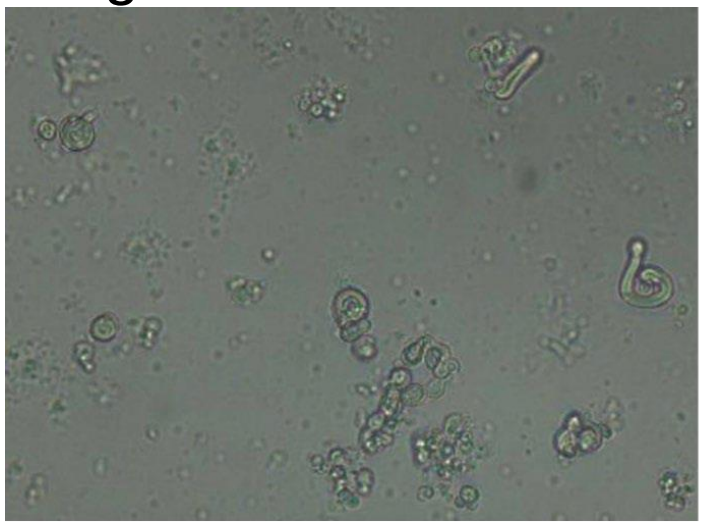
Characterization



Stability

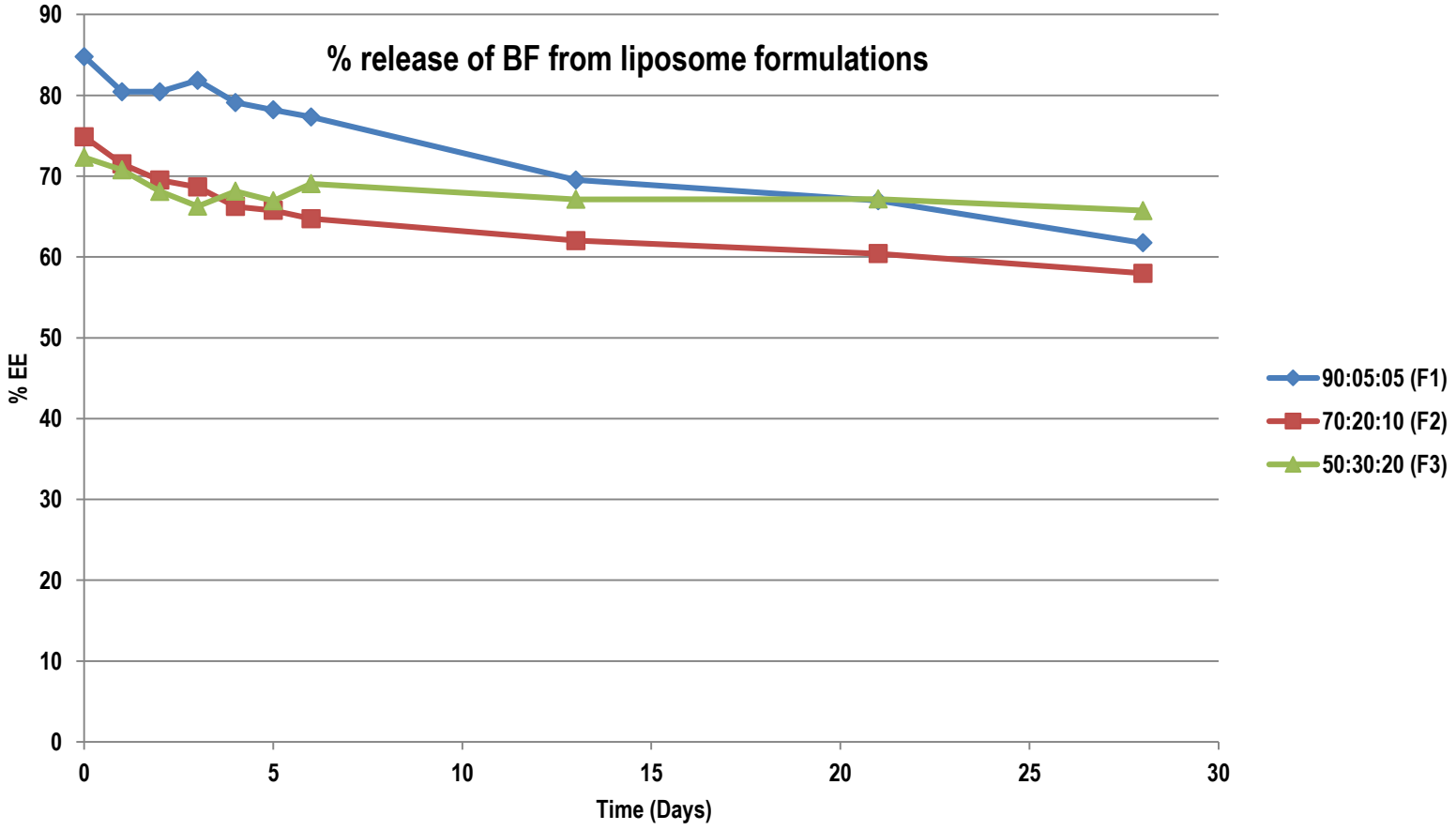
- Measure insecticide leakage
  - Sample A: micro liposome solution at time t = Day 1
  - Sample B: micro liposome solution at t = 2, 7, 14, 21, 28 days
    - Leaked insecticide is removed and two samples are compared

- Differential Light Scattering (DLS) – Measure change in size of carriers 600-1200 µm



An image of an aqueous solution of rehydrated Bifenthrin-liposomes vesicles (crude preparation without sonication; 40X).

Release studies of BF from various Liposomes Formulations



DPPC:DSPC :Chol (50:30:20) showed a constant and prolonged BF release profile as compared to other liposomal systems which showed initial burst and very short release profiles of BF i.e. DPPC:DSPC :Chol (70:20:10) and DPPC:DSPC :Chol (60:10:30)

- Plant-based bioassays using modified methods of Gassmann et al. (2011)
- Soil in 1-liter cups is treated with various liposome formulations
- Neonate WCR larvae are inoculated @≥V5 stage and allowed to develop for 17 days
- Surviving larvae are extracted using Berlese funnels
- Measure on-plant **larval survival (proportion)** and **size (head capsule width)** to assess the impact of formulations on WCR survival and development
- Lab studies on dynamics of WCR-liposome interactions and plot trials for field efficacy

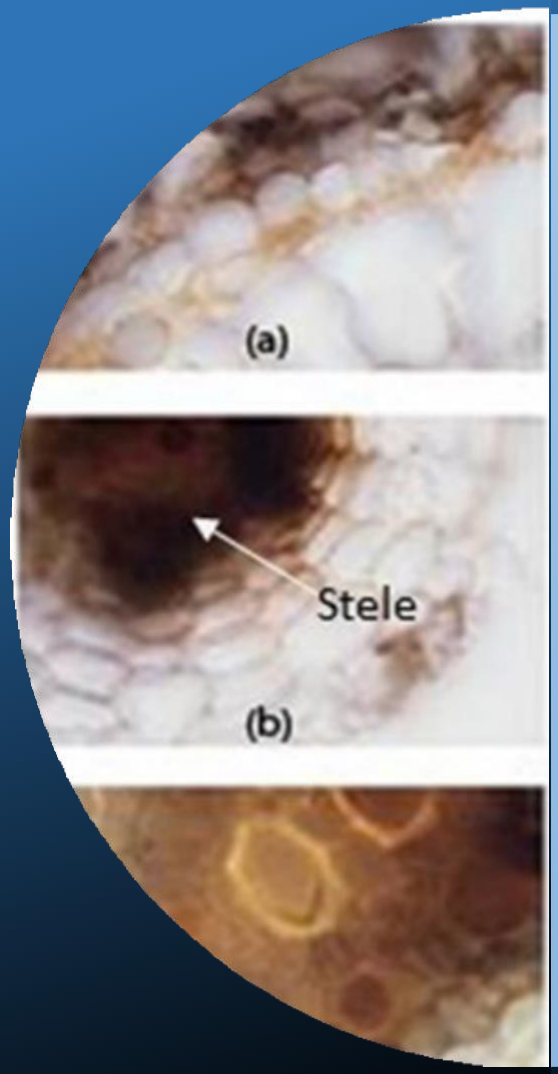
Gassmann A.J., Petzold-Maxwell J.L., Keweshan R.S., Dunbar M.W. 2011.
Field-evolved resistance to Bt maize by western corn rootworm.
PLoS ONE 6(7): e22629. doi:10.1371/journal.pone.0022629

Summary

Liposomes will slow the release of insecticides, prolonging the period when lethal concentrations are present in the soil

Protect corn roots in the field from larval injury longer than roots treated with un-encapsulated insecticide

Liposomes can also be used as a delivery system for different chemicals and gene delivery (i.e. small interference RNA)

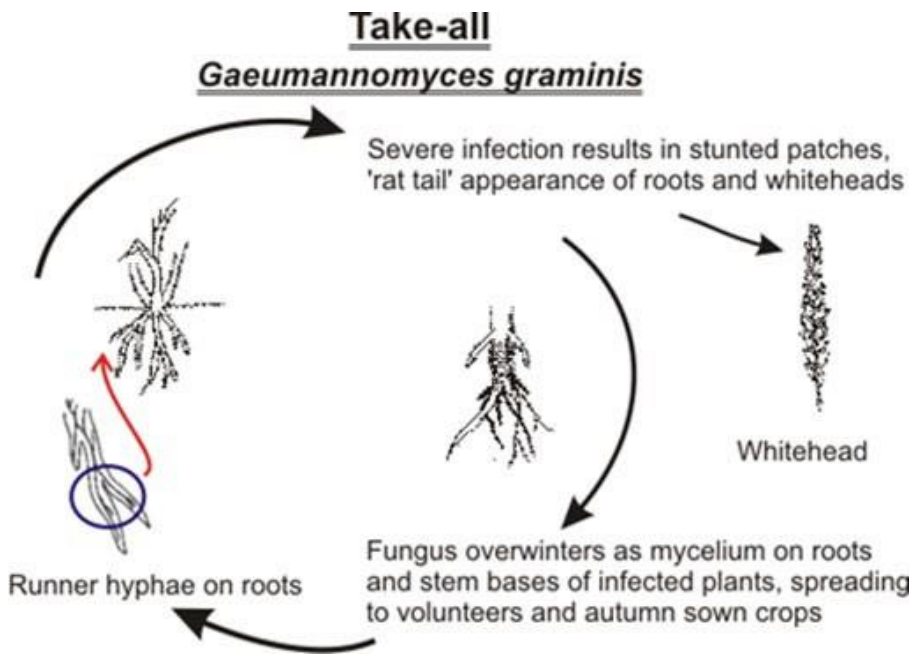


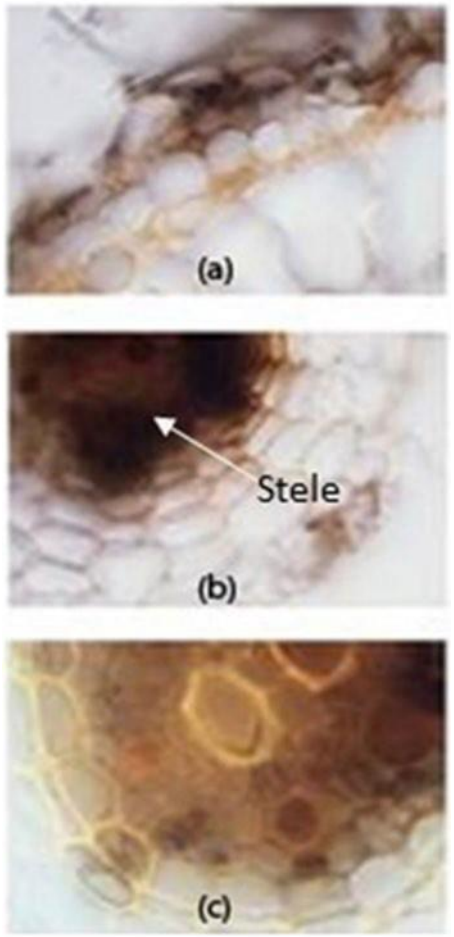
Pathogenesis of Fungi using NEMS

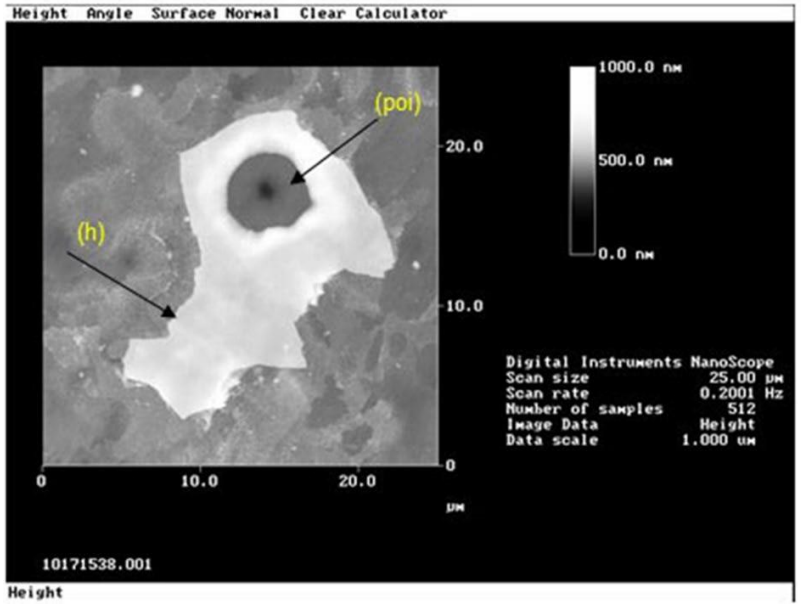
Hanafy Fouly, Taher Saif, Irfan S. Ahmad

Pathogenesis of Fungi using NEMS

- **Rationale: Take-all (*Gaeumannomyces graminis*)** is the most damaging root disease of cereals worldwide. It is estimated that one infected root in 10,000 is sufficient to cause an epidemic. Overall losses incurred by U.S. growers are estimated at $500-1000 million annually.







Distal end of Fungal Hypha (h) with Exposed Point of Indentation (poi)

Infection of wheat root by *Gaeumammonyces* sp. (a) ectotrophic, melanized (black) hyphae; (b) ectotrophic, melanized hyphae with hyline infectious hyphae invading the cortical tissue, transcending the endodermis and colonizing the stele with melanized hyphae; (c) wheat root with non-melanized hyphae at the surface of the endodermis and melanized hyphae in the stele

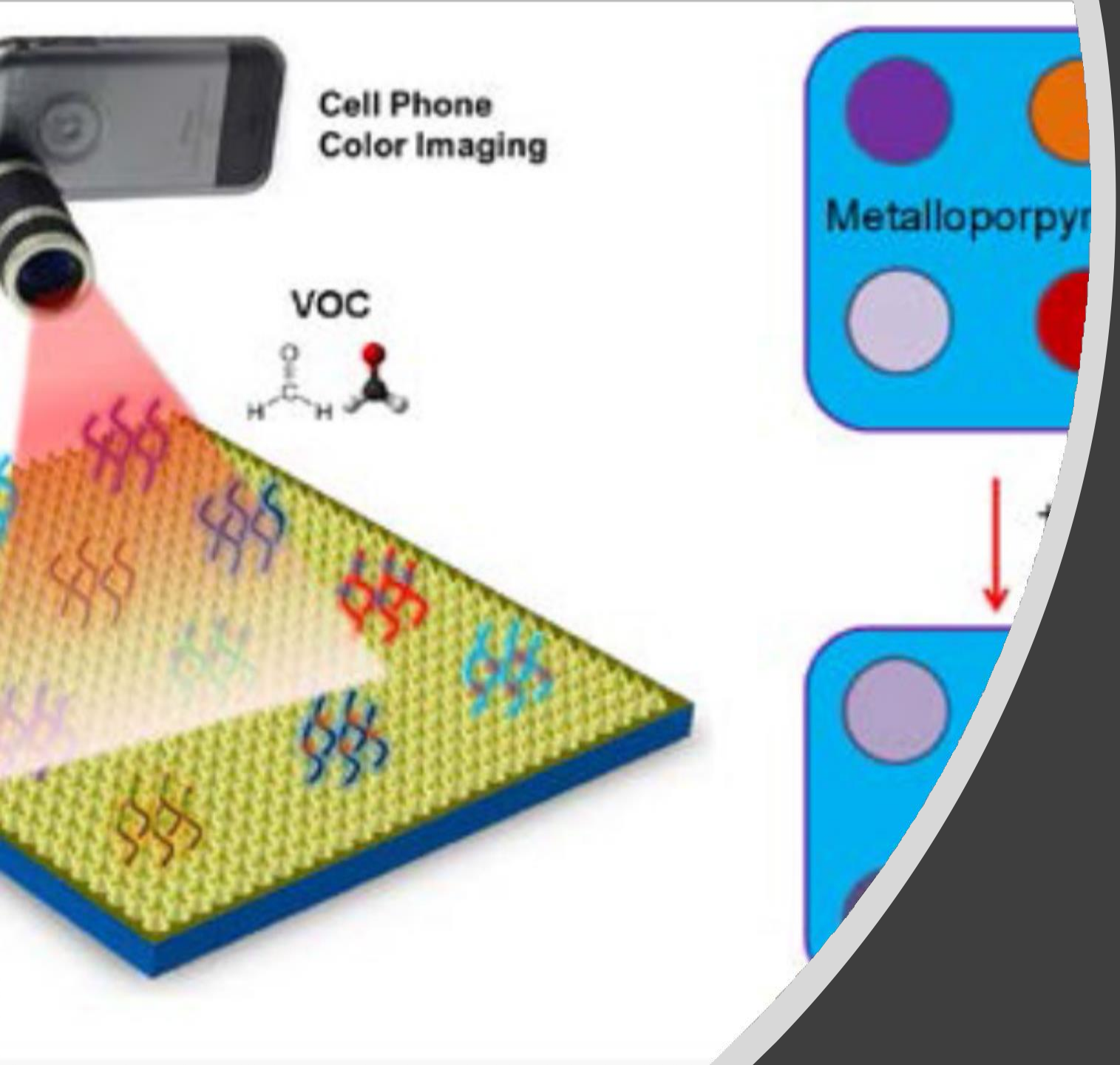
Biosensing of Soybean Rust Spores

- The **overarching goal was-** the deployment of a decision support tool to assist producers with 'if' and 'when' to apply fungicides for the management of soybean rust

- Soybean rust is a disease caused by the fungus *Phakopsora pachyrhizi*, with moderate to severe crop losses worldwide
- With the absence of soybean rust resistant varieties; producers have to resort to effective on-time fungicide application

- Developed a subtractive bioassay to specifically detect the binding of soybean rust spores to its primary antibodies.
- Rust spores are suspension particles in a buffer, difficult to immobilize the rust spores on the sensor surface.
- Using the subtractive bioassay technique, we did not need to immobilize rust spores on the sensor surface, but to detect the amount of antibodies not bound to the spores in the solution.
- The results were compared to a negative control with corn rust spores that did not show any decrease in signals, which means no binding to the available antibodies.
- **Specific detection of primary antibodies by binding to immobilized secondary antibodies on the photonic crystal sensor surface, potentially leading to the development of a hand-held sensing device**.

Irfan S. Ahmad[1,2,4], Leo Chan[3,4], Wei Zhang[3,4], Ramya Vittal[6], Brian T. Cunningham[1,3,4], Glen Hartman[5–7], Linda Kull[5]

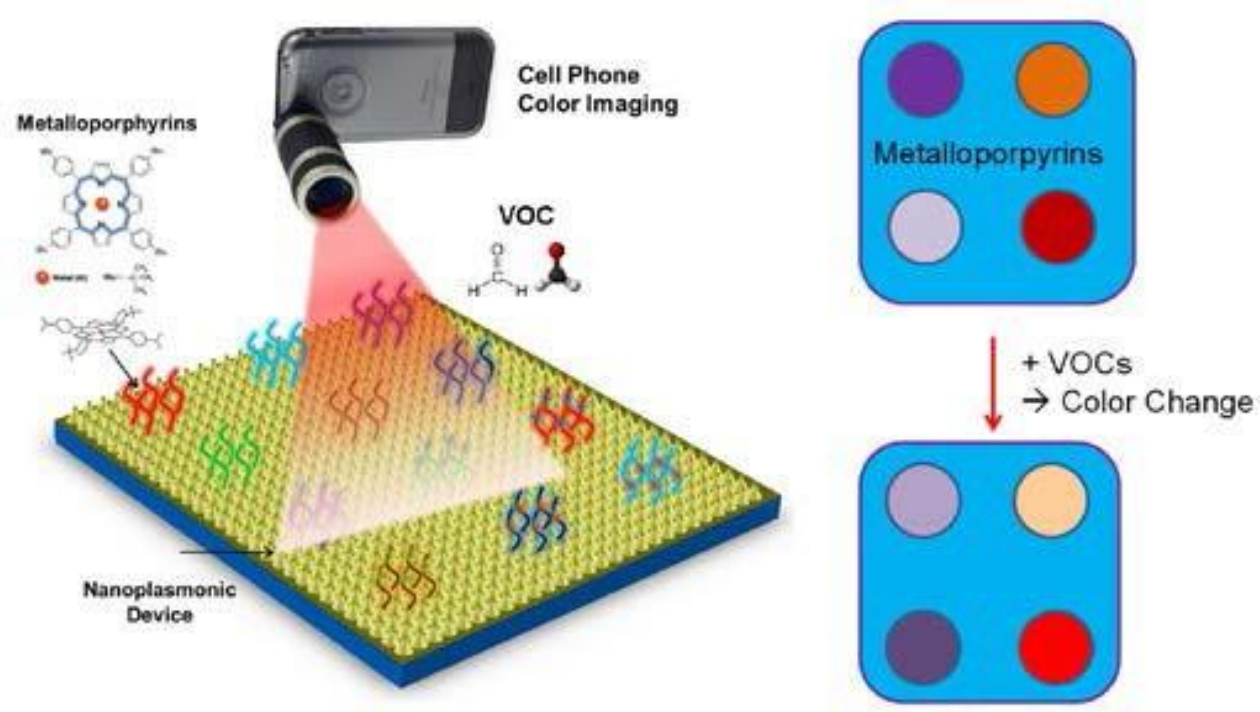


Characterization of Plant Diseases Suppressive Soils using Novel Technology

Hanafy Fouly, G. Logan Liu, Irfan S. Ahmad

Characterization of Plant Diseases Suppressive Soils using Novel Technology*

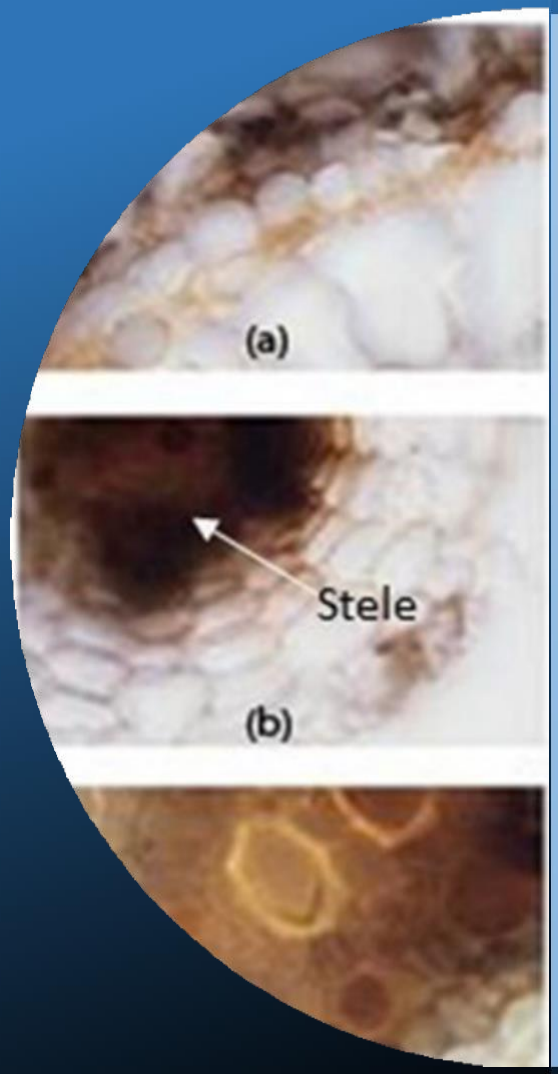
- **Rationale:** Microorganisms live in soil, and play a critical role for maintaining soil function in both natural and agricultural soils because of their involvement in such key processes as soil structure formation, decomposition of organic matter, toxin removal, and the cycling of carbon, nitrogen, phosphorus, and sulphur
- Microorganisms play vital roles in suppressing soilborne plant pathogens, in promoting plant growth, and in changes in vegetation.
- Some soils suppress plant pathogens by limiting either the survival or the growth of those pathogens. Such soils are known as pathogen- or disease-suppressive and are found throughout the world.



Colorimetric nanoplasmonic imaging sensor (device) and cellular phone color imaging system for detecting VOCs.

**Project initiative*

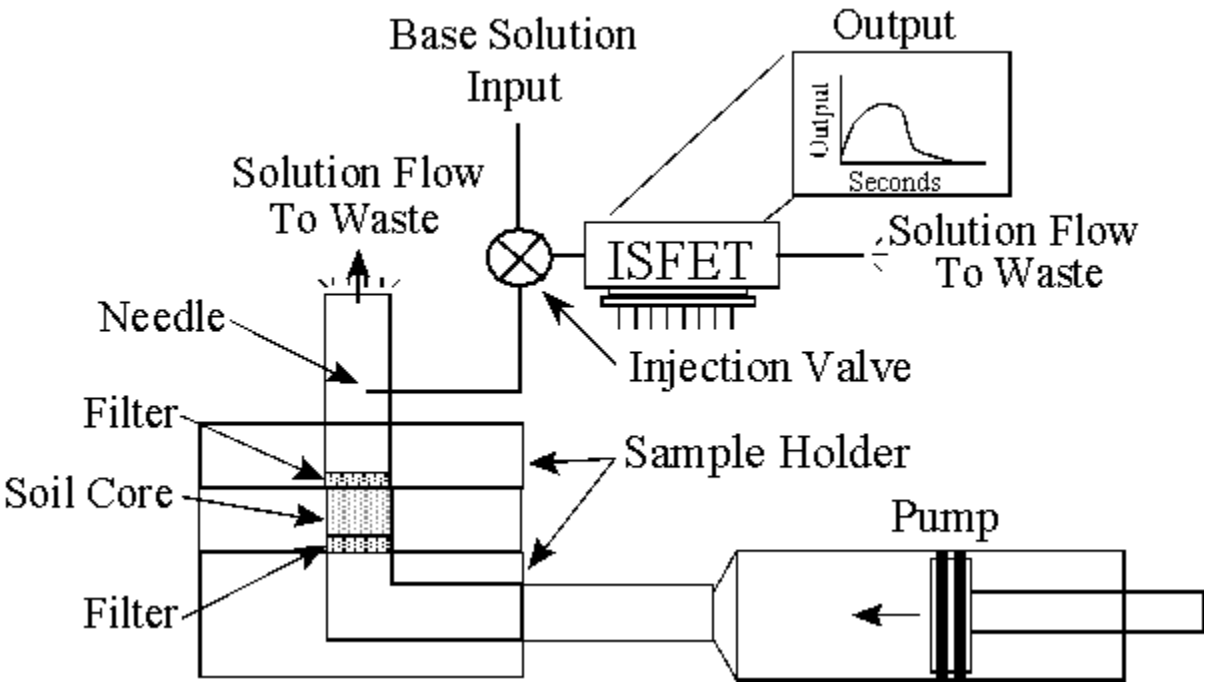
Ahmad, Eastburn, Liu, Fouly



Rapid Nitrate Soil Analysis with ISFETs

Randy Price, John Hummel, Irfan S. Ahmad

Rapid Nitrate Analysis of Soil Cores with ISFETs*



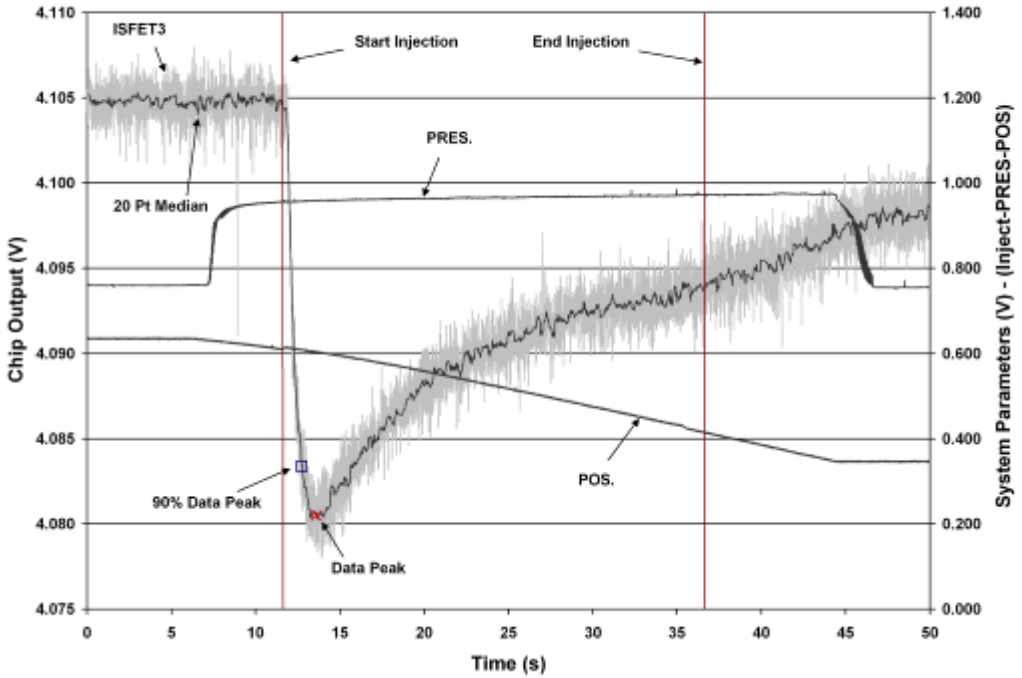


Fig. Nitrate extraction curve (ISFET3) for a low-nitrate Ade loamy sand soil (Test 336 - 31 ppm).

Rapid Nitrate Analysis of Soil Cores Using ISFETs

R. R. Price, J. W. Hummel, S. J. Birrell, I. S. Ahmad

ASAE Vol. 46(3): 601-610

*Ion-selective field-effect transistor/flow injection analysis (ISFET/FIA)

Plant Extracts for Cancer Nanomedicine

Plants-based Medicine

- In medicine, Muslim researchers focused on plant preservation in respect to its characteristics and medicinal features.

- **Wild Thyme**
  - "A wild fine leaves almost black plant. There is one kind of it called 'Donkey or Mountain thyme', wider in leaves, less in bitterness, but the garden thyme is planted like the mint. It is an antidote medicine against colic and almost all types of poisons. It gives a good taste for all foods and refines blood[4]."

    - Dâwûd b. 'Umar Al-Antaki.

Dawud b. 'Umar Al-Antaki, *Tadhkirat uli al-Albab*, Beirut, n. d., vol. 1, p. 223.

Nanomedicine for Cancer Research

Studies on Biologically Active Proteins/Peptides from Medicinal Plants

Irfan S. Ahmad[2,4,5], Atiya Abbasi[1], Saubia Naz[1], Uzma Zaman[1],

Kenneth L. Watkin[2,3], Ezzudin Mohammed[2,3], Brian T. Cunningham[2,4,6]

Sherine George[2,6]

Leo L. Chan[2,4], Saujanya Gosangari[3], Julia Drubinskaya[3], Roveiza Irfan[2,3]

[1]International Center for Chemical & Biological Sciences, HEJ Research Institute of Chemistry, University of Karachi, Pakistan

[2]Center for Nanoscale Science and Technology, Micro and Nanotechnology Laboratory, [3]Applied Health Sciences, and Beckman Institute, [4]Electrical and Computer Engineering, [5]Agricultural and Biological Engineering, [6]Bioengineering, University of Illinois at Urbana-Champaign, IL 61801, USA www.cnst.illinois.edu

George, S., et al., 2010; BioMed Central Complementary and Alternative Medicine;
Chan, Leo, et al. 2011; Evidence-Based Complementary and Alternative Medicine

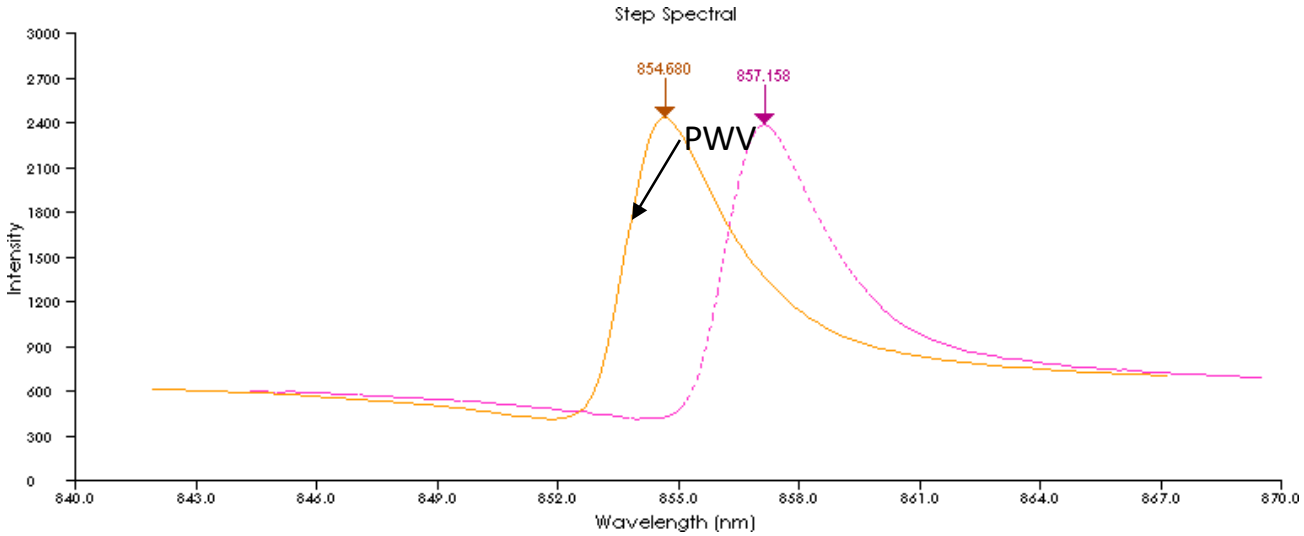
Motivation

- Pakistan has the third highest cancer rate of all thirteen South-Central Asian countries[1]
- Over 70% of the developing world's population still depends on the complementary and alternative systems of medicine (CAM)
- Evidence-based CAM therapies have shown remarkable success in healing acute as well as chronic diseases[2]
- There is a need for:
  - training and capacity-building programs for CAM practitioners
  - bringing CAM to mainstream healthcare

[1]Based on the 2002 world wide statistics reported by the International Agency for Research on Cancer

How the Photonic Crystal Biosensor Works

- Cell attachment to sensor surface causes a change in wavelength of reflected light
- Referred to as Peak Wavelength Value (PWV) Shift
- Sensor surface is illuminated with white light at normal incidence
- Reflected light is collected with a spectrometer



- Sensor is incorporated into 96/384/1536 well microplate format
- Imaging instrument - 22.3µm resolution mode


Cunningham, *et al.*

Human Breast Cancer Cell Screening

- **A baseline scan is taken (a)**

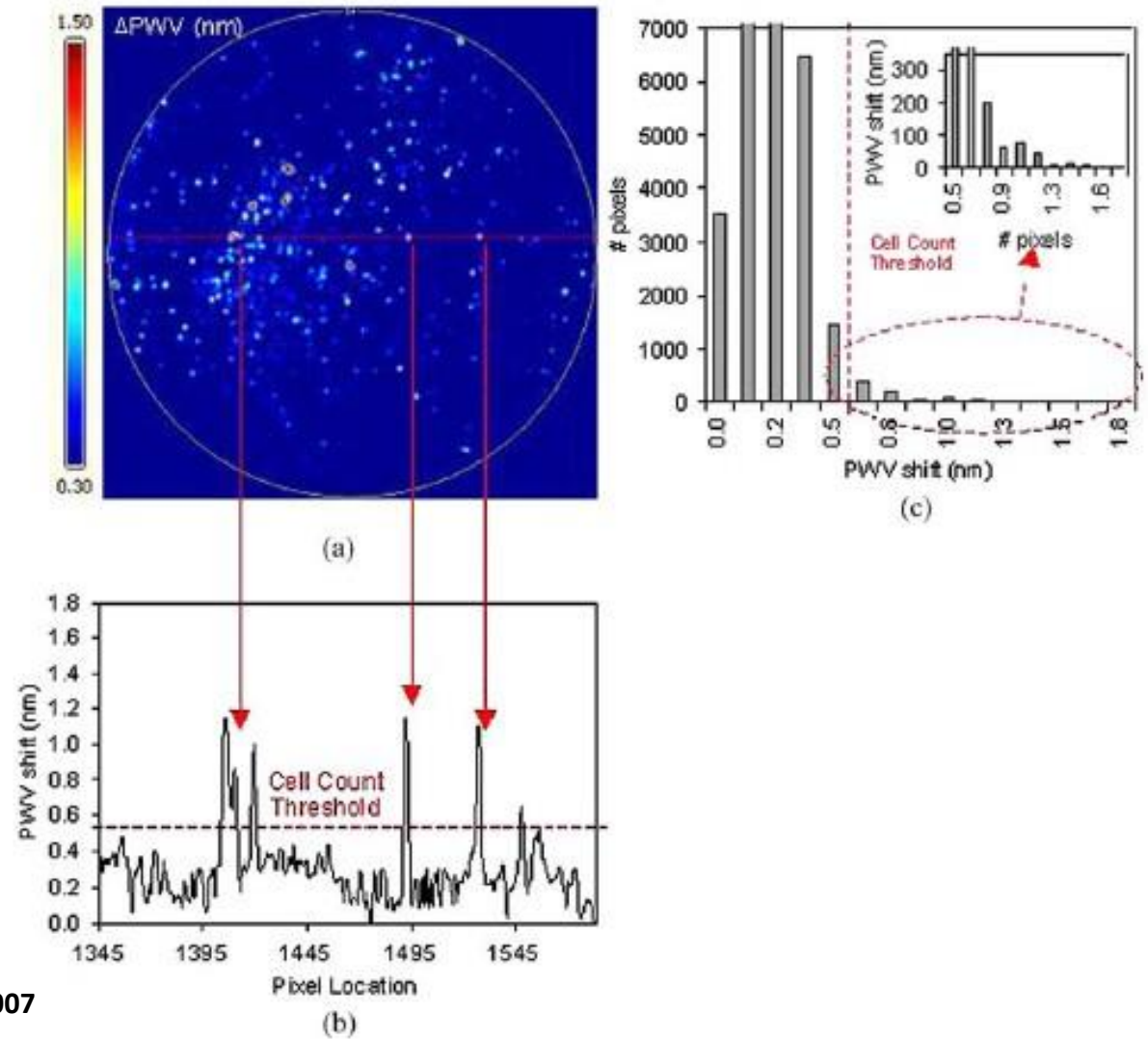
- **Breast cancer cells (MCF-7) are grown on biosensor surface in microplate wells**
  - 24 hr incubation (37 C, CO_2 incubator)
  - PWV shift image due to cell attachment is taken

- **Cells exposed to library of plant extracts**
  - 24 hr incubation (37 C, CO_2 incubator)
  - ~0.1 mg/ml concentration
  - PWV shift image due to cell apoptosis is taken (c)
  - 61 plant extracts from Bangladesh and Pakistan are screened

- **Cell death by apoptosis**
  - Results in LOSS of attached cancer cells from sensor surface

L. Chan et. al, 2007

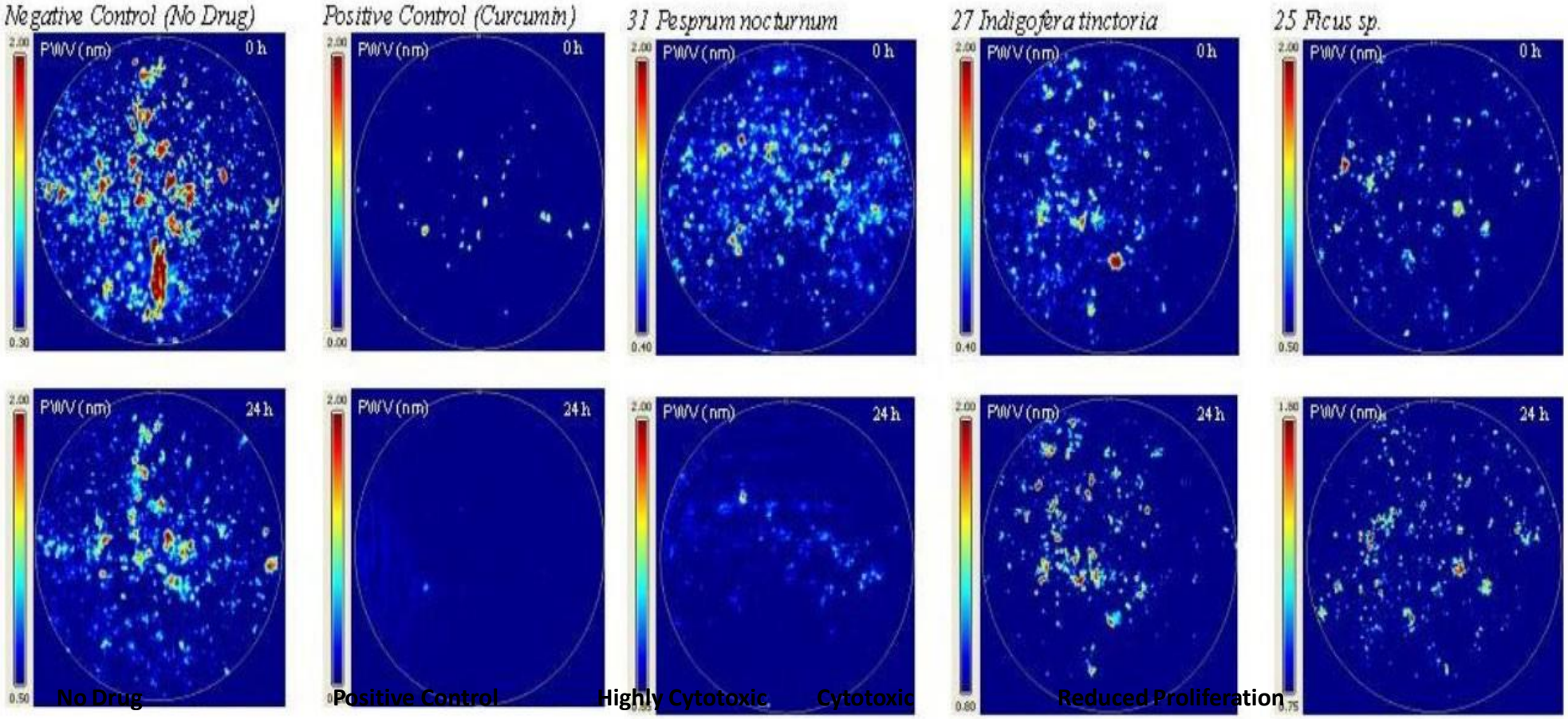
Cell Detection



L. Chan et. al, 2007

- Attachment of cells to biosensor causes a PWV shift
- Histogram of PWV shift values is used to set a threshold for cell attachment
- Cell count is obtained from the histogram

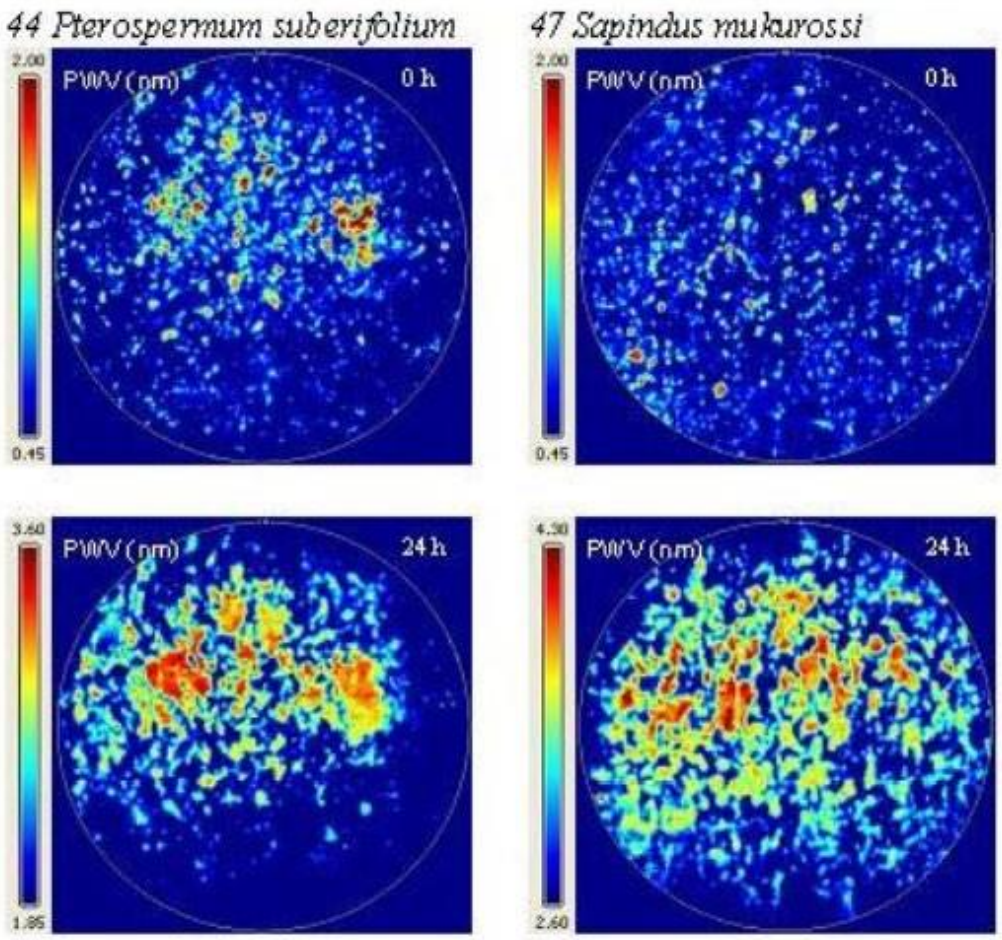
Screening Results



L. Chan et. al., 2007

Center for Nanoscale Science and Technology and College of Applied Health Sciences, University of Illinois

Screening Results



No Effect Enhanced Proliferation L. Chan et. al., 2007

Category	No. of Plant Extracts
Highly Cytotoxic	18
Cytotoxic	10
Reduced Proliferation	20
No Effect	7
Enhanced Proliferation	6
Total	**61**

Cunningham, *et al.*

Center for Nanoscale Science and Technology and College of Applied Health Sciences, University of Illinois

Human Pancreatic Cancer Cell Screening

- Developed cell assay for pancreatic cancer cells (Panc-1) for photonic biosensor system
- Studied cell proliferation in presence of drug
  - Gemcitabine Hydrochloride
  - Obtain a drug concentration curve using the biosensor
- Studied cell proliferation in presence of plant extracts from our collaborators in Pakistan
- Five extracts are currently the focus of this study

Cumin, *Cuminum cyminum*

Plant Extract	**IC 50 ± SD (µg/ml)**
White Cumin - *Cuminum cyminum* LTP	> 100
Black Cumin - *Carum carvi*	83.51± 1.08
Methi - *Trigonella foenum-graecum*	46.89 ± 0.65
Kalonji - *Nigella sativa*	20.13 ± 0.41
Mako- *Solanum nigrum*	1.82 ± 0.16
Doxorubicin -Standard	0.28

Results of *in vitro* cytotoxicity assay of some crude protein extracts/purified protein using Prostrate cancer cell line(PC3)

UI Bionanotechnology Research Facilities

The Center for Nanoscale Science and Technology (CNST)- a campus-wide collaboratory for facilitating research, education, and entrepreneurship in nanotechnology, and the College of Applied Health Sciences, University of Illinois

Bionano Lab

- Part of the CNST Collaboratory
- 8000 sq. ft Class 100 clean room
- BioNanotechnology labs
- Research Areas include:
  -Nanophotonics and Optoelectronics
  - Micro and Nanoelectronics
  -Bionanotechnology and Nanomedicine
  - MEMS and Integrated Systems

HEJ Research Institute of Chemistry

International Center for Chemical and Biological Sciences

University of Karachi




- Houses the single largest doctoral program in Pakistan with over 250 PhD students
- Member of the International Center for Chemical and Biological Sciences system (ICCS)
- Research Areas include:
  - natural product chemistry
  - protein chemistry
  - computational medicinal chemistry
  - plant biotechnology

Center for Nanoscale Science and Technology and College of Applied Health Sciences, University of Illinois

Plant Extracts for Cancer Nanomedicine

Type of data produced -Standardized data format? -Specific to any particle class of nanoparticle? -Data archived anywhere?	**-Plant extracts for medicinal use (cancer and infectious diseases)** **-Current Qty: 100, with 3000 more to study** **-Being explored with NanoHub at Illinois**
Importance and frequency of this type of nanocharacterization -Importance=(1-5 scale, 5 highest) -Frequency of use=(1-5 scale, 5 highest)	Importance: 4 Frequency: 4
Type of equipment/ instrumentation needed	Biophotonic crystal sensor and card reader
Reference materials available (if at all) -Interlaboratory studies performed?	-Beckman Institute for Advanced Science and Technology -Micro and Nanotechnology Laboratory -ICCS/HEJ Chemistry Institute, Karachi; USDA, ARS, National -Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]

ILLINOIS MEDICINAL PLANT DATABASE

Kenneth L Watkin PhD, Irfan S Ahmad PhD, Brian T Cunningham PhD

College of Applied Health Sciences & College of Engineering
University of Illinois at Urbana-Champaign USA

Atiya Abassi PhD

H E J Research Institute of Chemistry
University of Karachi Pakistan

Developed with support from -

The National Academy of Science
US Agency for International Development (USAID)

Pakistan Higher Education Commission (HEC)
A Pakistan – US Science Technology Cooperative Program

Illinois Medicinal Plant Database: Typical Plant Extract Entry

Brassica juncea

Scientific name(s): *Brassica juncea* (L.) Czern. (1), *Brassica integrifloia* (Vahl) O.E. Schulz, non Rupr. (1) *Brassica integrifolia* Rupr. (1). *Brassica japonica* Thunb. (1). *Brassica juncea* (L.) Czern. Var. *crispifolia* L.H. Bailey (1), *Brassica juncea* Czern. Var. *japonica* (Thunb). L.H. Bailey (1), *Brassica willdenowii* Boiss. (1) *Sinapis juncea* L. (1), *Brassica integrifolia* (West). O.E. Schulz (2), *Brassica juncea* (L.) Hook. F. & Thomson (3), *Brassica juncea* (L.) Coss. (3), *Brassica juncea* (Linn.) Czern. Et. Coss (4)

Family name(s): *Brassicaceae* (1)
Cruciferae (2)
English name(s): India mustard (1), curled mustard (4), brown mustard, leaf mustard, mustard greens,
chinese mustard (8)
Urdu name: Sarson (5) سرسوں
Arabic name: Khardal خردل

Scientific classification

Kingdom: Plantae
Division: Angiosperms
Order: Brassicales
Family: Brassicaceae
Genus: *Brassica*
Species: *B. juncea*

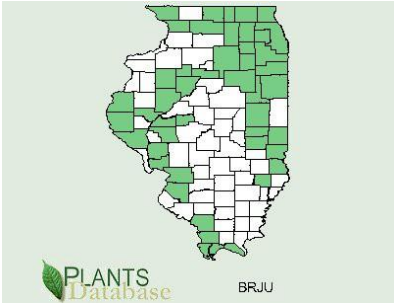
Imaged at Beckman Visualization Lab.

Introduction

Brassicaceae is a large family which include 350 genera and about 3000 species (5). It is a distributed nearly worldwide, especially in the temperate areas, with the highest diversity in the Irano-Turanian region, Mediterranean area, and Western North America (6). The genus *Brassica* includes plants that are annual, biennial, or perennial herbs. There are about 40 species in this genus distributed mainly in the Mediterranean region; only seven of them are found in Pakistan, among them is *Brassica juncea* (L.) Czern (5).

Brassica juncea (L.) Czern is native to Asia temperate, widely naturalized and widely cultivated (7).

Distribution



Description

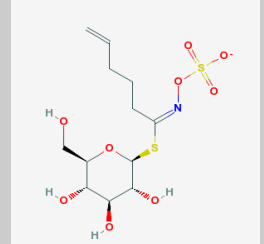
Brassica juncea (L.) Czern is an erect, reddish-brown (5). There is tremendous variation in the basal leaf morphology of *Brassica juncea* (L.) Czern., and minor variants have been recognized at specific, subspecifical, and varietal ranks (10).

Constituents and Uses

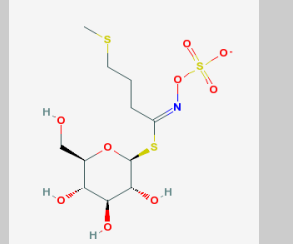
Brassica juncea (L.) Czern. is high in vitamin A, vitamin C, and iron. Seeds contain sterols, sinigrin, myrosin, sinapic acid, sinapine, and fixed oils. Hydrolysis of sinigrin by the enzyme myrosin yields allyl isothiocynate, glucose, and potassium bisulfate. Allyl isothiocynate is volatile. Allyl isothiocyanate is an irritant. It is also lachrymatory and has counterirritant properties when greatly diluted. It should not be tasted or inhaled when undiluted. It is one of the most toxic essential oils. Volatile mustard oil has strong antimicrobial (bacteria and fungi) properties (11).

Brassica juncea (L.) Czern is reported to be anodyne, aperitif, diuretic, emetic, rubefacient, and a stimulant. It is a folk remedy for arthritis, footache, lumbago, and rheumatism. Seeds used for tumor in China. Roots used as a galactagouge in Africa. Believed to be aperient and tonic, the volatile oil is used as a counterirritant and stimulant. In Java the plant is used as an antisyphilitic emmenagogue. Leaves applied to the forehead are said to relieve headache. In Korea, the seeds are used for abscesses, colds, lumbago, rheumatism, and stomach disorders. Chinese eat the leaves in soups for bladder inflammation and hemorrahe. Mustard oil is used for skin eruptions and ulcers (11).

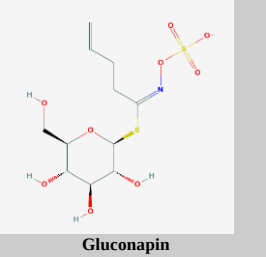
Phytochemicals



Glucobrassicanapin



Glucoiberverin



Gluconapin

Mohammed, et al.

Notes

Disclaimer: Everything mentioned in this database is for educational purposes. The University of Illinois cannot take responsibility for any adverse affect from the use of plants mentioned in this database. Always seek advice from a professional before using a plant medically.

Overall Conclusions

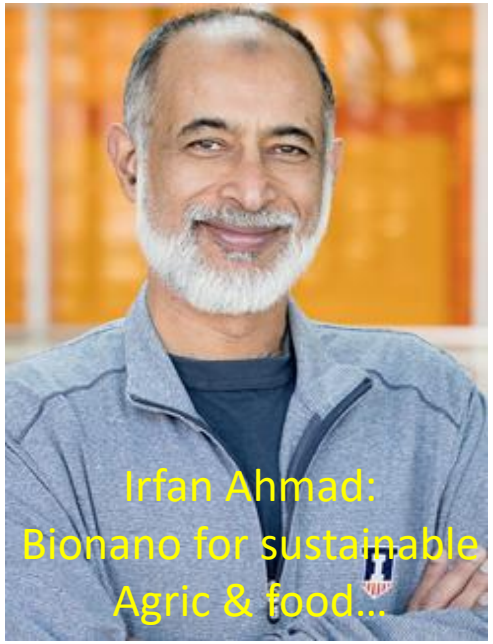
- Bionanotechnology research provides avenues for transitioning to **environment-friendly agriculture** and for enhanced **food security**
  - more research is needed

- **Digital Agriculture** in sync with Machine Learning/Artificial Intelligence and Bionanotechnology could revolutionize communities and improve livelihoods by alleviating poverty

- The **next generation agricultural engineering workforce** has to be prepared to work at the intersection of bionano in agricultural sciences, big data, and sensing technologies.

Egypt Saudi Arabia United States Pakistan Kuwait China Morocco Turkey Palestine Japan Jordan UAE

NanoPower Group*



* Formed in 2004 to promote nanotechnology research, innovation-based entrepreneurship, education/training, and outreach

Acknowledgements

- SmartSensing Research Group- Research scientists, graduate and undergraduate students
- National Academy of Sciences
- Nano Sensors Group, UIUC
- Holonyak Micro and Nanotechnology Lab, UIUC
- Beckman Institute, UIUC
- Center for Nanoscale Science and Technology, UIUC
- Profs. Munir Nayfeh, Taher Saif, Rashid Bashir
- ICCS/HEJ Chemistry Institute, University of Karachi- Prof. Atiya Abbasi
- Prof. Tehmina Anjum and collaborators, University of the Punjab

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Illinois Council for Food and Agriculture (C-FAR)

THANK YOU

Kingdom of Morocco

Islamic World Academy of Sciences (IAS)

Hassan II Academy of Science and Technology

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ENERGY SECURITY BETWEEN NUCLEAR, RENEWABLE AND NANOTECHNOLOGIES

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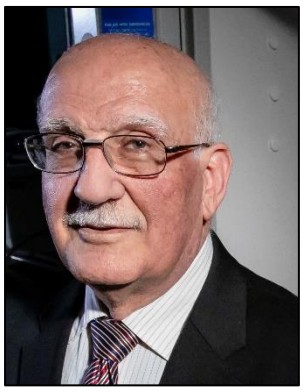
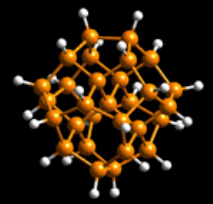
President, NanoSi Advanced Technologies, Inc. Champaign, Illinois, USA

ABSTRACT



The time of abundant oil and gas is at an end and the world is entering a stage where finding resources is becoming more "complex" and requiring more money and investment. In fact, energy security is becoming one of the leading issues in the world today, and as such great efforts are put to action to find solutions. Here we argue that there is no single solution for energy security, rather a multi-component solution is more likely. These include oil (+ natural gas + coal), nuclear energy, renewable energy, conservation as well as technology and innovation. Renewables such as solar, wind, geothermal, hydro, and biomass including biofuels constitute a potentially very useful component but they are intermittent. Technological innovation such as advanced material technologies and nanotechnology, which will bring cost reductions of energy technologies, is destined to be a driver of the uptake of renewable energy sources, conservation, and enhanced oil discovery and recovery. Nuclear energy however is pivotal, and we believe that there can be no real security without nuclear energy to provide a steady energy component. Finally, true security lies in the "stability of the energy market" for all participants, importer and exporters, rather than the narrowly defined interest of any one country.

Energy security between nuclear, renewable, climate and nano technologies



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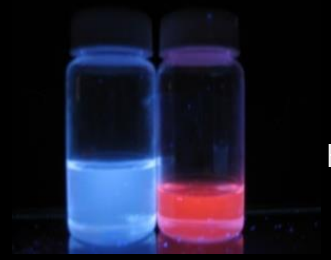


Hassan II Academy of Science and Technology Conference, Rabat , Morocco
October 17, 2022

What is energy security?

Energy Security is

(i) **uninterrupted** physical availability

(ii) **price** which is affordable & "steady"

(iii) respecting **environment** concerns

(iV) eliminating **climate** problems

Energy security has become one of the leading issues in the world today

Energy Security Between nuclear, renewable, climate, and nanotechnologies

The Energy Challenge تحديات الطاقة

Increasing global energy consumption - زيادة الاستهلاك

Acute Interruptions in supply chains, production and sanctions due to climate disasters, wars, pandemic disease or politics الكوارث الكبرى

Increasing oil and natural gas prices - زيادة الأسعار والتكلفة

Nearly 2 billion people live without electricity - عالم بدون كهرباء

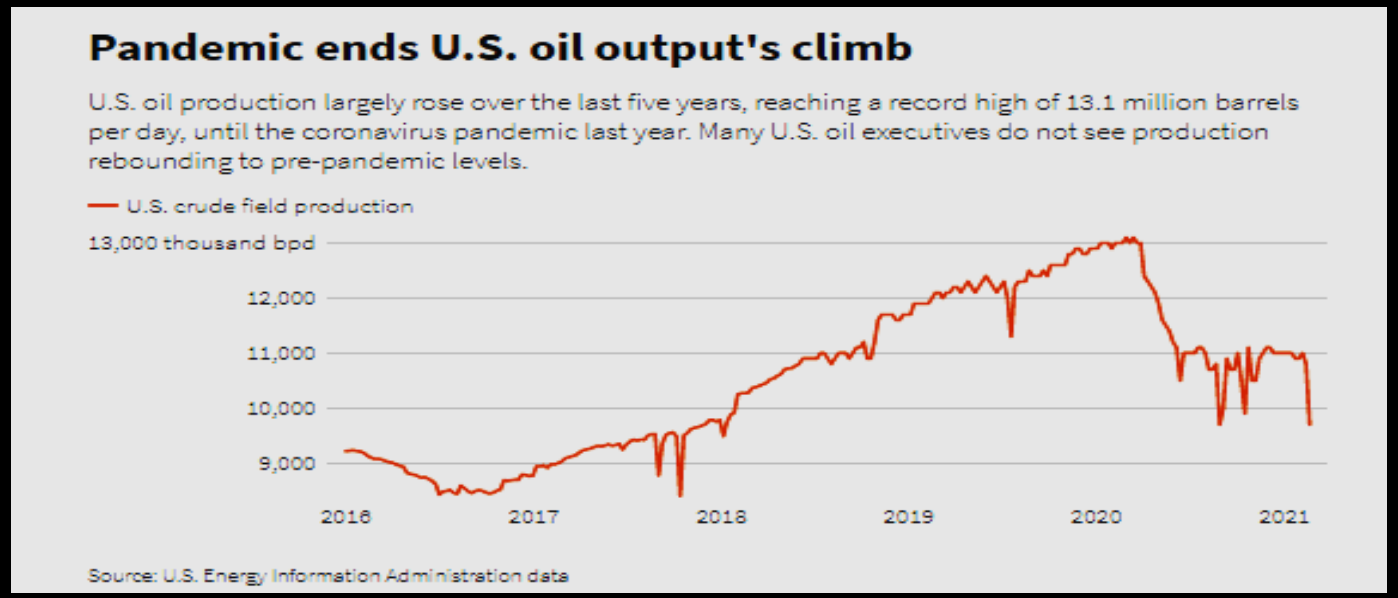
Global warming - الاحتباس الحراري

Environmental pollution - التلوث البيئي

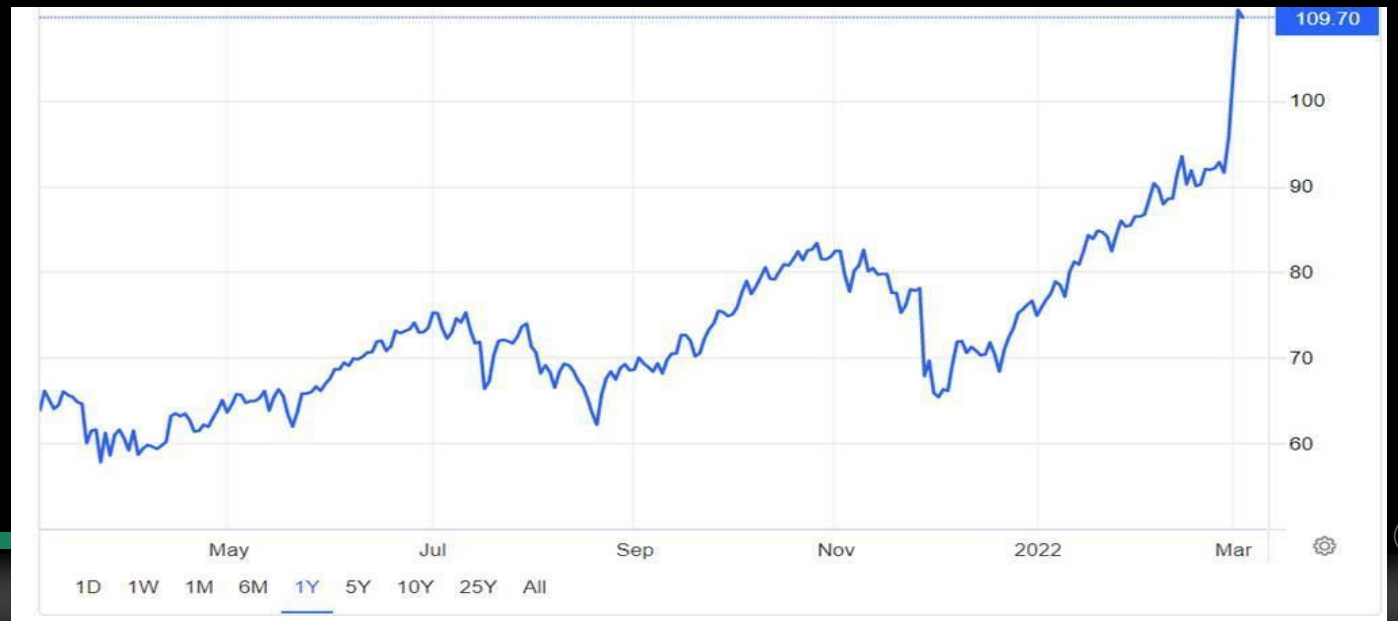
Crashes and spikes of oil production & prices

الكوارث الكبرى

Corona pandemic



Russia-Ukraine war



Energy Resources

Fossil (Oils, coal, natural gas, shale)

Renewable (solar, biomass, hydro (water), geothermal, wind

Nuclear

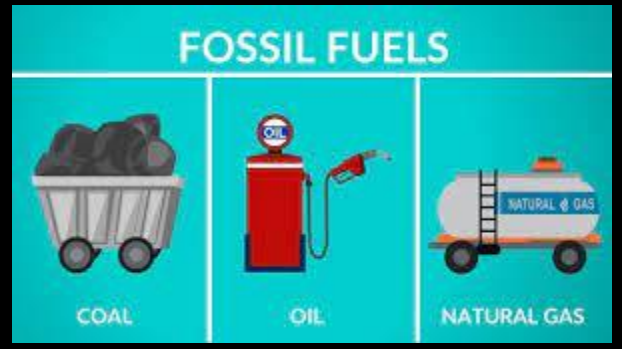
Oil to economy has become what **oxygen** is to humans

The new resources will become more useful as the **price** of exporting and importing oil increases due to the increase of demand.

Fossil- (oil, gas, shale, and coal)

Types: Crude Oil or Petroleum, coal, natural gas, shale, and orimulsion are the four fossil fuel. They are Nonrenewable energy resources. We can add nuclear energy to the non renewables.

Origin: Over millions of years, heat and pressure from Earth's crust decomposed organisms (remains or **fossil** of ancient marine organisms, such as plants, algae, and bacteria, dead animals and plants).



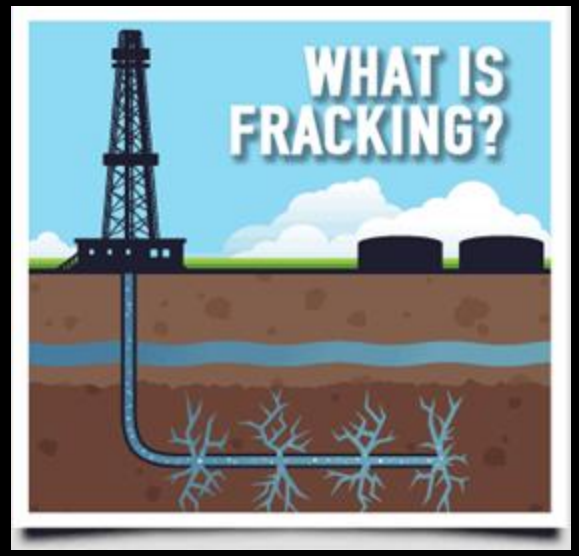
Burning to energy: Petroleum is mainly a mixture of hydrocarbons containing only **carbon and hydrogen**. The most common components are paraffins, naphthenes, and aromatic hydrocarbons. They are burned in the presence of oxygen. Heat energy is produced and used to heat water, which produces steam which rises and drives a turbine.

Shale Revolution

Unmature rock formations

The "fracking" technology — a combination of the words "hydraulic fracturing" — so far is a phenomenon limited largely to the United States, although many other countries including China, Australia and Mexico have similar energy exploration potential.

It's a deep-drilling technique that injects fluid into the ground at a high pressure in order to fracture shale rocks to release natural gas allows that previously were unreachable.



Fracking could turn the world market for energy upside down

Nuclear Power

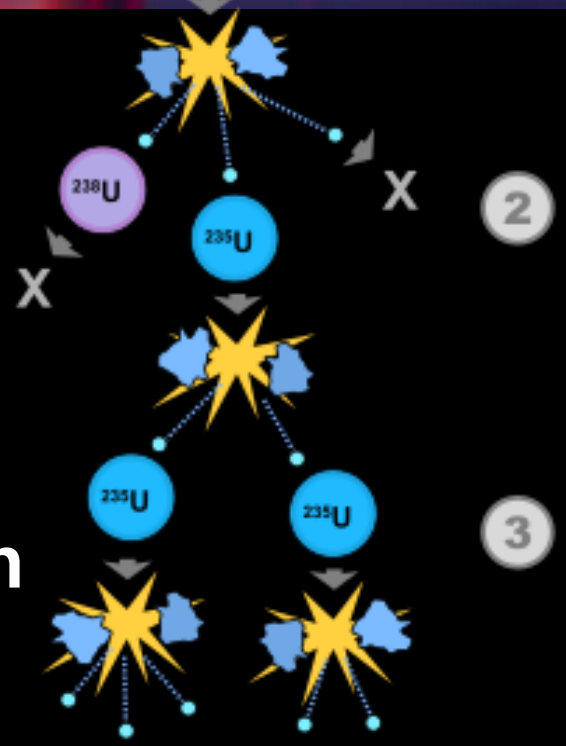
- Uranium is mined & enriched
- Relatively-**reliable** power

- **Peak** uranium does exist (Underwater sources)

- **Danger** associated to it

  -high waste energy

  -radiation leaks (nuclear runoff into streams & lakes)



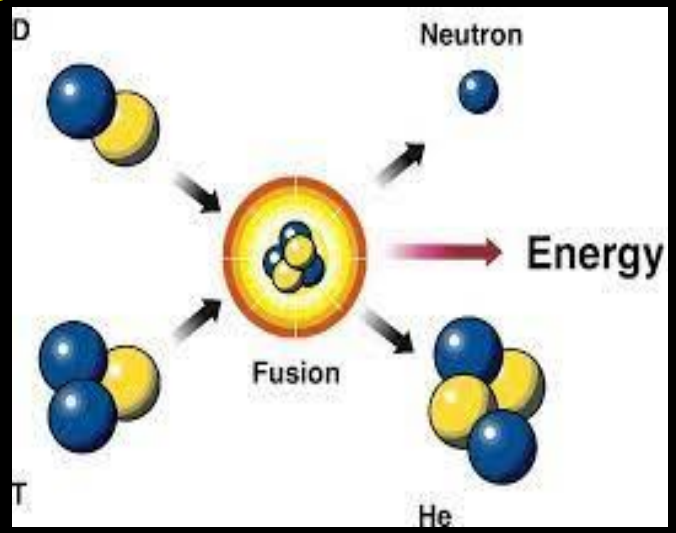
Currently it powers a small fraction of the worlds electricity (15%)

ITER Project: International Thermonuclear Experimental Reactor

" put the sun into a box. The problem is, we don't know how to make the box."

The 14 MeV neutrons produced by the fusion reactions will damage the materials from which the reactor is built.

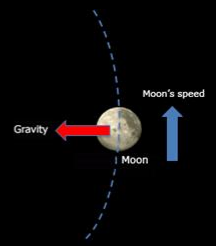
Neutron bombardment will induce radioactivity in the reactor material.

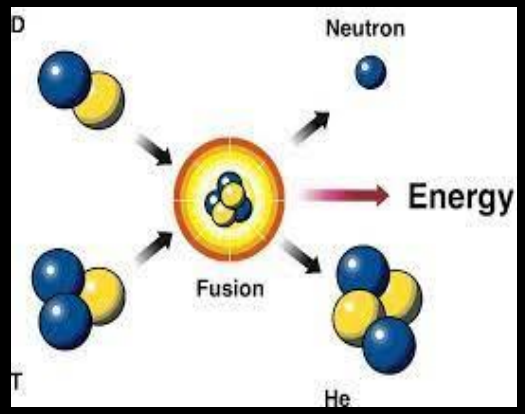


- A Tokamak uses a magnetic field to confine a plasma in the shape of a torus
- The Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory (PPPL) from 1982 to 1997

Gravitation: ultimate origin of energy

The origin of energy is:





Gravitation: **formed stars, gravitation collapse, burning star, sun for example (nuclear)**

The sun and stars use nuclear reactions to produce energy (matter is converted to energy).

Naturally: Some nuclear energy is produced naturally. The Sun and other stars make heat and light by nuclear reactions.

Stars work on fusion
Nuclear reactors work on fission

Man-Made: Nuclear energy can be man-made. N**uclear reactors** provide electricity for many cities. Nuclear reactions also occur in the explosion of atomic and hydrogen bombs

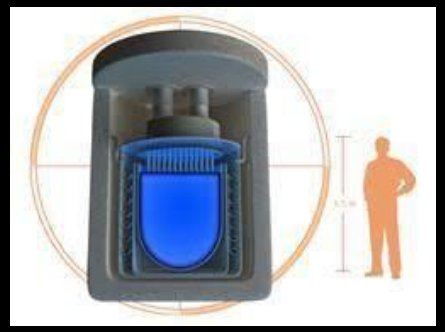
Presently, nuclear energy provides for ~ 16% of the world's electricity.

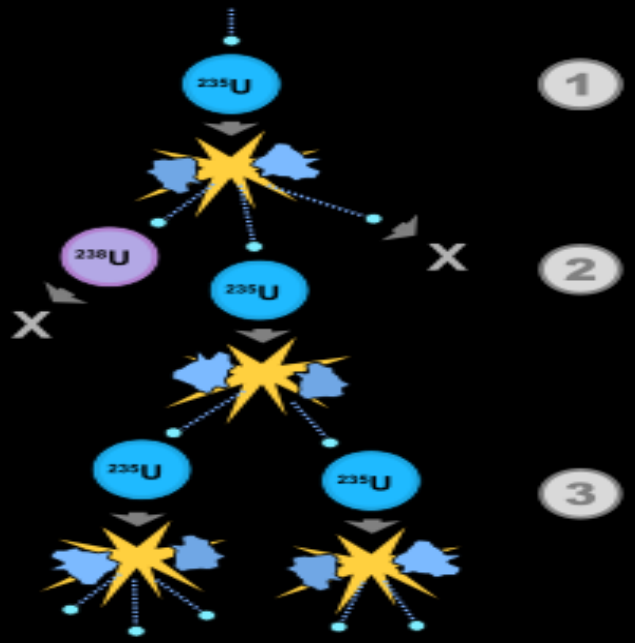
Fossil oil: organics under extreme pressure/temperature

Scientists are working to make fusion reactors with potential of providing more energy with fewer disadvantages than fission reactors.

Small modular reactors (SMR)

SMRs are nuclear fission reactors that are smaller than conventional nuclear reactors and typically have an electrical power output of less than 300 MW_e or a thermal power output of less than 1000 MW_{th}.





Power ~ 230,000 homes a year.
Construction time: 500-day
Cost $600 M (10% of standard)
Construction mode: *in situ*

Cooling: Conventional reactors use water as a coolant. SMRs may use water, liquid metal, gas and molten salt as coolants.

Modular Reactors in action

- The first and only completed working prototype in the world connected to the grid (2019)

- Place: Floating nuclear power plant Akademic Lomonosov, Russia

- Two each with a capacity of 35 MW_e.
- Concept based on the design icebreakers.

The construction of the world's first commercial land-based SMR started in July 2021 with the Chinese power plant "Linglong One".

The operation of this prototype is due to start by the end of 2026.

Many unfinished demonstration projects

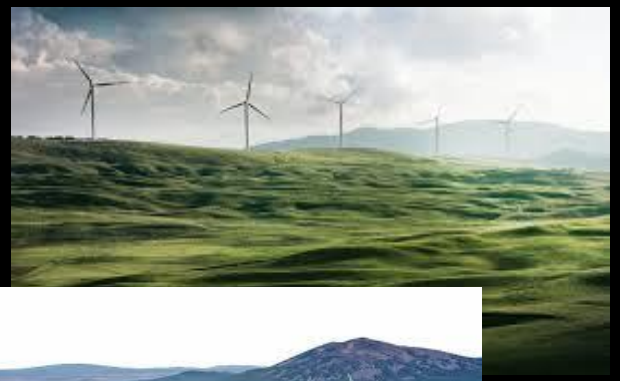
Impact of Climate on Energy

- electricity demand increases for air conditioning in the summer and natural gas and wood for heating. more investment for more electricity plants or purchasing electricity
- disruption of energy production & delivery, damage infrastructure, equipment, power plants, or storage facilities due to sea rise and extreme weather storms,

Reduce efficiency of power production (hot water)

Houses, industry and services construction change

Expensive clean water Need for energy to produce
Competition for domestic and industrial water



3.5˚C to 5˚C temperature increase means climate change increase need for additional electric generating capacity of 10% to 20% by 2050 requiring billions in investment.

Heat and Atomic Bomb
The effect of Climate Change

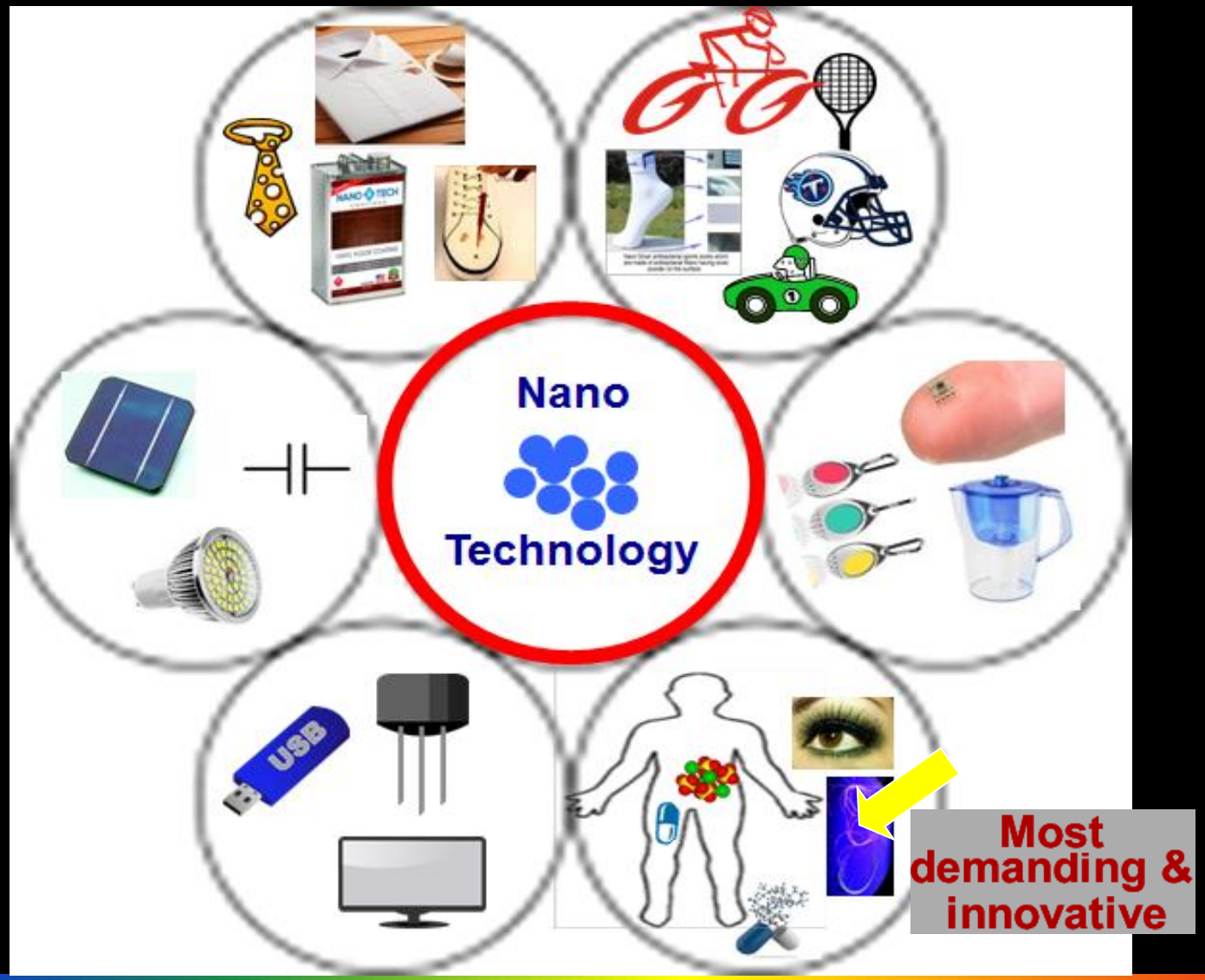
With a 1°C increase in global temperature (from 14°C to 15°C)

is equivalent to

The accumulated heat in our climate since 1998 is equivalent to heat liberated from 2.8 billion Hiroshima bombs

the heat liberated from explosion of about 300 million Hiroshima of atomic bomb.

Nanotechnology holds massive potential to transform many sectors



Energy Applications of Nano Technology - تطبيقات النانو في الطاقة

Create new nanomaterials - مواد جديدة

Affect thermal & electrical conductivity - خصائص حرارية وكهربائية

Allow hydrogen production and storage - إنتاج وتخزين الهيدروجين

More efficient solar power, batteries, fuel cells - تحسين الطاقة الشمسية والبطاريات وخلايا الوقود

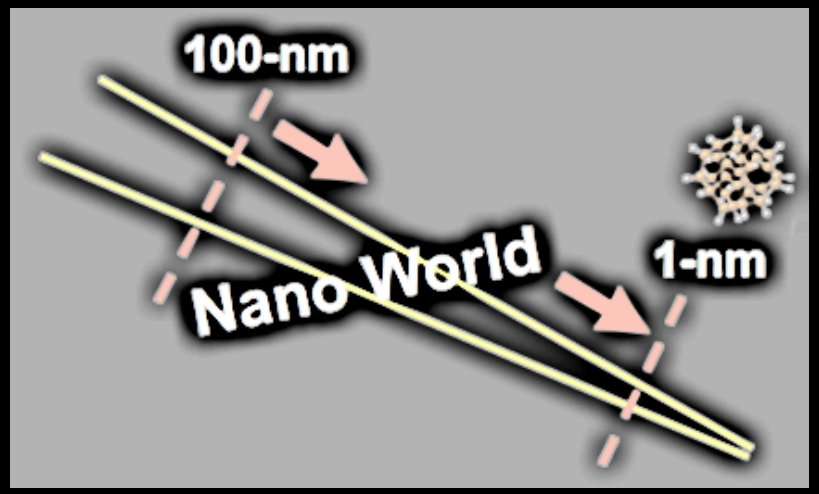
More efficient bulbs for lighting - تحسين المصابيح والانارة

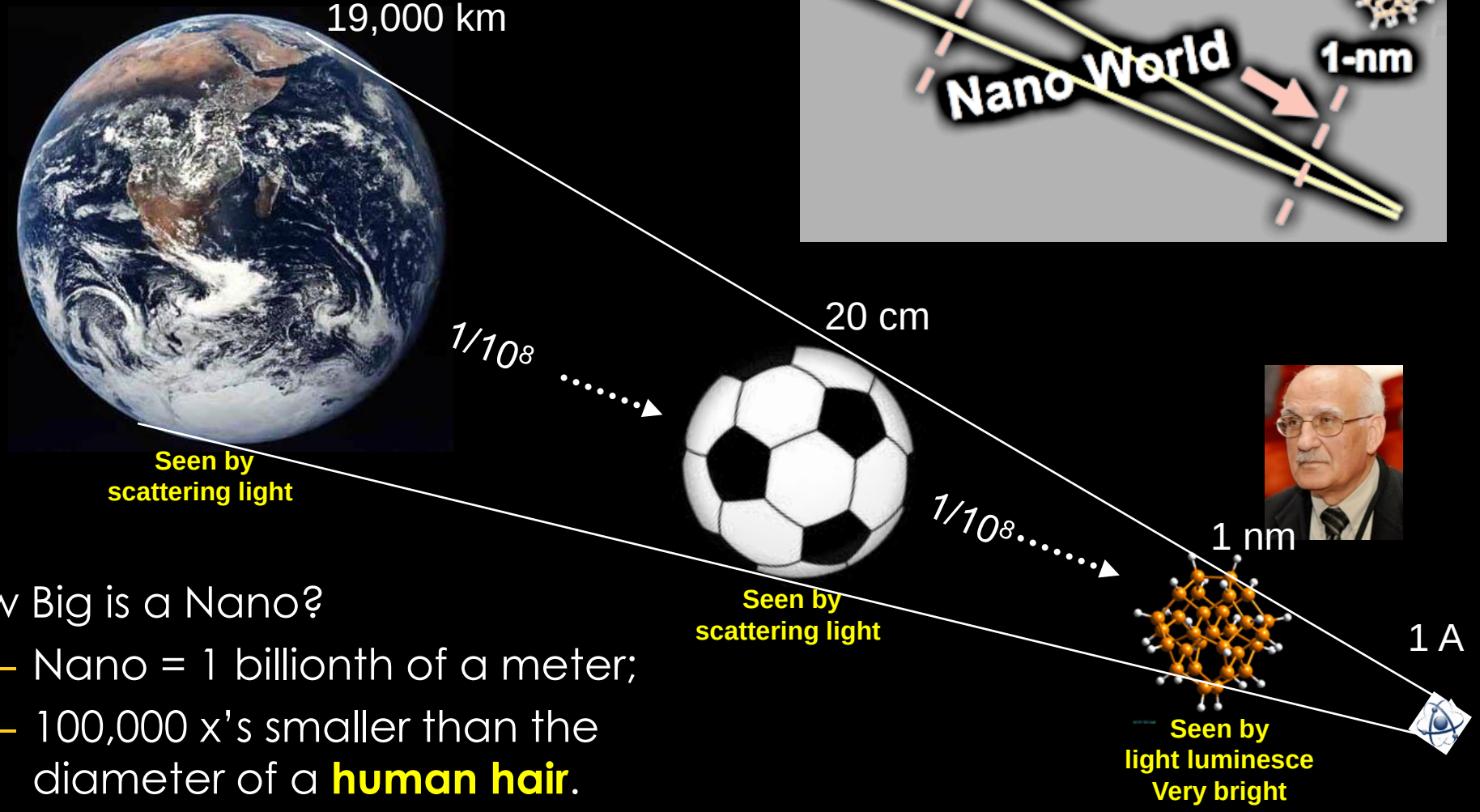
More efficient oil exploration and recovery

Popular material

Ultra small silicon nano particle
Silicon nanowires
TiO_2 particles
Pt particles
carbon nanotube
Graphene
conducting polymers
enzyme

Nano in my laboratory: *Material ST at the limit of size*





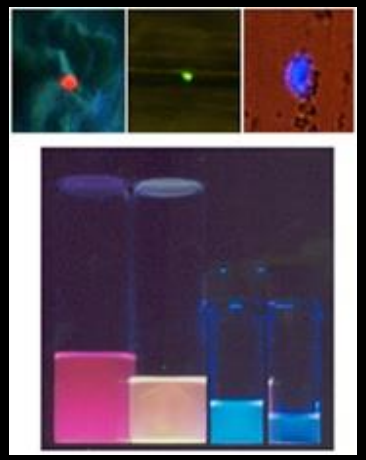
How Big is a Nano?

- Nano = 1 billionth of a meter;
- 100,000 x's smaller than the diameter of a **human hair**.

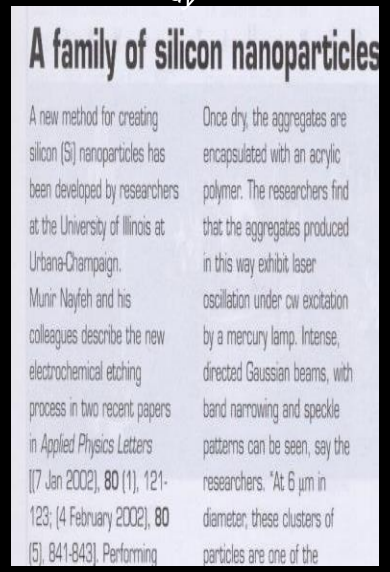
Enhanced Si nano tracers and commercial quantities

A family of magic sizes of hydrogenated Si nanoparticles

No magic sizes > 20 atoms for non-hydrogenated clusters



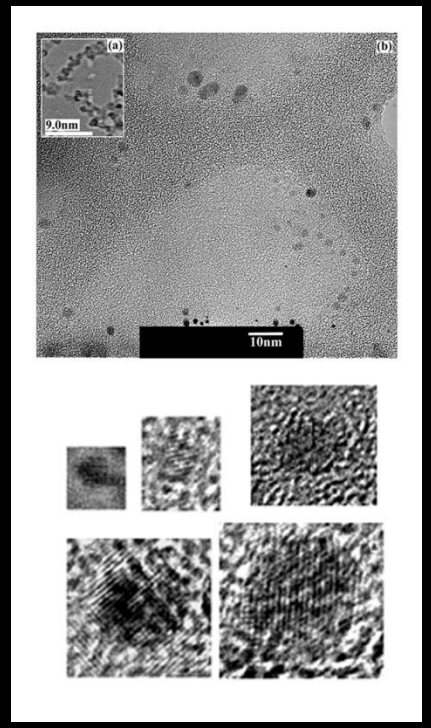
Materialstoday



A family of silicon nanoparticles

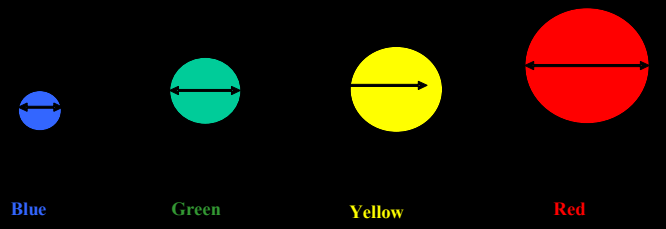
A new method for creating silicon (Si) nanoparticles has been developed by researchers at the University of Illinois at Urbana-Champaign. Munir Nayfeh and his colleagues describe the new electrochemical etching process in two recent papers in *Applied Physics Letters* [(7 Jan 2002), **80** (1), 121-123; (4 February 2002), **80** (5), 841-843]. Performing

Once dry, the aggregates are encapsulated with an acrylic polymer. The researchers find that the aggregates produced in this way exhibit laser oscillation under cw excitation by a mercury lamp. Intense, directed Gaussian beams, with band narrowing and speckle patterns can be seen, say the researchers. "At 6 μm in diameter, these clusters of particles are one of the



UI works on nano light show

Particles may find variety of functions



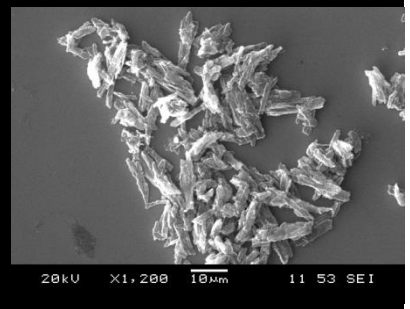
G. Belomoin, J. Therrien, A. Smith, S. Rao, S. Chaieb, M. H. Nayfeh, Appl. Phys. Lett. 80, 841 (2002)

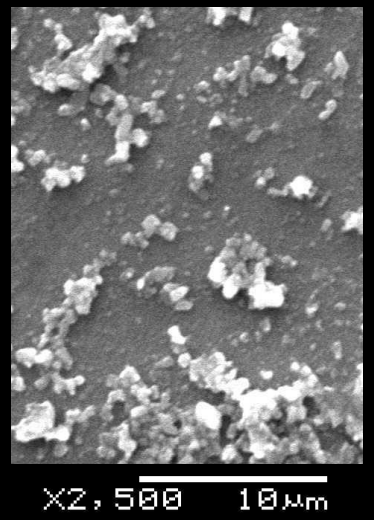

البروفيسور منير نايفة
عالم ذرة - جامعة إلينوي

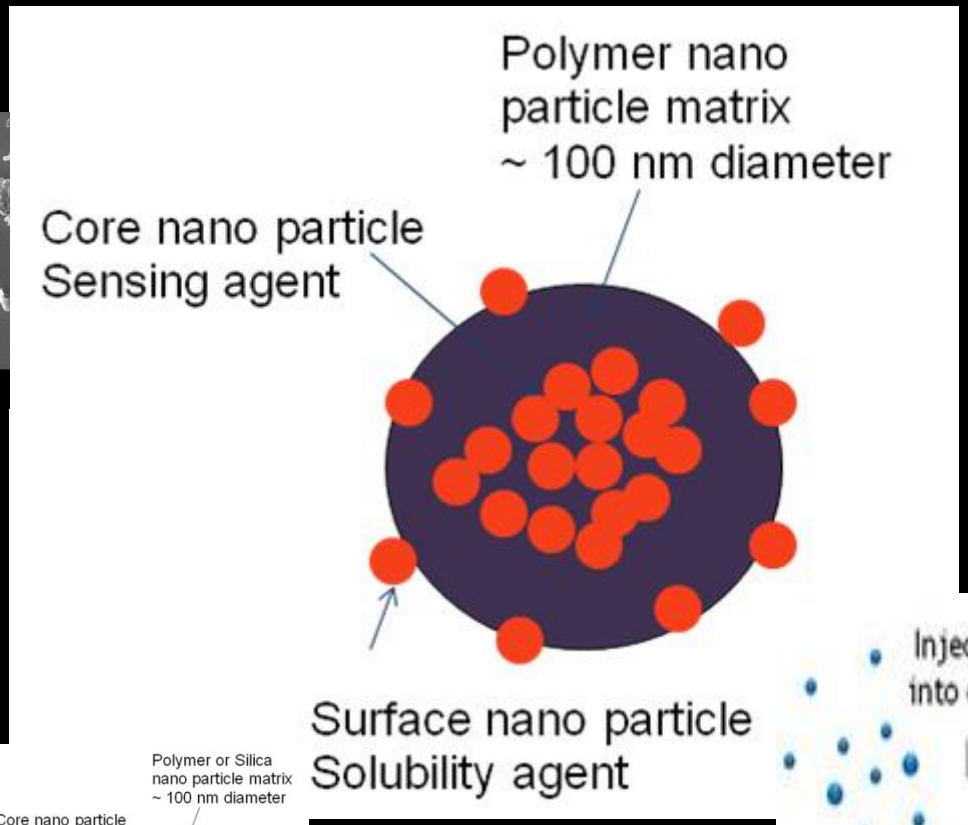
Enhanced Oil Recovery: Nano composite – encapsulation

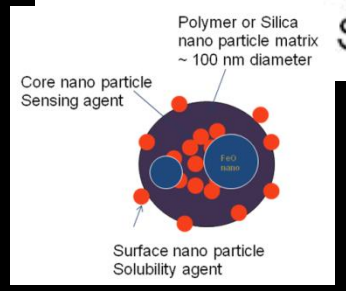
ARAMCO
KFUPM
National Research Council, Cairo (N. Elhalawany)
Cleveland State
University of Illinois

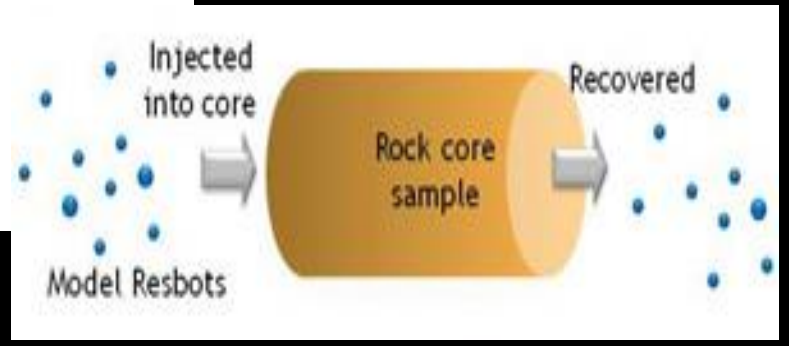
Polymer or Silica











Energy Storage - Supercapacitors — Flexible Capacitor Sheets

Q. Liu, M. Nayfeh and S.-T. Yau, Journal of Power Sources, in print

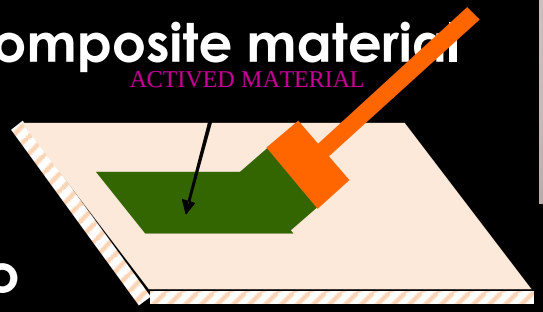
Nano-PANI conducting polymer composite material

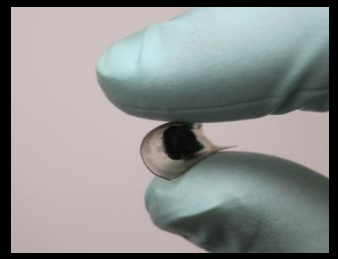
Paint material on both sides of solid electrolyte

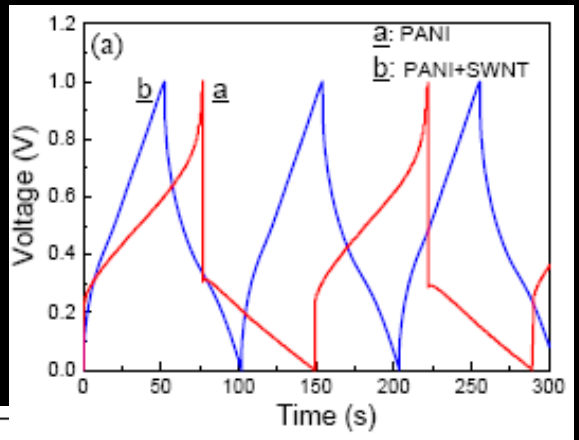
Charging/discharging shows nano adds conductivity to material

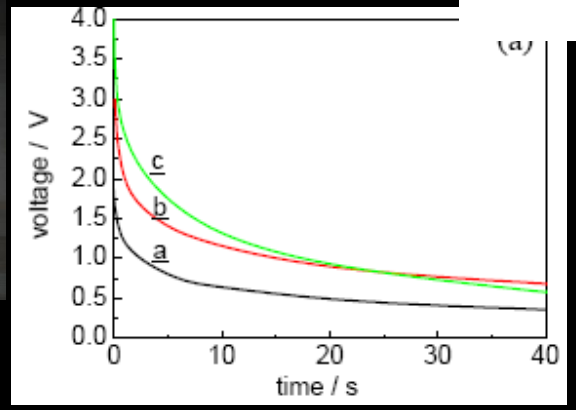
Use stack of three sheets to drive LEDs

Replace battery





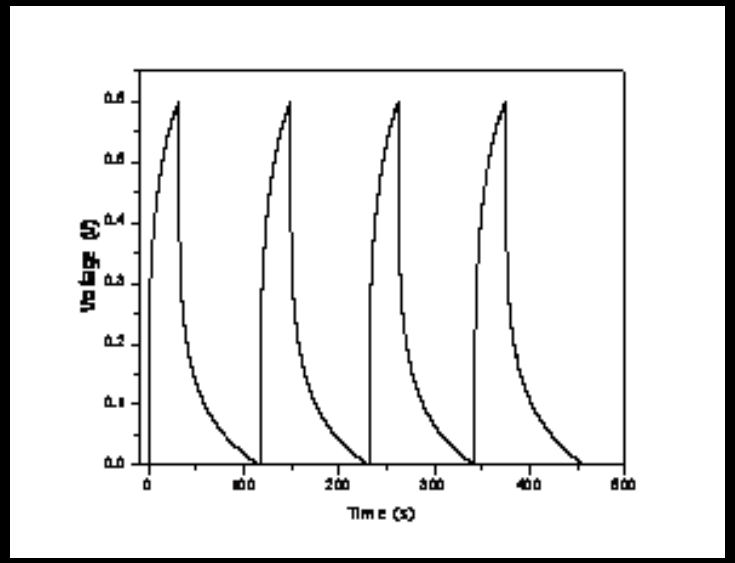


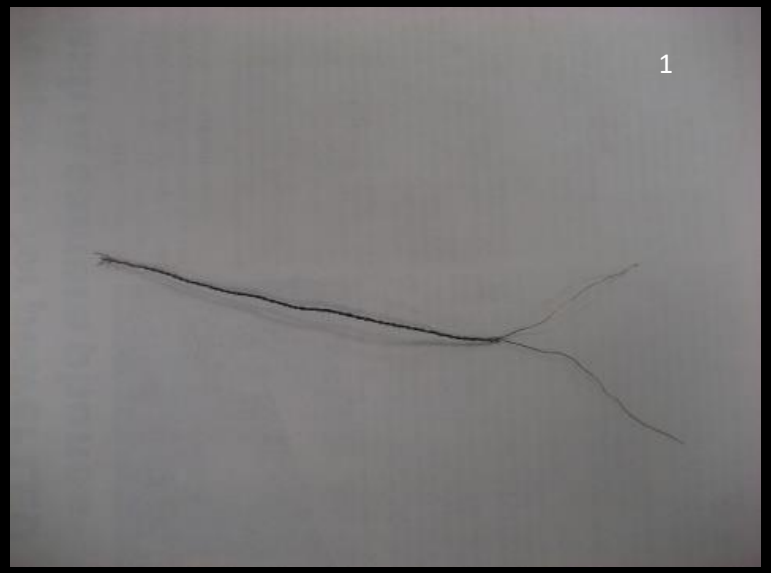


Super Capacitor Thread

Wearable electronics

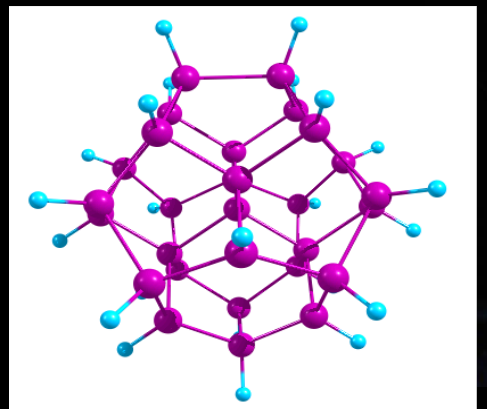
Designed

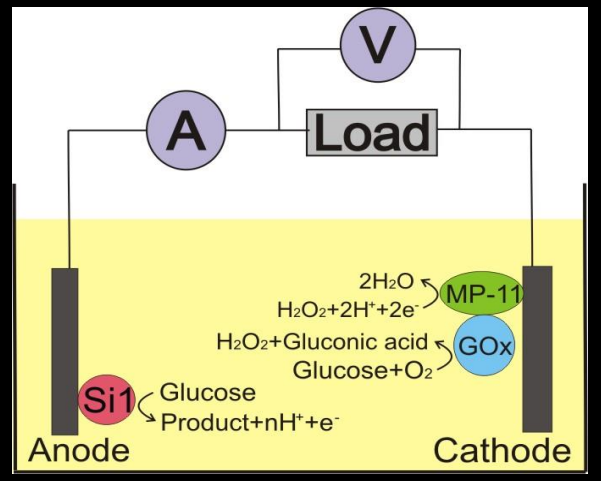


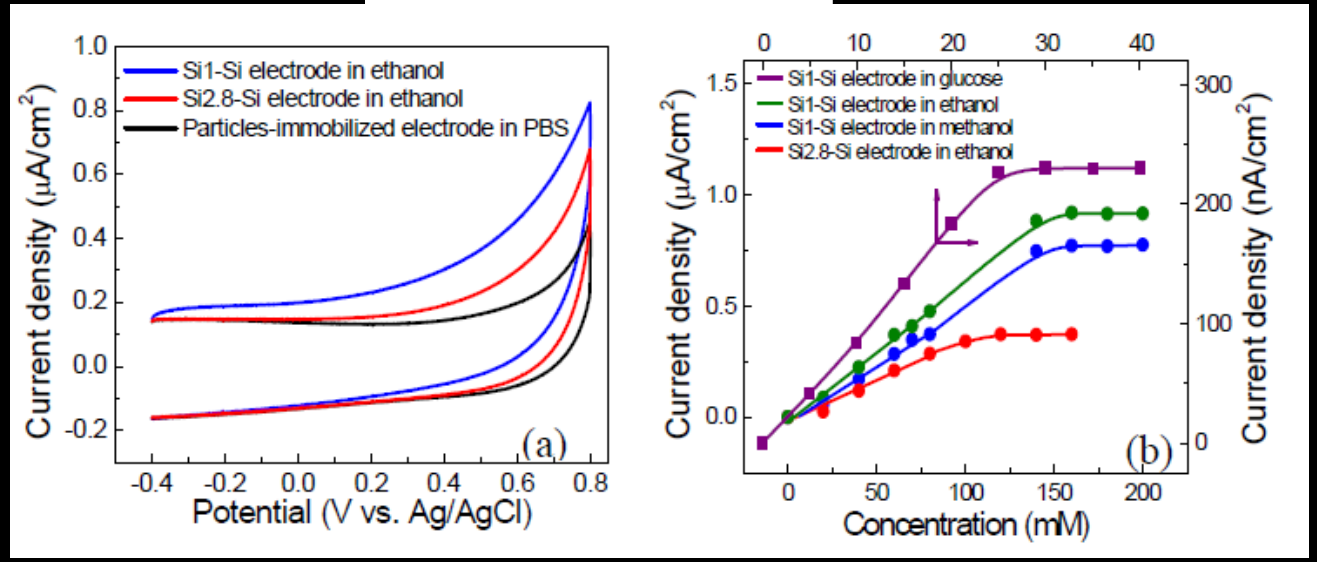


Biofuel (Renewable) current cell

- Electro-oxidation of ethanol, methanol, and glucose
- Non-precious-metal catalyst
- Low onset potential
- One electron oxidation
- No poisoning of electrode







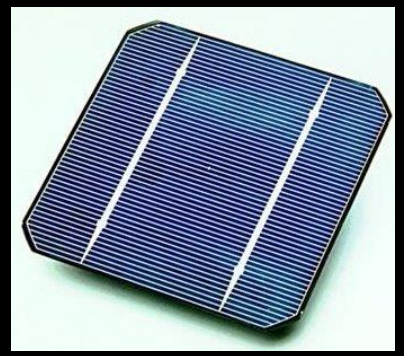
Nayfeh and Yau, Appl. Phys. Lett., 2008

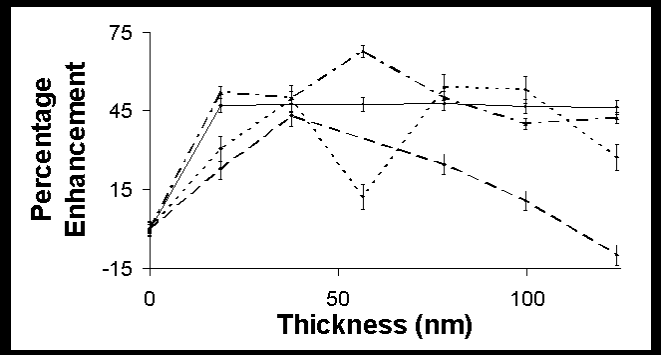
Enhanced solar cells: *Nanotechnology boosts performance of solar cells*

Solar cell innovation

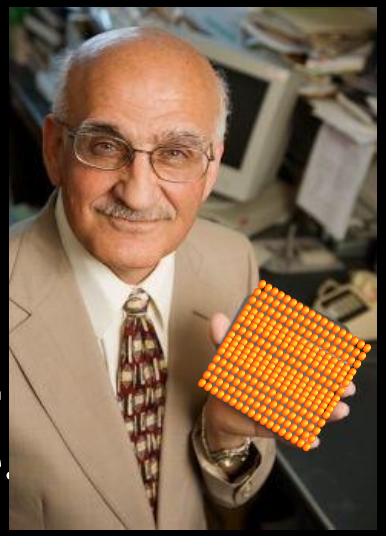
Collaboration with KACST and KSU, Saudi Arabia:

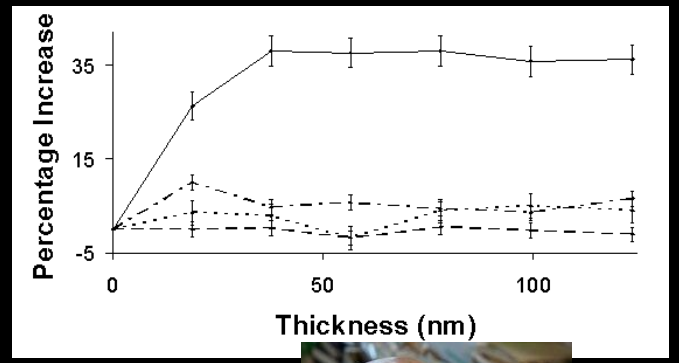
Dr. Turki Al Saud & Mohammad Al Salhi & Abdulrahman Al Muhanna





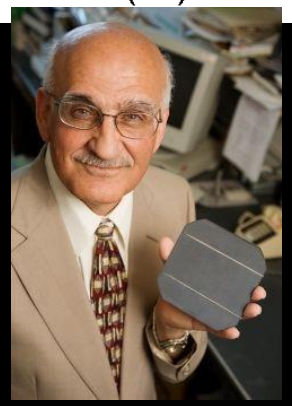
Masdar Institute: Ammar Nayfeh





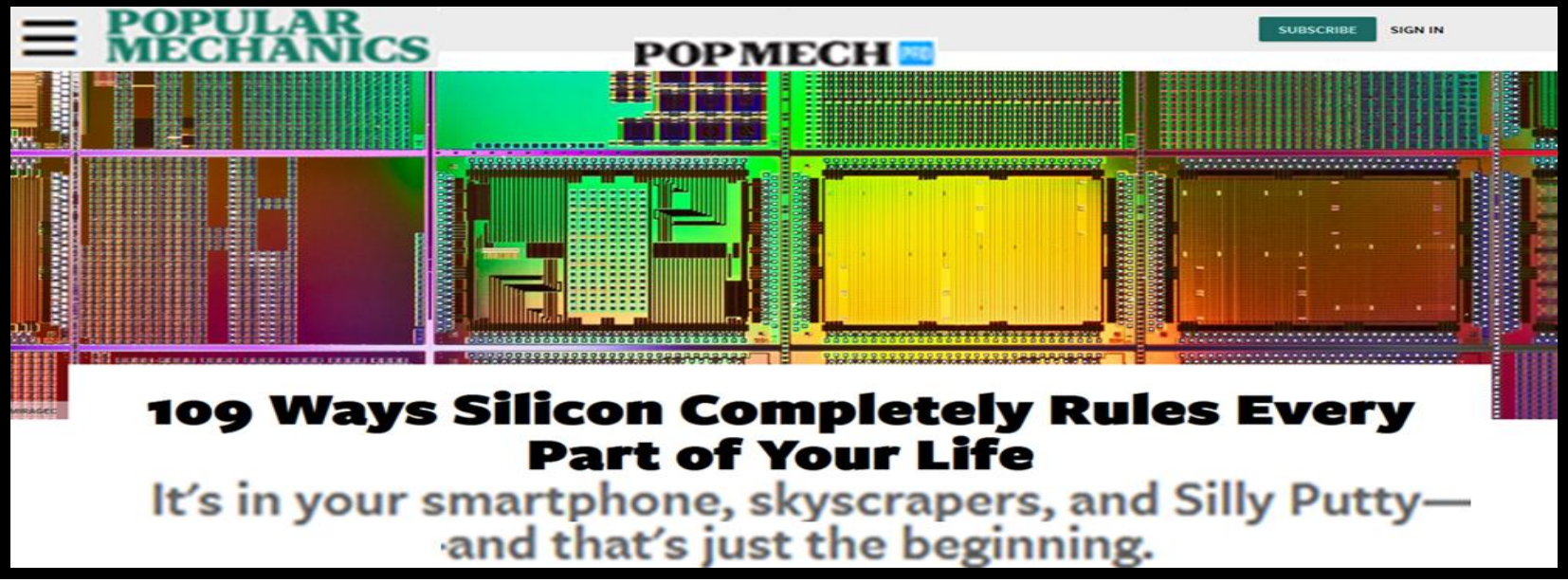
We integrated thin films of Si nanoparticles prepared *ex-situ* on polycrystalline photovoltaic (PV) Si solar cells.

Power efficiency enhanced by ~ 60% in UV and 10 % in the visible.



Nayfeh, Stuppca, Al Salhi and Al Saud, Patent has been submitted to US office of patents

Stuppca, Alsalhi, AlMuhanna, Al Saud, Nayfeh, APL, 2007



December 10, 2021

"The fundamental properties of silicon are heavily amenable to change under a variety of processes both naturally occurring or in the laboratory," notes Munir Nayfeh, Ph.D., professor of physics at University of Illinois Urbana-Champaign. "This has made silicon useful in diverse fields across history."

Solution to Energy Security

There is no single solution. Nuclear is not the solution, but a pivotal component

Diversification of supply is a vital component of energy security, but only one of several. A package may include:

1) Oil + natural gas + coal
2) Nuclear: provides steady source
3) Renewable: fill in the gaps, Intermittent
4) Conservation
5) Technology and innovation (nanotechnology): enhanced recovery, discovery, uptake of renewables, conservation

Addressing the effect of climate, wars, and pandemic disease

Is the role of nuclear energy pivotal?

منير نايفة :

أمن مصر لن يتحقق بدون الطاقة النووية

تحقيق التكامل العربي في البحث العلمي .. أمر صعب

الدول العظمى لن تسمح للعرب بامتلاك النووي ..لحماية إسرائيل

أجرى الحوار: طارق بهجات

بروفيسور منير حسن نايفة، من علماء الفيزياء النووية والطاقة المتجددة في جامعة إلينوى في "أوربانا شامبين" بالولايات المتحدة الأمريكية، ذو أصول فلسطينية، هاجر إلى أمريكا عقب انتهائه من دراسته للعلوم في الجامعة الأمريكية ببيروت عام ١٩٦٤، عاصر انتصارات وانكسارات العالم العربي، أفراحه وأتراحه، آلامه وأحزانه، له آراء سياسية في الأحداث الجارية في المنطقة العربية، أحد المهمومين بقضايا وطنه فلسطين الحبيب.

عمل البروفيسور نايفة على تطوير أبحاث هيئة الطاقة النووية بالمختبرات الأمريكية، وحصل على العديد من براءات الاختراع الأمريكية والأوربية، وبسبب جنسيته تم استبعاده أكثر من مرة بعد ترشحه لجائزة نوبل للعلوم والتي كانت آخرها العام الماضي.

ويترأس البروفيسور نايفة شبكة العلماء والتكنولوجيين العرب في الخارج، كما عمل في المعامل النووية داخل أدق الأماكن حساسية وسرية في تصنيع السلاح النووي الأمريكي إلى أن توقف قسراً في المراحل الأخيرة التي تسبق مرحلة التخصيب مباشرة.

هو مبعوث الرئيس الأمريكي باراك حسين أوباما لتطوير برنامج الطاقة في الشرق الأوسط باستخدام خاصية الهاي تكنولوجي عن طريق أحدث ما توصلت إليه علوم المانو.

"الفتح" التقت العالم الكبير منذ وصوله بلحظات إلى أرض الوطن

وطرحت عليه أسئلة عديدة عن أسباب الزيارة، وكيف ينظر علماء الوطن إلى مصر الثورة، وهل تستطيع مصر الوصول إلى استخدام الطاقة النووية السلمية ، وماهو رد العالم العربي تجاه ذلك.

وهل سنصل إلى الاكتفاء من الطاقة النظيفة ،ومتى سيصل إلى التكامل العربي في البحث العلمي ...وإلى نص الحوار

• ما سبب الزيارة؟

•• تأتي أهمية الزيارة في إطار اتفاقية التعاون التي تم

الفتح

صحيفة أسبوعية مستقلة تصدر عن المجموعة العربية للصحافة والإعلام ش . م . م

مدير التحرير
عنتر سعيد

مدير عام
محمد عياد

المدير التنفيذي
أحمد عبدالغني

المستشار القانوني
محمد حمد

العنوان: 43 شارع 6 امتداد من شارع النهضة المعادي الدور الثالث

ص ب 345

الرمز البريدي 11728
مكتب بريد المعادي
هواتف التحرير

UK and France have started to coordinate the return to the nuclear energy source

United K-Going back

UK dependency on imported gas expected to rise sharply between now and 2050, to 85%. Shale gas could provide a secure, stable source of energy and help diversify supply. Extraction is less carbon intensive.

The American Petroleum Institute put it, “without fracking, there’d be no American energy renaissance.”
With its own gas-rich shale formations, it’s tempting to think this could be Britain, too.

Is Germany next?

The forbidden and the intermitent

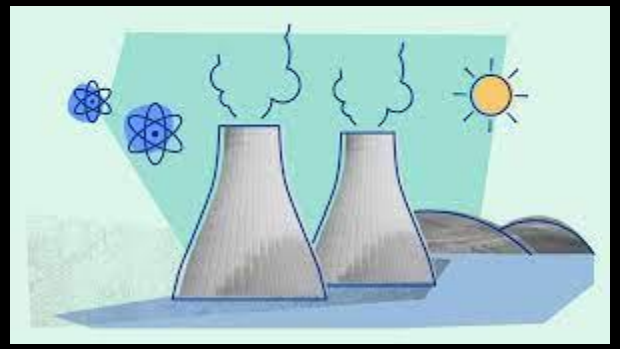
Back to the forbidden?:

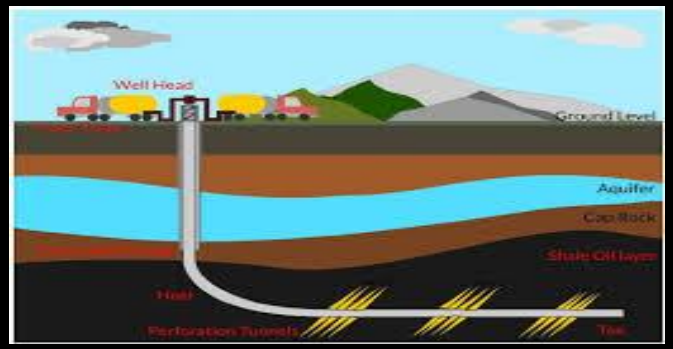
Coal

Fracking

More Nuclear

A shot in the arm for the Renewables





- Processing about 90% of rare metals and 60% of lithium takes place in China
- Revenues of renewable and nuclear energy companies would bring "more than 140 billion euros" to the European Union countries
- Rise in electricity prices with the increase in gas prices, these companies resell their production at much higher than production costs, which leads to high profits

Lowering Tax

Funds may be redistributed to families and companies at risk

Today, Jeremy Hunt reverses!

Will the Moroccan desert illuminate Britain?

Electrical interconnection project

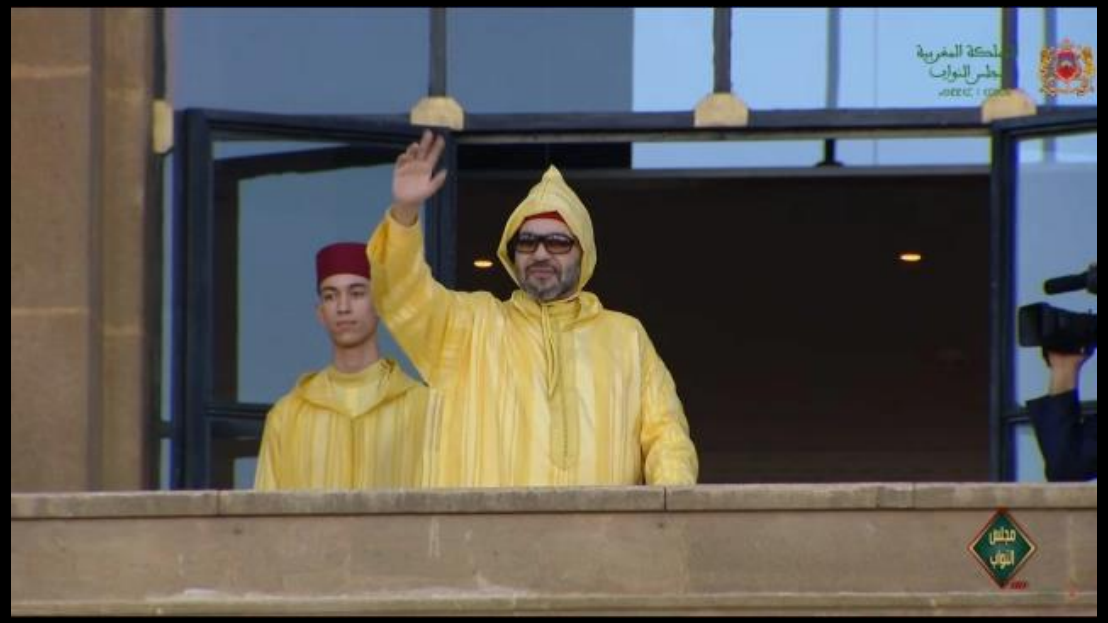
submarine cables, the longest in the world, and extends from plants of solar and wind energy in Morocco to Britain

calls for a sound management of water resources

With the continuation of the energy crisis...

Huge gigantic projects provide the UK clean energy Kalmim-Wad Noun region. " Gateway to the Desert".

Morocco a magnet for foreign and local investments in renewable energies, solar and wind



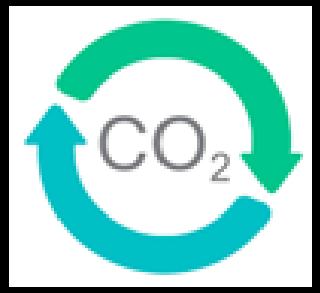
Morocco’s King calls for a sound management of water resources amidst an acute water stress

The Xlinks Morocco-UK Power Project

10.5 GW of renewable generation, 20 GWh of battery storage, a 3.6 GW high-voltage direct current interconnector to carry solar wind-generated electricity from Morocco to the UK.

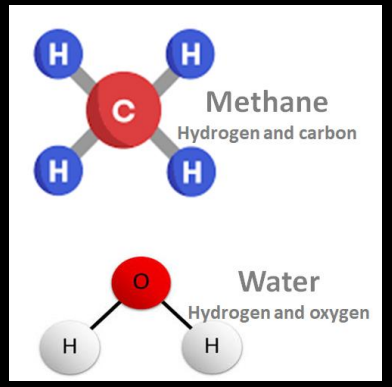
Morocco has **consistent weather, consistent solar** power even in midwinter.
 3,800 km (2,400 miles) cable will be the longest undersea power cable and supply up to 7.5% of the UK's electricity consumption.

Energy Transition, Transformation



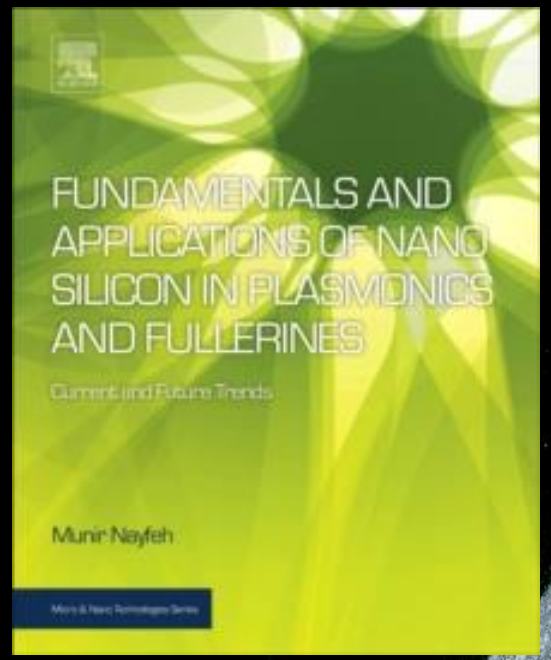
- **Fossil-based to zero-carbon to reduce CO_2**
- **Carbon Capture and storage**
- **Electric cars with PV roof, high technology of batteries to store power**
- **Electrolyzers to extract H2 from water, and storing H2 energy**

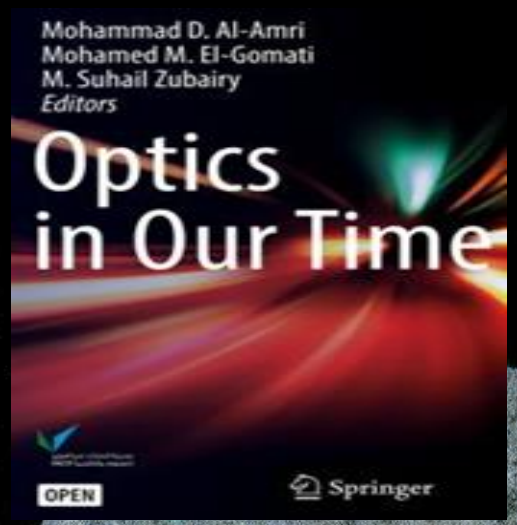
Nanoparticles / nanostructures enhance absorption of light, increase conversion of light to energy, improved thermal storage and transport, convert incident UV radiation to visible to produce more PV electricity

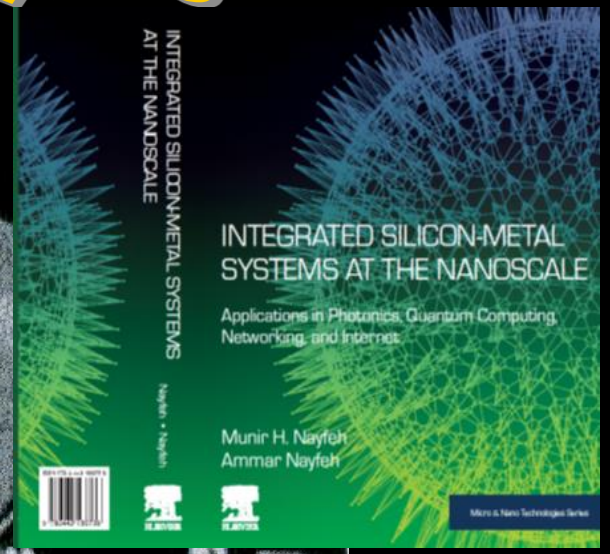


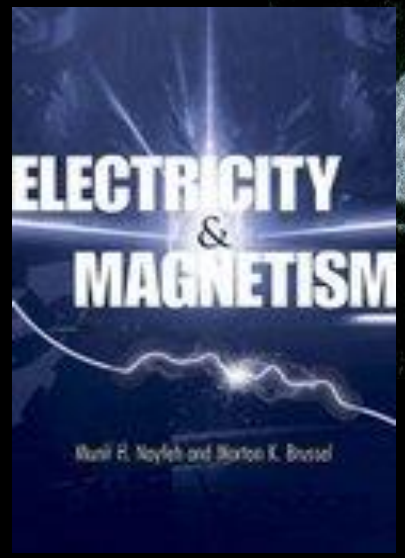
23% increase in efficiency of using Si, InN and Au nanoparticles. show improvement of 25% in short circuit current and reduce the reflection by 2.7%.

النهاية









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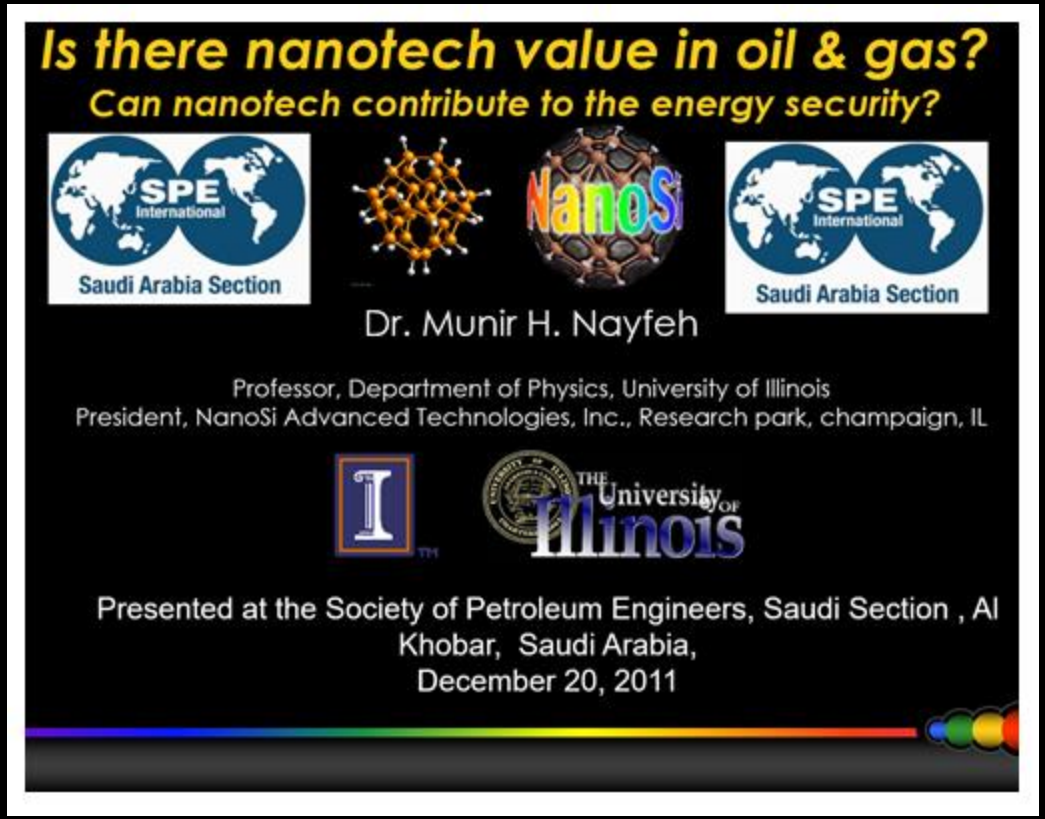
كتب حرف "أي" في مختبري بالذرات

Dr. Zain Yamani



Presented at the NURER 2014 meeting , **Antalya, Turkey,**
October 26-29, 2014

Presented at Advances in Materials & Processing Technology Conference, **Dubai , UAE**,
November 17-20, 2014


Atmospheric and Climate Sciences > Vol.12 No.2, April 2022

Worrying about Climate Change

Naser W. Alnaser[1], Roger Flanagan[2], Lawrence Kazmerski[3], Ali A. Sayigh[4], Munir H. Nayfeh[5], Waheeb E. Alnaser[6]

DOI: 10.4236/acs.2022.122026

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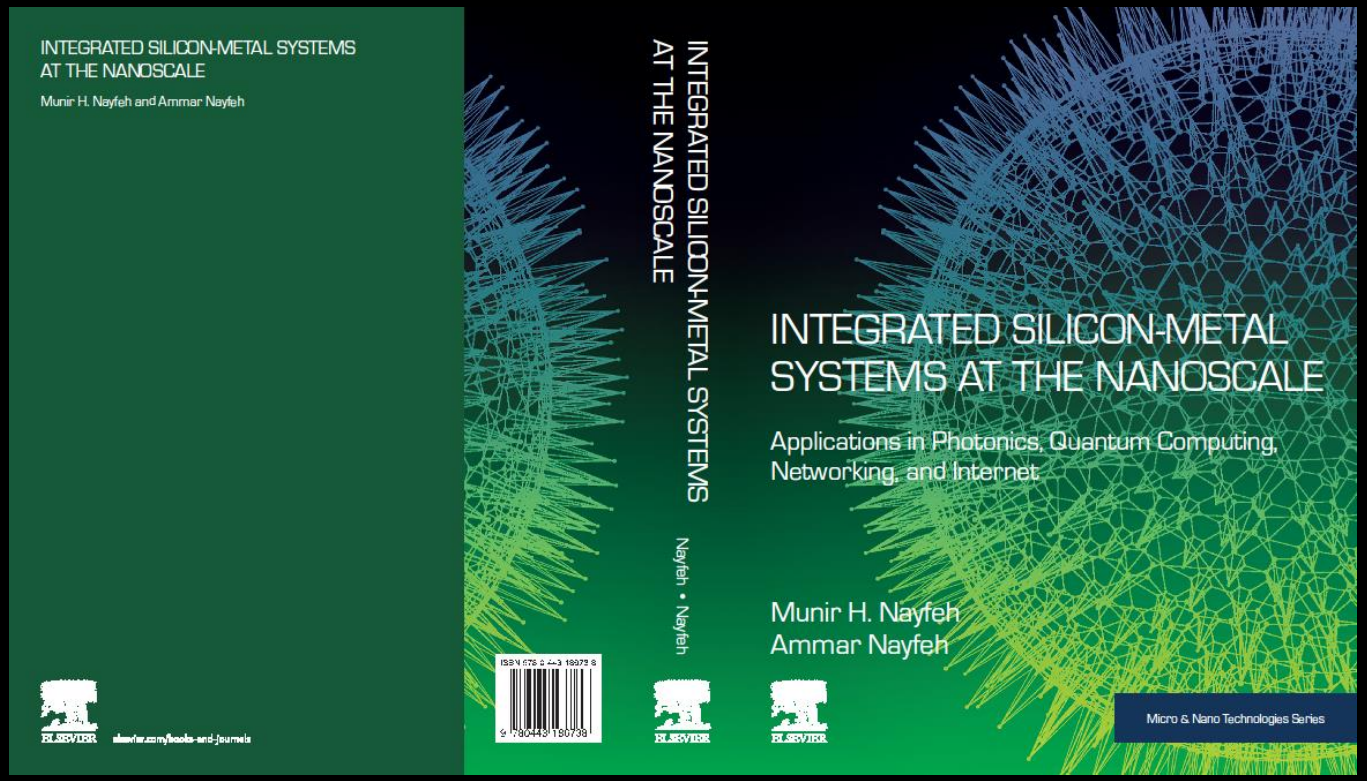
Jordan: Irbid, Amman

Lebanon: Beirut

USA: Stanford, California

Worked in

Stanford university, Oak Ridge National Laboratory, Yale University, Argonne National Laboratory, Princess Sumayya University, University of Illinois.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Munir H. Nayfeh and Ammar Nayfeh
ELSEVIER
INTEGRATED SILICON-METAL SYSTEMS AT THE NANOSCALE
Nayfeh • Nayfeh
INTEGRATED SILICON-METAL SYSTEMS AT THE NANOSCALE
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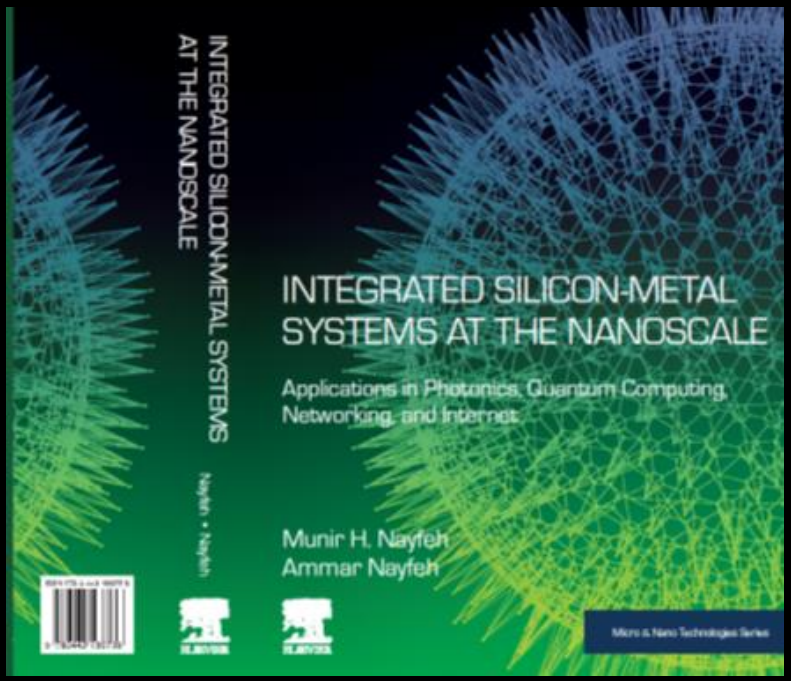
Micro & Nano Technologies Series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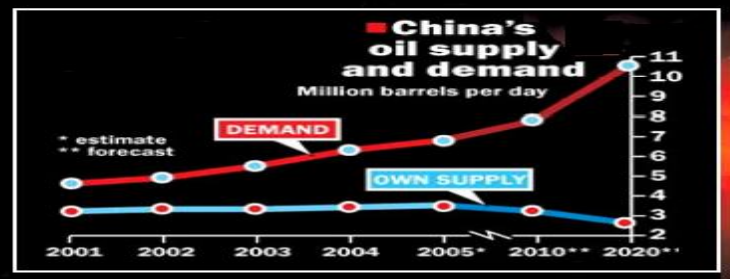
Energy security between nuclear, renewable climate, and nano technologies

The time of abundant oil and gas is at an end and the world is entering a stage where finding resources is becoming more “complex” and requiring more money and investment. In fact, energy security is becoming one of the leading issues in the world today, especially when compounded by modern global military and economical wars and acute climate changes as we are presently face. In view of these conditions, great efforts are put to action to find solutions.

Here we argue that there is no single solution for energy security, rather a multi-component solution is more likely. These include oil (+ natural gas + coal), nuclear energy, renewable energy, conservation as well as technology and innovation. Renewables such as solar, wind, geothermal, hydro, and biomass including biofuels constitute potentially very useful components, but they are intermittent. Climate effects and calamities increase consumption and demand, disrupt energy production & delivery, and damage infrastructure, equipment, power plants, or storage facilities

Technological innovation such as advanced material technologies and nanotechnology, which will bring cost reductions of energy technologies, is destined to be a driver of the uptake of renewable energy sources, conservation, and enhanced oil discovery and recovery. Nuclear energy however is pivotal, and we believe that there can be no real security without nuclear energy to provide a steady energy component. Finally, true security lies in the “stability of the energy market” for all participants, importer and exporters, rather than the narrowly defined interest of any one country.

HUNGRY FOR OIL



Oil & gas supplies will struggle to keep up with demand

making energy prices more expensive and more volatile

A lot of volatility ahead of us that we cannot avoid

[Peter Voser, the chief executive of Royal Dutch Shell, the head of Europe's largest oil company, has warned in Financial Times on Sep 21, 2011]

Security Issues-Nuclear Proliferation

Nuclear proliferation problem, use of SMR to create weapons is a concern. As SMRs have lower generation capacity and are physically smaller, they are deployed in many more locations than conventional plants.

Guards SMRs are expected to **(i)** substantially reduce staffing levels, which creates physical protection and security concerns.

(ii) SMRs use low-enriched uranium (< 20% fissile ^{235}U). This is sub-weapons-grade uranium for weapons production. **(iii)** Once irradiated, becomes highly radioactive and requires special handling, preventing casual theft.

(iv) SMR are designed for one-time fueling. eliminating on-site nuclear fuel handling sealed within the reactor. However, this design requires large amounts of fuel, which could make it a more attractive target. A 200 MWe 30-year core life light water SMR could contain about 2.5 tonnes of plutonium at end of life.

(v) Light-water reactors designed to run on thorium offer increased proliferation resistance compared to the conventional uranium cycle, though molten salt reactors have a substantial risk.

(vi) SMR factories reduce access, because the reactor is fueled before transport, instead of on the ultimate site.

Drawbacks of shale oil

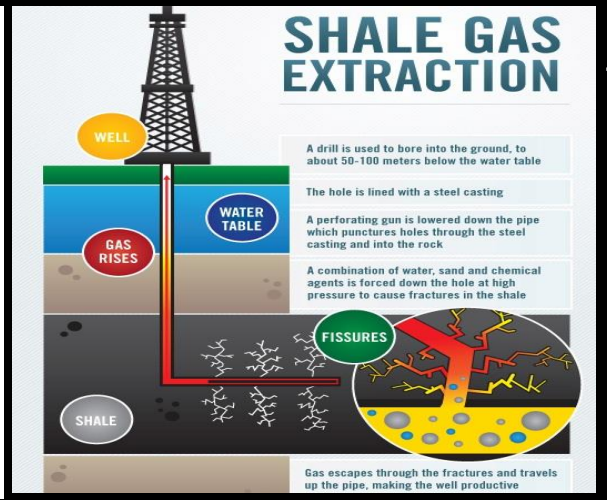
Each gas well requires ~ *400 tanker trucks* to carry water and supplies.

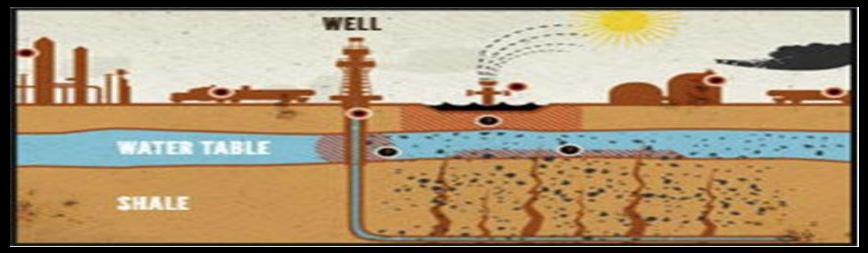
It takes *1-8 million gallons of water* to complete each fracturing job.

Up to *600 chemicals* are used in fracking fluid, including known carcinogens and toxins such as Lead, uranium, mercury, ethylene glycol, radium, methanol, hydrochloric acid, formaldehyde

The Math

500,000
Active gas wells in the US
X
8 million
Gallons of water per fracking
X
18
Times a well can be fracked
==========
72 trillion gallons of water
and
360 billion gallons of chemicals
needed to run our current gas wells.





Left Behind

Only 30-50% of the fracturing fluid is recovered, not biodegradable.

Contamination

methane gas & toxic chemicals leach out & contaminate groundwater. Methane concentrations are *17x higher* in drinking-water wells near fracturing sites than in normal wells

Drinking Water

1,000 documented cases of water contamination next to areas of gas drilling as well as cases of health problems

Produces approximately *300,000 barrels* of natural gas a day

World use of Nuclear Power

Can play a crucial purpose in the 21st century in aiding to attain global energy security, fight global climate change and bring down air pollution.

China plans to build up its nuclear capabilities to > 40 million kilowatts by 2020.

This year, building of six new reactors accompanied by with another five in 2010.

60 countries showed interest in using atomic energy, up from the currently 30.

Global In 2007, atomic power's share of global electricity dropped to 14%.

The US produces the most nuclear energy, with atomic power providing 19% of the electricity it consumes France produces the highest percentage of electrical energy from nuclear reactors – 78% as of 2006.

European Union as a whole, nuclear energy provides 30% of the electricity.

In the US, while the coal and gas electricity is projected to be worth $85 billion by 2013, nuclear power generators are forecast to be worth $18 billion.

Strong Intellectual Property Rights

Twenty six US Patent Applications

- 23 US issued
- 2 US pending

23

2 patents (issued)
1 patents (pending)
with Zain Yamani, KFUPM / CENT, Saudi Arabia

2

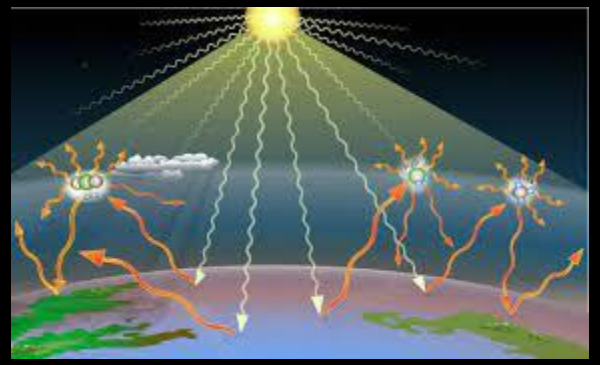
1 patent with PolyBrite Lighting

1 patent with Dow Chemical

1 patent (pending) with Dr. Laila Abuhassan, Jordan
1 patent (pending) with Dr. Hanan Malkawi, Jordan
2 patents (pending) with Dr. Olayan, Ghamdi, Rokayan; Dwayyan & Salhi, KSU, S Arabia
1 patent pending with Drs. M. Alsalhi and T. AlSaud, S. Arabia

Alleviating global warming: green house gases (GHG)

Reaching zero emissions by 2060



States that had a large share in accumulating a lot of GHG

innovative solutions to low-income countries with a high population

Must offer/provide

great technical

financial

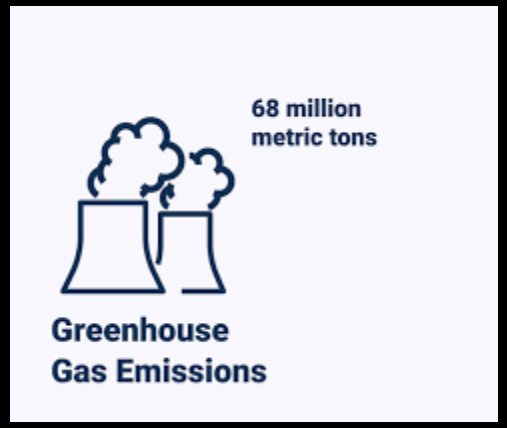


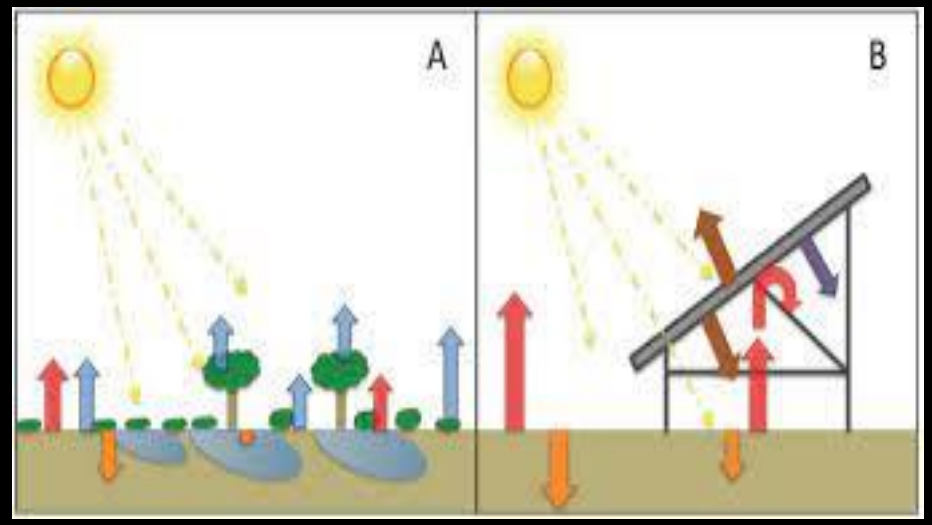
Photo Voltaic Heat Island (PVHI)

- Solar PV may be a contributor to global warming (so called Heat Island (PVHI))
- Simultaneously monitoring three locations (a natural desert ecosystem, a parking lot surrounded by commercial buildings, and a PV power plant) for one full year
- Temperatures over the PV plant are higher by 3˚C to 4˚C than the natural desert ecosystem (wildland) at night.

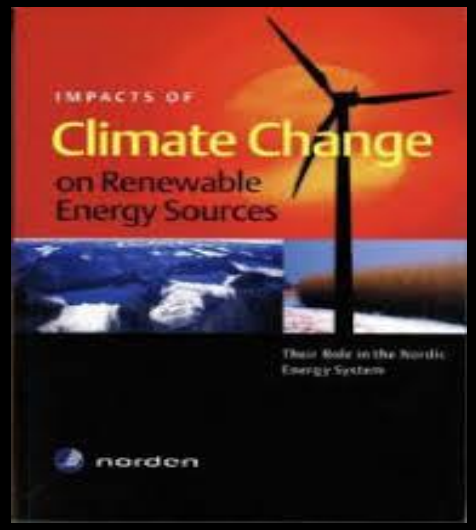
Overcome PVHI heating

white color to have higher albedo

supports of PV systems made of low specific heat capacity material (wood for example)



Impact of Climate on Renewable Energy



Random and uncertain

Hydropower & wind energy, are uncertain; declines/increases in different regions,

solar power are unaffected.

Direct & indirect effects on renewable energy.

Higher wind speeds increase wind power (direct).

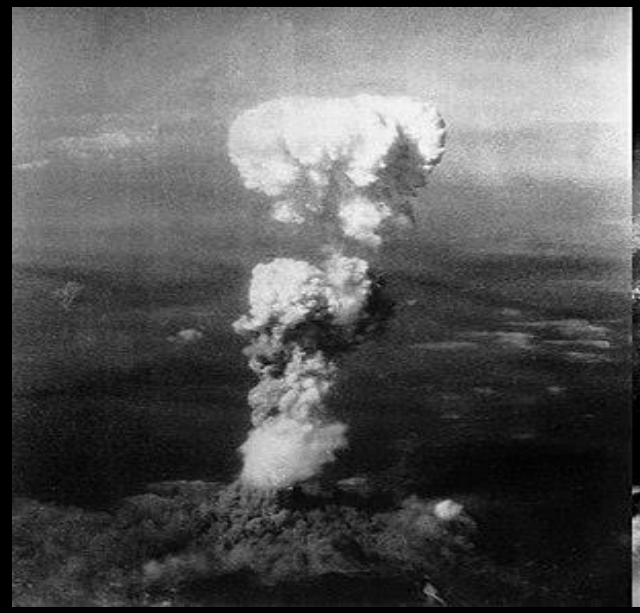
Higher temperature lower PV & CSP efficiencies (indirect)

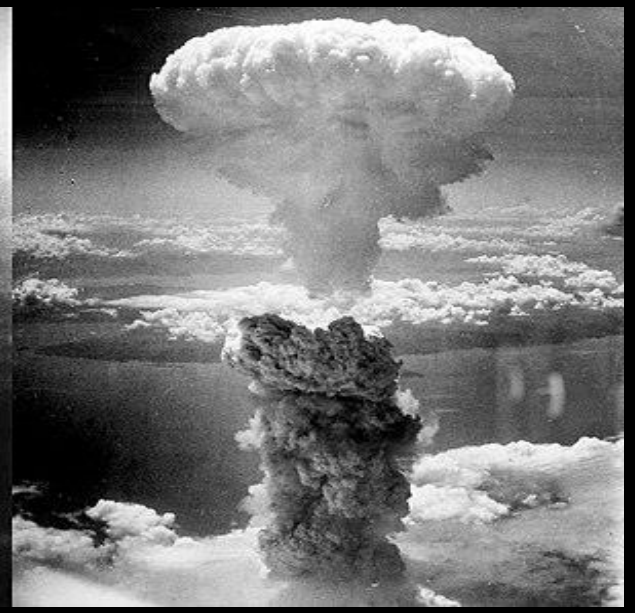
more complex relationship between precipitation changes and hydropower potential.

complex optimization in hydropower design, hub height in wind turbines, and to a less extent is PV and CSP.

climate change affects global markets. To face growing climate risks, energy companies integrate climate risk into business strategy (72%).

Hiroshima and Nagasaki





The bomb was dropped on Hiroshima, Japan August 6, 1945, at 8:15 AM.

A B-29 dropped the bomb from 31,000 feet

The bomb exploded about 1,500 feet above city

A force of **15,000 tons of TNT**

BRICKLAYING AT NANOSCALE

MOSTAPHA BOUSMINA*
President, Euromed University of Fes
Chancellor, Hassan II Academy of Science and Technology, Morocco

ABSTRACT

Behind each material and its functionalities, there are atoms and their interactions, then molecules and their association and then self-assembly at long scale generating a variety of structured species responsible for plenty of functionalities. It is a mix of physics and chemistry and the final material finds its application in several fields encompassing biology, medicine, pharmacy, electronics and spintronic and other sectors, where material science play a crucial role.

The presentation will focus on a generic route for structuring matter at nanoscale with various sizes, shapes and functionalities. Selected applications in biology, medicine and material science will be exposed.

* *m.bousmina@ueuromed.org ; m.bousmina@academiesciences.ma*

UEMF
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EURO-MEDITERRANEAN UNIVERSITY OF FES
UNIVERSITÉ EURO-MÉDITERRANÉENNE DE FÈS

Hassan II Academy of
Science & Technology

M. Bousmina

Bricklaying at nanoscale

Euro-Mediterranean University of Fes
Hassan II Academy of Science and Technology
Morocco

Outline

1. Fabrication (Physical Chemistry)

2. Applications

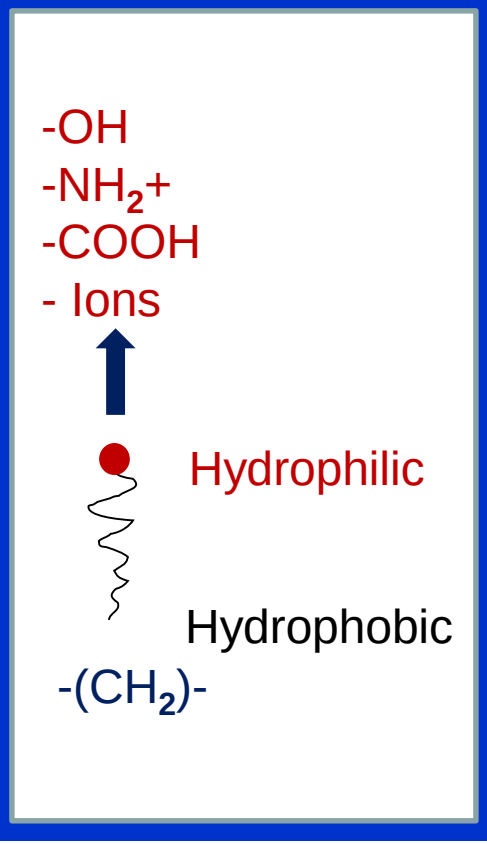
   i) Carbone Nanotubes: Appl. Cancer cells (Bio)

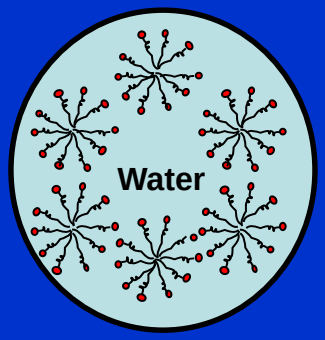
   ii) Organic Nanotubes : Appl. Spinal cord (Medical)

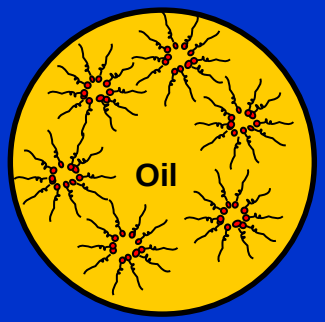
3. Graphene/polymer nanocomposites

   Piezoelectric material (Physics: Electro-mechanics)

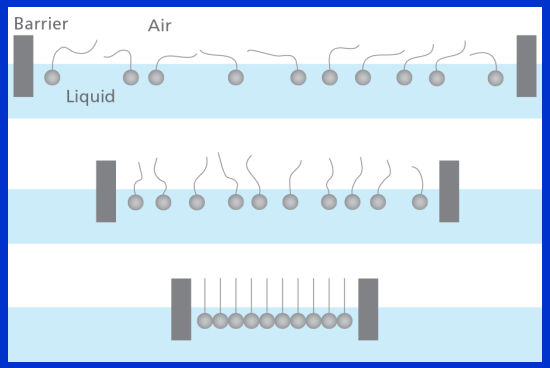
Self-Assembly and micelle templating

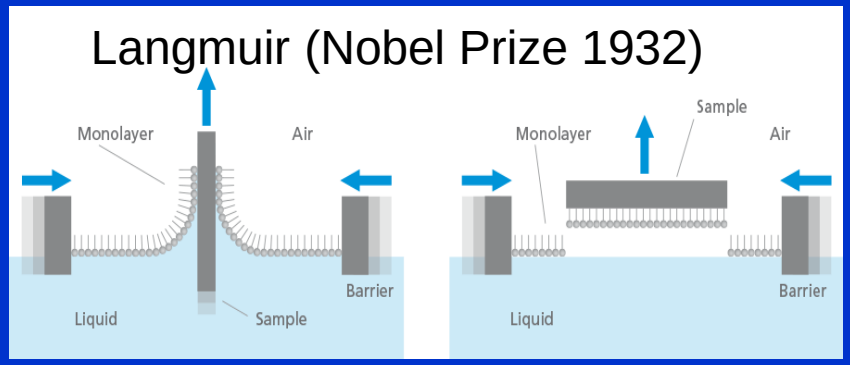




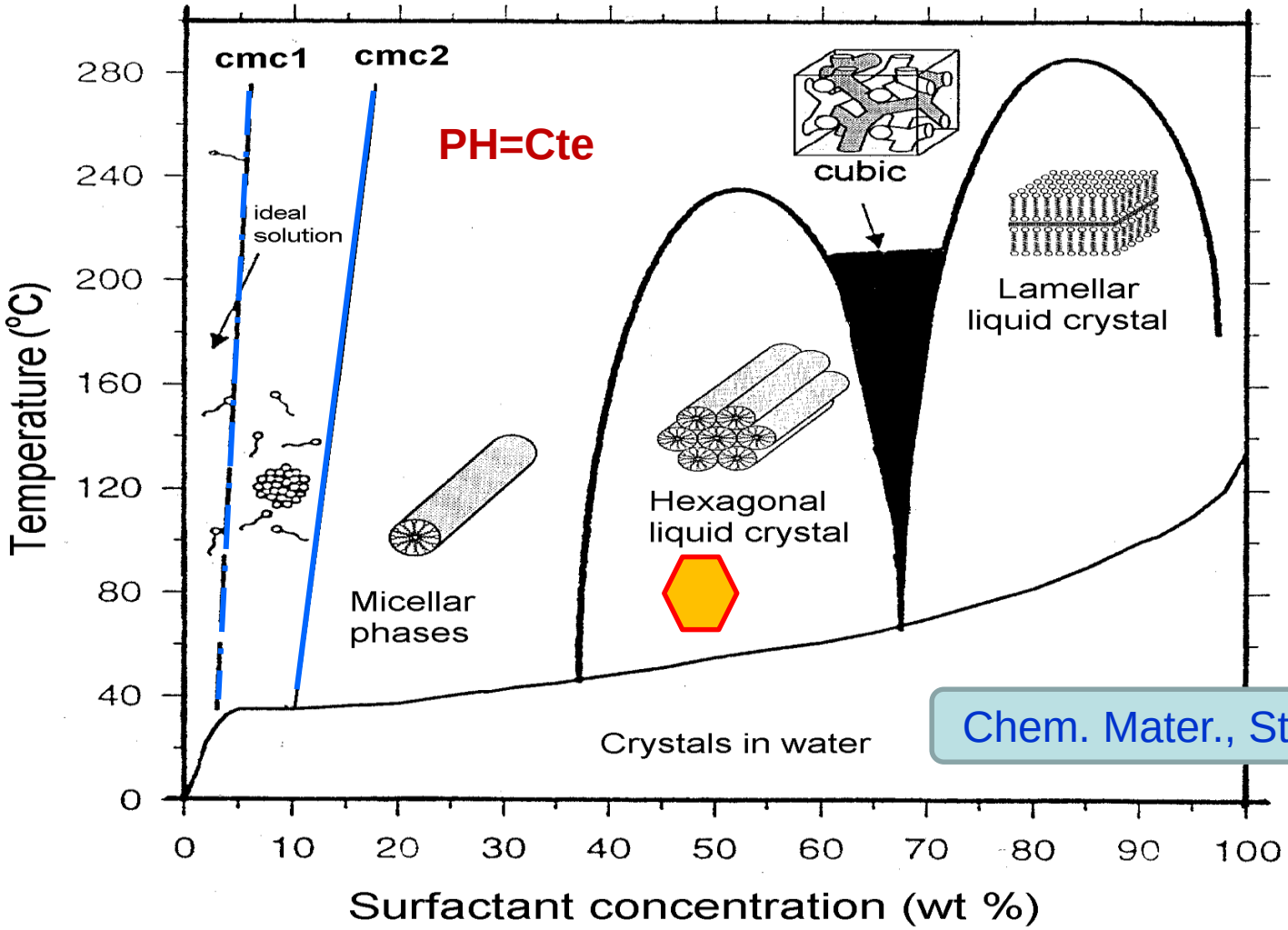


Agnes Pockes
1862-1935





Self-Assembly and micelle templating



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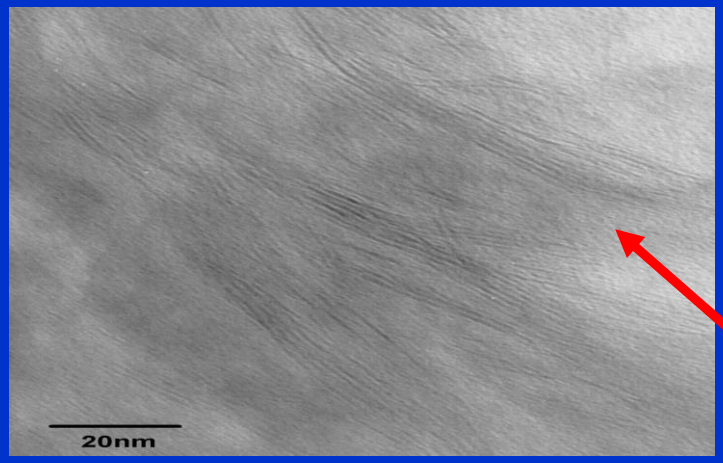
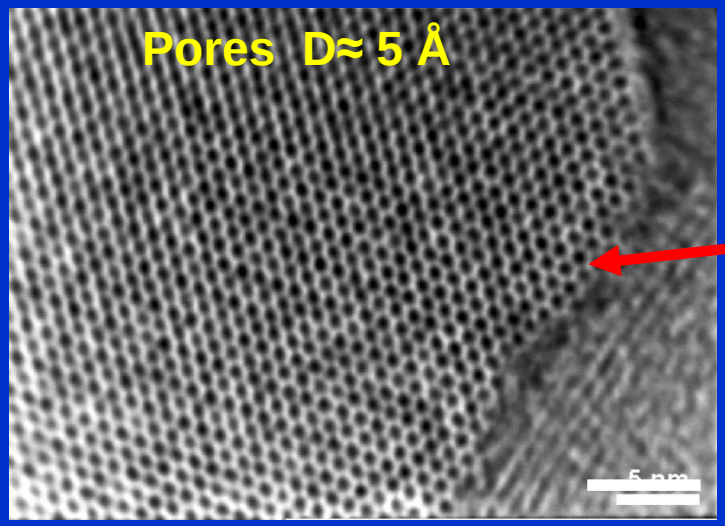
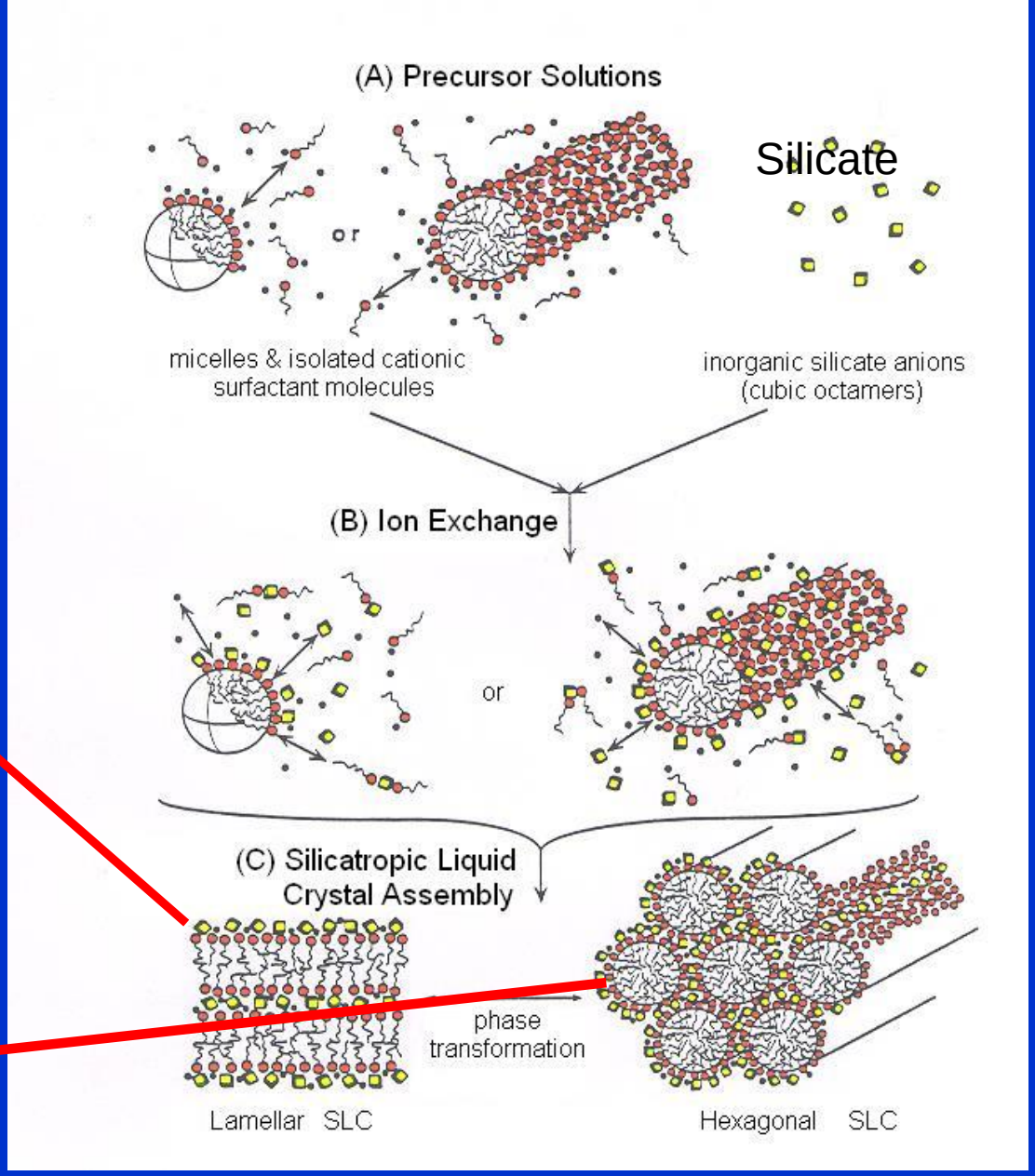
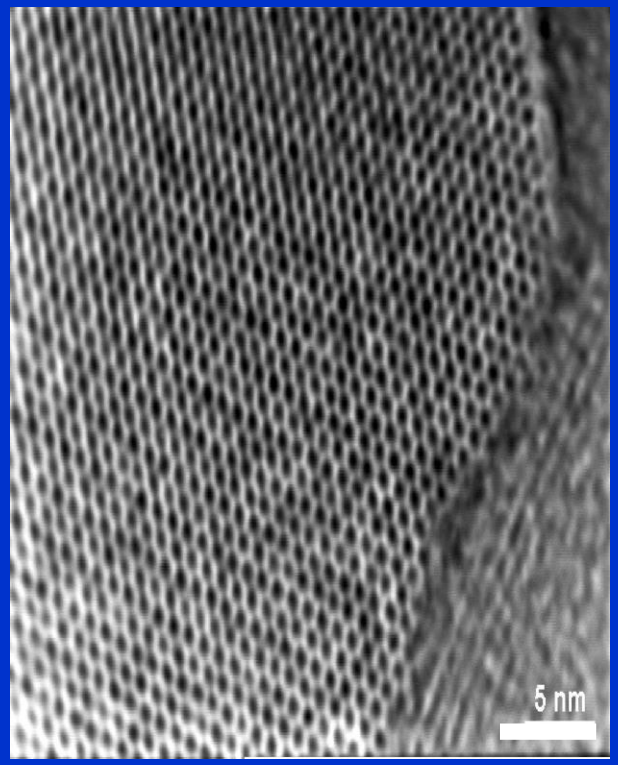
Dalton Transactions. 42, 1591-1602 (2013)







Vaudreuil, & Bousmina et al.: J. of Porous Materials (2007)
Vaudreuil & Bousmina, Microporous & mesoporous Mat. 46, 475 (2001).
Vaudreuil, Bousmina & Kaliaguine ADVANCED MATERIALS 13,1321 (2001)
Danumah, & Bousmina. Microporous & mesoporous Mat. 46, 356 (2001)

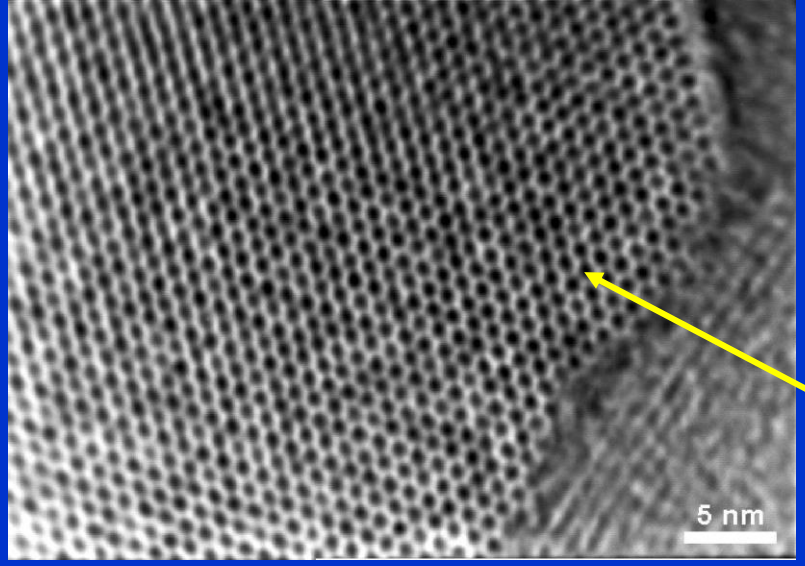


Specific surface area:
1100 m^2/g

Tuning pore size dimensions

Applications:

1. Membranes for filtration
   - Water and other solvents
   - Dialysis
2. Chromatography
3. Lasers
4. Catalysis

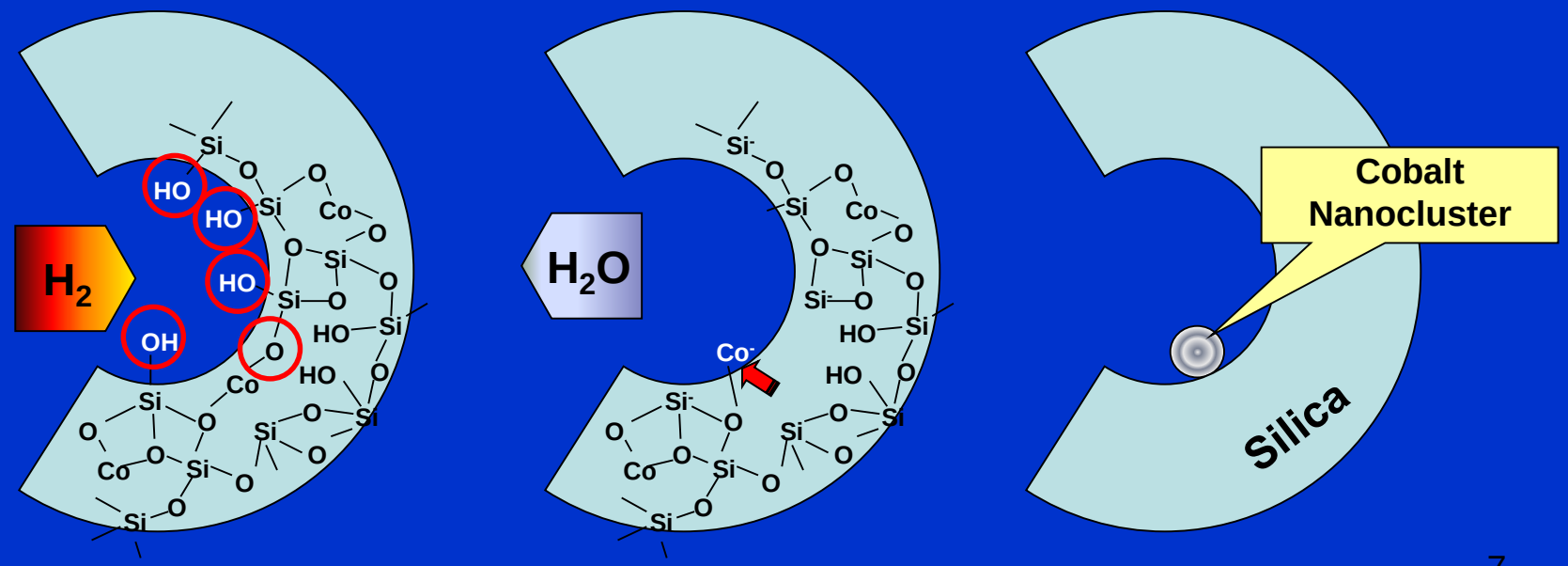


J. of Porous Materials (2007)

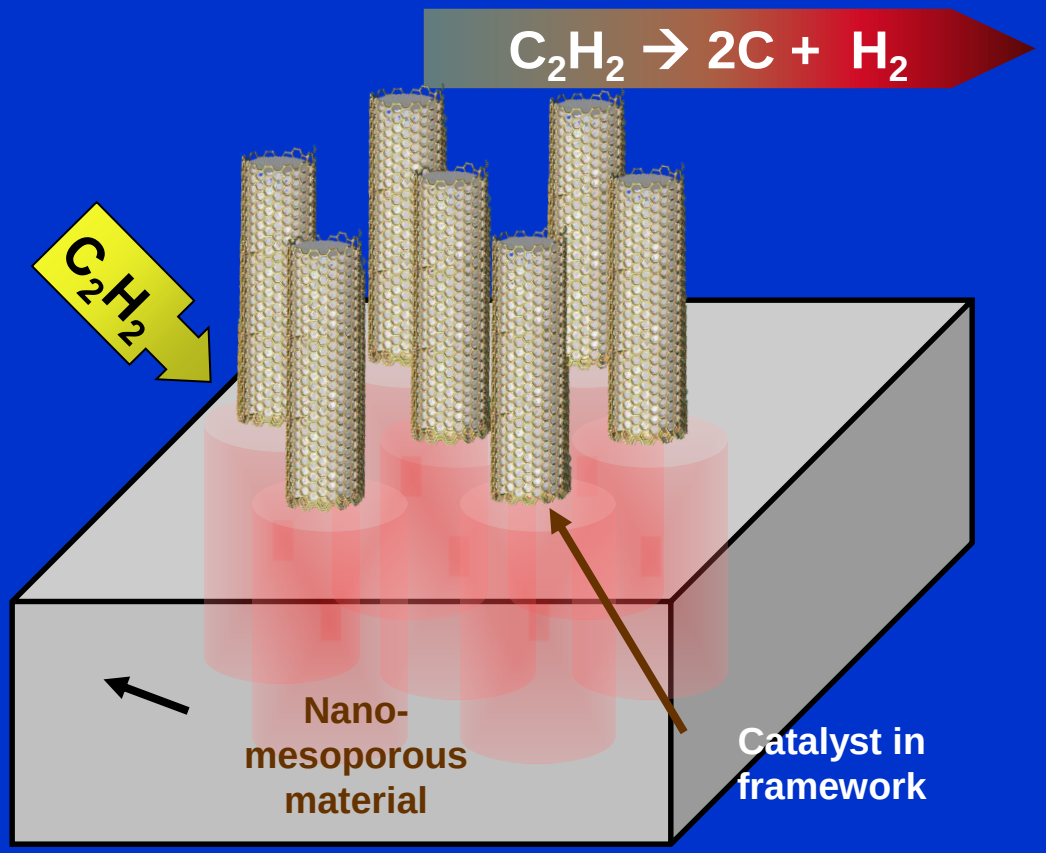
Dalton Transactions: DOI:10.1039/C2DT31835K (2012).

Nanoscale, 5, 2850-2856 **(2013)**

Co, Ni



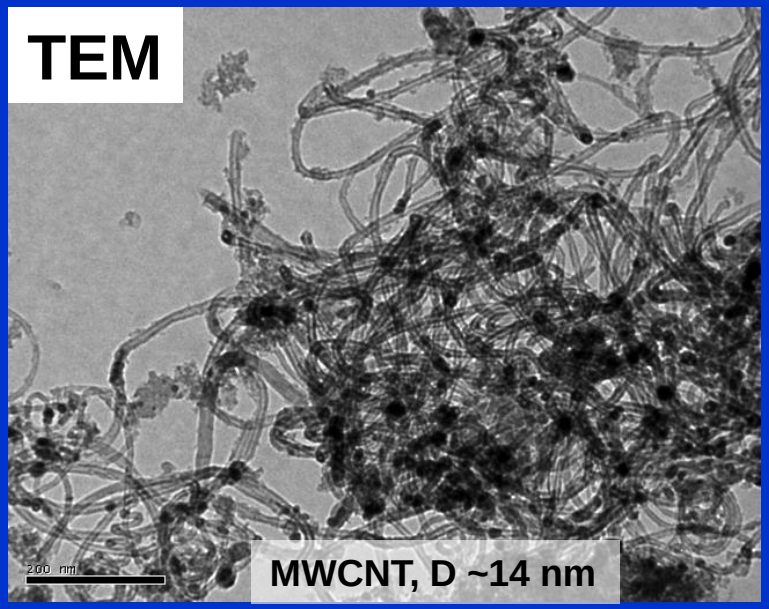
New Route for CNT Synthesis



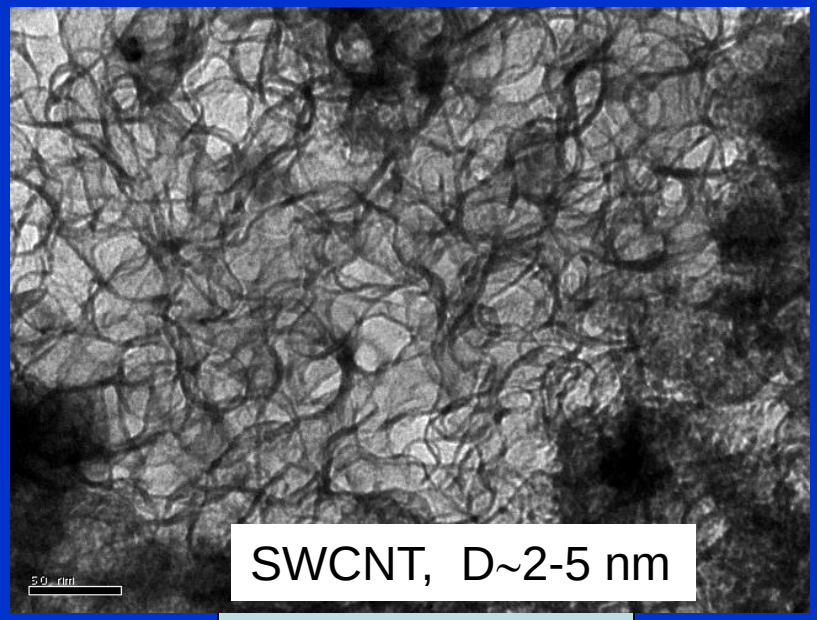
J. of Nanoscience and Nanotechnology 9, 4880-4885 **(2009)**

Grown Carbon Nanotubes

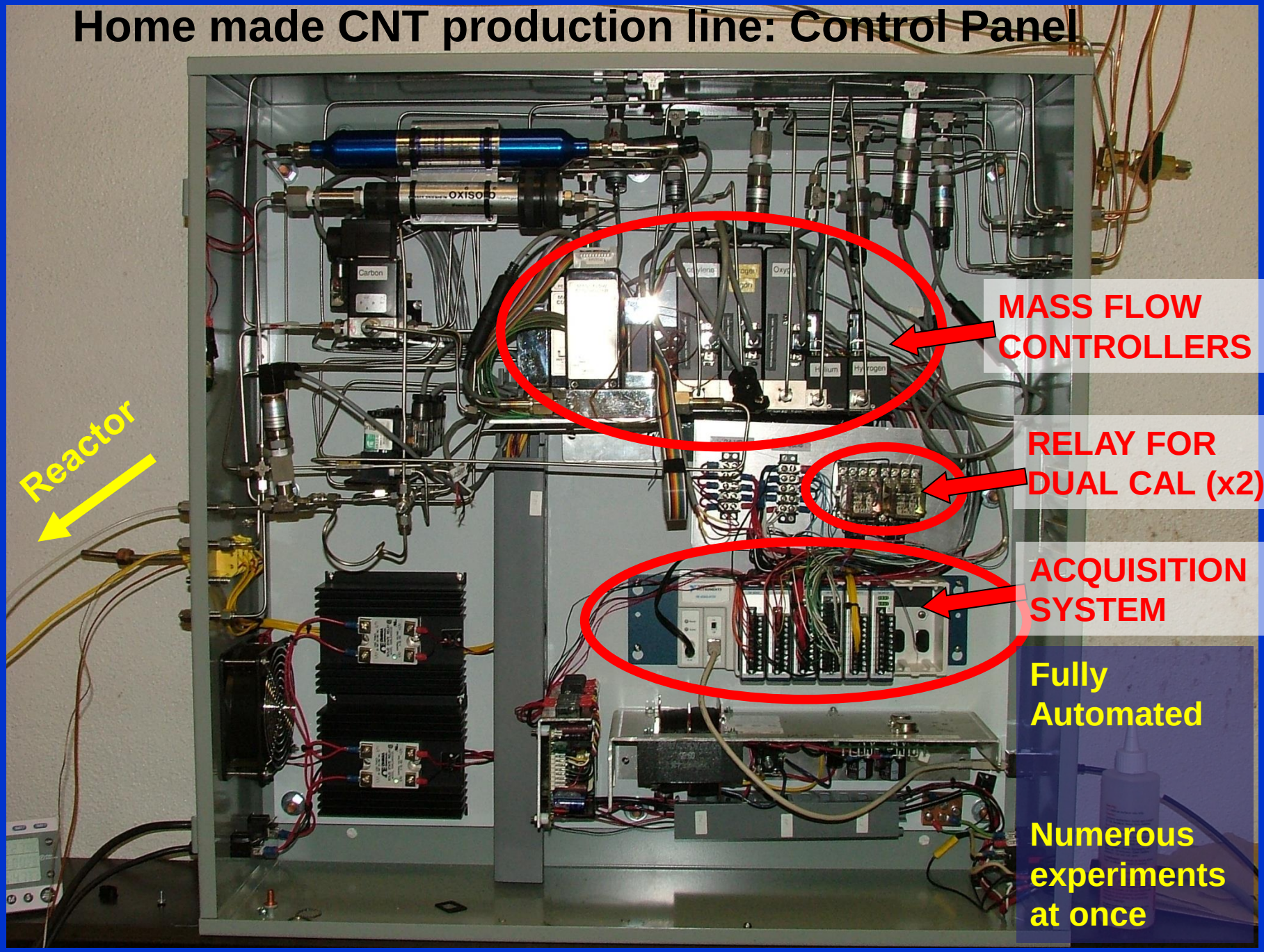
- C_2H_2 as carbon source
- Synthesis temperature : 700°C
- Vertical or horizontal furnace

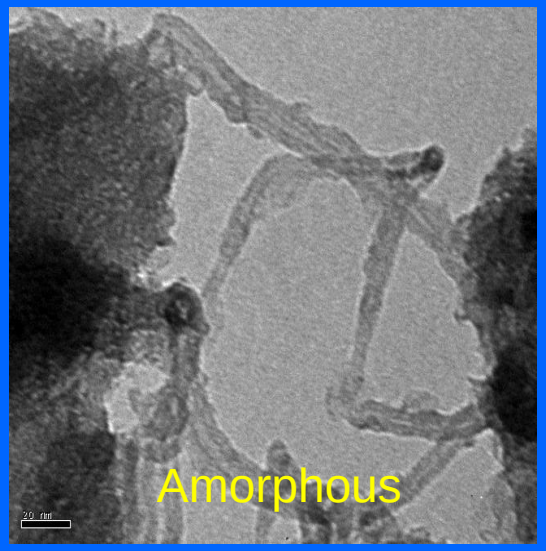


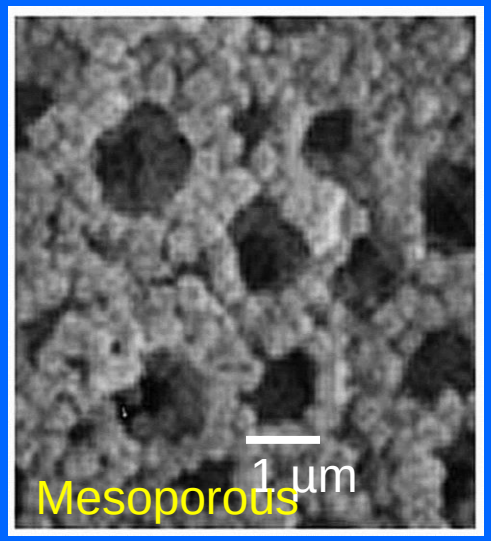
SP^2

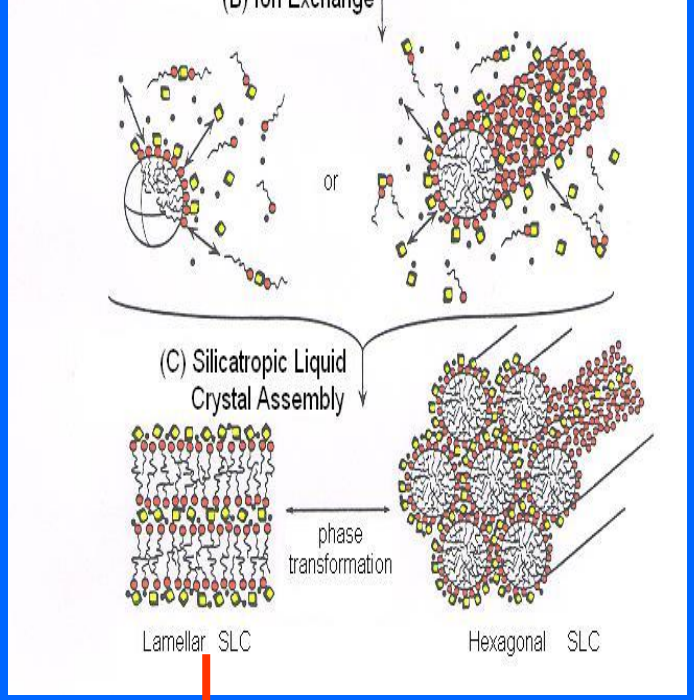


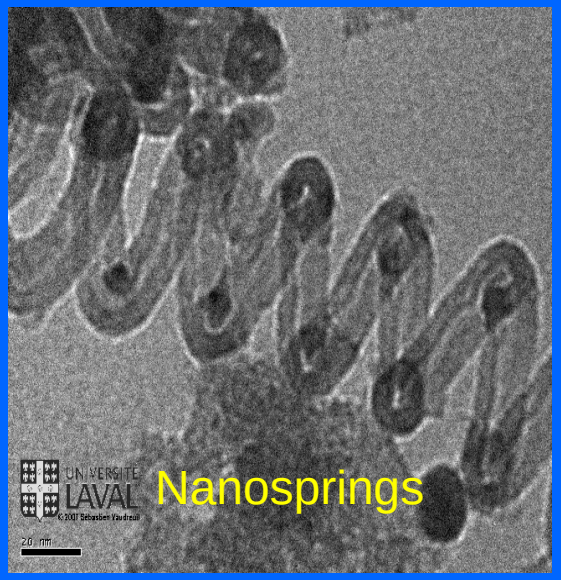
Home made CNT production line: Control Panel

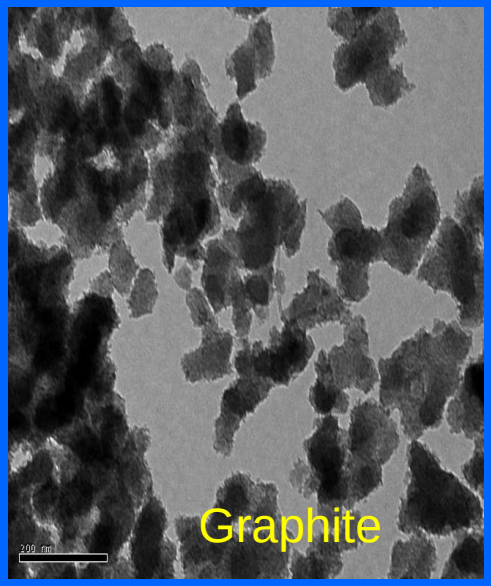


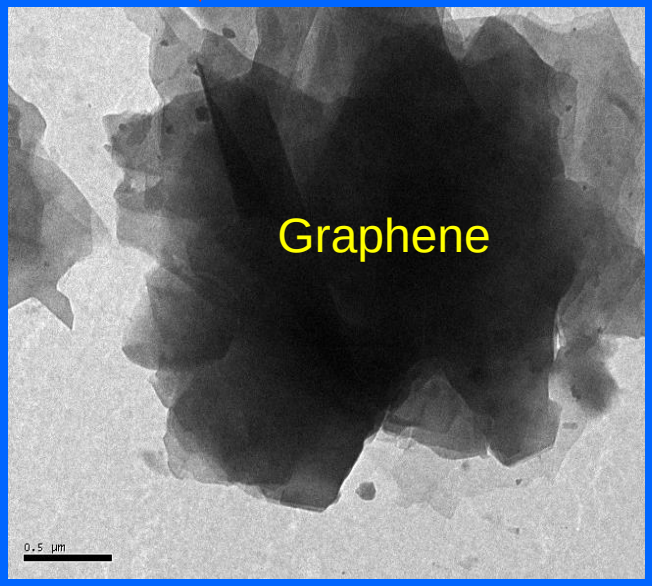

Amorphous


1 µm
Mesoporous

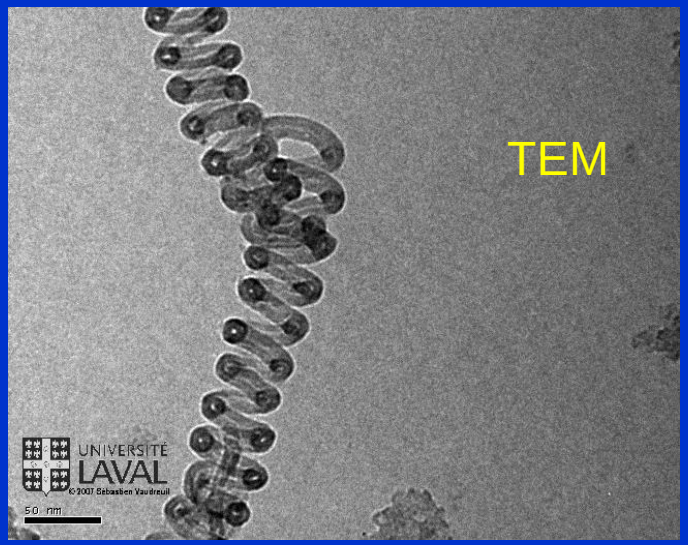

(D) Ion Exchange
or
(C) Silicatropic Liquid
Crystal Assembly
phase
transformation
Lamellar SLC
Hexagonal SLC

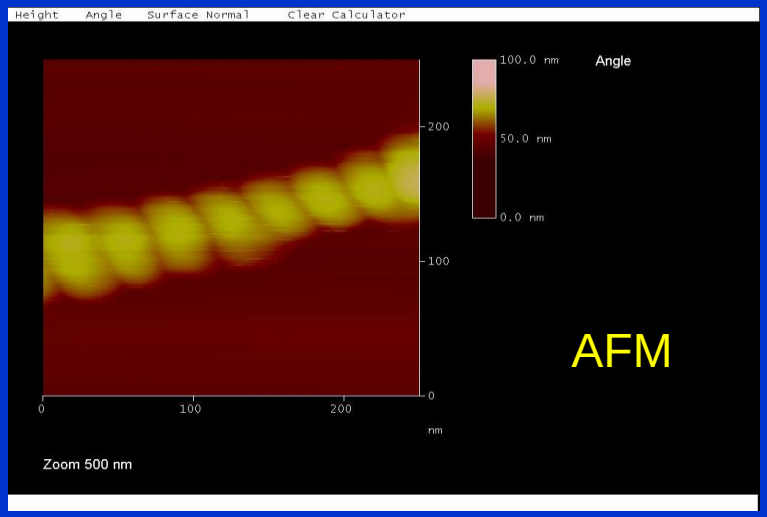

UNIVERSITÉ
LAVAL
Nanosprings

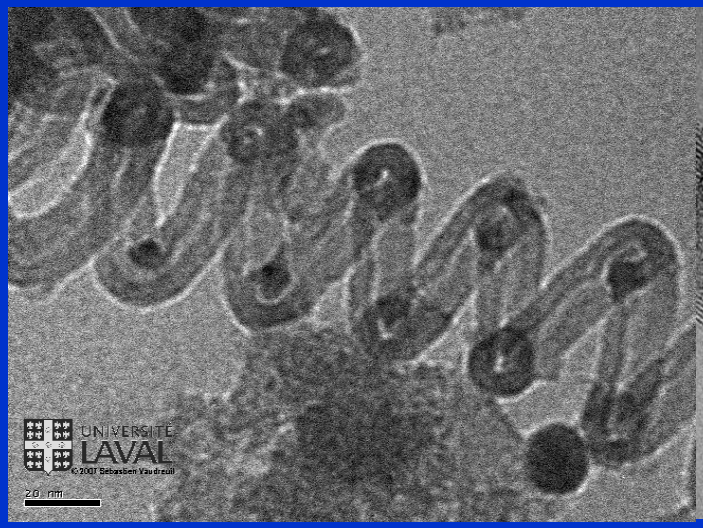

Graphite

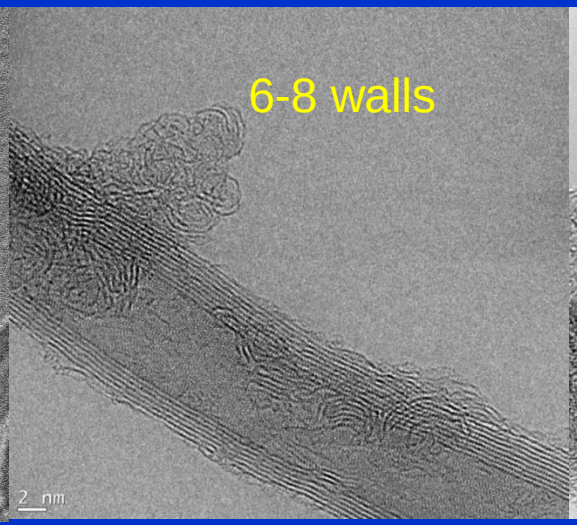

Graphene

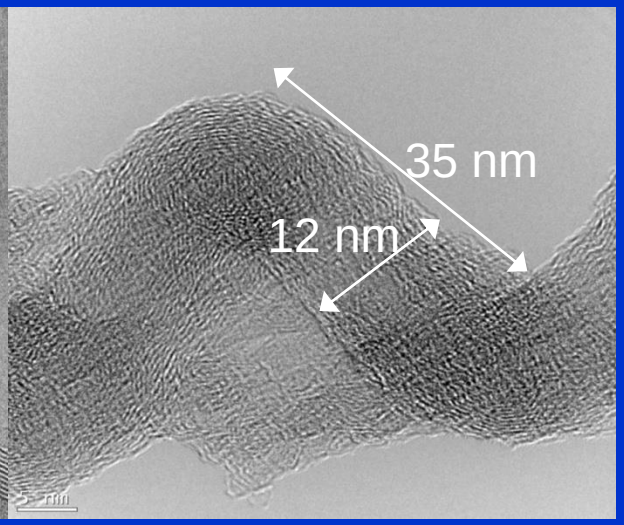
Nanosrpings & Nanosolenoids ??????







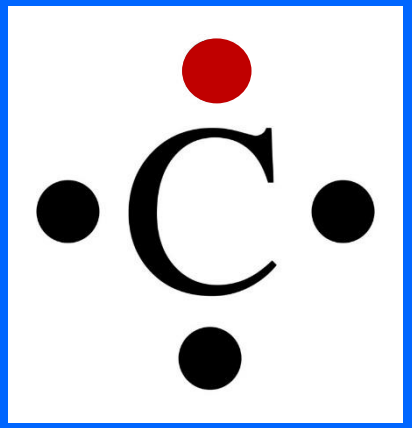




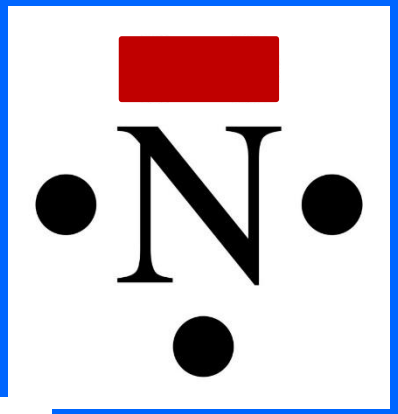
Vaudreuil and Bousmina. J. Nanosci. & Nanotech 9, 4880-4885 **(2009)**

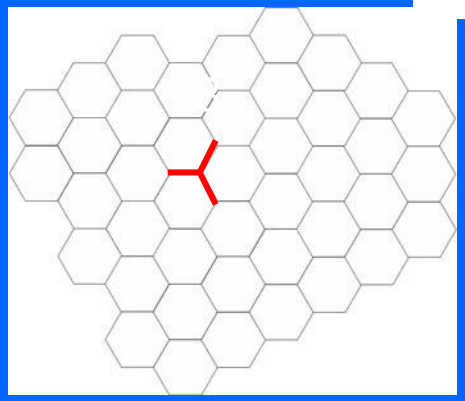
Nitrogen can be inserted within the graphene lattice

Tetravalent



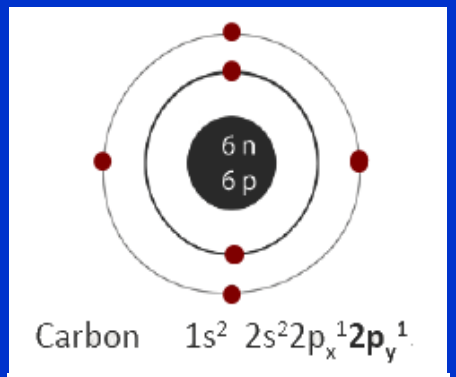
Pentavalent

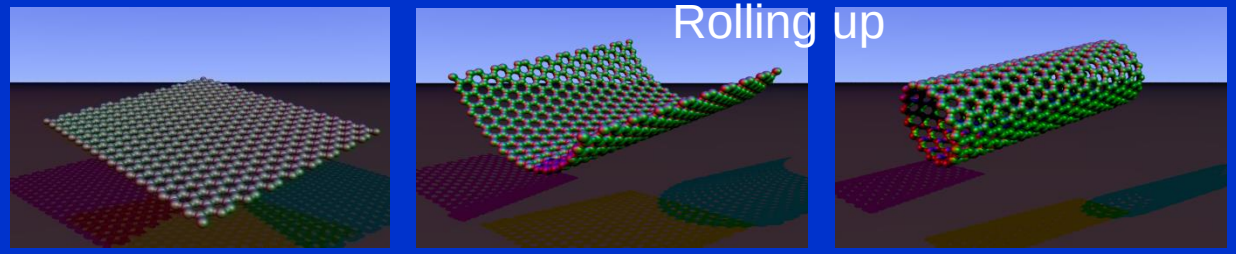




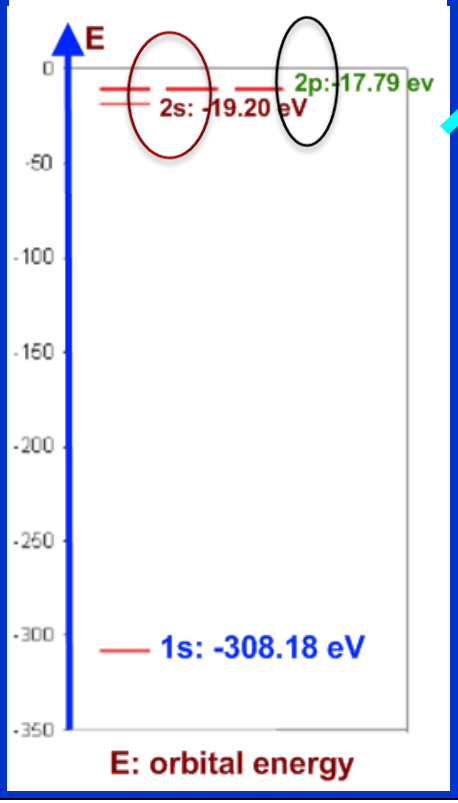
Graphene

$1S^2 1\sigma^3 \pi^1$





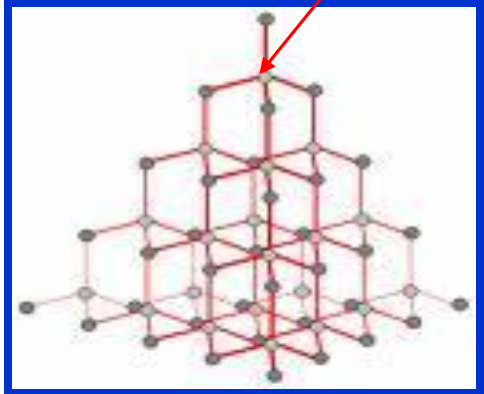
Combination of s and p : Hybridation sp^x

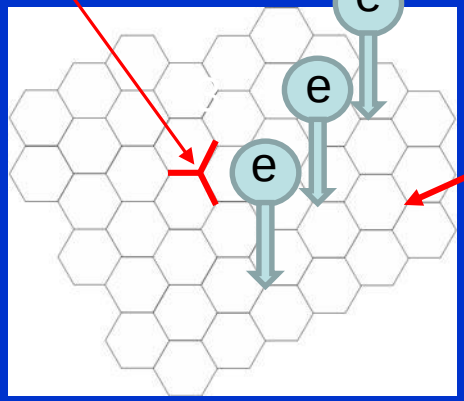


Hybridation

sp^3

sp^2





N: sp^2

Diamond

$1S^2 1\sigma^4$

Graphene

$1S^2 1\sigma^3 \pi^1$

High electron mobility

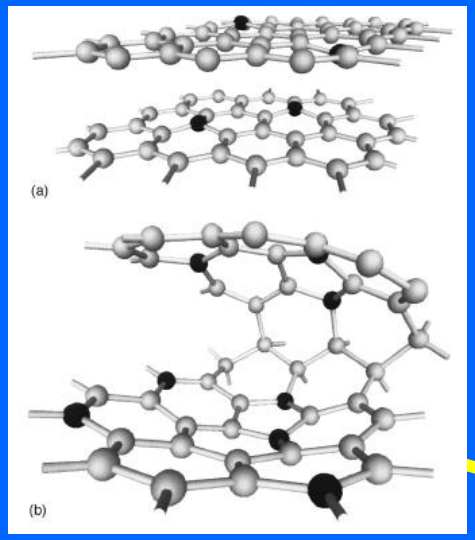
Unique relativistic Properties

$V=10^6$ m/s

B. Drissi, K. Sadki, H. Saidi & M. Bousmina, Computational Materials Science 96,165-170 (2015)
B. Drissi, F. Ramadan, H. Saidi, M. Bousmina. J. of Phys. Soc. Jap. 82, No 104711 (2013)
H. Saidi, O. Fassi-Fehri and M. Bousmina J. Math. Physics. 53, 7, -072304 (2012)
B. Drissi, H. Saidi & M. Bousmina, J. Mathematical Physics. 52, 022306 (2011)
B. Drissi, H, Saidi & M. Bousmina, Phys. Rev. D 84, 014504 (2011)
Saidi & Bousmina, AJ.Math. Phys. 10, 93-115 (2011)
B. Drissi, H. Saidi & M. Bousmina, Nuclear Physics, 3, 523-533 (2010)

Nechanism of NS formation

1. Insertion of Nitrogen into substitutional graphene sites



5% N

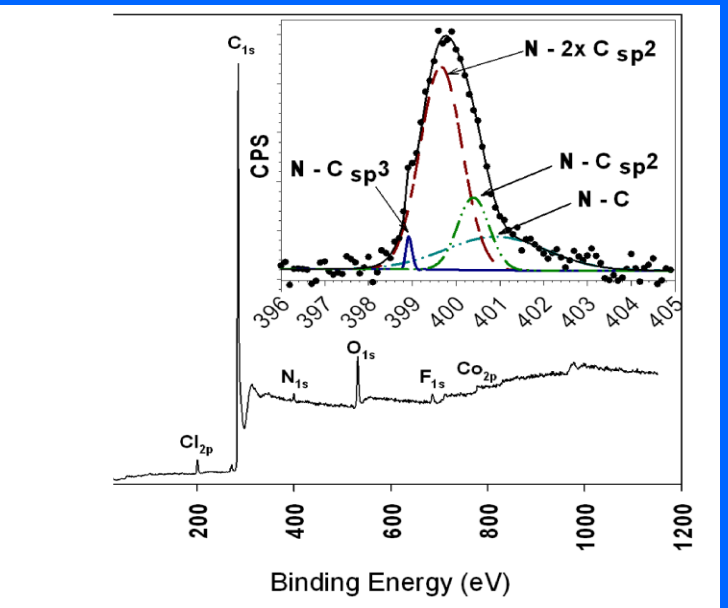
15% N

C sp^2

N sp^2

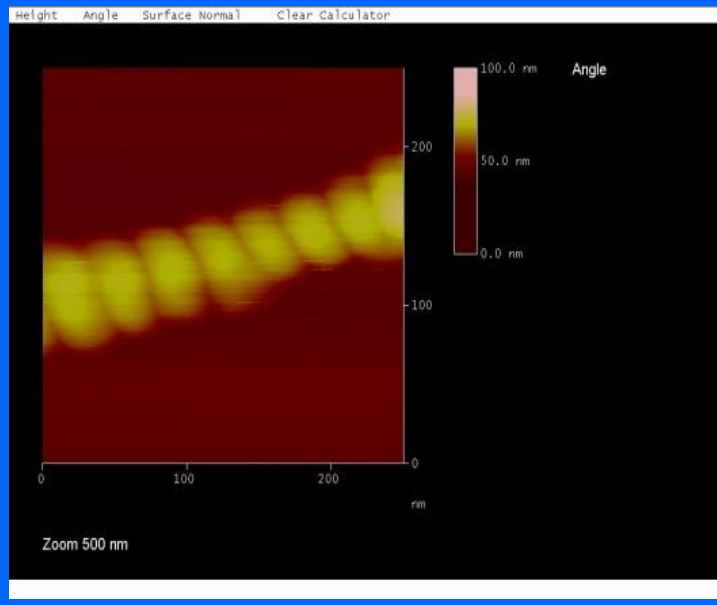
Only three involved electrons

X-Ray Photoelectron SPectroscopy



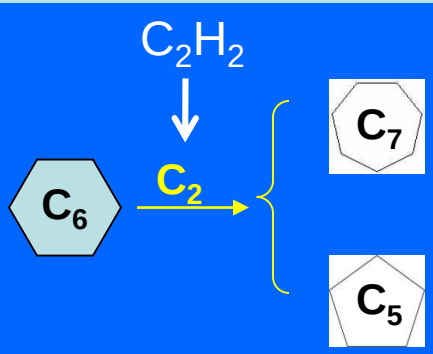
Simulations

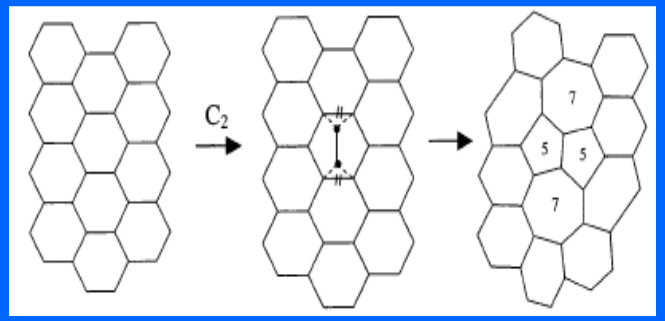
Cigare
Roll up

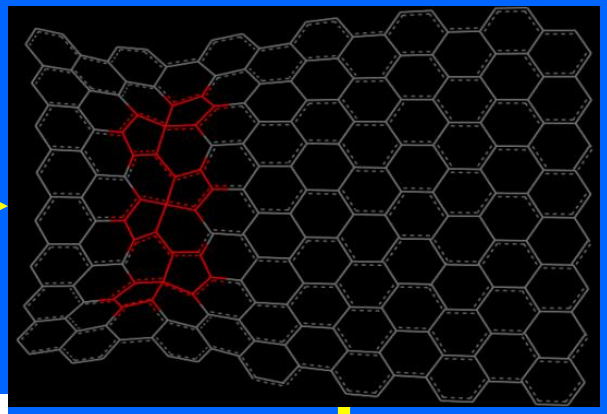


Nechanism of NS formation

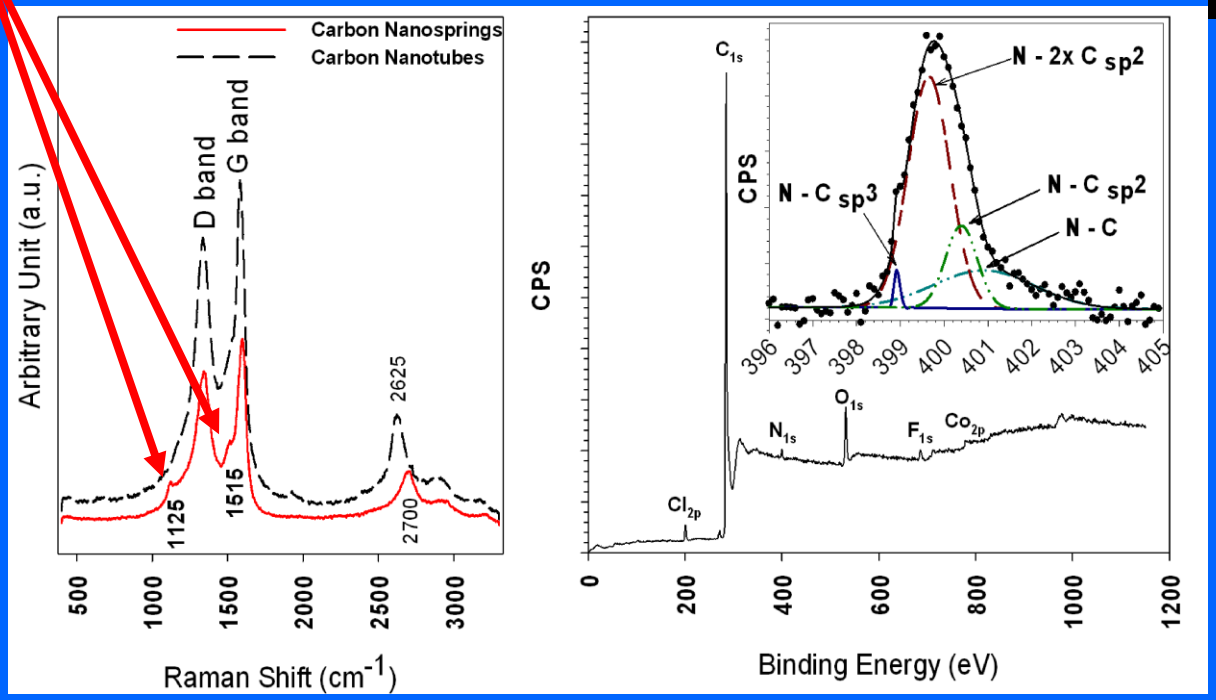
2. Pentagonal-Heptagonal defects → curvature in the graphene sheet

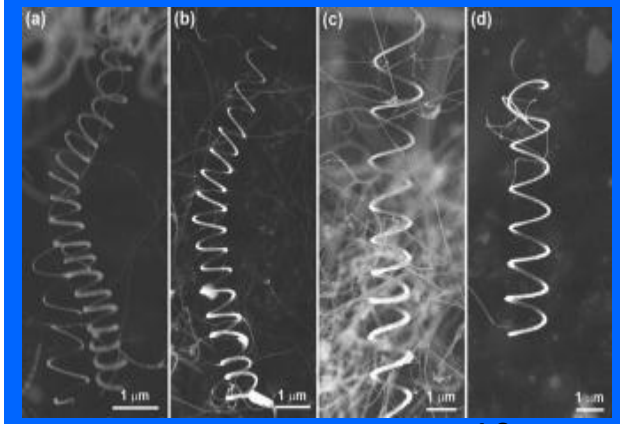




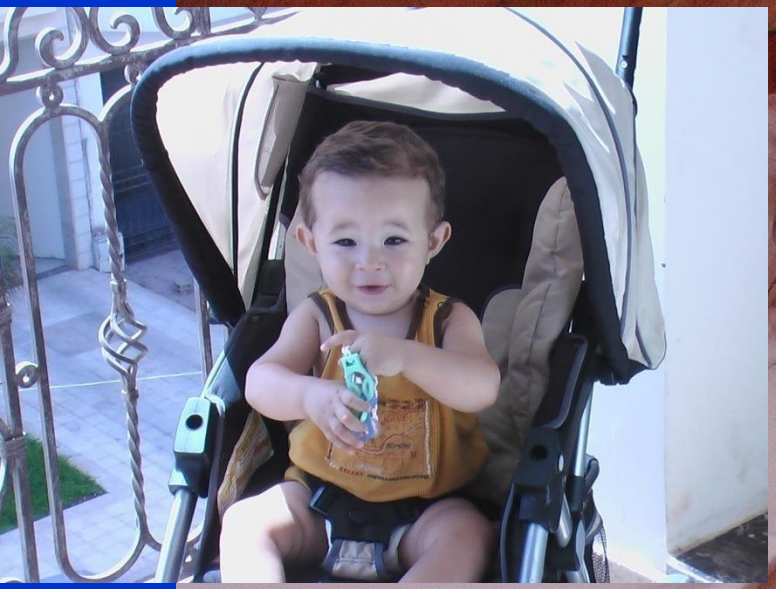


C5 & C7

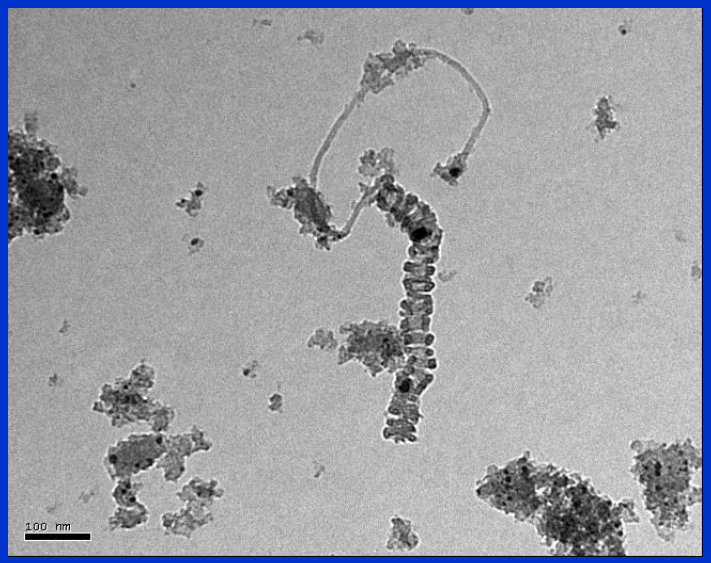


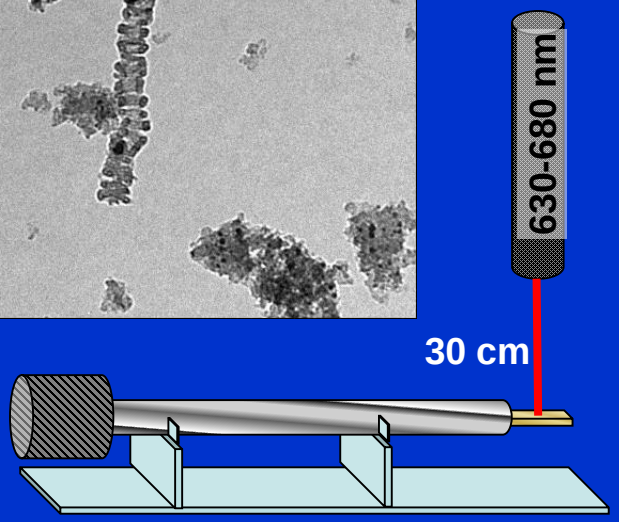


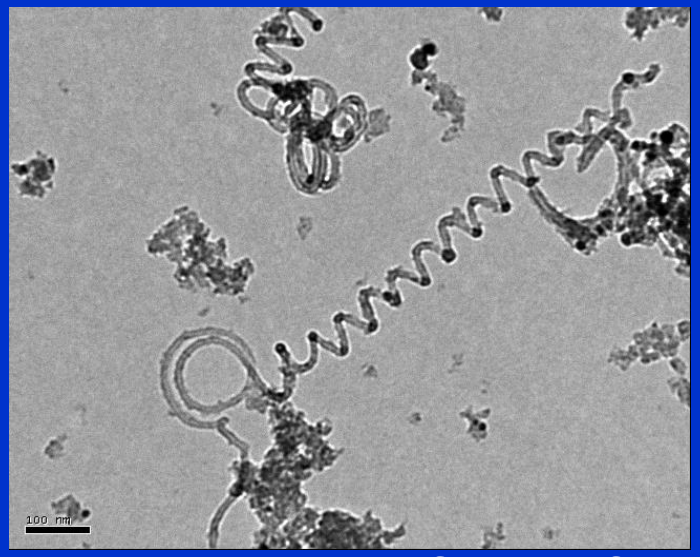
Bousmina Ryan: Let’s stretch it daddy



Carbon Nanosprings and Nanosolenoids exposed to laser light: Accordion process







		Before		After
Diameter (nm)	:	46	➔	43
Pitch (nm)	:	18	➔	42

Nanosprings and Nanosolenoids show reversible strain release.

Shape memory nanomaterials

Vaudreuil and Bousmina JNN . 9, 4880-4885 **(2009)**.

Outline

1. Fabrication (Physical Chemistry)

2. Applications

   i) Carbone Nanotubes: Appl. Cancer cells (Bio)

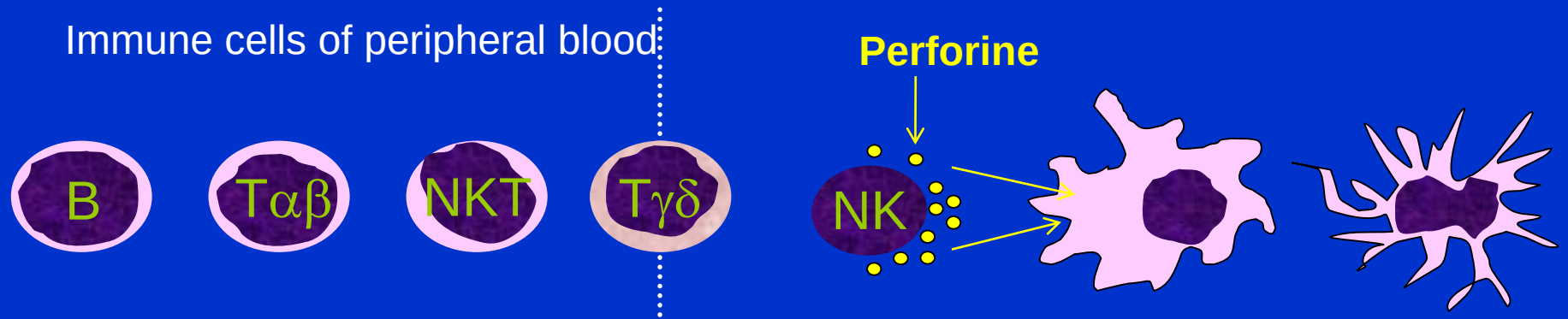
   ii) Organic Nanotubes : Appl. Spinal cord (Medical)

3. Graphene/polymer nanocomposites

   Piezoelectric material (Physics: Electro-mechanics)

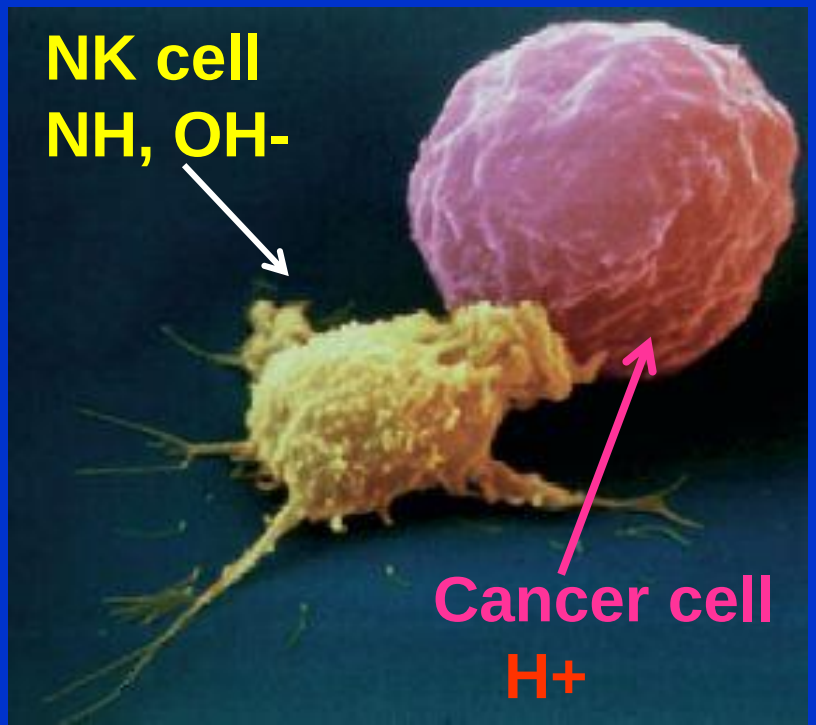
Collaboration with Prof. J. P. Majoral LCC Toulouse (France).

Immune cells of peripheral blood



adaptive immunity

innate immunity

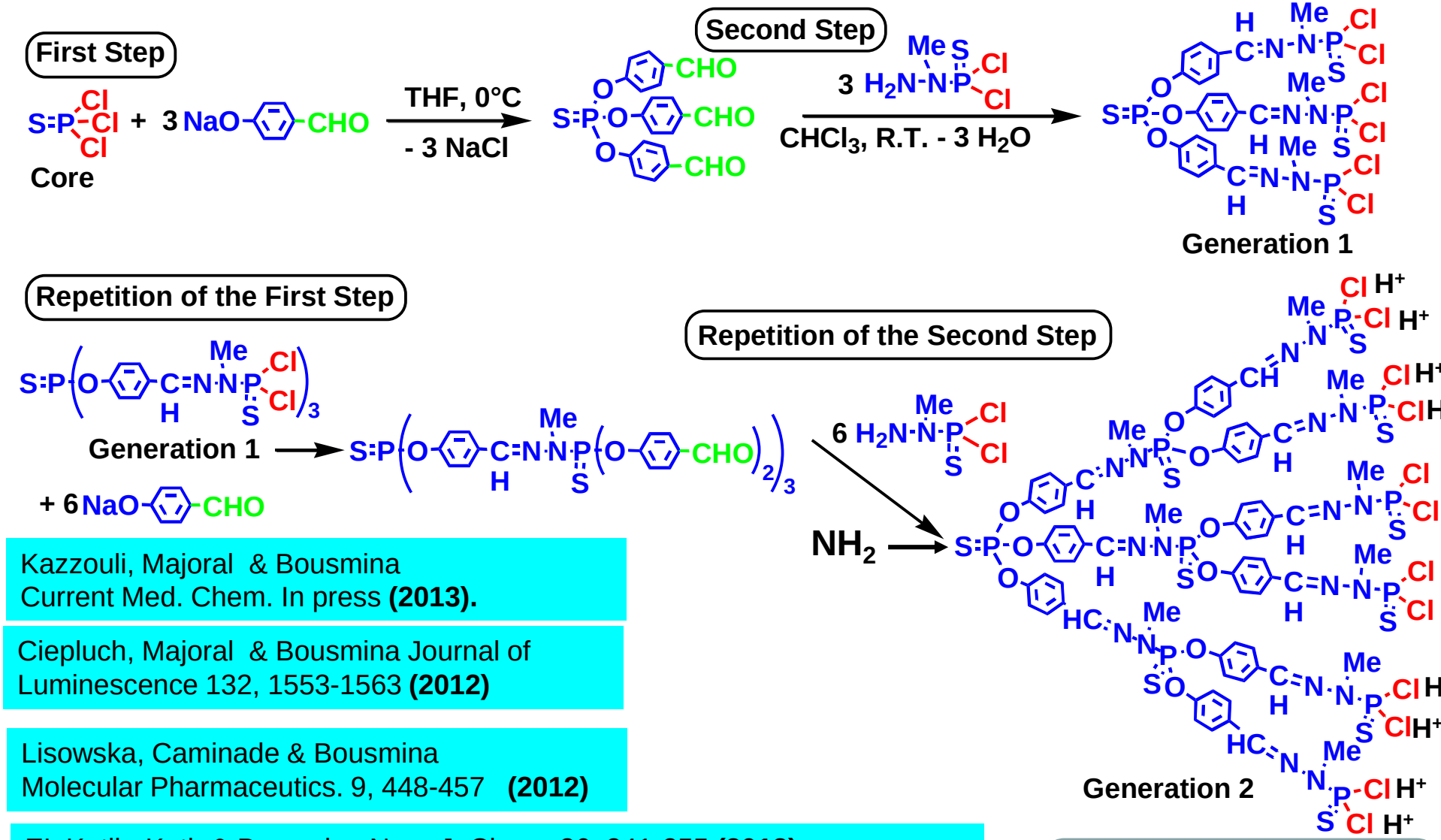


NK Cells: Natural killer cells (or **NK cells**) are a type of cytotoxic lymphocyte that constitute a major component of the innate immune system.

With age: decrease in

- Number
- Efficiency & specificity
- **Mobility**

First neutral phosphorus dendrimers (divergent synthesis)



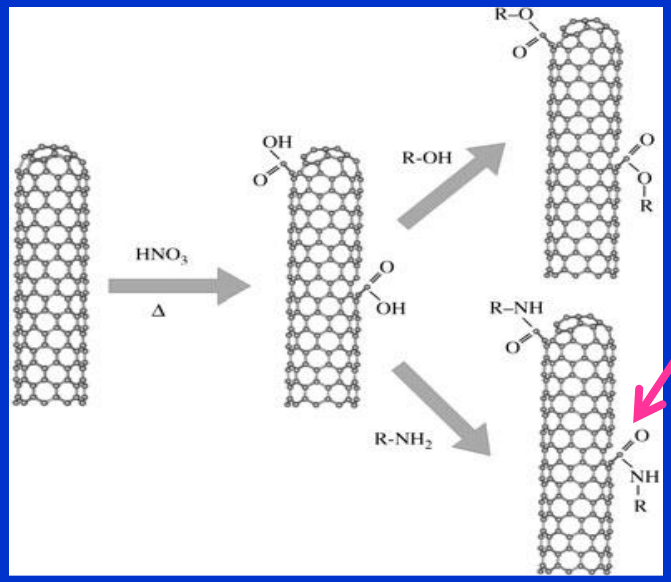
Kazzouli, Majoral & Bousmina
Current Med. Chem. In press **(2013).**

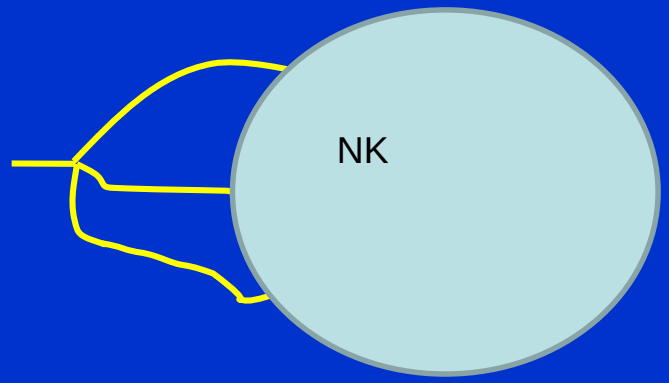
Ciepluch, Majoral & Bousmina Journal of Luminescence 132, 1553-1563 **(2012)**

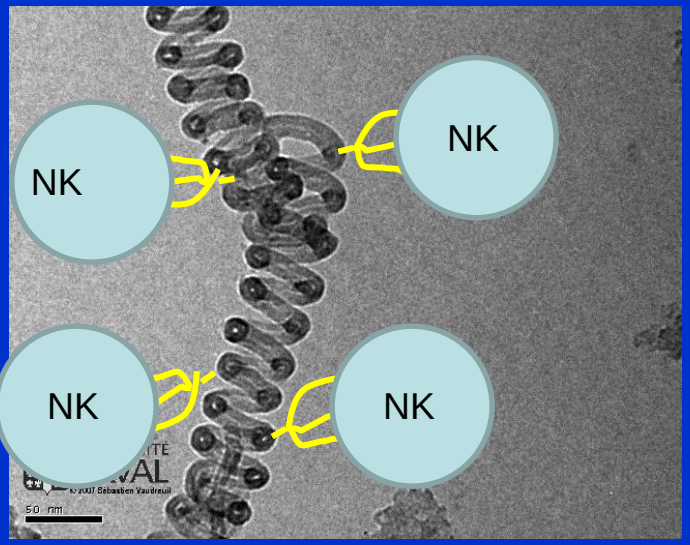
Lisowska, Caminade & Bousmina
Molecular Pharmaceutics. 9, 448-457 **(2012)**

EL Katib, Katir & Bousmina New. J. Chem. 36, 241-255 **(2012)**

El Kazzouli, Mignani & Bousmina New J. Chem. 36, 241-255 **(2012)**.
Katir, Majoral, & Bousmina. Europ. J. Org. Chem. 2, 269-273 **(2012)**

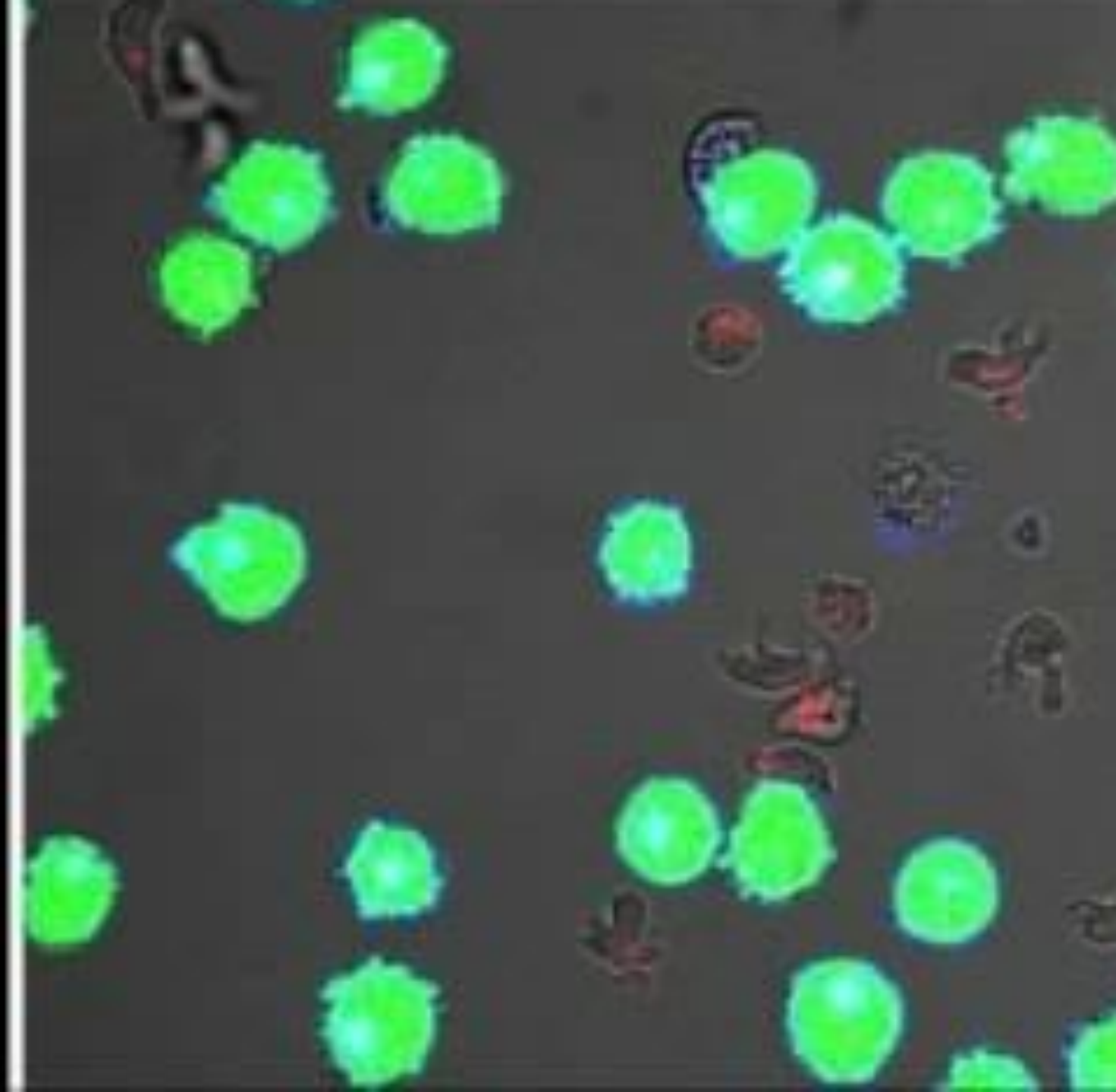




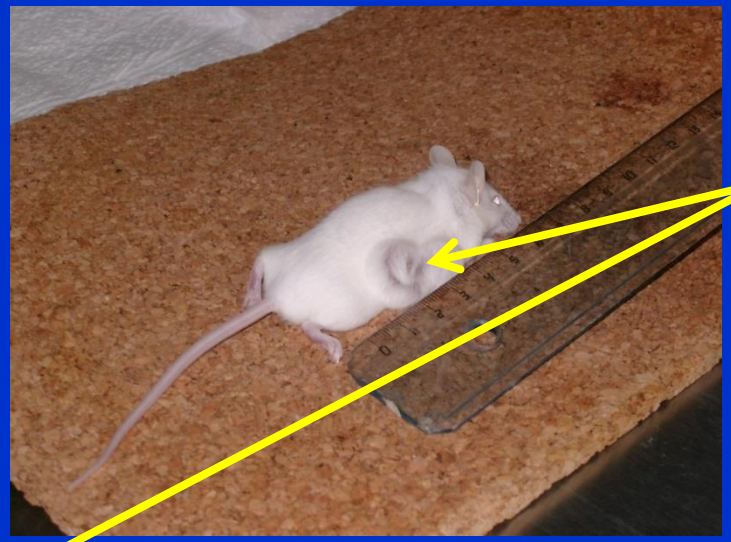


NK+Dendrimer+CNS

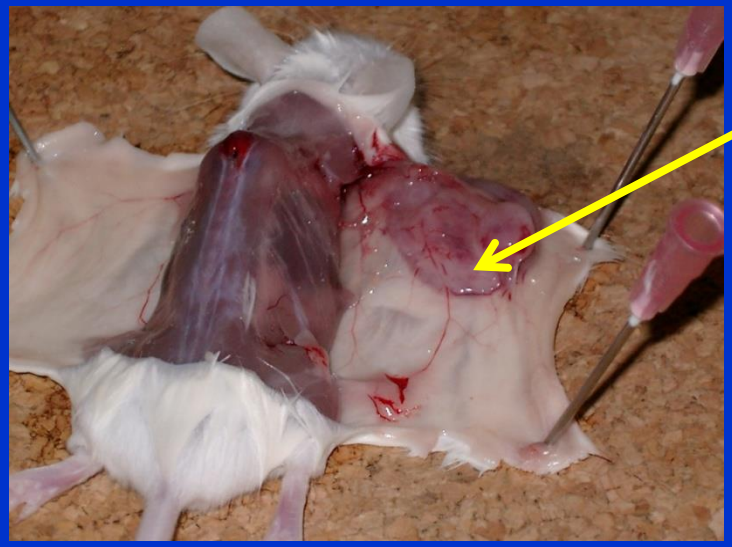
Advanced Drug Delivery Reviews (2013):



+ Cancer cells



4 weeks Tumour



+ DMM

CNS Laser

N. Brahmi, S. Mignani, S. El Kazzouli, M. Bousmina & JP. Majoral, **Nanoscale 7, 3915-3922 (2015)**

N. Katir, A. EL Kadib, M. Bousmina & S. Mignani. **Chem Com. 50, 6981-6983 (2014)**

S. Mignani, S. El Kazzouli, M. Bousmina, JP. Majoral. **Chem Rev. 114, 1327-1342 (2014)**

S. Mignani, S. El Kazzouli, M. Bousmina, JP. Majoral. **Progess in Polym. Sci. 38, 993-1008 (2013)**

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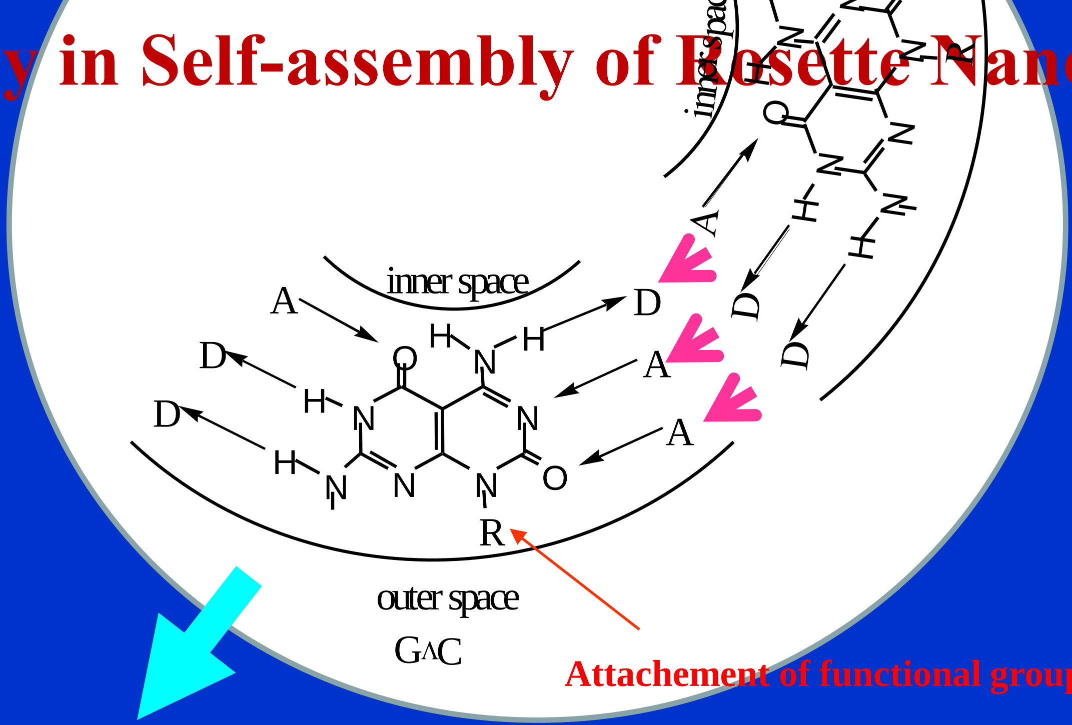
   Piezoelectric material (Physics: Electro-mechanics)

Hierarchy in Self-assembly of Rosette Nanotubes

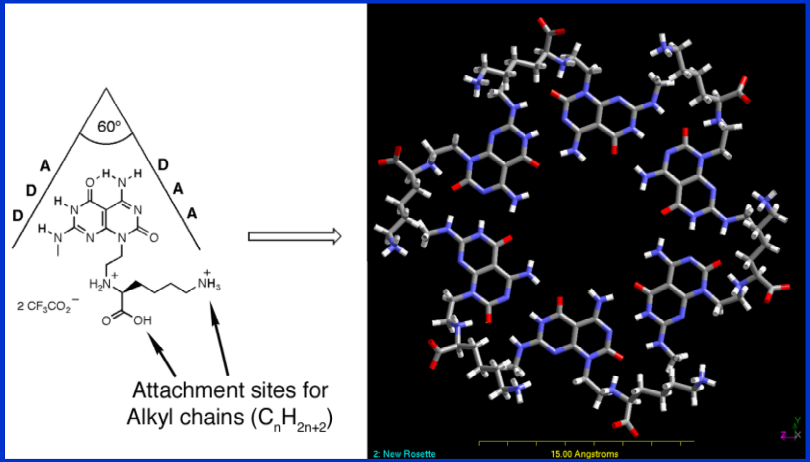


G: Guanidine
C: Cytosine

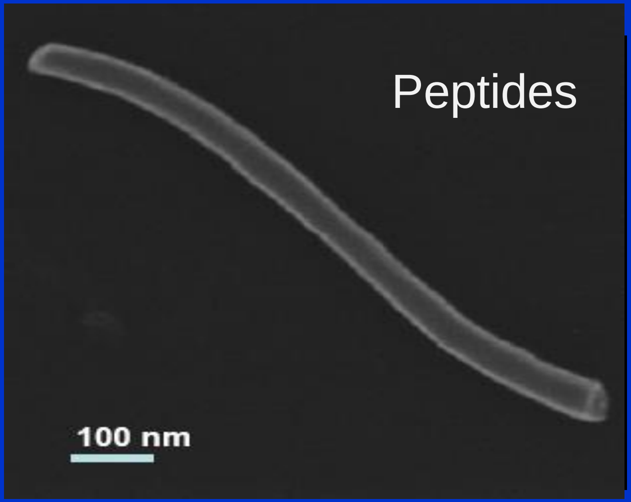
1995-1997
Post-docs
Pinet, Dannumah
Laval University.

Prof. Hicham Fenniri
Alberta University

Attachement of functional groups



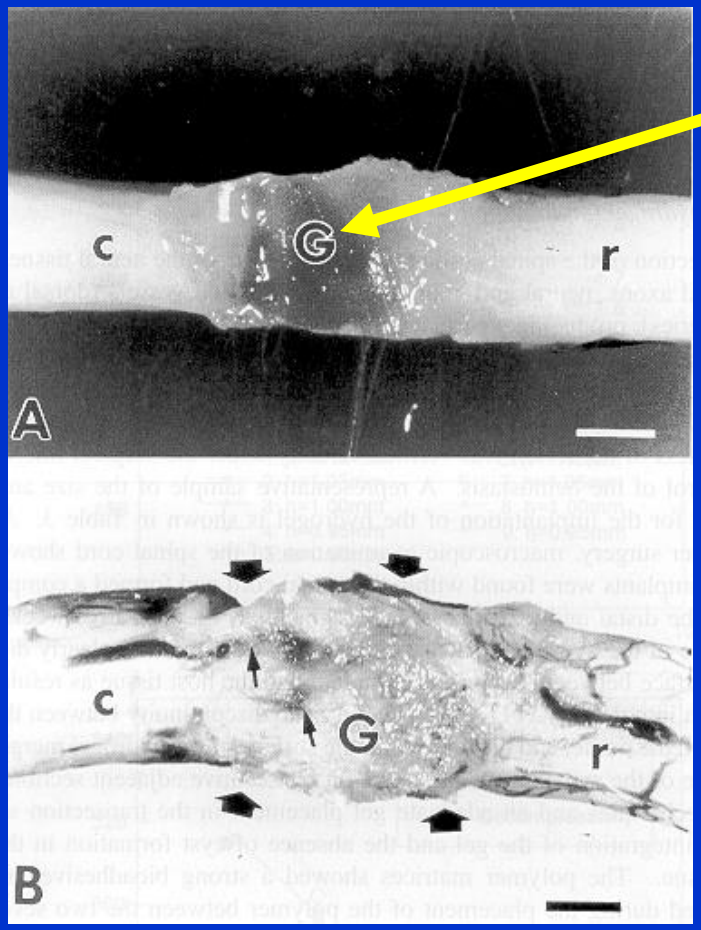
Formation of disc-helical structure
by hydrogen bonding: **Hexamers (rosettes)**



Stacking of the discs via π-π interactions

Organic Nanotubes
Rosettes Nanotubes

Spinal Cord Repair: PHPMA/Rosette Nanotube



Hydrogel

Hind Legs

Woerly et al. International Patent, 2000, 2002 & 2003

S. Woerly, E. Pinet, Van Diep and M. Bousmina.. J. BIOMAT. 22, 1095 (2001).

S. Woerly, E. Pinet, L. de Robertis, M. Bousmina, G. Laroche. . J. BIOMATERIALS. 9, 681 (2000).

M. Iza, S. Woerly, E. Pinet and M. Bousmina. POLYMER, 41, 5885 (2000).

Outline

1. **Fabrication** (Physical Chemistry)

2. **Applications**

   i) Carbone Nanotubes: Appl. Cancer cells (Bio)

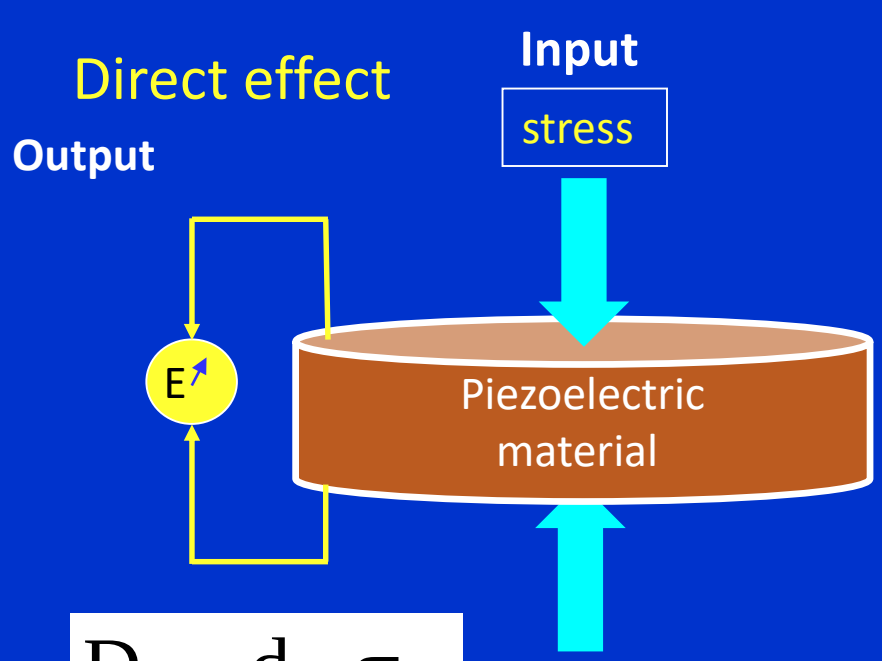
   ii) Organic Nanotubes : Appl. Spinal cord (Medical)

3. **Graphene/polymer nanocomposites**

   Piezoelectric material (Physics: Electro-mechanics)

Graphene/Polymer Piezoelectric materials

Direct effect



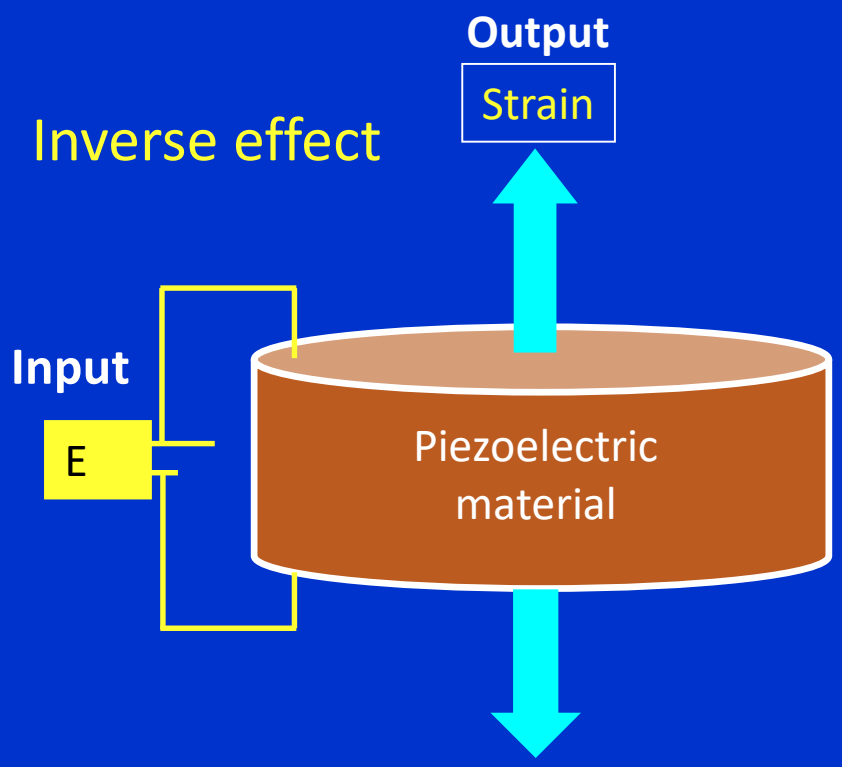
$$D_i = d_{ijk}\sigma_{jk}$$

Stress

Piezoelectric coefficient

Density of charge

Inverse effect



$$S_{ij} = d_{kij}E_k = d_{kij}^{-1}E_k$$

Strain Electric field

$$d_{33} = \frac{\partial D_3}{\partial \sigma_3} = \frac{\partial S_3}{\partial E_3}$$

Motivation :

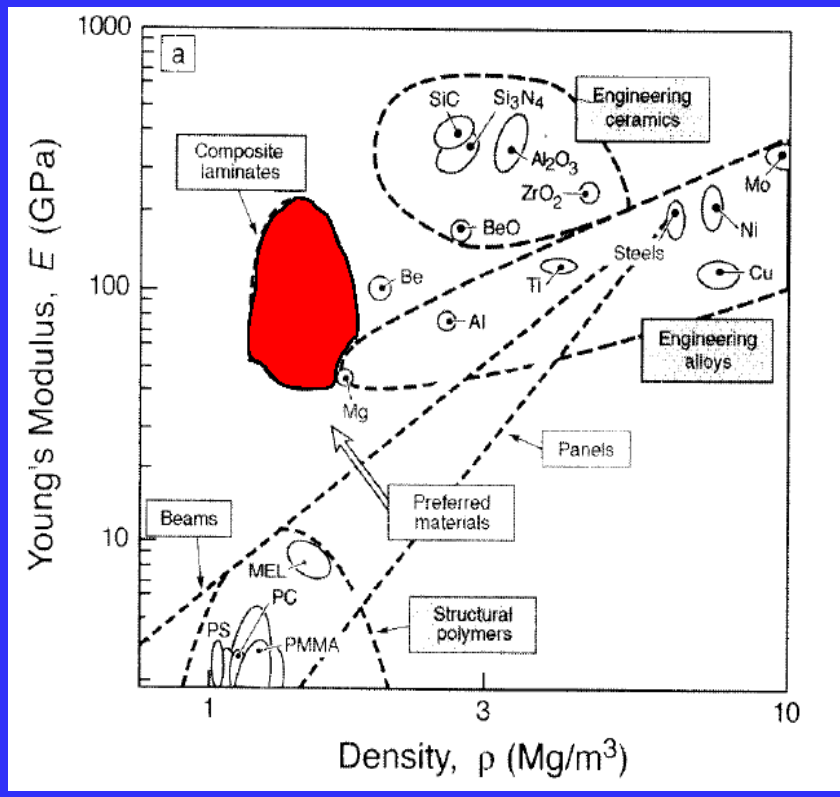
Fiso-technologies: Quebec-Canada

Piezoelectric Actuator

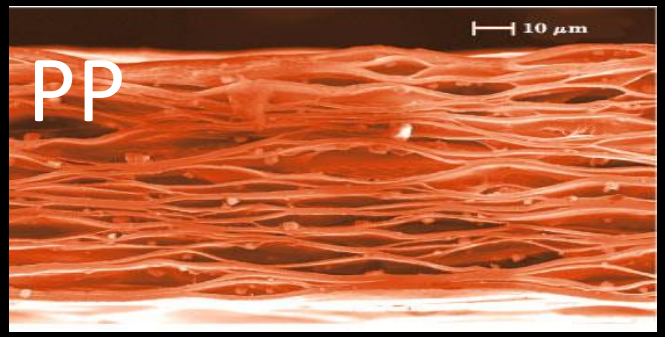
Piezoel coef	> 650 pC/N
Modulus	< 150 MPa
Density	< 0.85

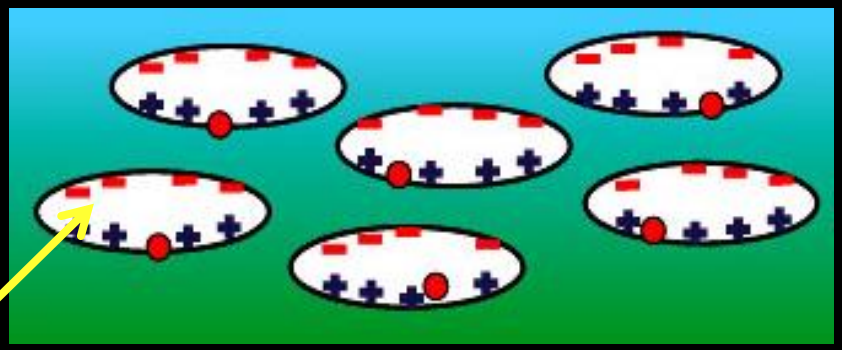
Cellular Polymer/Polar filler

Polymer/Graphene Nanocomposites

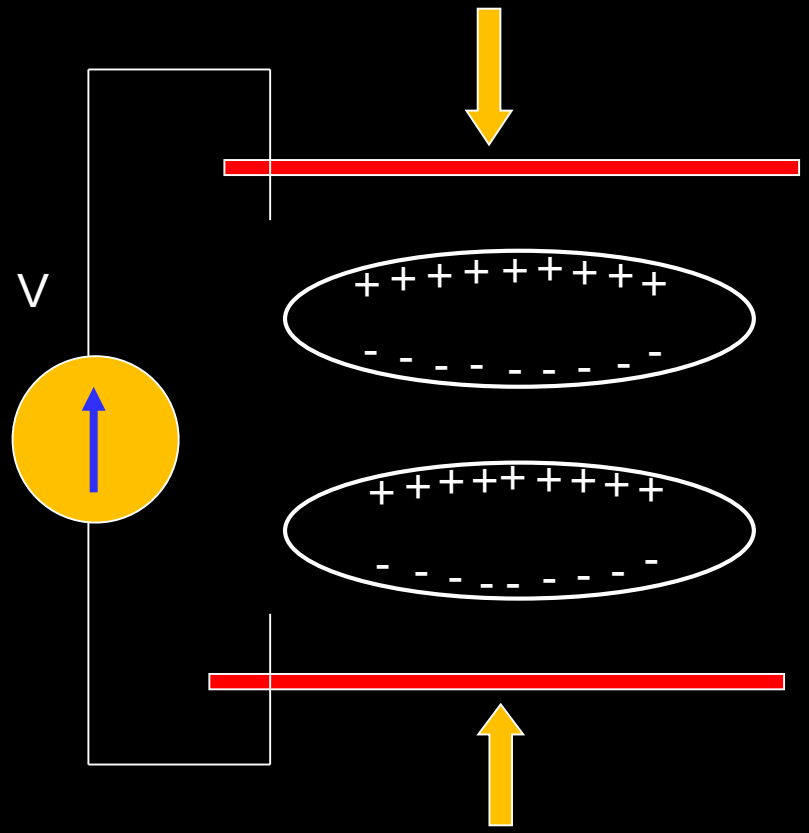


Piezoelectric cellular PP film



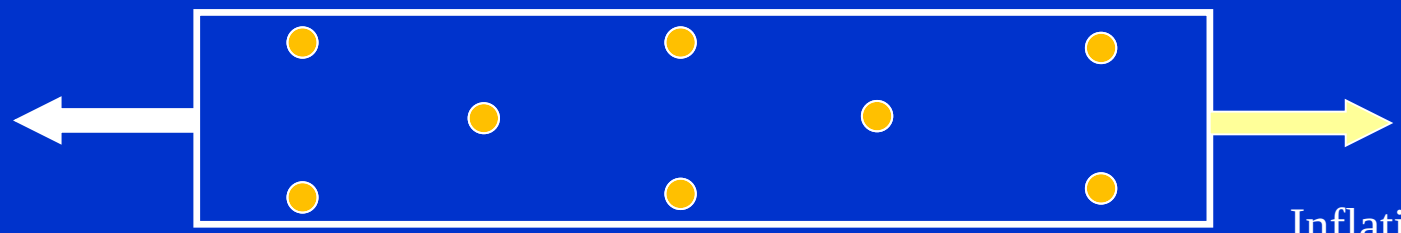


Ionised gas

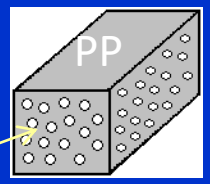


Stress → ΔPolarisation

Piezoelectric cellular PP films

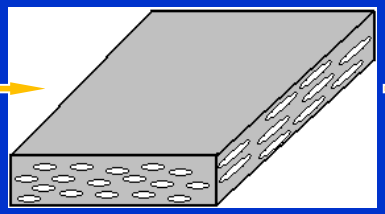


Film Extrusion

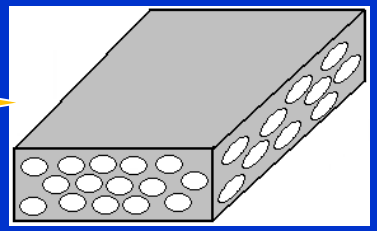


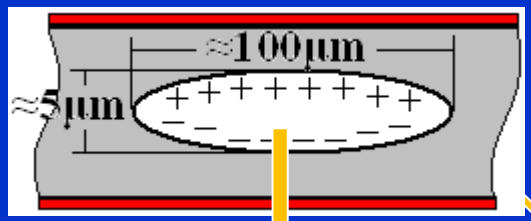
$CaCO_3$
10µm
Micro dipole

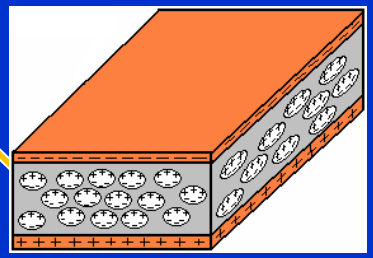
bi-axial stretching



Inflation by the diffusion of Gas

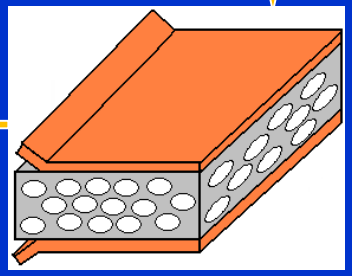






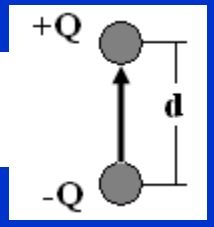
Electrical charging

Corona



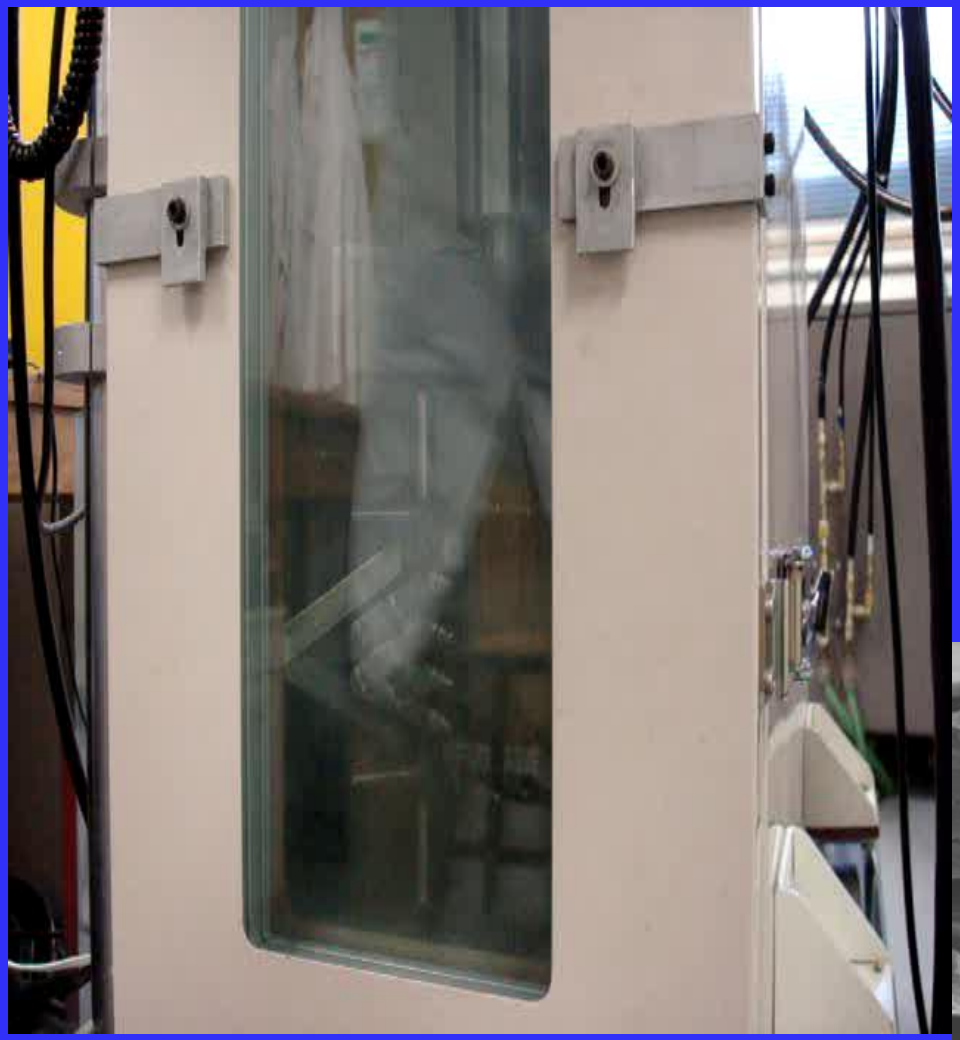
Metalization

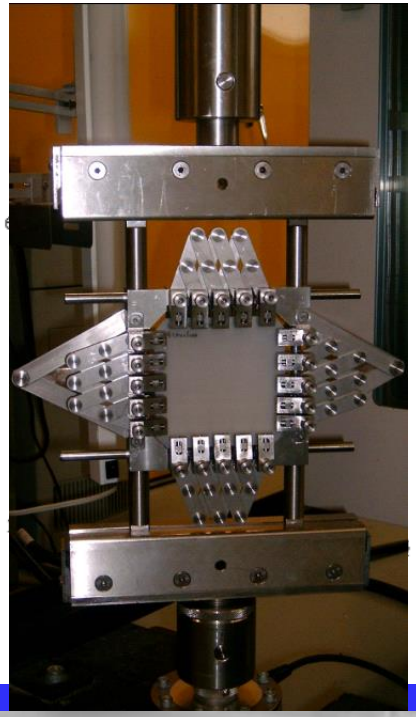
$$\vec{P} = Q.\vec{d}$$

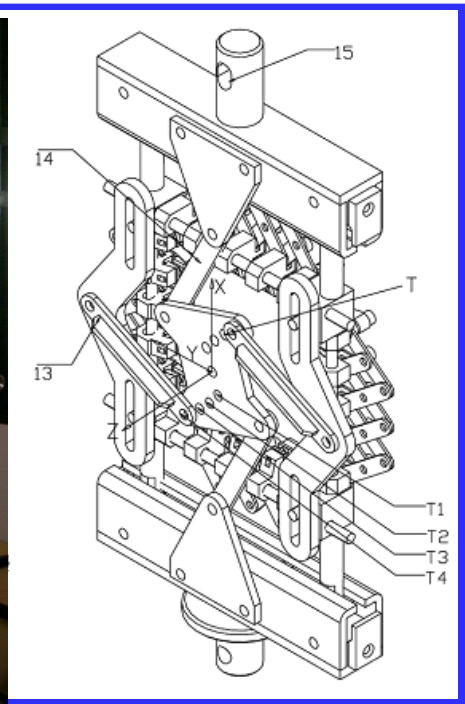


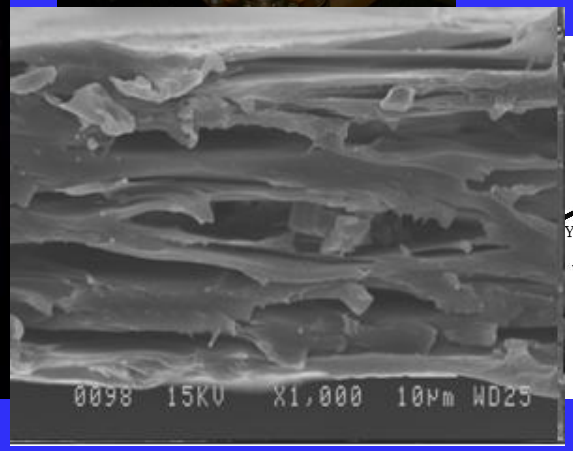
Qaiss and Bousmina: Polym. Eng. Sci. 51, 1347-1353 (2011)
JAPS. 123, 3425–3436 (2012)

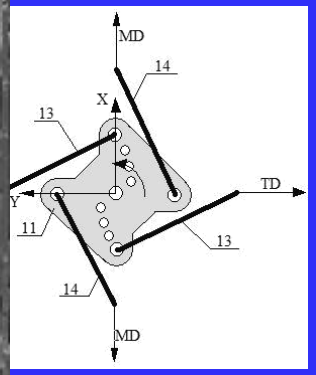
Biaxial stretching







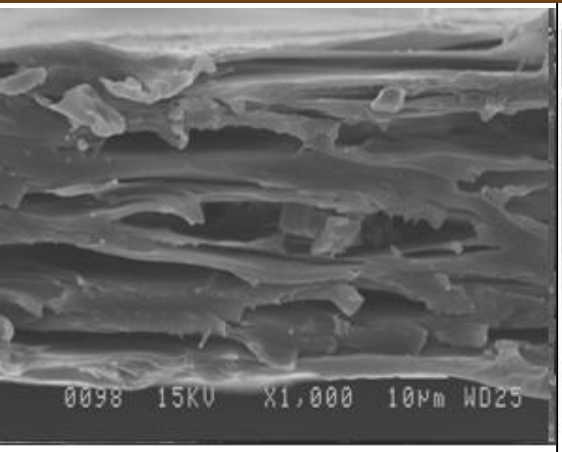


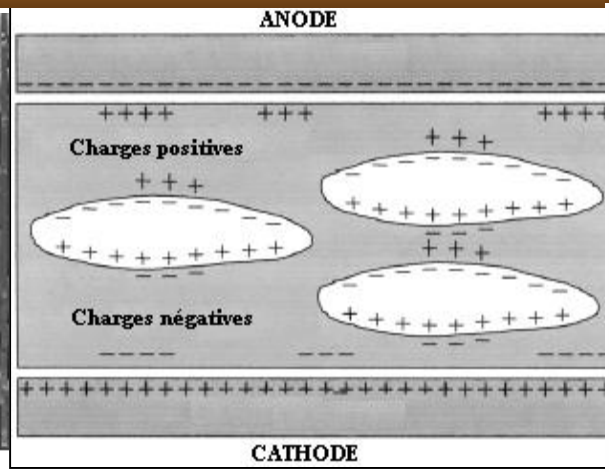


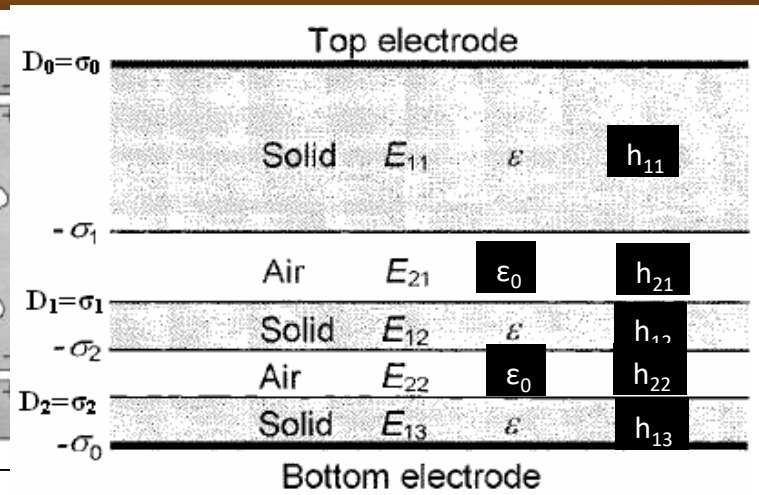
A. Qaiss and M. Bousmina, International Patent N° 61/129, 127 (2008).

A. Qaiss and M. Bousmina, Polym. Eng. Sci. 51, 1347-1353 (2011)

Electromechanical Modelling







$$S_i = s_{ij}\sigma_j + d^t_{im}E_m$$

$$D_m = d_{mj}\sigma_j + e_{mn}E_n$$

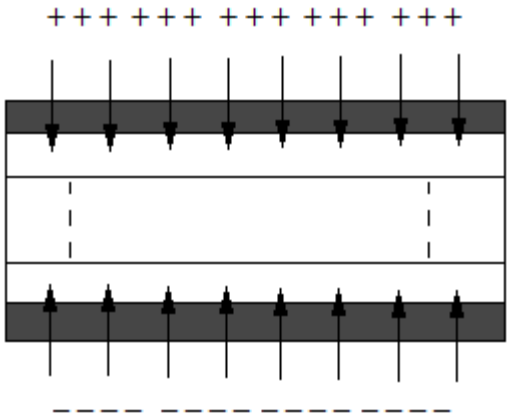
$$d_{33} = \frac{\Delta D_0}{\Delta\sigma}$$

$$h_2 = P.h = \sum h_{2i}$$

$$h_1 = (1-P).h = \sum h_{1i}$$

$$d_{33} = \frac{\Delta D_0}{\Delta\sigma} = \frac{\Delta D_0}{M(M_i, P, \phi, I)\Delta h / h}$$

$$h_1 + h_2 = h$$



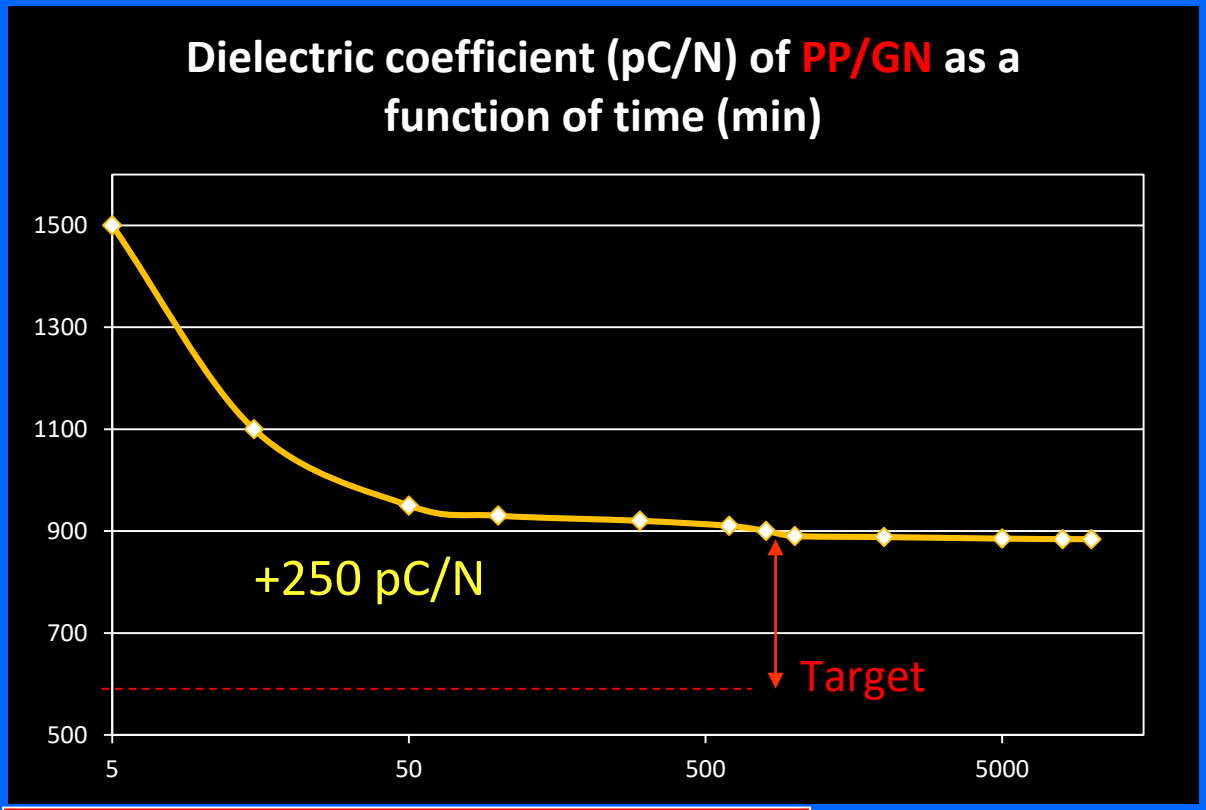
Gauss-Kirchhoff Law

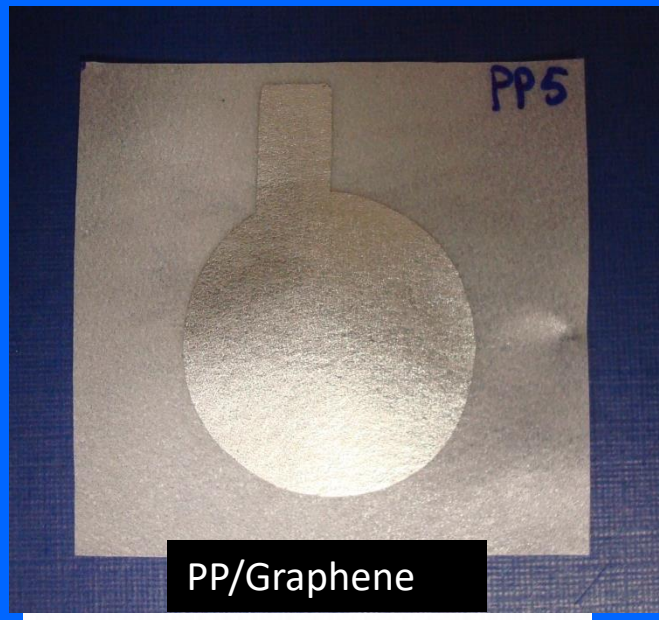
$$D_0 = \frac{\varepsilon.P}{(1-P+\varepsilon.P)}.<D_i>$$

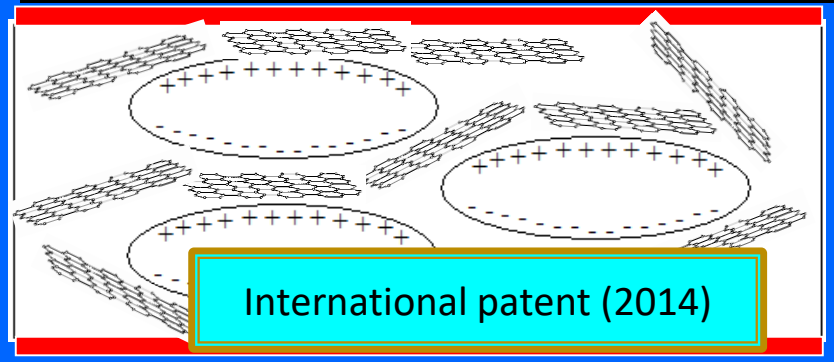
$$<D_i> = \frac{1}{n-1}\sum_{i=1}^{n-1} D_i$$

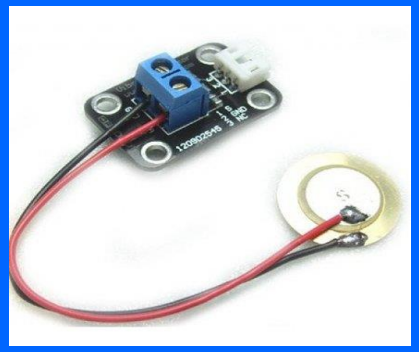
Bousmina, Palierne, Utracki: Polym. Eng. Sci. 39, 1049-1059 (1999)

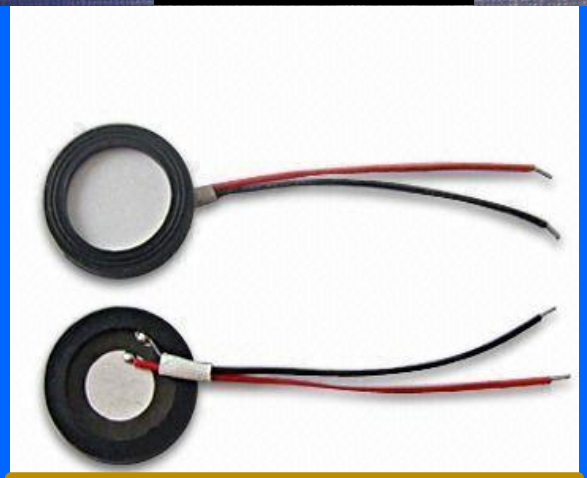
Prototype of the acoustic and displacement piezoelectric actuators











Piezoelectric transducer

Concluding Remarks

Nature

Shape

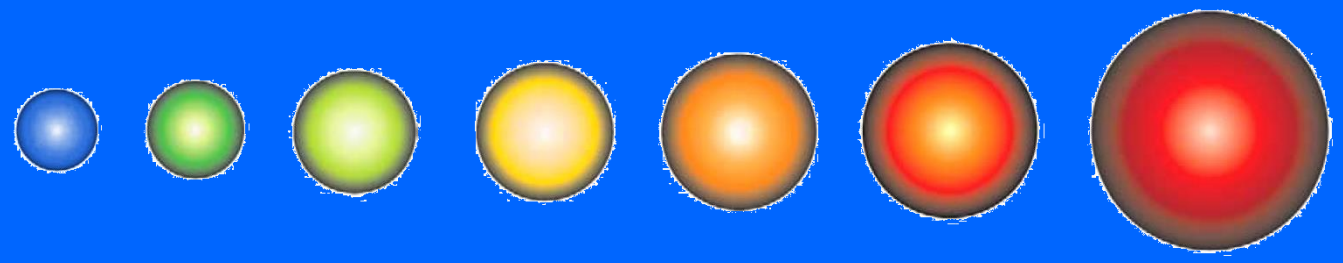
Size

DIAMETER

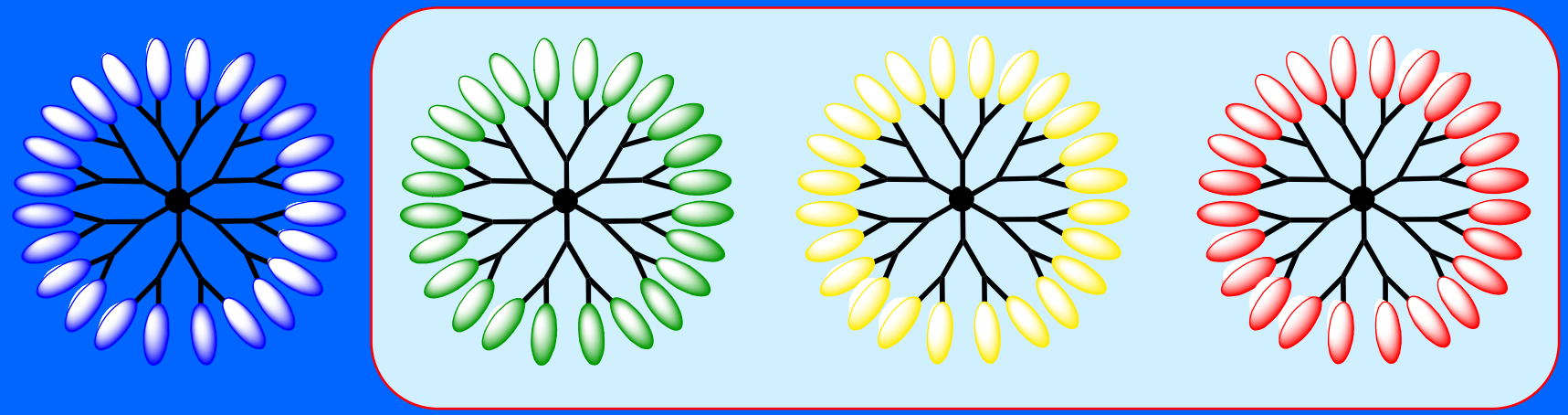
© Georges Dolisi

Modulation of the fluorescence color

quantum dots : color ⇔size



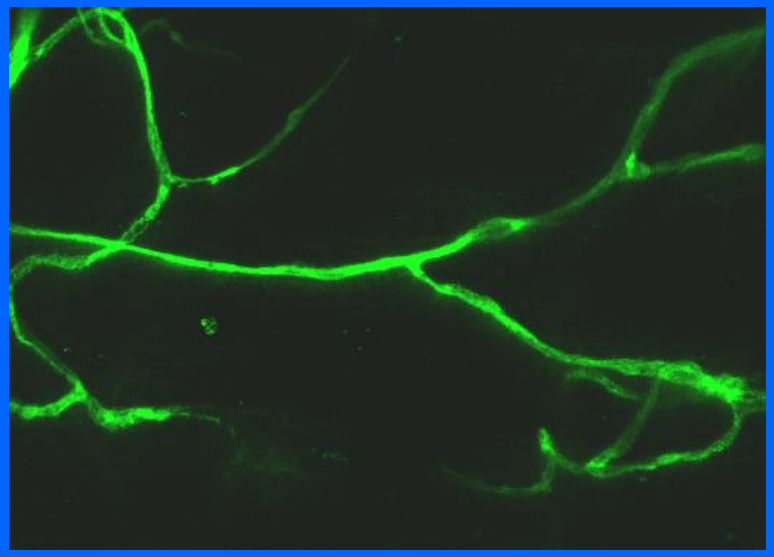
nanodots : color ⇔ ***composition***

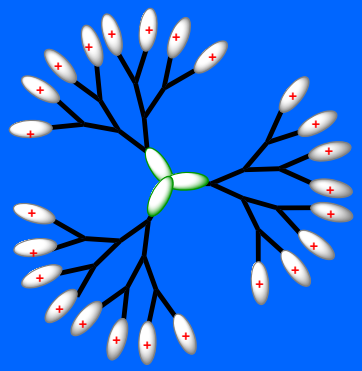


→ Choice of the fluorophores compatible with the confinement

In vivo multiphotonic imaging

2D Projection





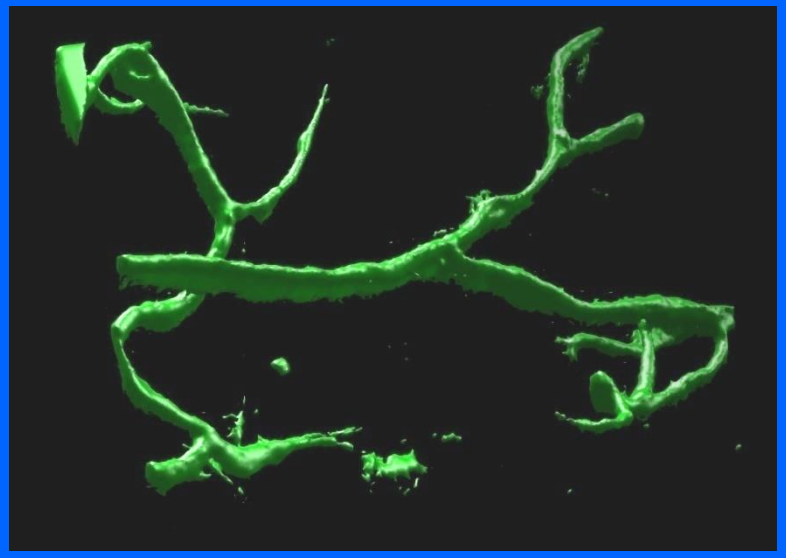
Muscle tissue of the vascular system of tadpole visualized with hydrosoluble green nanodot.

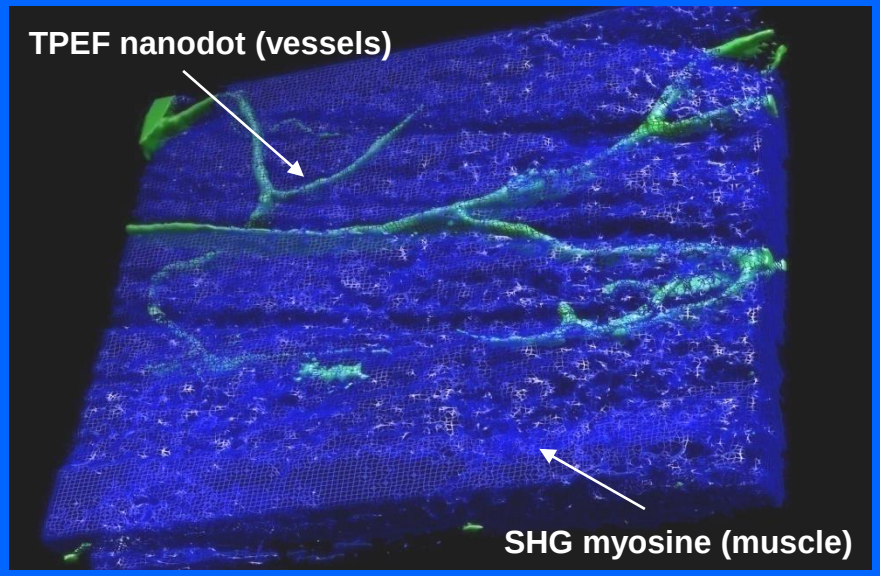
(injection : 0.1 pmol)

Excitation: 900 nm

Detection: 530 nm

3D Representation





Katir. El Kadib & Bousmina J. Luminescence (2012)

Katir & Bousmina. Molecular Pharmaceutics (2012)

WATER FOR DEVELOPMENT AND DEVELOPMENT FOR WATER: REALIZING THE SUSTAINABLE DEVELOPMENT GOALS (SDGS) VISION

MOHAMED AIT-KADI
President of the General Council of Agricultural Development and Resident Member of Academy Hassan II of Science and Technology, Morocco

ABSTRACT

The UN Sustainable Development Goals (SDGs) agenda is an unprecedented effort that embodies universal aspirations for a better, more just, equitable, peaceful, and sustainable future. The SDGs agenda provides a framework that fosters collaboration across countries, mobilizes all stakeholders and inspires action. It invites us to accept and embrace comprehensiveness and interconnectedness.

Growing global concerns over water resources, are closely reflected in the SDGs, not only in terms of SDG 6 which specifically addresses water resources (the 'Water Goal'), but also in recognizing that water affects the entire development agenda. Water connects us all. Water is the gossamer that links the web of the 17 SDGs and their 169 targets. No longer can water be addressed as a separate element in isolation from the other goals. But this interconnectedness has important implications. It means that the Water Goal will only be achieved if the other goals are attained, and in turn, that other SDGs will only be achieved if the Water Goal is attained.

The question thus arises: are our current approaches to managing water still valid in the context of the SDGs? Delivering the SDGs vision requires setting in motion new strategies governing the way we all live and interact with our environment in order to ensure that there will be enough water to support, rather than constrain, development and inclusive well-being.

ISLAMIC WORLD ACADEMY OF SCIENCES

WATER FOR DEVELOPMENT & DEVELOPMENT FOR WATER: REALIZING THE SUSTAINABLE DEVELOPMENT GOALS VISION

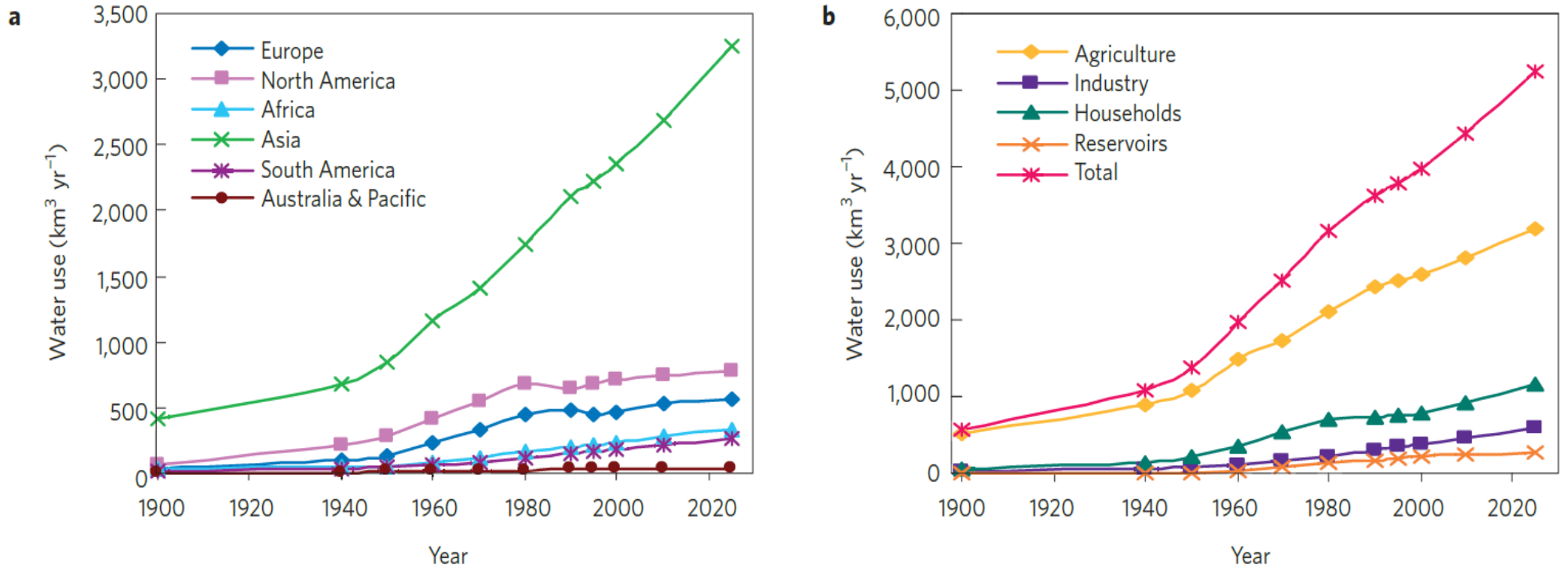
Mohamed AIT KADI
Resident Member
Hassan II Academy of Sciences and Technology

October 18th 2022

Q1	Why water security is a global concern?
Q2	What is the dynamic of water security and sustainable development?
Q3	What tools do we need to enable effective and sustainable use of water resources?

Q1	Why water security is a global concern?
Q2	What is the dynamic of water security and sustainable development?
Q3	What tools do we need to enable effective and sustainable use of water resources?

THE WATER CHALLENGE



Breakdown of water-use data. **a**, Global water-use by region. **b**, Water used across different sectors.

BOTH SUPPLY AND DEMAND PRESSURES LEAD TO WATER STRESS AND ASSOCIATED RISKS

Demand pressures

- **Population growth**
  - Increased domestic / urban use
  - Increased food demand
- **Economic growth –**
  - Increased urban water use
  - Increased industrial water use
  - More water-intensive diets
- **Climate change**
  - Increased crop water demand
  - More reservoir evaporation

Impacts of Water Stress

- Localized ground water overdraft
- Pressures on ecosystems (quantity and quality impacts)
- Impact on cost and viability of activities, and increased competition across water-using sectors
- Economic / political conflict

Risk to Growth

Supply pressures

- **Spatial / temporal mismatch** between supply and demand
- **More expensive supply curve** to transport water
- **Continued water quality deterioration**
- **Climate change pressures**
  - Reduced availability with increased intensity
  - Increase in frequency and intensity of extreme events→ damage to infrastructure & unreliable supply
  - In some cases, decline in renewable water

5

Water Security = A Global Concern

Ban Ki-Moon
Secretary – General
UN, New York

« As the global economy grows, so will its thirst. This is not an issue of rich or poor , north or south. All regions are experiencing the problem of water stress. There is still enough water for all of us – but only so long as we keep it clean, use it more wisely and share it fairely. Gouvernements must engage and lead, and the private sector also has a role to play in this effort.. »

The INDEPENDENT

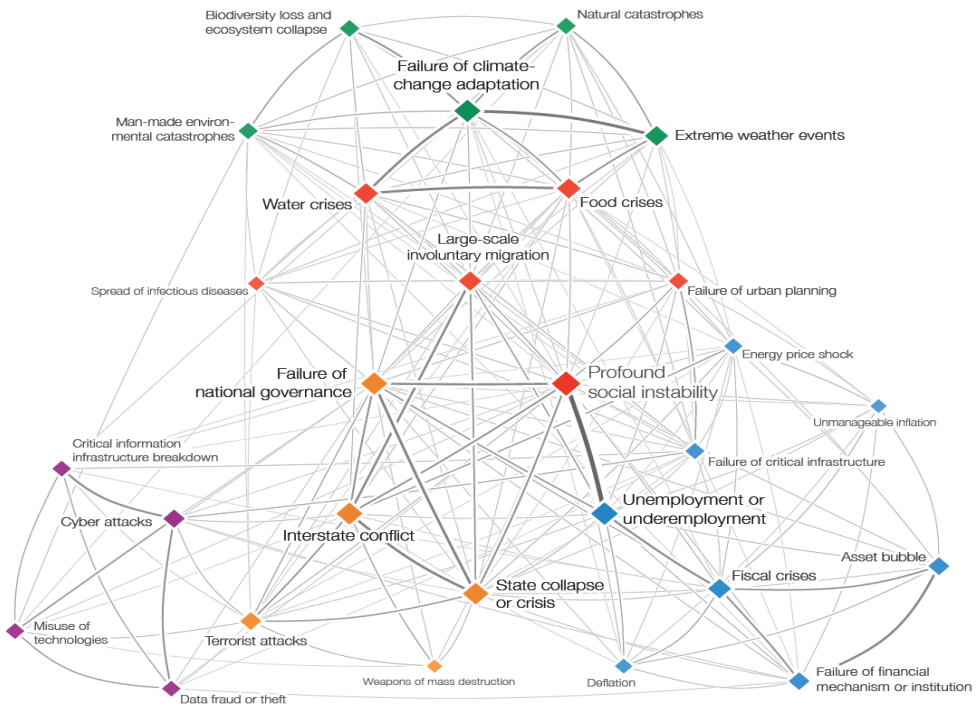
Humanity is facing « water bankrupcy » as a result of a crisis even greater than the financial meldown now destabilizing the global economy … it is already beginning to take effect, and there will be no way of bailing the earth out of water scarcity …

G. Lean, The Independent, 15 March 2009

Water Security and Interconnected Risks

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1st	Asset price collapse	Asset price collapse	Asset price collapse	Fiscal crises	Major systemic financial failure	Major systemic financial failure	Fiscal crises	Water crises	Failure of climate-change mitigation and adaptation	Weapons of mass destruction	Weapons of mass destruction
2nd	Retrenchment from globalization (developed)	Retrenchment from globalization (developed)	Retrenchment from globalization (developed)	Climate change	Water supply crises	Water supply crises	Climate change	Rapid and massive spread of infectious diseases	Weapons of mass destruction	Extreme weather events	Extreme weather events
3rd	Slowing Chinese economy (<6%)	Oil and gas price spike	Oil price spikes	Geopolitical conflict	Food shortage crises	Chronic fiscal imbalances	Water crises	Weapons of mass destruction	Water crises	Water crises	Natural disasters
4th	Oil and gas price spike	Chronic disease	Chronic disease	Asset price collapse	Chronic fiscal imbalances	Diffusion of weapons of mass destruction	Unemployment and underemployment	Interstate conflict with regional consequences	Large-scale involuntary migration	Major natural disasters	Failure of climate-change mitigation and adaptation
5th	Pandemics	Fiscal crises	Fiscal crises	Extreme energy price volatility	Extreme volatility in energy and agriculture prices	Failure of climate-change mitigation and adaptation	Critical information infrastructure breakdown	Failure of climate-change mitigation and adaptation	Severe energy price shock	Failure of climate-change mitigation and adaptation	Water crises

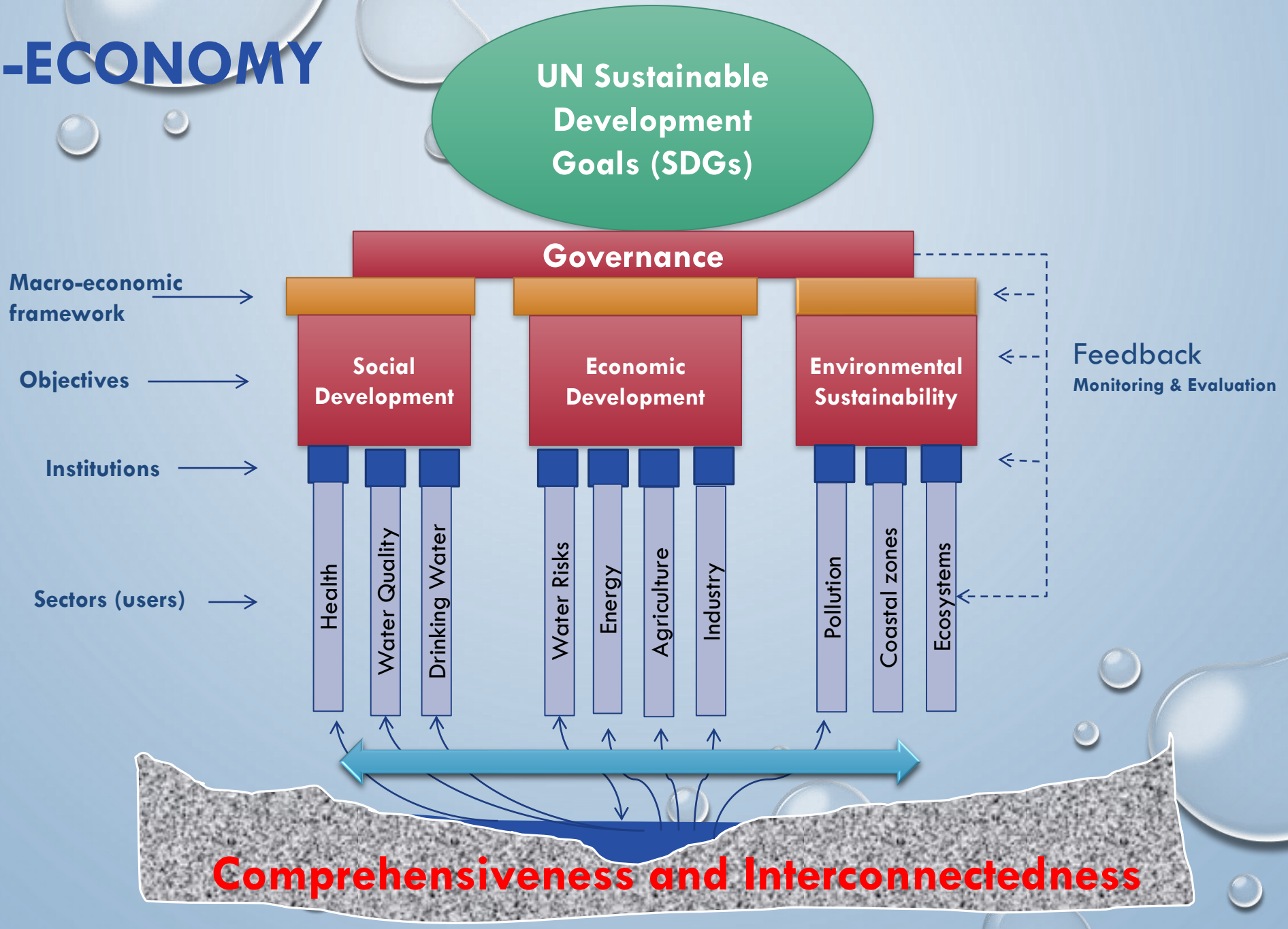
Economic Environmental Geopolitical Societal Technological



SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD

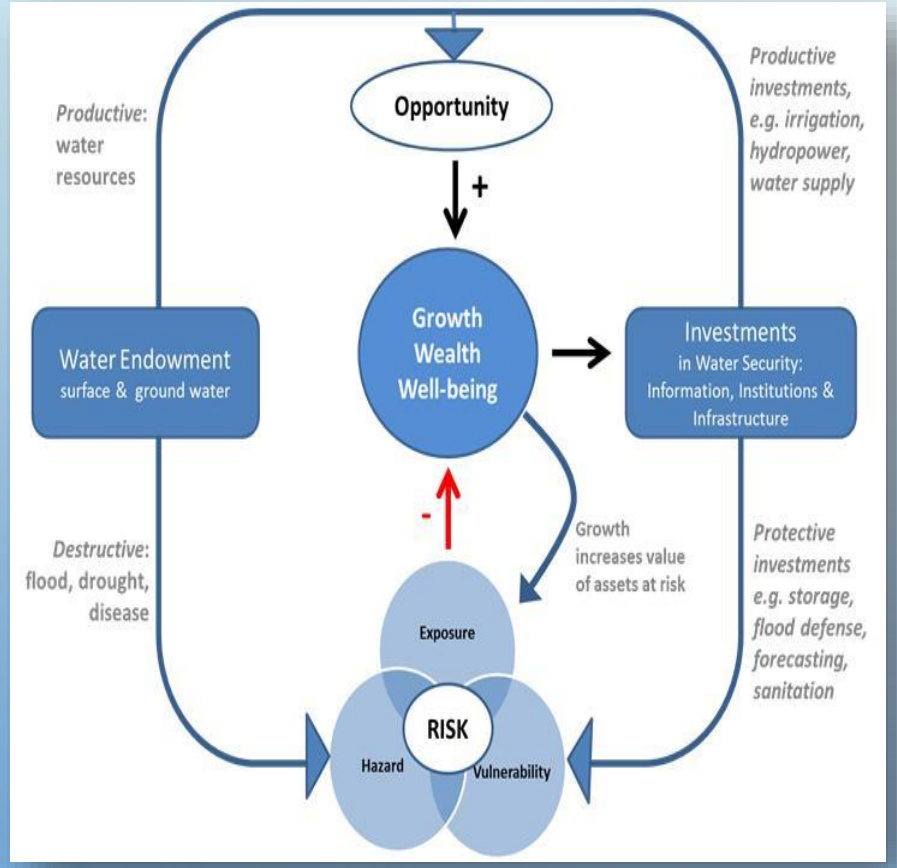
SDG6	Ensure availability and sustainable management of water and sanitation for all
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and at least doubling recycling and safe reuse globally
6.4	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and at least doubling recycling and safe reuse globally
6.5	By 2030 implement integrated water resources management at all levels, including through transboundary co-operation as appropriate
6.6	By 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
6.6a	By 2030, expand international co-operation and capacity-building support to developing countries in water and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.6b	Support and strengthen the participation of local communities for improving water and sanitation

HYDRO-ECONOMY



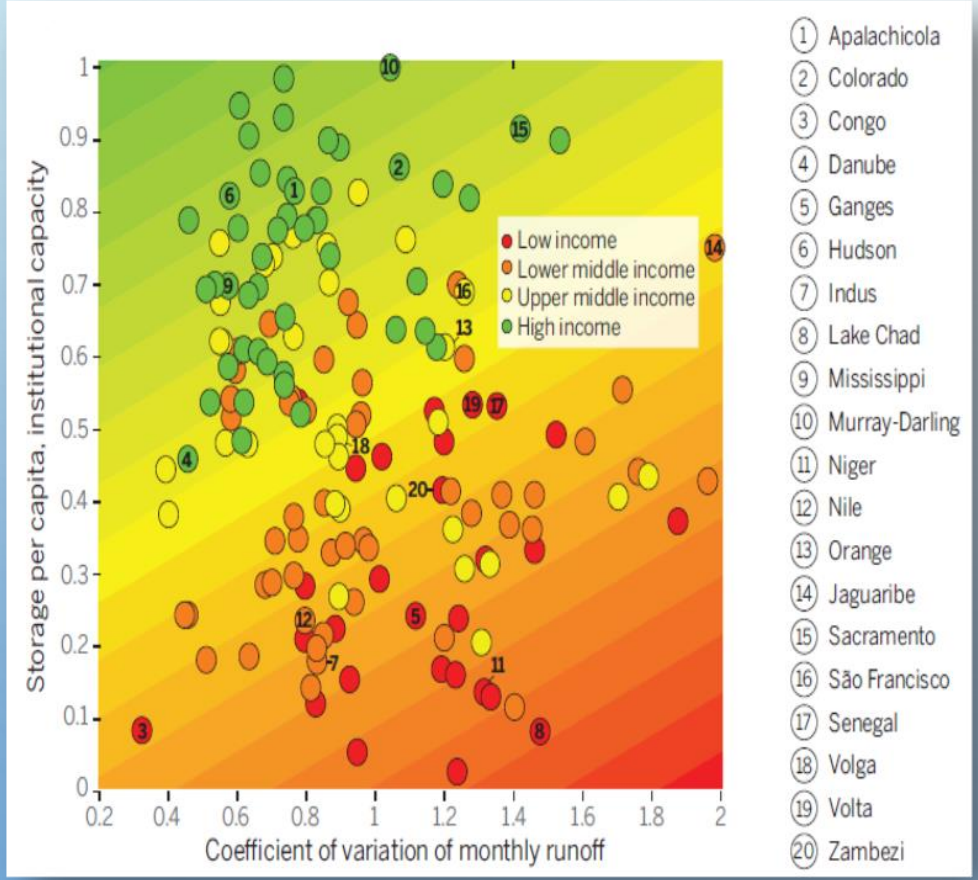
Q1	Why water security is a global concern?
Q2	**What is the dynamic of water security and sustainable development?**
Q3	What tools do we need to enable effective and sustainable use of water resources?

Framing the Water Security Dynamic



- Sustainable growth, wealth & human well-being are at the core
- Focuses on the interplay between:
  - water endowments (water availability & variability)
  - water security investments
  - growth/wealth/well-being
- Recognizes that a country's water endowment influences the nature & level of investment needed to achieve water security

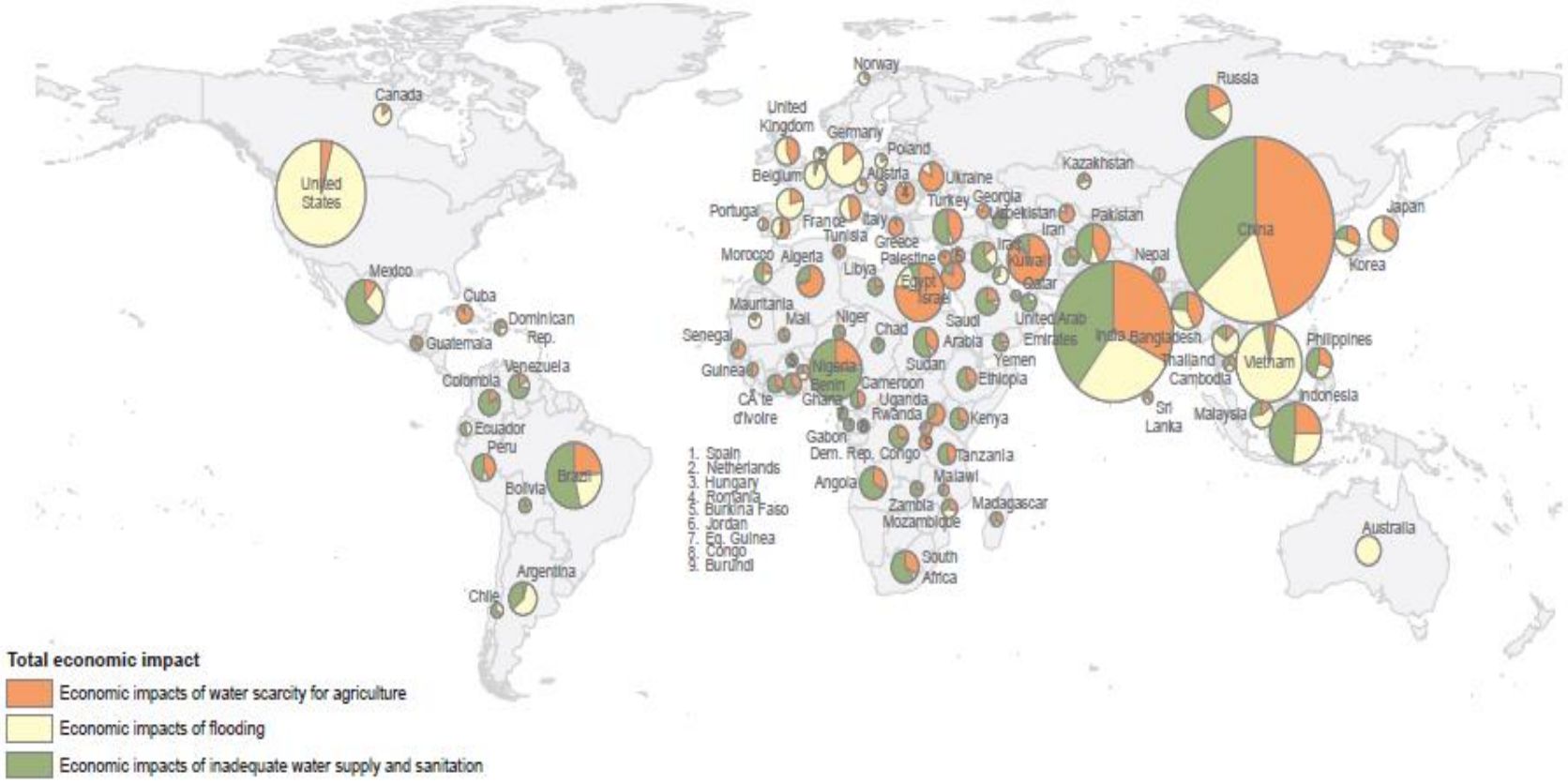
WATER ENDOWMENTS MATTER



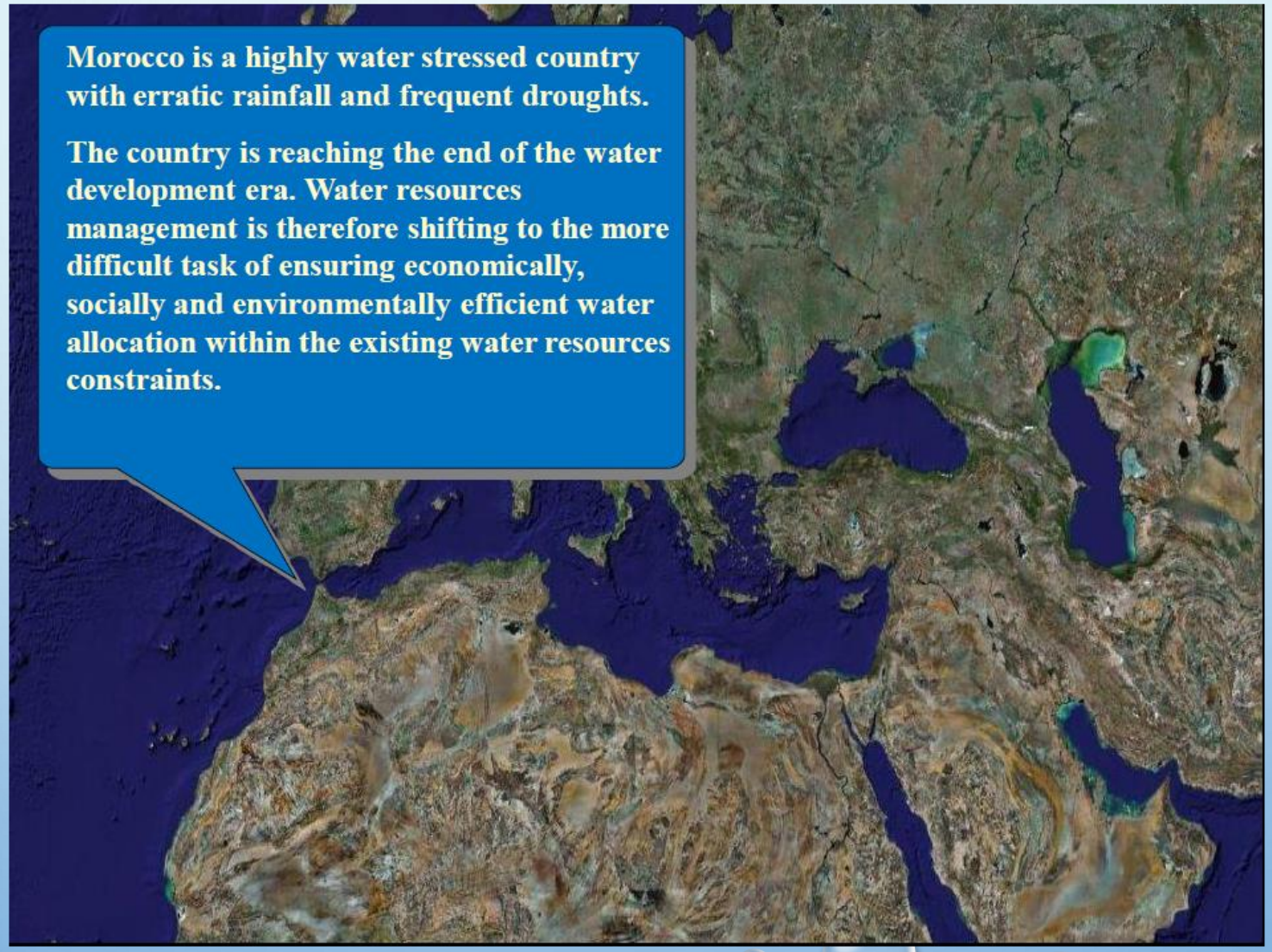
COUNTRIES WITH SIMPLE HYDROLOGIES & HIGH INVESTMENTS IN WATER SECURITY HAVE HIGH INCOMES

Basins with population > 2 million
Colors reflect GDP per capita
Horizontal axis = hydrological complexity
Vertical axis = investment in water security (storage, institutions, information)

Relative economic impacts of water insecurity

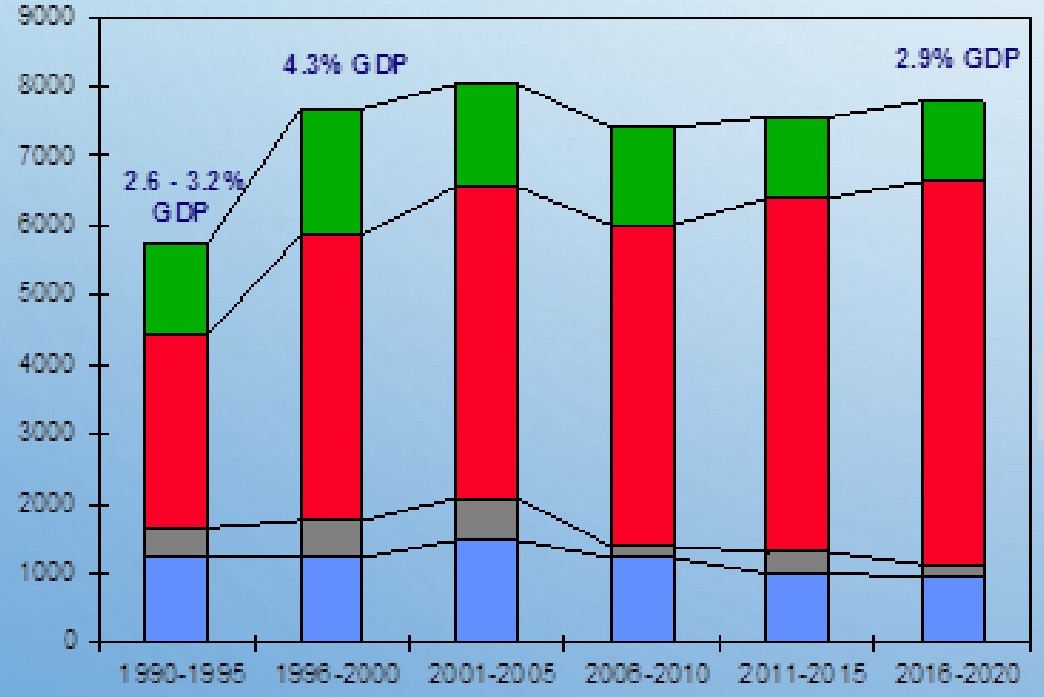


THE CASE OF MOROCCO



MOBILISATION & USE OF WATER RESOURCES

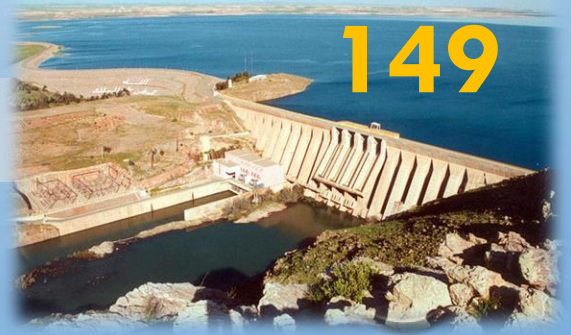
Total Expenditures (Investment + O&M) US$



Irrigation

Potable water & Sanitation

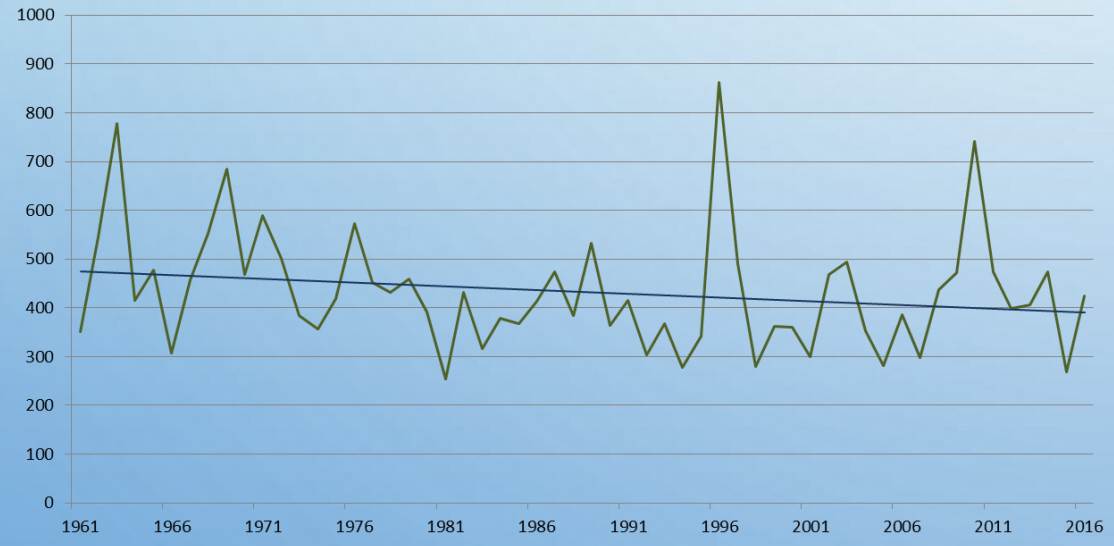
Hydroelectricity **Mobilisation**

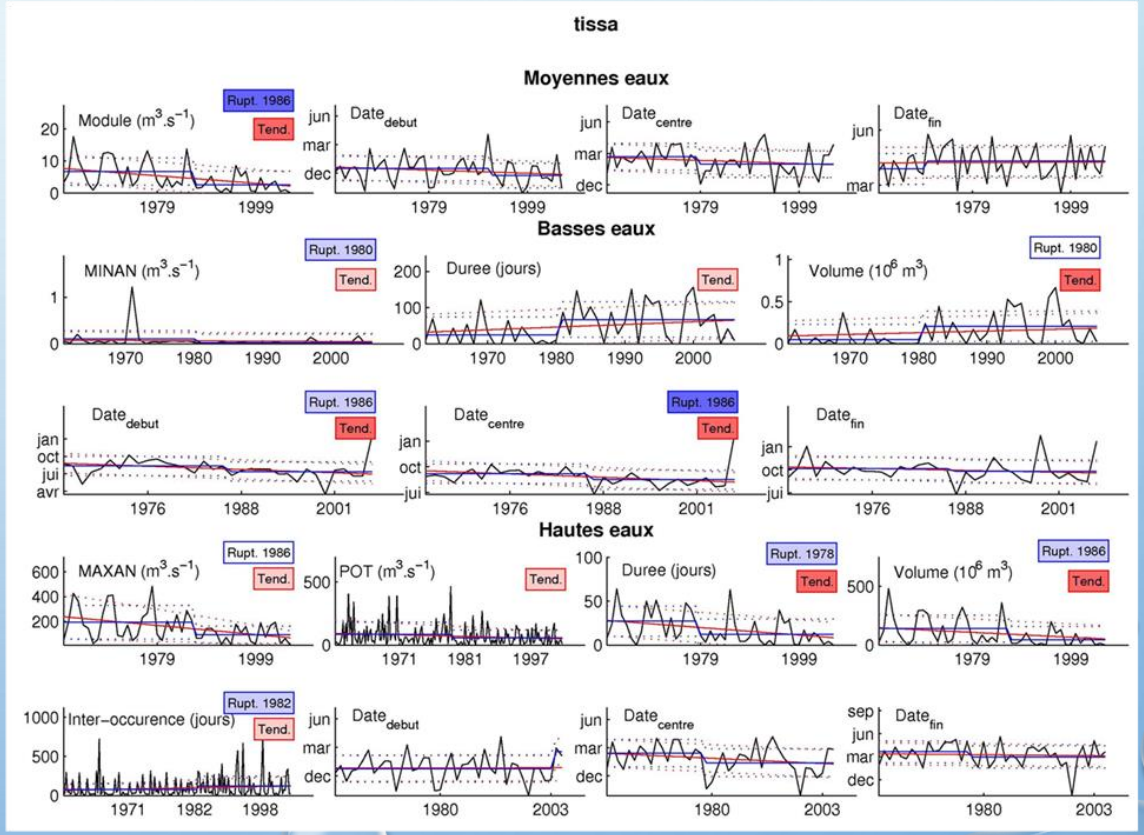


ISSUES & CONSTRAINTS

Decline of water resources

Annual rainfall (mm) 1961-2016



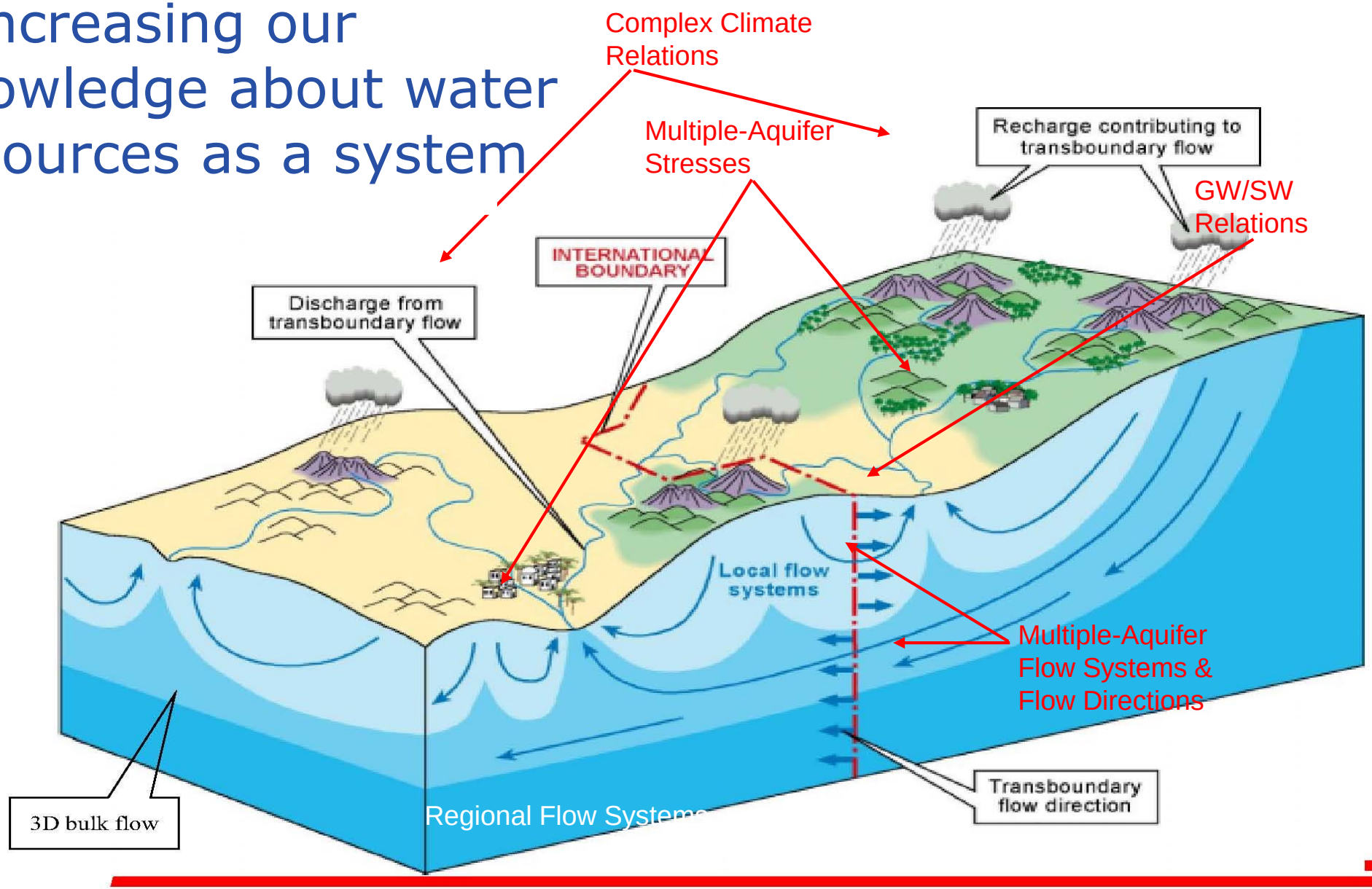


DIVERSIFYING SOURCES OF SUPPLY THROUGH REUSE & DESALINISATION


COUNT EVERY DROP-
EVRY DROP COUNTS!
MORE CROP PER DROP
MORE JOB PER DROP
MORE DH PER DROP

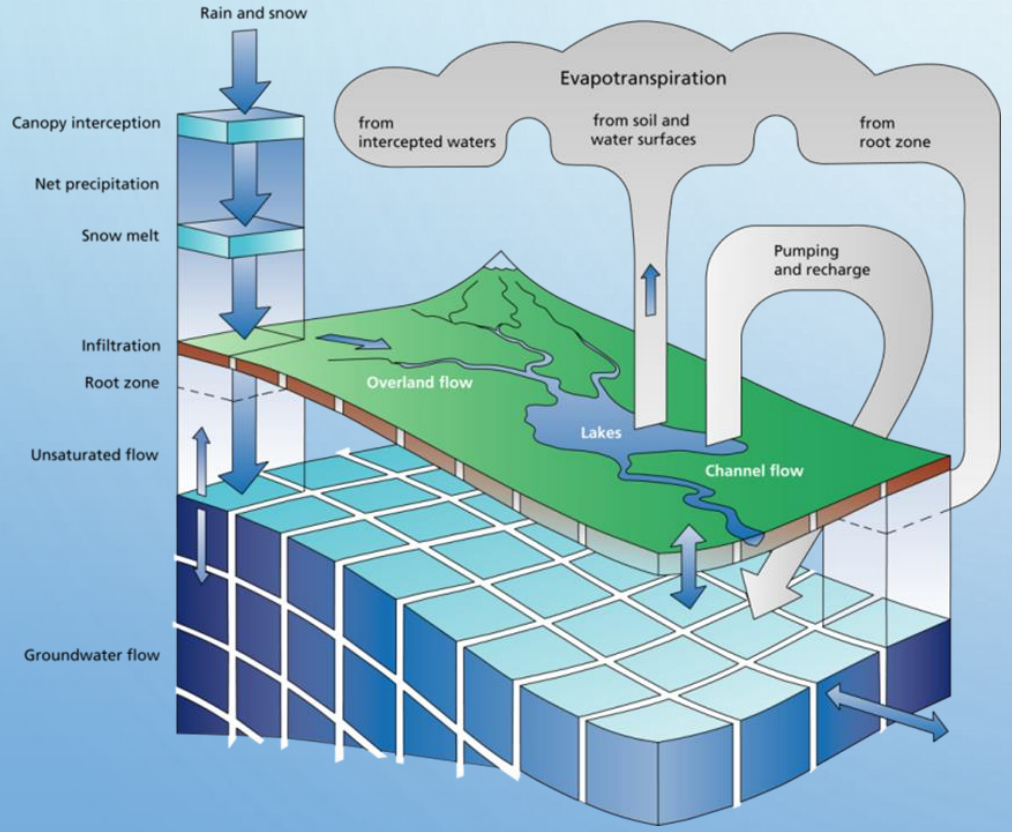
Q1	Why water security is a global concern?
Q2	What is the dynamic of water security and sustainable development?
Q3	**What tools do we need to enable effective and sustainable use of water resources?**

➢Increasing our knowledge about water resources as a system

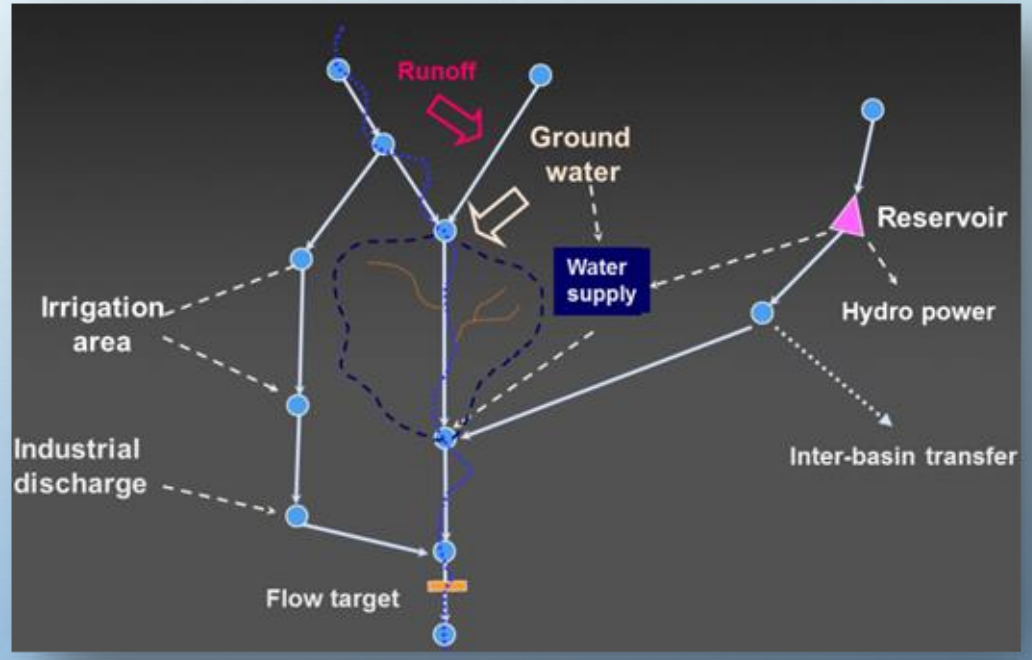


Modified from Puri & Arnold, 2002

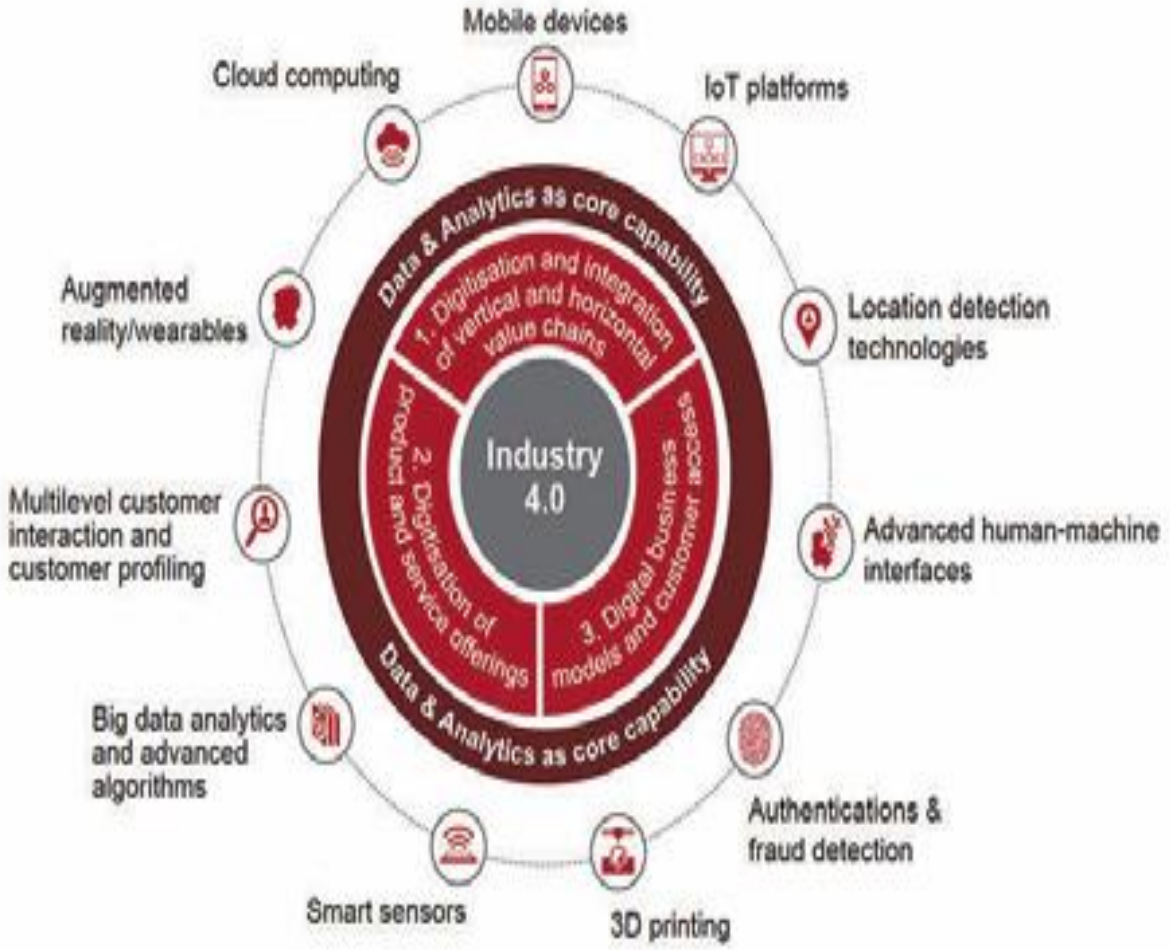
➢ Developing water system modeling techniques and the monitoring systems and data collection to validate them

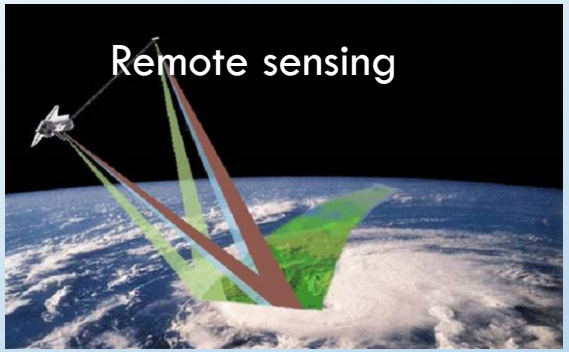


Process oriented models

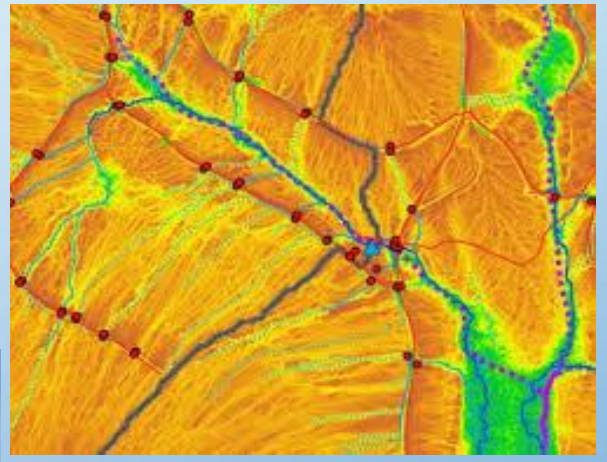


Planning oriented models





Drone with Lidar



Modelling of linear hydrography

- BUILDING INSTITUTIONAL CAPACITIES TO STRENGTHEN INSTITUTIONAL ARRANGEMENTS THAT FUNCTION WITHIN INCREASING COMPLEXITY, CUTTING ACROSS SECTORAL SILOS AND SOVEREIGN BOUNDARIES

CONCLUSION

- THE SIZE OF TODAY'S WATER SECURITY CHALLENGE SHOULD NOT BE UNDERESTIMATED.
- WHILE THE SCALE AND COMPLEXITY OF THIS MULTIDIMENSIONAL CHALLENGE ARE HUGE, SOLUTIONS ARE WITHIN REACH.
- UNDERSTANDING THE CONNECTIVITY BETWEEN THE MULTIPLE DIMENSIONS OF WATER SECURITY IS A CRITICAL STEP IN EFFECTIVE POLICY DESIGN, POLICY IMPLEMENTATION, AND CONSENSUS BUILDING.

➢A HISTORICAL CHALLENGE

➢*“RIVAL" PROCEEDS FROM LATÍN "RIVALIS", WHICH MEANS “THOSE THAT SHARE A RIVER“*

Finally: the Water Challenge is mainly an *opportunity*…

…to innovate, to invest, to become economically and societally savvy, smart and just, and to ascertain our sustainable future…

Thank You

THE POST COVID-19 HIGHER EDUCATION: LESSONS FROM A PANDEMIC

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Chancellor of the University of Petra and
the Chairman of the Board of Trustees of the University of Jordan
JOELLE MESMAR[2] *and* **ELIAS BAYDOUN[3] FIAS**

ABSTRACT

In December 2019, an outbreak of pneumonia cases with unknown etiology was reported in Wuhan, China. It had then quickly spread to other provinces with more and more patients having fever and cough symptoms. Within a few weeks, a novel coronavirus was identified by the Chinese Centre for Disease Control and Prevention and named as severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). The World Health Organization called the illness associated with this infection as "coronavirus infectious diseases 2019 (COVID-19) and on June 27, 2021, it was declared a pandemic, as the virus spread across the globe, reaching 210 countries and territories with 181 million confirmed cases and over 3.9 million deaths.

In April 2020, the number of students staying at home due lockdown measures implemented by their educational institutions reached 1.598 billion in 194 countries. Such lockdown has forced these institutions to switch to online pedagogy. In developing countries, and among them the Arab world, this has exposed inequalities and challenges, such as uneven distribution of internet connectivity between urban and rural areas, with some poor areas not able to afford even the price of the hardware. Students and teachers were not well trained and equipped for online and virtual education. And schooling and campus social life was missed and the student's psychology under online pedagogy may have changed human behavior, which needs to be studied further by social scientists. As for academic conferences, these were postponed, cancelled or carried out online using various platforms.

There is no doubt that online learning has saved the educational sector from disaster. However, after the pandemic, the style of educational pedagogy will be changed, and will not be business as usual.

New learning process will be emerged from face to face to electronics and distance learning. This pedagogy would lead to blended interactive resilient learning to stimulate the minds and thoughts of students toward a challenging future.

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1 Introduction

What it is the purpose of higher education? What is the value of higher education? What is the core mission of higher education? These are questions that today's students, faculty, staff, policy makers and stakeholders in the higher-education sector are most likely asking themselves .

Although the higher-education sector is often described as rigid and resistant to change, the history of higher education points to continuous transformation. At different points of time, the purpose of higher education has taken on a variety of angles. Higher education institutions first targeted a single stratum of society: the elite and the privileged, focusing primarily on religious and theological education, literature and philosophy, mainly designed to nurture the mind as well as preparing students for leading roles in government and learned professions, such as divinity, law and medicine. Then as the number of students increased and higher education institutions expanded ,accompanied by a massification in enrollments, staff and faculty recruitments, and institutional infrastructure and disciplines, higher education started its transformation into mass higher education, in order to be able to cater for a broader range of students with a broader age group and range of functions. With this growth, the purpose of higher education shifted from mainly the shaping of character to the preparation of technical elite roles through the transmission of technical knowledge. Today, the higher education sector entered a third phase, described as the universal phase and designed for universal access, which was facilitated by technology, consequently breaking the boundaries of institutions, and increasing diversity and collaborations.[2 ,1]

While the higher education sector transformed from the diffusion of bookish knowledge and training to the advancement of knowledge through critical thinking and research, Newman argued that teaching and research should be separated, and that higher education should be about liberal education for "the achievement of a particular expansion of outlook, turn of mind, habit of thought, and capacity for social and civic interaction .[3] "Clearly, the purpose and functions of higher education have been long debated, and one cannot deny that the higher education sector witnessed great transformation" .*This great transformation is regretted by some, accepted by many, gloried in, as yet, by few. But it should be understood by all.*[4] "

Nowadays, the definition of the purpose of higher education is a non-compulsory learning stage that occurs beyond high school, with the main aim to prepare students to become professionals and effective citizens. At the core of higher education institutions there are three major missions: (1) to educate, (2) to generate new knowledge through research, and (3) to engage with the community and contribute to the development of society by providing public service .[5] In other words, higher education institutions aim to prepare students to join the workforce by teaching subjects that are required to tackle the society's needs and challenges, ultimately contributing to social mobility and economic growth.

From the student's perspective, enrolling into university is often seen as the next obvious step and a means to enter the labor market. This vocational orientation towards learning places the student as the customer of a service provided by the university. The downside of such orientation is that the students become passive and tend of focus on having a degree regardless of learning or their responsibilities towards society. However, with a growing number of students seeking higher education and the addition of non-traditional cohorts such as full-time working adults and part-time students who have different characteristics and educational needs, the student body has become increasingly diverse with consequently diverse needs and purposes. Yet the reality is different. With higher education institutions still mostly geared towards the traditional type students as a "one-size-fits-all" model, offering overcrowded and fragmented curriculum

that remiss about the vocational and personal development of students, there is a pressing need to adjust the purpose of higher education to meet the requirements of a growing and diverse student body. A student body that is still seen as a customer, rather than a learner, of an institution-centered provider .

As from the society's perspective, the lack of investment in higher education can have dire consequences, negatively impacting the country's economic growth and participation in the global knowledge economy, mainly due to lack of investment in the country's human capital resulting in loss of talent through brain drain, poor research activity because of limited access to facilities and capacity for solving local problems .

Over the last 50 years, the Arab countries of the Middle East and North Region (MENA), have made great progress in improving enrollment rates and gender parity at all education levels. Until 1953, there were only 14 public and private Arab universities in the Arab world, most of them as very old or foreign institutions. Today there are over 800 universities, associated with an expansion in student enrollments, mainly fueled by an exponentially growing population with a high youth composition and the recognition of the importance of higher education for social and economic development .[7 ,6] However the gap between the educational output and labor market demands and development needs is still growing. Young citizens in the region feel that higher education only serves them to get credentials without offering links or relevance to the labor market. While Arab countries vary in the political, economic and social challenges they face, they all suffer from this disconnect and are not conducive of critical thinking. Years of conflict and instability in many countries of the region have further exacerbated this situation, failing to meet the demands of a large growing young population and leading to more and more isolation of the Arab countries from global knowledge and progress. Although the region has witnessed many advances, their education system remains the same and is in dire need to transform in order to be able to create the required change .[10-8]

A higher education sector in crisis is not breaking news. Articles ,issues and books on higher education in crisis have been calling repeatedly for change. Looking at a past with various challenges, and having survived with relatively little institutional change, will the higher education sector's response to the COVID-19 crisis by any different? During an interview with Forbes magazine in 1997 discussing the escalating cost of education and the rise of the "internet mania", management guru Peter Drucker had said that the current setup for higher education is "doomed" and predicted that" thirty years from now the big university campuses will be relics .Universities won't survive. It's as large a change as when we first got the printed book ."Will higher education institutions embrace this opportunity and respond accordingly by making the necessary adjustments and adopting sensible reforms for building an effective educational system that actually meets the needs of students and society ?Will higher education embrace change in its purpose to become relevant? Will these changes be coupled with a transformation at the institutional level and improvements in governance structures, curriculum, pedagogical delivery, educational technologies, and interactions between the various stakeholders involved?

Only time will tell .

2 The COVID-19 Pandemic

The 2019 novel coronavirus (2019-nCoV) is the most recently discovered type of coronaviruses which causes respiratory infections. When first detected in December 2019 in Wuhan, the capital of the Hubei province in China, it was described as "pneumonia of unknown cause". On 11 February 2020, the World Health Organization (WHO) announced "COVID-19" as the name of the disease caused by the 2019-nCoV virus and the International Committee on Taxonomy of Viruses renamed it as severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). By the first week of March 2020, the virus had reached over 100 countries with over 100,000 cases ,causing a global outbreak and becoming a major public health issue .[11] A year later, there were 115 million confirmed cases and over 2.5 million deaths globally .[12]

Outbreaks occur when the number of disease cases in a community rises suddenly above the expected occurrence in a defined community, geographic area or season .While epidemics consist of outbreaks in specific geographical areas without necessarily being contagious, pandemics occur when the disease grows exponentially, crossing geographical boundaries and affecting several populations. The disease is then declared a pandemic by the WHO, regardless of its severity and population immunity, but rather based on its rate of spread and transmission.[13]

The COVID-19 outbreak is not the first disease that shook the world. The Black Death (1346-1353) was a highly contagious disease that was caused by the bacillus *Yersina Pestis* in the Afro-Eurasia region, and which claimed over 20 million lives in a period of about five years before running its course in the early 1350s, with some estimates reaching 200 million .[14] Symptoms included sever aches ,fever, vomiting, swelling of the lymph nodes and black pustules on the skin ,causing death within three days. The Black Death (also known as the Plague) caused major terror and uncertainty around the world leading to social and religious upheavals, with many describing the pandemic as "God's punishment". The Plague also had profound economic consequences. This may have given incentives for innovation, such as the shift of labor-intensive grain farming to animal husbandry, mainly fueled by lack of cheap labor due to the death of countless workers. Efforts to contain the disease included social distancing and isolation of sailors on their ships for initially a period of 30 days, which was then increased to 40 days (hence the origin of the term "quarantine") ;practices that are still applied today. Later during the modern industrial age ,the expansion of new transportation routes facilitated the spread of influenza viruses causing the Flu Pandemic (1889-1990); within a few month the earlier cases reported in Russia had wreaked havoc worldwide, killing around 1 million people. The Spanish Flu (1918-1920), also referred to as the 1918 influenza pandemic, was caused by the H1N1influenza virus. It was considered the most severe in recent history, infecting over 500 million people, equivalent to one third of the world's population at the time, and killing at least 50 million sparing no age group, especially the youth. Then came the Asian Flu ,(1958-1957) another influenza pandemic, which started in China and claimed over 1 million lives worldwide due to infections with avian flu viruses .[15]The cousin of the H1N1 virus resurfaced again in 2009 announcing the swine flu pandemic, which has touched over 60 million people in the United Sates alone and caused an estimated 575,400-151,700 deaths worldwide .[16] Some pandemics such as HIV/AIDS ,which has claimed over 35 million lives so far since the first infections by the human immunodeficiency virus (HIV) virus were discovered in 1981 virus, are still ongoing today. Although a cure has not been found yet, the disease is no longer as deadly and infected people can have normal life expectancies because of new medications developed in addition to prevention and treatment strategies.[17]

Looking at such a history of pandemics, one cannot deny that the warning signs were there. The number of infectious diseases and outbreaks have been increasing with time, in line with a growing population,

global trade networks ,travel and globalization .[18] The era of the Anthropocene, our newest present day geological epoch during which human activity is significantly impacting the Earth's ecosystems, climate and geology, is becoming the "pandemic era .[20 ,19] "The Global Preparedness Monitoring Board had issued in September 2019 its first annual report, "A World at Risk", with the aim to accelerate the preparedness of the world for health emergencies and threats focusing first on biological risks, and drawing on lessons learned from previous outbreaks such as the 2009 swine flu pandemic and the Ebola virus disease .[21] The report warned that "there is a very real threat of a rapidly moving, highly lethal pandemic of a respiratory pathogen killing 50 to 80 million people and wiping out nearly 5% of the world's economy", stressing that the world would be unprepared for a global pandemic. As a matter of fact, the COVID-19 pandemic highlighted even more how interconnected the world has become, how quickly a contagious disease could spread, and how fast an outbreak could turn into a catastrophe. This pandemic proved that not only the world was clearly unprepared for such an environmental threat but that it was also divided and politicized in its response strategies. Leaders around the world have responded differently to the threat , and the "Prozac leadership" type emerged, which encourages leaders and their administrations to be positive, all the while denying the bad news, ending up with a distorted picture of the reality, impinging on the actions and responses taken towards public health policy. It states that "excessive positivity constitutes a significant barrier to reflection and learning. By silencing critical voices, Prozac leadership has hindered our leaders' response to the pandemic .[22] "

This is where the relationship between science and politics has been severely strained and where the value of science and expert advice have often been decried, from the initial stages of the pandemic to vaccine development .[24 ,23] Around the world, scientific advisers and committees have been attacked, questioned, criticized, and held responsible for creating an economic crisis, and increasing poverty and unemployment. Following science to set policy is not a straightforward matter, but rather a breeding ground for bias and conspiracies. Where science and politics intersect, it is the idea that fits best or that suits certain purposes that survives. For example in the UK, as COVID-19 was declared a high consequence infectious disease (HCID), it was later downgraded without prior expert consultation, until it was eventually removed from the HCID list .[25] The reason for such political decisions takes its origin in the unpreparedness of the government and its underestimation of the situation and medical requirements, which was translated into a shortage of protective personal equipment such as medical gowns, visors ,respiratory masks, and even swabs for testing the ill and body bags for the dead, not to mention the saturation of hospitals and the need for ventilators. Countries in the Arab world were of course not spared from such situations .

COVID-19 had covered all the Arab world by April 2020. While the countries in the region differed in their response strategies, most adopted strict lockdown measures in an effort to curb infection spread and prevent overwhelming the medical systems. These measures included: applying social distancing protocols; closing schools and universities; shutting down malls ,shops, restaurants and cafes; suspending employee attendance; closing ports ,airports and restricting travel; and banning enclosed prayer places and gatherings. Other countries went for the herd immunity strategy, putting priority on saving a collapsing economy. In fact, the socio-economic fallout of the pandemic in the region is very heavy. A loss of USD 420 billion in market capital was reported by April 2020, equivalent to 8% of the region's total wealth .[26] And Arab youth unemployment peaked to 23%, the highest in the world .[27] Until mid-2020, containment efforts in the region were successful compared to the rest of the world and death rates were low, mainly due to a relatively young population. However, as lockdown measures were lifted, infection rates started rising exponentially ,with more than 2.2 million cases by the end of the same year .[28] The health sector in the various Arab countries has also been put under tremendous strain. In Syria for example, a decade of war has left the sector crippled with only 64% of hospitals and 52% of primary health care centers fully functional. Other conflict-affected countries such as Iraq, Libya, Yemen and the Palestinian Authority follow suit .[29]

However this pandemic is not all foreboding. It could be an opportunity for Arab leaders and stakeholders to tackle indelible issues such as updating an outdated and weak healthcare infrastructure, investing in science and technology, and promoting innovation. Additionally, revisiting the education system and investing in research and development should be an important long-term strategic goal for the region to reduce inequalities and provide opportunities for the Arab young population .

3 The COVID-19 Educational Response: Maslow before Bloom

The COVID-19 pandemic has left no one spared and touched all domains of life. Education is of course one that has been hit hard, forcing higher education institutions to confront problems and issues they have long shirked. Experts and critics claim this is the crisis the higher education sector needs, hoping the disruption this pandemic has caused to education will be more than just a blip on the long-run, but rather an opportunity to reset and to re-imagine the purpose and operations of the whole sector .

3.1 Immediate measures

The pandemic came as an unexpected storm. With cases skyrocketing all over the globe, just a few months after the virus had taken over China, higher education had to react swiftly .With fear, anxiety and uncertainty in the air ,it is "Maslow before Bloom" when it comes to learning and academic success; in other words, the students' needs and well-being come first and are essential for educational attainment .[30] So first came the decision to close higher education institutions, a measure that was part of the social distancing and confinement protocols adopted by China and recommended by the WHO to contain the virus. According to UNESCO by 1 April 2020, 89.4% of enrolled students were affected by the closure of schools and higher education institutions, amounting to 1.5 billion learners worldwide. Generally institutions closed completely for a short break, suspending all campus-activities and announcing extra holidays and vacations, in order to prepare the necessary measures for remote learning. Such measures included changes to the curricula, setting up technical infrastructures, platforms and educational tools. Learners and educators had no choice but to transition and adapt quickly from traditional face-to-face teaching to virtual education. In Europe for example, most universities closed their campuses as of March 2020 and 95% of universities shifted to distance learning .[31]

All countries in the Arab world initially applied the same measures. However the impact of the pandemic on education was more negative than other parts of the world and showed how badly the sector is in need for reforms. The absence of proper technical infrastructure and platforms for delivering classes online, over and above the reluctance and unreadiness of faculty to teach online, not to mention limited access to internet and often a non-conducive environment at home, meant that teaching had to be cancelled in many higher education institutions in the Arab countries and that students had to rely on self-study means. Such situation of course is not ideal; it is associated with negative impact on learning and shouldn't last long. As a matter of fact, institutions who were unable to deliver distance learning either shifted their academic year, postponed graduation, adopted a blended learning approach or had no choice but to re-open their campuses .[32]

3.2 Immediate effects

The current pandemic impacted the enrollment of international students who had to be brought back home, mainly due to imposed travel bans in many areas and closure of dormitories and halls of residence at universities. Those institutions relying on international enrollment for revenue have been heavily affected. Some countries in the region have taken initiatives to retain and attract international students. For example the United Arab Emirates (UAE) issued a new policy that allows new students to sponsor their relatives during the time of their studies .[33] And several Egyptian universities are establishing new branches in other countries in Africa, such as Ain Shams University in Cairo and Tanta University which have signed agreements with Tanzania and Djibouti, respectively .[34]

The pandemic-induced recession also caused a decrease in the enrollment rates of local students, particularly underserved and low-income students as well as non-traditional part-time and working students, which would eventually impact their educational attainment and consequently their future. In the United States, first-year enrollments dropped by 13% in fall 2020 compared to the previous year, with two-year institutions hit the most, accounting for an %18.9 drop. The latter cater mostly for low-income students and nontraditional students. Reasons for dropping out are mainly related to higher education affordability and that the cost of virtual education is not worth the cost. Experts worry that when these students leave higher education, it is very unlikely that they will return .[35] Additionally, during a recession, what is usually observed is an increase in higher education enrollments because the newly unemployed often decide to study again until the economy improves. However this was not the case during the COVID-19 recession. In fact, student enrollment was already on the decline due to rising education cost. Similar trends were observed in the Arab world, where the majority of households have seen a decline in living standards and purchasing power, as has been reported in Egypt, Lebanon and Morocco, with many families unable to pay tuition fees. Financial constraints have also caused students to shift from private universities to public universities in an attempt to lower tuition costs .[32] As for prospective students ,admission deadlines were extended in many universities and admission tests were waived. While for new students, their visits and orientations had to be carried out virtually, and graduating students saw their ceremonies cancelled.

The disruption of education and closure of campus have also caused a drop in the auxiliary fees, such as housing, parking, dining, sports facilities, events and other activities. Refunds of fees were also asked for , leaving a gaping hole in the operating revenue. Also universities relying on their hospitals for revenue were also affected as non-essential and selective procedures and visits had to be postponed in order to care for COVID-19 infected patients.

The decrease in government funding has also put a strain on higher education institutions, having its roots in the health crisis and drop in oil prices that the Arab region has been witnessing. This reduction in higher education public funding is also expected to last for the coming few years. As a consequence ,financial assistance to students was strongly affected, as government spending had to be re-directed to pressing health needs. Institutional budget cuts were also implemented and translated into a reduction in staff salaries, early retirements, contract freeze and even suspension, elimination of tenure, as well trimming benefits, closing programs, merging departments, and decreasing research funds. In Lebanon, the American University of Beirut, one of the most prestigious and prominent universities in the region, announced it would lay off around 25% of its staff in mid-2020, mostly in administrative positions as it is facing "its greatest crisis since its foundation in 1866", according to its President.[36]

3.3 Immediate challenges

COVID-19 has directly and heavily impacted the teaching and learning processes. Shifting to online modes of education seemed like the immediate panacea to ensure continuity in teaching and learning. Although digitally enhanced learning and teaching has been on the table for higher education reform for years and many education technology tools have been developed or are under development and are slowly being integrated in educational practices, it is COVID-19 that really acted as the catalyst for distance learning. However such sudden change is not without challenging consequences. Stating that online learning is the only way forward would be a dicey prediction.

Although the shift to online teaching and learning has rescued the academic year at the beginning of the pandemic, it has revealed several challenges: the first one on the list is the internet. With this comes not only poor internet connection and penetration, but also access to digital devices and acceptance towards online education, especially in developing countries. In fact, many Arab countries have showed skepticism towards online education pre-COVID-19 and suffer from digital illiteracy, which is observed among both educators and students .[37] Based on International Telecommunication Union (ITU) estimates for 2020, only 54.6% of individuals use the internet and more than half of households don't have internet at home in the MENA region, with the exception of the Gulf Cooperation Council (GCC) countries (scoring over 90%) .[38] There is therefore a great digital divide between countries in the region, which explains the variety of educational strategies adopted in light of the pandemic. Some countries such as Lebanon, Syria and Iraq had to face even more challenges such as electricity cuts, which severely disrupted online sessions and access to educational material, making distance learning difficult. Also in terms of digital divide ,a significant gap exists between rural and urban areas, as well as public and private universities, which is likely to exacerbate inequalities between students within the same country and region .[40 ,39]

Another challenge students and teachers had to face was online evaluation and examinations, creating a lot of stress and confusion for everyone involved in the process. Examinations are a critical and important part of the learning process, and therefore cancelling them was not an option .Teachers had to create and design proper assessment tools, which were associated with trial and error approaches, to counteract cheating. For this, several universities adopted tools for the detection of any fraudulent activity during an exam, such as ProctorU or Respondus. Of course, this is not without its drawbacks, including weak internet connections – a prevalent issue in the Arab region- and privacy concerns among students. Yet, this experience could be seen as an opportunity to re-think traditional approaches as these are still based on 20th-century mindsets, emphasizing on compliance and conformity rather than critical-thinking and creativity, as well as enhancing collaboration and knowledge transfer. Besides, in-person examination is a tedious and costly process with often human error problems.[42 ,41]

Knowledge sharing, mobilization and production through networking and collaboration is an essential purpose of academic conferences. By February 2020, in-person conferences around the world were cancelled and shifted online. To replicate the conference experience online is for sure challenging. Though the main purpose people chose to participate in conferences is to create networks, which is an essential characteristic of on-site gatherings, it is often costly and time-consuming .And under-resourced less privileged institutions or academics often miss out on such opportunities. Going online is therefore not without benefits, especially when it comes to convenience, accessibility, visibility and inclusion, which would allow to cater to the needs of a larger and diverse group of academics and researchers .[44 ,43] Creating a hybrid format for conferences in the future could be the way forward. Oftentimes, in-person academic conferences are more of a routine than a necessity. In his article on academic conferences after

the pandemic, Dr. Joshua Kim envisions that "in the future ,we may see smaller but more resource-intensive (lavish) in-person events .Academics will not travel to an in-person conference unless that event offers benefits far and above what can be gained virtually. This will maybe mean better conferences, with less boring panels and passive talks, and more in the way of opportunities for collaboration and conversation " .[45]An opinion shared by many .

Clearly the pandemic has accelerated the digital transformation of societies, and with it higher education. It underscored the importance of technology and the need for reforms to improve the digital infrastructure and digital literacy among both students and educators. Having faced so many challenges and undertaken a lot of changes in the way education is delivered ,the higher education community is now ready to exit the crisis stage, re-think the pre-COVID-19 status, assess the implemented solutions and invest in remote learning in order to plan for a future with quality education, as new challenges will continue to emerge. This will not only mean developing or learning new tools, but working in collaboration internationally to find joint solutions. It will also necessitate a shift in mindset in seeing challenges as opportunities and focusing on change, progress and growth.

4 The Impact of the Pandemic on Various Educational Fields and Activities

The impact of COVID-19 on education differs from one field of study to another. While distance learning was efficient in some areas, it often had many limitations in others. This section provides examples of how the pandemic has effected the educational delivery in different fields, recognizing gaps and reflecting on possible solutions .

4.1 The academic research enterprise

As institutional lockdowns were instigated, eerily empty classrooms together with labs going quiet was a typical scene on campuses in 2020. Apart from essential research including COVID-19-related research, many research programs were suspended worldwide, being a campus-based activity, with laboratories and fieldwork at their core. While educators and staff were given instructions and advice on how to carry on their work remotely, this was not the case when it came to scientific research, especially research requiring heavy equipment in the lab, fieldwork and clinical trials. Having to pause their work, researchers were left confused on how to safeguard their research activities and uncertain about their future. Many have changed their priorities and are assessing new directions .[46] Graduate students were also put in difficult situations, often finding themselves unable to complete their projects due to lab access constraints and funding shortages, consequently having to rethink their degree timelines. Post-docs and young researchers were the most vulnerable among the research cohort, as their career progression was put at stake .[48 ,47]

As labs had to be closed for some time and access was limited to carry out only critical activities such as maintaining cell lines and looking after animals, many scholars shifted their priorities to COVID-19-related research ;all the while "non-essential" research has slowed down. A bibliometric analysis of the COVID-19 global research output showed that from December 2019 to March ,2021 there were over 140,000 publications worldwide .[49] The Arab world's contribution during that period constituted only 4.26%,

with mostly original journal articles and reviews related to: "public health and epidemiology; immunological and pharmaceutical research; signs, symptoms and clinical diagnosis; and virus detection ."Saudi Arabia (35.65%) was in the top of the list followed by Egypt (20.78%) and the UAE (11.73%). When taking into consideration population size and GPD, Saudi Arabi, the UAE and Lebanon were placed in the lead. These publications were the result of collaborative work with mostly the United Sates and the United Kingdom .[50]

The impact of the pandemic on academic research is without any doubt challenging .However the virus created a state of urgency and a matter of survival that catalyzed collaborations and accelerated the pace of research and innovation. The development of the COVID-19 vaccine is an example of unprecedented and fruitful international collaboration in scientific research, putting aside secrecy and personal agendas ,51] .[52Scholarly communication is an essential element in the process and much has changed during this pandemic. Preprints, such as the medRxiv and bioRxiv servers, saw a surge in submissions, facilitating the early sharing of information publicly. Many peer-reviewed journals and publishers also accelerated their submission-to-publication procedures and made coronavirus-related research openly available and free to read. Whether this improvement in efficiency will persist or not is unclear. Stefano Bertuzzi, chief executive of the American Society for Microbiology, thinks that "this is just the emergency situation that we're dealing with .[53] "It might be too early to predict what academic research will look like post-COVID-19. Nevertheless research agendas will certainly be affected and revenue generation will most likely be the main concern.

4.2 Medical and nursing education

The COVID-19 crisis has severely disrupted medical education and the lives of medical and nursing students. At the onset of the pandemic, lectures were moved online and clinical clerkships were halted based on recommendations from the Association of American Medical Colleges, measures that were adopted in many countries worldwide .[54] In order to protect patients and the healthcare workforce and limit the risk of transmission, many hospitals suspended regular clinical care in an attempt to minimize non-essential staffing and reduce the number of patients seeking non-COVID-19 related care. The shortage of protective personal equipment was also an additional obstacle preventing medical and nursing students from interacting with patients, fulfilling their required patient care hours, and practicing bedside medicine training. This is in contrast to other disasters, such as earthquakes, fires, or other outbreaks, where students were able to involved in emergency responses, while continuing their education .[56 ,55]

Pre-clinical students may not have been affected as much as their senior counterparts as their main educational activities were lecture-based and the virtual move was not a disadvantage, especially for the tech-savvy universities .However an essential element in a physician's learning and training journey is the development of communication skills and empathy with patients, further limiting the students' overall educational experience. Such changes and disruptions in medical education are large losses in learning opportunities. However in some institutions, final year medical students have been put in the frontline in the fight against COVID-19; an issue that has been highly debated .[58-56]

In order to keep students on track for graduation and enter the workforce, many schools around the world have developed strategies to help them finish their degrees such as introducing emergency waivers to reduce the number of required clinical hours for nursing students or showing flexibility using virtual simulations

.[60 ,59]This relaxation of requirements comes at a time where many countries have been suffering from overstretched healthcare systems and having to face a crisis-level shortage of medical and nursing staff .

In the Arab world, surveys were conducted in Saudi Arabia ,[61] Jordan [62] Egypt [63] and Libya [64] to assess the medical students' circumstances and the impact of the pandemic on their education, given that many countries in the region suffer from instability and a poor digital infrastructure, necessary for conducting virtual learning. Online learning also raised the issue of inequity in terms of access to devices and the internet. Another common issue was the readiness of the educators to embrace online learning, as the majority are considered "digital immigrants", often unwilling to adapt and not able to reap the benefits of technology. During the lockdown period, students had taken on different approaches to education. While some got accommodated to online learning, others relied on self-study, and some undertook research activities or participated in volunteering efforts part of the COVID-19 response .[65] Suggestions to encourage academic coaching were also made to enhance the communication between educators and students so they stay motivated. In fact, the pandemic has had severe psychological effects on students worldwide, with many suffering from anxiety and depression, which could eventually impact their career plans .[66]

Although the pandemic was a source of uncertainty, disruption and chaos for medical students, it has provided them with an opportunity to view firsthand medicine as a dynamic field. It demonstrated the qualities required from a 21st-century physician and the importance of cross-disciplinary interactions to solve complex issues in healthcare and respond rapidly and efficiently to threats. This crisis will surely change the way physicians are educated. "There may be no better time in history to learn what it means to be a physician.[67] "

4.3 Pharmacy education

The COVID-19 pandemic has challenged healthcare providers and workers as they had to stand in the frontline and fight a disease in an uncertain and unpredictable environment with little scientific evidence on its management. Pharmacists were no exception. They quickly had to respond and assume prominent roles in health promotion by informing and enabling the public in an effort to control the outbreak, while putting their safety aside .[70-68] Pharmacists also saw their roles expanding during the pandemic and their responsibilities growing as pharmacies became sites for testing and vaccinations .[71]

Such responsiveness requires a robust educational background and special sets of skills. In fact, curricular changes in the pharmacy program have been taking place since the 1960s, resulting in profound transformations, and making pharmacy a patient-centered career .[71] The COVID-19 pandemic has highlighted the important role of pharmacists in health crisis and management ,and pharmacy education needs to keep evolving to further advance the role of pharmacists.

An analysis of the academic pharmacy's response during the pandemic [72] and surveys from Jordan [68] and Saudi Arabia [73] summarize the status of pharmacy education and the challenges faced during the pandemic, while reflecting on opportunities for improvement. The suspension of on-site laboratory teaching and experiential training were a major challenge although virtual alternatives were provided. Nonetheless, the pandemic has surely provided a learning opportunity for pharmacy faculty, staff and

students, highlighting the important role of pharmacists in the management of pandemic and health crises, as well giving them a drive for becoming agents of change.[74]

4.4 Engineering education and skills

Engineering education, a usually hands-on ,content-centered and design-oriented type of education, is a challenging domain when having to face the pandemic-induced social distancing measures. These are more or less similar to the challenges described in the previous sections and mostly related to online delivery and technological obstacles such as poor internet connection, absence of software licenses, lack of devices, or even space in the house, in addition to exhaustion and lack of focus during virtual sessions. Educators also had their own challenges, many being unprepared for online class delivery, digitally incompetent and having difficulty adapting the syllabus for online and hybrid teaching. They often had to resort to sharing handwritten notes and virtual videos of labs with their students .[76 ,75]

Several projects and initiatives were undertaken during the pandemic to serve the global health efforts in the fight against the virus. For example ,the Department of Electrical and Computer Engineering's high voltage lab at Mississippi State University in the United States quickly converted battery-operated ventilators, originally designed for temporary and emergency responses, to AC power so that they can be used for longer periods of time .[77] Another example is an interactive map by the Johns Hopkins Center for Systems Science and Engineering to track the spread of the virus in real-time .[78] From the Arab world, the American University of Beirut developed "Ma3an – Together Against Corona", a contact tracing and exposure notification mobile app for Lebanon, a partnership between the university's Humanitarian Engineering Initiative and the Ministry of Public Health .[79] The American University of Beirut also launched a series of projects and initiatives for the development of medical and personal equipment involving collaborations between the faculties engineering and medicine, such as designing a self-disinfecting robot for hospital use, developing environmentally friendly biodegradable masks as alternatives to the N95 mask, among others .[80] In Tunisia, a team of engineering students from the Sousse National School of Engineering developed3 D-printed protected masks, a project that was officially supported by the President of the republic .[81]

Clearly COVID-19 has put educators and students out of their comfort zones, forcing them to think what learning should be about and to embrace change .

4.5 Business education

Business schools had to ensure instructional continuity during the pandemic through emergency remote teaching as in other fields. Business as usual. However business education has long been questioned regarding its lack of relevance, public value and general impact on society .[83] [82] The COVID-19 pandemic has re-ignited this long debate, creating a pressing need to re-think in the long-run the purpose and meaning of the business school in order to secure its future to fit in a business world that is changing faster than ever .[84]

The missions of business schools have been centered around the understanding of management and the preparation and training of men and women to become leaders that are mainly oriented towards the pursuit

of profit or profit maximization in a competitive environment where the strongest survives. Instead of producing graduates that look at the needs of the wider society, we have "unethical graduates" that lack moral reasoning .[85] However the post-COVID 19-world will be different than the one we know. The nature of the workplace is changing ,which will demand not only a new set of skills and services but also new insights and perspectives. Business schools have already started overhauling their curricula and reshaping educational services and programs that would be relevant to the student's needs and closer to the changing reality. For instance, shortly after the early months of the pandemic, business schools started introducing courses and workshops on leadership in a time of crisis ,[87 ,86] and saw the resurgence of financial technology (Fintech) programs, which is "the design and delivery of financial products and services using disruptive technologies in order to reduce cost, improve efficiency and provide better personalized service .[88] "The meaning of the MBA is also changing; once a "must have" despite soaring costs and having to leave the workforce for two years for a full time degree, it is no longer considered a high return on investment .[89 ,83] As the lure of the business school with a huge reliance on international students, COVID-19 has significantly impacted the MBA's cash cow status, forcing business schools to reconsider their business model.

COVID-19 has also accelerated the change in admission requirements. For instance, early during the pandemic, undergraduate business programs made the SAT or ACT scores optional and the GMAT was waived for graduate programs .[90]

However will this adaptation period be enough for the needed transformation of the business school ?

4.6 Legal education

The typical traditionalist law school had no choice but to adapt to the COVID-19-imposed remote learning methodologies. Law schools have been long facing criticism related to their business model and pedagogy, creating graduates drowning in debts due to the ever-escalating costs of their studies.

Looking at the job market, COVID-19 has created a "boom" for the law industry despite a plunging economy. In fact, the pandemic has highlighted the complexity and vulnerability of a rapidly changing business world. Lawyers will be needed more than ever to protect and promote the rule of law .[92 ,91]

A re-imagined legal education will consist of training students "to think like a lawyer" not only in the traditional sense of learning legal basics and thinking critically, but also learning soft skills such as emotional intelligence, collaboration and communication abilities in addition to competencies required by legal professionals in the post-COVID-19 era. Referred to as augmented skills, these include project management, data analytics ,crisis management, and the use of technology in legal delivery, to name a few .[93 ,91]The law degree will no longer be the end goal but rather the start of the legal learning process .

4.7 Arts and design (creative disciplines)

Online learning proved to be successful in various disciplines. However in the case of creative education such as graphic design, architecture and fashion, it raises question marks. A blended or hybrid approach

has mainly been adopted in institutions around world and consists of a combination of both online and face-to-face teaching .[94] To mitigate some of the limitations of online learning in the arts, Adobe provided free access to many of its applications during the pandemic, which are usually used during design classes on campus .[95] Several companies have also come up with resources for teachers and students, in an effort to enhance their learning experience .[96] However with limited access to design studios, students found themselves missing out on a special kind of learning experience, one that embraces the interaction and intimacy that develops between students and faculty, encouraging the exchange of thoughts and ideas. To overcome this, educators have had to resort to making time for digital feedback. But it is not enough and something is lost in the process .Online teaching in arts requires a lot more work than in-person teaching and a lot of flexibility from all parts .

4.8 Adult education

Adult education, also referred to as continuing education, is an educational activity undertaken by adults beyond traditional schooling. It recognizes education as a lifelong process that shall" enable all persons to participate effectively in a free society .[97] "Adult education comprises diverse modes of study to fill various purposes such as: (1) advancing vocational and professional skills; this is the most common type and aims at preparing adults for the job market, improving skills required for a profession ,and adapt to a changing workplace; (2) promoting personal development and contributing to self-fulfillment and leisure, which is mostly learning for the sake of learning; (3) acquiring literacy and numeracy skills as well as remedying neglected primary or secondary education; and (4) participating fully in democratic and civic processes. Adult learning is essential to reduce social inequalities related, but not limited to gender, social status, disability, and race .

However adult education is inadequately funded, and even underfunded, as very few governments have been dedicating the recommended 3% of their educational budget .[98] According to the Fourth Global Report on Adult Learning and Education, the major focus of adult learning goes to the workplace and serving economic needs .[99] Often it is the employed, often high-waged staff that benefit the most from this type of education, leading to a Matthew effect, where the rich get richer and the poor get poorer .[100] In fact, cost of participation is the main barrier for accessing adult education, putting vulnerable and underprivileged members in the society such as women, refugees, and adults with low literacy, at a major disadvantage, and even more marginalized, further widening inequalities.

While governments and education authorities have taken measures to respond to the educational emergency triggered by the pandemic and ensure the continuity of education, adult learning was more or less neglected. Besides ,adult learners had to face many barriers. As online learning was the most suitable way to resume education in schools and universities, many adult education programs lack the technological resources and rely on face-to-face teaching, plus adult learners often suffer from poor digital literacy skills , suddenly finding themselves having to upskill their digital capabilities ,adding more to their stress and anxiety. Many of these learners also lost their jobs during the pandemic or were given pay cuts, and so had to prioritize earning over learning .

It was estimated that 773 million adults lacked basic literacy skills before the pandemic, a number that will most likely increase in the near future. With a global economy in its worst recession since World War II, this crisis is forcing education providers to re-think how adult learning opportunities are provided, focusing

on the development of new skills for a changing market. Aside from the vocational aspect, there is also a need to look into the other purposes of adult learning, such as "basic health and citizenship education to safeguard a future society that is sustainable and cohesive .[101] "In a report prepared by the UNESCO Institute for Lifelong Learning, different programs and best practices from different countries are presented as examples of promising approaches for adult learning education for the post-COVID-19 period .[101] Among the countries represented are Algeria and Egypt from the Arab region, showcasing programs on the empowerment women and young community members from disadvantaged areas respectively, while highlighting the importance of building strong partnerships for the delivery of initiatives .

5 Beyond the Pandemic :The Challenges of Recovery

Faced with exceptional challenges, higher education institutions had to be proactive in confronting the COVID-19-induced change. They proved to be responsive and responsible. Leaders showed speed and agility in decision-making, educators changed their delivery methods, and students adapted to digital learning. However, there is no doubt we are facing an era of uncertainty and unprecedented complexity. Even before the pandemic, questions around the value, the relevance, and the need of higher education were arising, as students seemed unprepared for the job market. In other words, the higher education sector seemed disconnected from the real world .Now is the time for higher education institutions to re-think their operating models, their purpose and their mission if they want to survive and create a sustainable model" .When a wave of challenges hit, speed gives more control over destiny and agility increases your options. It is important to take advantage of the opportunities that arise.[102] "

5.1 The student pool

The recruitment of prospect students and the retention of current ones was a major challenge during the first few months of the pandemic in 2020. Although domestic student recruitment has not been majorly affected, it is the international students that posed a problem, especially that universities rely on them in their operating models .

The ability to connect and communicate with students, current and prospective, has never been more important. Higher education institutions have been working hard on setting-up communication and marketing strategies for the recruitment of students. With open-days on hold and in-person interactions with an institution's community being still very limited, they had to develop and expand their digital outreach. The institutions' response and operations during these challenging times may have also impacted current students, leaving them concerned about their study plans and future. Higher education institutions will have to face competition not only among each other, based on their responsiveness to challenging situations and the treatment given to their community, but also with online-only providers, which have been recently put in the spotlight. Besides, these institutions need to take into consideration that the pandemic may have changed the students' attitudes and perspectives towards education in general, their developmental needs and eventually their perception on the importance of the degree. Now more than ever, the higher education sector has to face issues of affordability, relevance and equity in education, issues that have long been sidelined. They have to keep up with the student's changing expectations and they have to differentiate themselves from an increasingly diverse and attractive pool of education providers. For this,

it is important to look at the students' perspective and provide answers to where, how and why they want to learn .

5.2 The academic programs

While the world is planning to return to some kind of "pre-COVID normal", there is no going back for higher education institutions. Uncertainty around student enrollments and the decline in public funding, re-assessing the portfolio of courses seems like the next obvious step in order to manage balance sheets and ensure financial sustainability in the long run. This involves redefining the value proposition of the institution, reviewing academic programs by assessing those that are essential to its mission, and reconsidering those that are non-essential from the student's standpoint. For so long, higher education institutions have been designing curricula and pedagogies around the interest of departments, away from the students' expectations and needs, and many are considered impractical and disengaging. This would entail closing certain programs as well as investing in new ones to attract an ever-more conscious and diverse pool of students .

There is also a need to determine the appropriate balance between face-to-face and online teaching. While tuitions from the first type usually cover fixed administrative, faculty and estate costs, the latter will not necessarily be enough. Moreover, there is general apprehension towards paying for online classes, even doubting if it is worth it .[103] Just like a digital book costs less compared to the physical version, students expect to pay less for online course offerings .

Implementing blended learning programs should not affect the quality of education and the reputation of the institution. However while online programs can fulfill a course learning outcomes, certain skills such as promoting problem-solving ,encouraging critical thinking, enhancing social skills, and even motivating and inspiring students cannot easily be attained online. Delivery models should be responsive and innovative. And academic programs should aim at closing the gap between learning and the real world by embracing "learning by doing" and engaging students in real life experiences to develop knowledge and skills through collaborations, internships or other hands-on experiences as part of the learning cycle. This is where experiential learning comes into play. And this is at risk today. The process of learning through experience has significant advantages such as actively involving the learner in the learning process, encouraging reflection and analysis, and improving decision-making effectiveness and problem-solving skills. It is and must remain a crucial part in the evolution of education.[104]

5.3 The real estate

The rise of online learning ,accompanied by flexible working models and arrangements, has impacted the demand on estate and campus footprint, causing higher education institutions to re-visit their space management strategies. Over recent years, there has been a drive to expand campus construction and build new facilities to attract prospective students. This "academic building boom" was often described as irrational .[106 ,105] Today, re-purposing the higher education estate is on the agenda of policymakers and leaders. For example, it is projected that personal office space used by academic and administrative staff, which typically consists of over a third of the institution's property, will be altered and even reduced. The emphasis will shift to investing in the digital IT infrastructure and digital learning environments as well as providing communal areas for the students' learning and recreational use and lecture theaters, in an effort to overcome the challenges of providing socially-distanced teaching space .[106] In other words, "COVID-

19 has underscored the burden of physical campus infrastructure and the need for technical infrastructure improvements.[107] ”

The COVID-19 crisis has surely put to the test the financial resilience and strength of higher education institutions. Depending on each institution’s type and circumstances, re-structuring will be essential in order to survive for some or expand for others. It is important to recognize the benefits of collaboration and the timely potential for merger and acquisitions. “While higher education has stood the test of a thousand years, many individual schools will simply not survive the next five.[108] ”

5.4 The academic jobs

Technology-supported work flexibility and outsourcing are new major employment trends in the labor market, which have seemingly started to impact the higher education staff .Higher education institutions have long been advocates of fixed staffing costs ,as exemplified by a tenure-track faculty workforce. However the COVID-19 pandemic has changed the operating dynamics of these institutions by accelerating the financial strain. Budget cuts, hiring freezes, layoffs were all common topics, making higher education employment not as desirable and secure as it used to be. The young, non-tenured, and part-time professors are of course the ones hit the most, having to suffer furloughs and layoffs. Virtual learning was also a challenge many older tenured professors had to face, whereas tenure-track professors found themselves in career limbo and an uncertain future. In addition, the loss of job opportunities in academe is driving graduates and PhDs to seek non-academic careers. However is the grass really greener on the other side .[109] ?According to a survey by The Chronicles of Higher Education in the United States, over half of faculty of all ranks consider leaving teaching by changing their careers or retiring [110] and experts are warning of a “coming exodus of academics.[111] ”

Moreover, outsourcing services usually provided in-house instead of hiring permanent staff for these jobs have been on the rise ,allowing the institution not only to increase efficiency but also to control costs , save money on job security, compensation and benefits .[112] Such services can include core activities (certain administrative functions, cleaning and security) as well as non-core functions (housing, bookstores and dining facilities). This kind of arrangements needs robust partnerships and does not come without its own challenges and disadvantages, including but not limited to: loss of managerial control ,reputational risk due to inefficiencies by the provider and quality issues, lack of flexibility, instability and hidden costs .

6 Future Trends and Possibilities

The COVID-19 pandemic has accelerated the transformation of education. The phase of global experimentation with virtual learning has changed the learning experience and the higher education sector can start looking now beyond immediate demands. While it is still difficult to predict what the higher education landscape will look like once the COVID-19 threat has dissipated, it has undoubtedly instilled a new mindset and methodologies.

“ In 1665, Cambridge University closed because of the plague. Isaac Newton decided to work from home. He discovered calculus and the laws of motion. Just saying.”, said Paddy Cosgrave ,chief executive of Web Summit .

6.1 A new perspective on 21st century skills and learning methodologies

COVID-19 has transformed the way we live and work and consequently highlighted the skills and key competencies that are needed for the student's development. Communication, collaboration ,critical thinking creativity, agility and ability to solve complex problems are key components of 21st century skills .[113]Educators have to play an important role in developing and promoting these skills to produce graduates who can thrive and succeed in these changing times and difficult circumstances. This requires a shift in instructional approaches, assessment methods and training ;a shift from a mostly "lecture-based learning" approach to "problem-based learning", centered around the belief that students learn through active collaboration and interaction with others .[114]

Digital literacy and information and communications technology (ICT) skills have also drawn major attention as a core element of 21st century skills. The digital transformation of education however is not a new phenomenon. It is COVID-19 that induced a "paradigm shift" for higher education institutions and hastened virtual teaching and remote working .[115] This global pandemic has also put the spotlight again on Massive online open classes (MOOCs), a term coined in 2008 for open-access online course providers, available to anyone with internet connection, anywhere in the world. Back then, George Siemens and Stephen Downes decided to experiment the concept of connectivism by teaching a course called "Connectivism and Connective Knowledge" to a small cohort of traditional students at the University of Manitoba in Canada, while providing open access to anyone who wished to attend online. The 25 students at the university were joined by 2,200 people from around the world. The purpose of MOOCs was to "democratize higher education" by providing affordable or free education accessible to anyone .[116] MOOCs were mainly attractive to learners seeking professional advancement to close a skills gap not provided by traditional education in a rapidly evolving marketplace as well as for those looking for personal growth. After a successful start, by 2015 academics thought MOOCs were" almost dead .[117] "Five years later, they were booming: enrolments at the online platform Coursera was up 640% compared to the year before and Udemy saw a surge of 400% between February and March 2020 .[116]

Digital education requires appropriate and robust technological infrastructures and platforms to support virtual teaching and learning. This was accompanied by a surge in the use and types of learning management systems (Blackboard ,Moodle, Edmodo, Microsoft teams) and software applications (Zoom, Skype, Google Hangouts, Google Meet, Cisco WebEx, GoToMeeting, Loom, OBS) to facilitate the management and delivery of online courses .

Now that technology advances are progressing exponentially, focus is switching to methodologies for generating dynamic, proactive and collaborative sessions. To improve the learning experience through the use of educational technology, various methodologies resurfaced such as the "flipped classroom" pedagogical model, which is a blended learning model whereby students use technology resources to prepare for their classes in advance and use the actual session for fruitful interactions among each other and the educator in order to promote deeper understanding and knowledge of the subject .

However technologies are still widely criticized for separating the learner from the educator and creating a weak sense of community. This debate is as old as the beginning of civilization. Socrates was a strong advocate of face-to-face interactions and was critical of using writing to transmit knowledge. Nonetheless, he hadn't thought that the written word or books, the hot technology of the time, would provide a richer

learning experience .[118] In today's world, the fear of digital education is well-founded, however it is no longer a matter of whether we should use technology or not, but rather how to use it and how to create a sense of community .

6.2 Innovations in teaching technologies from the Arab world

The inconveniences and negative effects caused by the COVID-19 pandemic were also sources of opportunities ,inspiration and innovation. The pandemic has triggered the capacity of people to come together and created an innovation ecosystem. In these challenging times, a myriad of initiatives in the delivery of education emerged around the world. This section sheds the light on some of the technological innovations from various Arab countries, addressing structural weaknesses in the education sector in the region .

The rise of online platforms hosting digital learning resources has been remarkable in the Arab region, whether it is granting access to educational content or providing online courses. In Morocco, the MOOC platform Maroc Université Numérique (MUN) uploaded digital educational resources from various universities of Morocco to serve university students .[119]

The Skilling Up Mashreq (SUM) initiative, which was launched in Amman ,Jordan in 2019 during the Digital Mashreq Forum is part of the World Bank's commitment to prepare young women and men from the Mashreq region (Lebanon ,Jordan and Iraq) for the digital workspace by addressing the digital skills gap .SUM serves as a platform to boost initiatives in digital skills training through collaborations between the government, private sector and universities. It also aims at attracting digital technology players to invest in the region. So far this initiative has established partnerships with major international and regional players. For example in Jordan, the partnership between Edraak – an MOOC platform established by the Queen Rania Foundation – and Code.org – an international nonprofit organization that aims to encourage people to learn computer science, especially students from underrepresented groups – resulted in the localization of computer science education resources. This included the translation of Code.org videos into Arabic, which will be used for the design and implementation of a computer science curriculum. In Lebanon, Code.org partnered with the Beirut Digital District – a hub for the digital and creative industries – in April 2020 under SUM's World Bank umbrella, to provide free online Arabic coding lessons. Another SUM initiative stems from the collaboration with Microsoft, LinkedIn and GitHub, and aims to offer free digital skills courses and certifications to young people in partnership with the Beirut Digital District in Lebanon and Injaz in Jordan – a non-profit organization in Jordan which aims at providing vocational training and skills to young people.[120]

The UAE's largest applied higher education institution, Higher Colleges of Technology (HCT), led the digital transformation of education as soon as classes were suspended at the beginning of the pandemic by launching first a two-day virtual learning pilot program to test its digital infrastructure in delivering its curriculum fully online at the regularly scheduled times. The online platforms were set up in partnership with Etisalat, Zoom and Blackboard .HCT then sought to establish a service-on-demand "uber-like" virtual classroom model, which then evolved into DIGI Campus, an online learning platform that aims at keeping students engaged and providing them with virtual off-campus activities such as E-counselling, life skills, E-sports and health activities ,an E-reading space with book review sessions, and E-volunteering.[121]

In Bahrain, the Ministry of Education and the Bahrain Information and eGovernment Authority were also quick to set up an electronic online portal for students, in collaboration with Amazon Web Services, completed with an additional online service using Microsoft Teams and Office 365 programs that connects students to teachers and a specialized support staff.[122]

Educational television was another solution used in Arab countries to overcome the obstacles of remote learning, especially with regards to internet penetration challenges. In Morocco for example, the state television broadcasted live sessions and educational material across the nation, in partnership with the Ministry of National Education, Vocational Training ,Higher Education and Scientific Research.[123]

7 Conclusion

COVID-19 is a virus that has turned into a pandemic. It is a virus that has brought our lives and the world as we know it to a halt, taking us out of our comfort zones, causing a rupture with the past, and forcing us to think about the future. Epidemiologists and health risk analysists have repeatedly warned of coming pandemics with huge social and economic impacts. It was no longer a matter of if but rather when. The world was warned and the world was unprepared. Now that vaccinations are underway to achieve herd immunity and limit the spread of the virus, a sense of normality is gradually being restored and populations around the world are embracing the pre-COVID-19 status quo. With systemic risks likely to increase in the future, has this pandemic taught us a lesson in setting global public health policy, the importance of international collaborations, and realizing the need for the adoption of the Sustainable Development Goals and the Paris Agreement. COVID-19 could be a once-in-a-generation opportunity .

However will we ever learn from our mistakes? Will the voices of experts be ever heard? Form history and experience, it seems we learned nothing. German philosopher Georg Hegel once famously said: "The only thing that we learn from history is that we learn nothing?". Will this time be any different ?

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جامعة البترا

الأكاديمية العربية للعلوم
Arab Academy of Sciences

Higher Education in the Post COVID-19:

Lessons from a Pandemic

The 23rd Conference of the Islamic World Academy of Sciences (IAS)
on
Sciences, Technology and Innovation (STI) Under Ever Changing Global Events
18-19 October 2022
Rabat-Morocco

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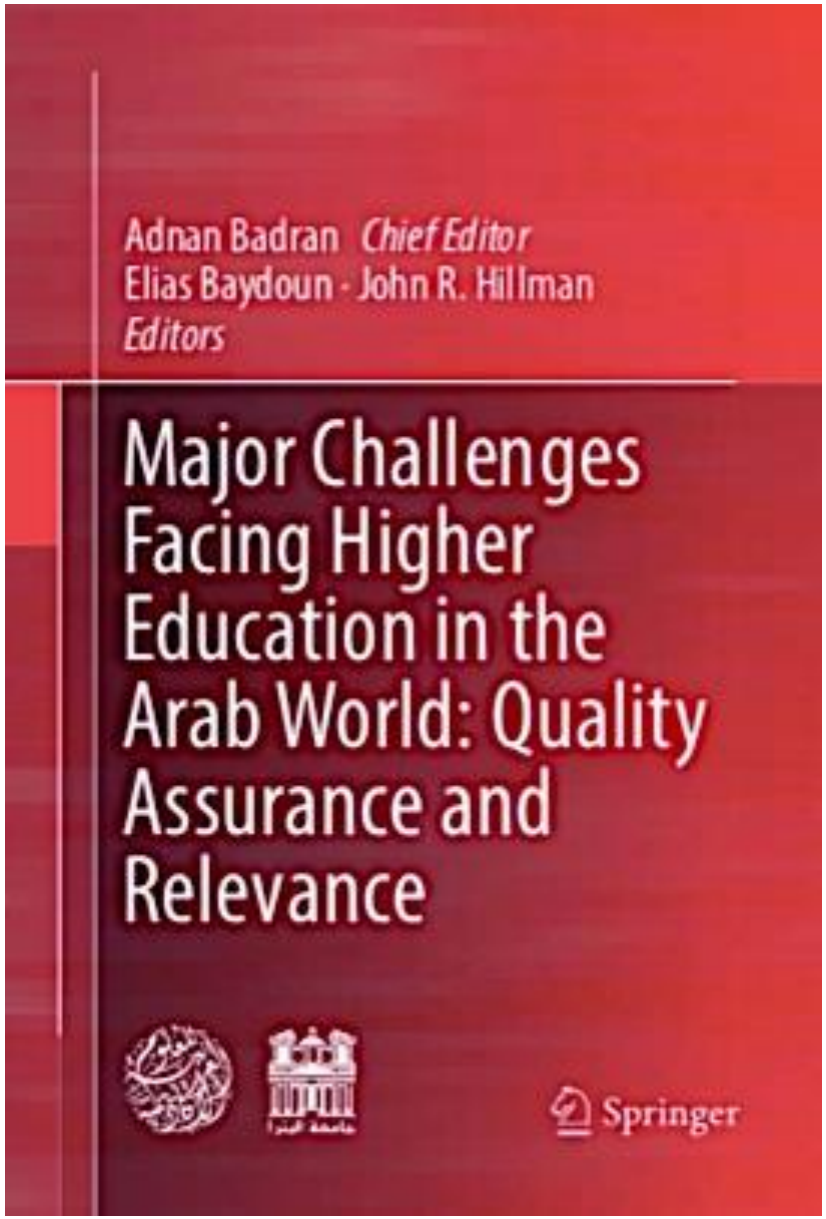
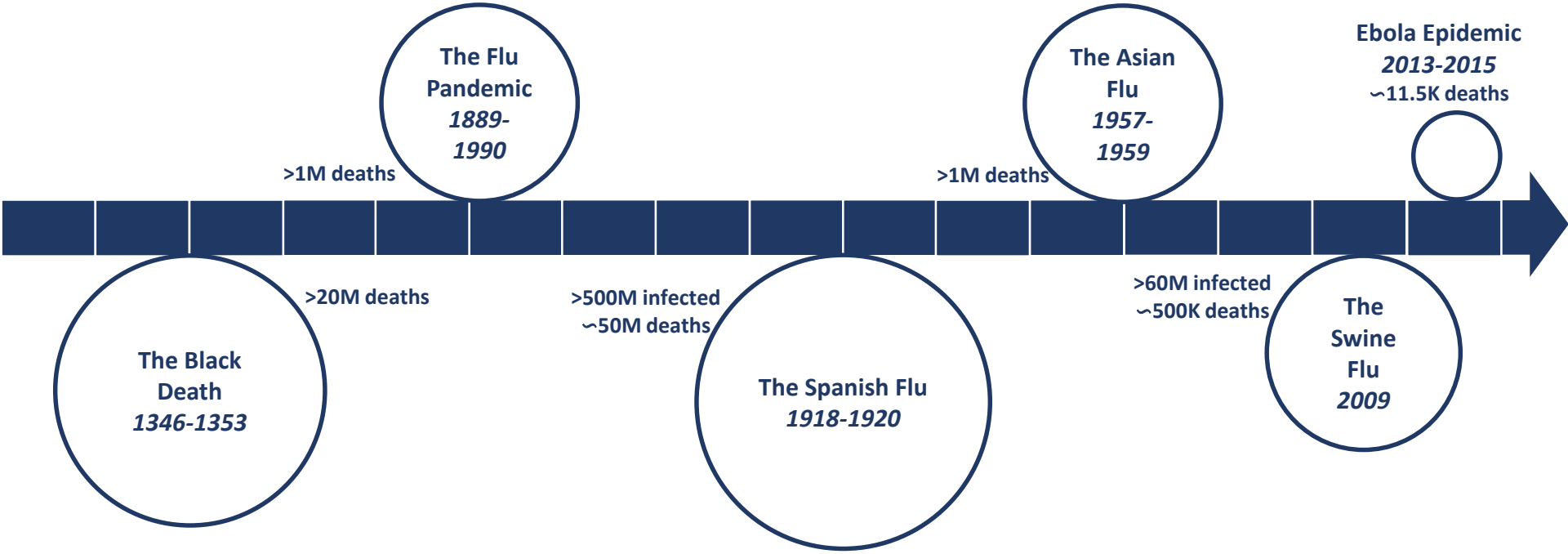


Summary:

- Online E-learning has saved the educational sector from locking disaster.
- Style of educational pedagogy will be changed.
- Blended architecture of resilient interactive learning will be emerged to stimulate the minds, to think of future challenges.

The Pandemic Era

The **2019 novel coronavirus (2019-nCoV)** is the most recently discovered type of coronaviruses which causes respiratory infections. It was first detected in Wuhan, China in **December 2019** and has since spread to all continents affecting **243 million people** and causing **4.94 million death** worlwide *(As of October 24, 2021)*



The COVID-19 Educational Response: Maslow before Bloom

According to UNESCO by 1 April 2020, **89.4%** of enrolled students were affected by the closure of schools and higher education institutions, amounting to **1.5 billion learners** worldwide

Immediate measures

The students' needs and well-being come first and are essential for educational attainment.

So first came the decision to **close** higher education institutions, a measure that was part of the **social distancing** and **confinement** protocols adopted by China and recommended by the WHO to contain the virus

The COVID-19 Educational Response: Maslow before Bloom

Immediate measures

The impact of the pandemic on education in the Arab region was more negative than in other parts of the world and showed how badly the **sector is in need for reforms** (absence of proper technical infrastructure; the reluctance and unreadiness of faculty to teach online; limited access to internet).

Institutions who were unable to deliver distance learning either shifted their academic year, **postponed graduation**, adopted a **blended learning approach** or had no choice but to **re-open their campuses.**

The COVID-19 Educational Response: Maslow before Bloom

Immediate effects

Drop in enrollment of international students

Initiatives to retain and attract international students

- UAE: allows new students to sponsor their relatives
- Egypt: establishing new branches in other countries in Africa

Drop in enrollment of local students

Experts worry that when these students leave higher education, it is very unlikely that they will return

The COVID-19 Educational Response: Maslow before Bloom

Immediate effects

Decrease in government funding

- Financial assistance to students strongly affected
- Institutional budget cuts (reduction in salaries, early retirements, contract freeze and even suspension, elimination of tenure, as well trimming benefits, closing programs, merging departments, and decreasing research funds)

Drop in the auxiliary fees

- Gaping hole in the operating revenue

The COVID-19 Educational Response: Maslow before Bloom

Immediate challenges

- Although the shift to online teaching and learning has rescued the academic year at the beginning of the pandemic, it has revealed several challenges

The internet	• Only 54.6% of individuals use the internet and more than half of households don't have internet at home in the MENA region, with the exception of the Gulf Cooperation Council (GCC) countries (scoring over 90%), based on ITU estimates for 2020
Examinations & evaluations	• Opportunity to re-think traditional approaches as these are still based on 20th-century mindsets, emphasizing on compliance and conformity rather than critical-thinking and creativity, as well as enhancing collaboration and knowledge transfer
Conferences & networking	• Academics will not travel to an in-person conference unless that event offers benefits far and above what can be gained virtually

The COVID-19 Educational Response: Maslow before Bloom

Immediate challenges

Having faced so many challenges and undertaken a lot of changes in the way education is delivered, the higher education community is now ready to :

- To **exit** the crisis stage
- To **re-think** the pre-COVID-19 status
- To **assess** the implemented solutions and invest in remote learning

→ in order to plan for a future with quality education, as new challenges will continue to emerge

→ ***Stating that online learning is the only way forward would be a dicey prediction***

The Pandemic has impacted various educational fields and activities

The academic research enterprise

Medical and nursing education

Pharmacy education

Business education

Legal education

Arts and design

Engineering education and skills

Adult education

Beyond the pandemic: The challenges of recovery

The student pool

It is important to look at the students' perspective and provide answers to where, how and why they want to learn.

The academic programs

Curricula and pedagogies have been designed around the interest of departments, away from the students' expectations and needs, and many are considered impractical and disengaging

The real estate

The "academic building boom" was often described as irrational.
It is important to recognize the benefits of collaboration and the timely potential for merger and acquisitions

The academic jobs

Higher education employment not as desirable and secure as it used to be
Experts are warning of a "coming exodus of academics"

Future trends and possibilities

"In 1665, Cambridge University closed because of the plague. Isaac Newton decided to work from home. He discovered calculus and the laws of motion.

Just saying." Paddy Cosgrave, Chief Executive of Web Summit

Future trends and possibilities

A new perspective on 21st century skills and learning methodologies

Key 21st century skills | Communication, collaboration, critical thinking creativity, agility and ability to solve complex problems

MOOCs

Technological infrastructures and platforms

In today's world, the fear of digital education is well-founded, however it is no longer a matter of whether we should use technology or not, but rather how to use it and how to create a sense of community

Future trends and possibilities

Innovations in teaching from the Arab world

- The pandemic has triggered the capacity of people to come together and created an **innovation ecosystem**

Maroc Université Numérique

Uploaded digital educational resources from various universities of Morocco to serve university students

كلّيات التقنية العليا
HIGHER COLLEGES OF TECHNOLOGY

Led the digital transformation of education as soon as classes were suspended at the beginning of the pandemic

Future trends and possibilities

Innovations in teaching from the Arab world

SKILLING UP MASHREQ

SUM serves as a platform to boost initiatives in digital skills training through collaborations between the government, private sector and universities. It also aims at attracting digital technology players to invest in the region

Code.org

BEIRUT DIGITAL DISTRICT

Provides free online Arabic coding lessons

EDRAAK

An Initiative of Queen Rania Foundation

Translated Code.org videos into Arabic, which will be used for the design and implementation of a computer science curriculum

Conclusion

With systemic risks likely to increase in the future, has this pandemic taught us a lesson in setting global public health policy, the importance of international collaborations, and realizing the need for the adoption of the Sustainable Development Goals and the Paris Agreement?

COVID-19 could be a once-in-a-generation opportunity.

However, will we ever learn from our mistakes?

"The only thing that we learn from history is that we learn nothing?" *Georg Hegel*

Will this time be any different?


Thank You!
alt

JOINT VACCINES DEVELOPMENT AND MANUFACTURING POTENTIAL IN OIC COUNTRIES

ABDULLAH AL MUSA
Director General, Islamic World Academy of Sciences (IAS), Jordan

ABSTRACT

Vaccines can provide prophylactic treatment and could have therapeutic affect for some diseases. Despite the fact that 90% of the world population are living in developing countries, only 35% of all manufactured COVID 19 vaccine is sold to them whereas 65% were sold to developed countries. This disparity created a huge gap in vaccine coverage between developed and developing countries. The slow vaccination roll-out in developing countries will have a cascading effect on the economies of developed countries; estimated by the International Chamber of Commerce (ICC) to range from $4.3-9 trillion over the next few years.

In the backdrop of vaccine roll-out hassles; OIC-member states are to reposition themselves to best ensure their countries are well-equipped and prepared for current and potential emergencies. We herein advocate the initiative of establishing a joint OIC vaccine production and development enterprise.

The overarching dimension that justifies this venture at the OIC level if the member states politically choose to include ever-increasing global demand for vaccines, the existence of a viable market (economy of scale) at the OIC level; the vaccine manufacturing experience in some OIC countries and OIC capacity for manufacturing and joint funding capabilities.

Joint Vaccines Development and Manufacturing Potential in OIC-member States

presented at the 23rd IAS Conference

18 - 19 October 2022

Islamabad - Pakistan

Prof. Abdullah Al-Musa

Director General, IAS

This proposal was submitted to the COMSTECH Steering Committee for the Implementation of the OIC STI Agenda 2026 Meeting and was adopted.

This paper will tackle two questions:

ONE. Why should OIC-member States establish a Consortium for Development and Manufacturing Vaccines?

TWO. Why the Joint Vaccine Manufacturing and Development Enterprise Success is Reasonably Justified?

Why should OIC-member States establish a Consortium for Development and Manufacturing Vaccines?

1.a. History of current and previous vaccine nationalism trends during pandemics.

The west is being accused of vaccine nationalism by prioritizing their domestic vaccination programs in an attempt to go back to business as usual as seen in the current COVID19 and 2009 H1N1 influenza virus pandemics.

The extent of this trend was seen in some countries' measures to block locally produced vaccines from being exported during these two pandemics.

Thus, prudent precautions (specially in developing countries) should be taken into consideration in the face of highly expected flare of other pandemics.

Why should OIC-member States establish a Consortium for Development and Manufacturing Vaccines?

1.b. This trend is manifested by data posted in the Access to Vaccine Index (AVI) which showed the statistics of COVID19 vaccine production sold in the first year of the pandemic was as follows:

- 65% of the vaccine production is sold to developed countries.

- 23% to upper middle-income countries.

- 8% to lower middle-income countries.

- 4% to lower income countries.

Why should OIC-member States establish a Consortium for Development and Manufacturing Vaccines?

It is noteworthy, however, that vaccine nationalism by developed countries may backfire on their economy.

According to the International Chamber of Commerce (ICC) the slowdown in the economies of developed countries is estimated to reach a $4.3-9 trillion loss in GDP across wealthy countries.

The message is that the inward domestic prioritization would cost more than sharing and donating vaccines specially to low-income countries.

Why should OIC-member States consider Joint Vaccines Development and Manufacturing?

2. The limited capacity worldwide to produce vaccines.

3. Existing capacity and capability of vaccine manufacturing and development in different OIC-member states.

4. Joint manufacturing and development of vaccine production enterprise constitute a mechanism for technology transfer specially when venturing in vaccine manufacturing of generic types based on license from international pharmaceutical companies.

That constitutes an initial step towards novel vaccine development endeavor.

5. The joint enterprise provides a mechanism to share the rather extremely costly human, physical and financial resources.

The estimated cost of developing and manufacturing a new vaccine from scratch could range from $500 million to $1 billion.

Why the Joint Vaccine Manufacturing and Development Enterprise Success is Reasonably Justified?

1. High demand for vaccines globally and particularly in the developing world including all OIC-member states due to:

a. High fertility rate coupled with low GDP.

The world birth cohort is currently 140 million explaining the increasing trend in the world population that is estimated to reach 9.7 billion by the year 2100. The fertility rate in OIC-member states which mostly falls in the range between low-income to upper-middle-income category is higher than that in high-income countries.

High fertility coupled with the low GDP constitutes a financial hurdle to cover all newborn needs for vaccination in OIC-member states.

Countries by income	% Global Share		Fertility
	GDP	Population	
High income	47	16	1.6
Upper-middle income	37	37	1.9
Lower-middle income	15	38	2.8
Low-income	1	9	4.6

Why the Joint Vaccine Manufacturing and Development Enterprise Success is Reasonably Justified?

b. High population coupled with high mortality rate.

The increasing population in the world generally and in developing countries particularly created tremendous need for vaccine manufacturing capacity that is not matched by current supply capacity of affordable vaccine to curb mortality rates caused by vaccine-preventable diseases. As shown in Table 2, the under-five mortality for 1000 live births during 2000-2010 was significantly higher in OIC-member states than that in developed countries or non-OIC developing countries. The situation is exacerbated by low GDP in developing countries rendering their market unattractive for vaccine manufacturers located mostly in developed countries.

Countries	Mortality/ 1000 live birth
OIC-member States	76.2
Developed Countries	5.6
Non-OIC developing countries	75.0
World	65.7

Why the Joint Vaccine Manufacturing and Development Enterprise Success is Reasonably Justified?

2. Manufacturers in developed countries are reluctant to participate in the Extended Program on Immunization of WHO that supplies vaccines for developing countries. Instead, they devote their efforts to cover more lucrative markets in developed countries. This translates into the fact that the pharmaceutical industry in the developed world is responding to the needs of high-income countries. They at the same time shy off from providing generic vaccines to markets in developing countries.

Why the Joint Vaccine Manufacturing and Development Enterprise Success is Reasonably Justified?

3. Moreover, the diseases common in developing countries may not be common in developed world. Diarrheal diseases, malaria and other childhood diseases appear on the developing world's top 10 causes of death. The share of total diseases burden in low-income countries is higher than that in high-income countries.

Diseases	% of total diseases burden in high-income countries	% of total diseases burden in low-income countries
Communicable diseases	6.2	56.4
Tuberculosis	0.1	3.0
Malaria	0.0	4.9
Respiratory Infection	1.2	8.4
Cancer	4.7	2.4

Why the Joint Vaccine Manufacturing and Development Enterprise Success is Reasonably Justified?

4. The initiative could anchor on the already available experience in OIC countries:

12 companies in developing countries are members of the Developing Countries Vaccine Manufacturers Network (DCVMN) currently supply 30 different generic prequalified vaccines. Only one company in OIC-member states (Indonesia) is among those who provide prequalified vaccine to WHO through its Extended Program on Immunization (EPI). There are also 3 more OIC states namely Bangladesh, Egypt and Iran who are members of (DCVMN). Other OIC-member states either showed interest in vaccine production under license, partnered with foreign companies or exhibited self-reliance.

Country	Potential vaccine production	Production under license	Self-reliance	Partnering company
Algeria		+		Sputnik
Egypt		+		Sputnik, Sinovac
Iran			+	
Morocco		+		Sinopharm
Turkey			+	

Why the Joint Vaccine Manufacturing and Development Enterprise Success is Reasonably Justified?

5. Viable Market.

Market for proposed vaccine facility output would not be a problem for the following reasons:

5.1. The OIC-member states high population (1.8 bn) with high fertility rate.

5.2. Manufacturers in developed countries are not any more interested in markets in the developing world because of insufficient return.

5.3. EPI increasing demands for vaccines at affordable prices. Some manufacturers in developing countries (Indonesia among them) started to supply vaccines to UN agencies after getting them prequalified by WHO.

6. Rising interest in vaccine manufacturing in some OIC-member states such as Iran, Turkey, Egypt, Morocco and Algeria.

Thank you.

GENOMIC SURVEILLANCE OF SARS-COV2 IN MOROCCO: A MAJOR COMPONENT OF THE INTEGRATIVE APPROACH ADOPTED BY THE HASSAN 2 ACADEMY OF SCIENCES AND TECHNIQUES TO SUPPORT BIOMEDICAL RESEARCH ON COVID-19

ELMOSTAFA EL FAHIME
Professor at National Center for Scientific and Technical Research (CNRST) and Head of Functional Genomic platform, Morocco

ABSTRACT

The current COVID-19 pandemic, caused by the SARS-CoV-2 virus, represents a major threat to health. Morocco, like other countries in the world, has experienced the disastrous consequences of the coronavirus disease "COVID-19". In this context, the Hassan II Academy of Sciences and Techniques, through its college of Life Sciences and Techniques, initiated the establishment of a national research consortium on Covid-19.

This consortium has assembled human skills, know-how and national infrastructure around a multidisciplinary research project on Covid-19, which will allow Morocco to enrich scientific knowledge on Covid-19 and to contribute to the international effort to fight against the pandemic virus Sars-Cov-2.

Indeed, the consortium includes, Sample collection centers, screening and diagnostic centers, Genomic Analysis Centers equipped with high-throughput sequencing platform, hospital recruitment centers for Covid-19 patients, and join together, multidisciplinary skills.

In this conference, an overview of the Moroccan Covid-19 consortium will be given, with details on structural organization and the ongoing research project. Four themes have been so far retained for financial support and deal with Viral genomic, and the host genetic predisposition, the host immune response and the epidemiologic study.

In fact, the virus genome data will be combined with, host genetic predisposition, host immune response, clinical and epidemiological datasets in order to help to guide Moroccan public health interventions and policies. The subsequent analysis will permit evaluation of the effectiveness of novel treatments and non-pharmacological interventions on SARS-CoV-2 populations and spread. It will provide information on whether or not outbreaks are due to introductions from outside or ongoing transmission within the community. The data will also enable researchers to identify and understand genetic changes that affect how easily the virus is passed on and the severity of the symptoms it causes. Finally, the information will help in the development of treatments and vaccines and monitor their impact as they are introduced.

Islamic World Academy of Sciences (IAS)

Hassan II Academy of Science and Technology

GENOMIC SURVEILLANCE OF SARS-COV-2: A MAJOR COMPONENT OF THE INTEGRATIVE APPROACH ADOPTED BY THE HASSAN II ACADEMY OF SCIENCES AND TECHNOLOGY TO SUPPORT BIOMEDICAL RESEARCH ON COVID-19

Pr. Elmostafa EL FAHIME , CNRST, RABAT, Morocco

The IAS 23rd international conference on

Science, Technology and Innovation (STI) Under Ever Changing Global Events

RABAT 19 OCTOBRE 2022

Outlines

- Overview about the integrated strategy adopted by H2AST to Promote biomedical research on Covid-19
- Details about the implementation of research themes and organization of the BM research on Covid-19
- Why genomic surveillance is requested for the management and the control of the pandemic?
- Examples of Scientific Data to Illustrate How genomic data are used for Covid-19 mitigation
- Conclusion

The first Covid-19 Case was officially announced on March 3, 2020

Moroccan Authority reacted rapidly and decisively to the threat of Covid-19 pandemic. Exceptional measures were implemented to control the spread of the virus

Closing Border (Mars, 20 , 2020)

Declaration if state of emergency, Imposition of curfew on Mars 20, 2020)

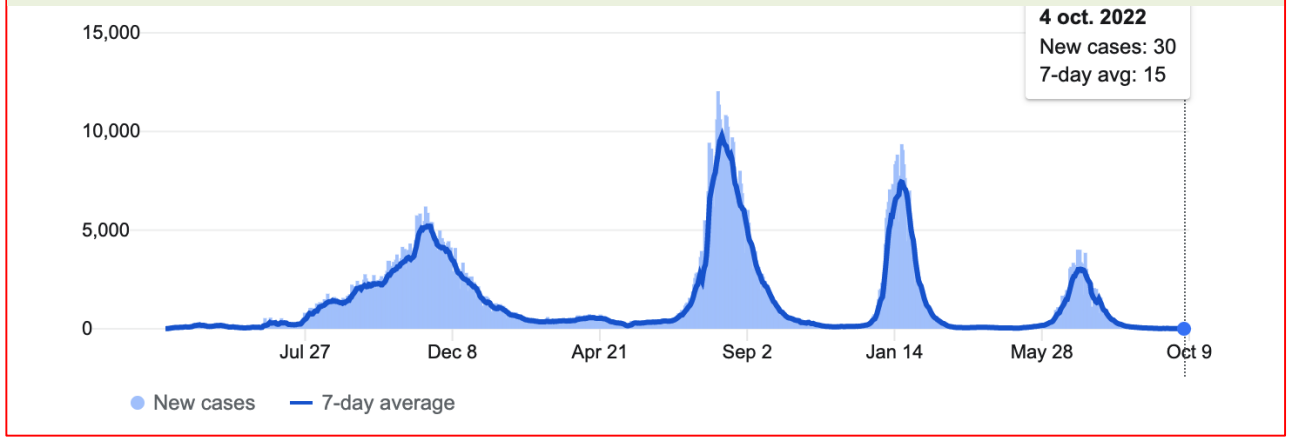
Being aware of what was going on in Europe, where hospitals were being overwhelmed by Covid-19 cases.

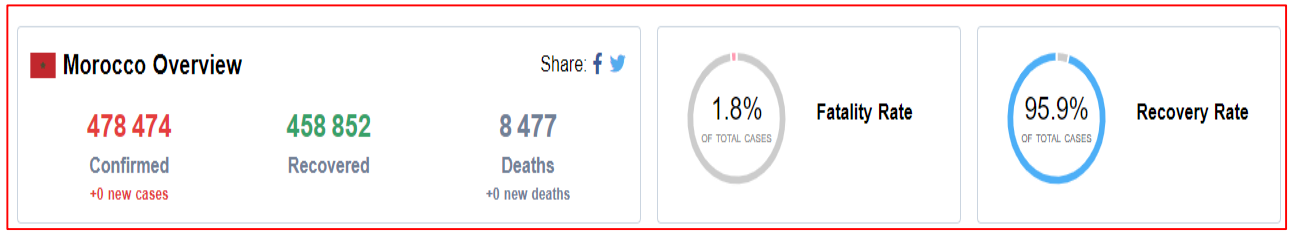
A substantial investment was made to upgrade medical equipment. Increasing hospital capacity.

Mobilization of the military medical staff and infrastructure

considerable efforts to promote public awareness and invite individuals to join collective efforts were made

All of the above strategic initiatives help to reduce the impact of the pandemic, as evidenced by the main epidemiological indicator, the fatality rate, which ranks among the lowest in the world.





The Hassan II Academy of Sciences and Techniques proposes measures to support Morocco's strategy for the management of the Covid-19 pandemic.

H2AST adopts an integrative strategy to support and promote critical area of research on Covid-19 in Morocco

Royaume du Maroc

Académie Hassan II des Sciences et Techniques

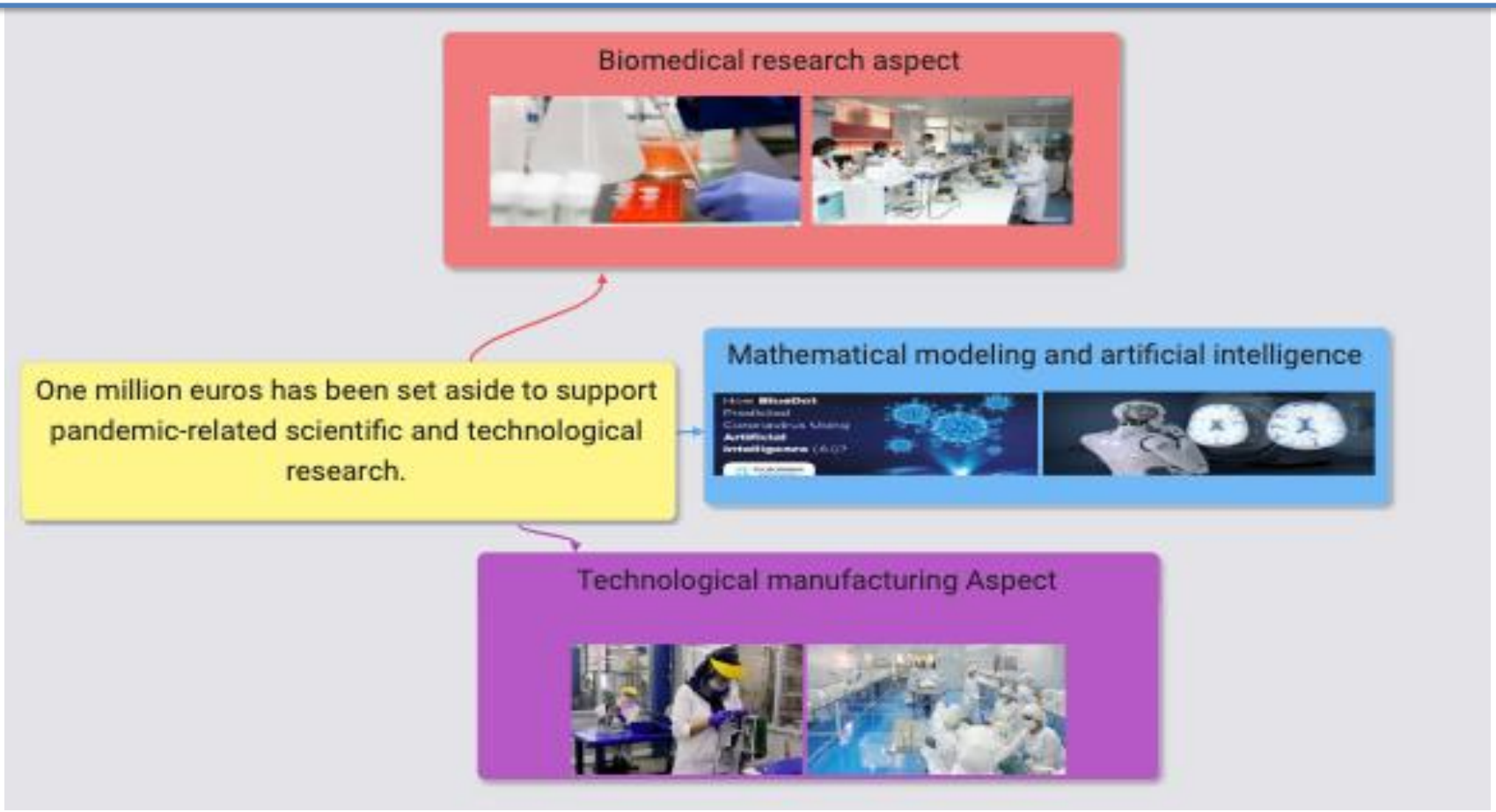
The primary goals are to get Moroccan scientists together to discuss all of the efforts that have been or will be done to combat the epidemic. Identifying critical research areas that will help immediately in pandemic mitigation.

Quoi de neuf

Gestion du Covid-19: les propositions de l'Académie Hassan II des sciences

L'Académie Hassan II des sciences et techniques propose de mettre en place un ensemble de mesures d'accompagnement de la stratégie du Maroc de la gestion de la pandémie du Covid-19.

(PHOTO MAP)



On Mai, 15, 2020 The LST college of H2AST hosted the first webinar on the BM research perspective for studying Covid-19.

Scientists and clinicians from several disciplines addressed the research vision that will be pursued, based on the existing skills, knowledge and infrastructure.

L'Académie Hassan II des Sciences et Techniques organise un webinaire sur le thème :

Perspectives de recherche autour du virus SARS-COV-2 et de la pandémie COVID-19

Modérateurs : Pr. Taïeb CHKILI et Pr. Sellama NADIFI
Membres résidents de l'Académie

PROGRAMME

-10h30-10h45 :

- Mot d'ouverture du Pr. Omar FASSI-FEHRI, Secrétaire Perpétuel de l'Académie Hassan II des Sciences et Techniques
- Introduction de la modératrice, Mme Sellama NADIFI, Membre résidente de l'Académie et Directrice du Collège Sciences et Techniques du Vivant

- 10h45-11h10 :

- Quelles recherches en épidémiologie ?
  Chakib NEJJARI, Président de l'Université Mohammed VI des Sciences de la Santé, Casablanca

- Que nous apprend la clinique et la physiopathologie de COVID-19 ?
  Hicham AFIF, Directeur du CHU Ibn Rochd, Faculté de Médecine et de Pharmacie, UH2, Casablanca

- Quelles recherches en infectiologie virale ?
  CHAKIB Abdelfettah, Professeur, CHU Ibn Rochd, Faculté de Médecine et de Pharmacie, Casablanca

- Quelles recherches en immunologie ?
  Brahim Admou, Professeur, Faculté de Médecine de Marrakech, UKA.

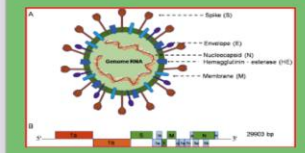
- Quelles recherches génomiques, biologie moléculaire ou virologie ?
  Elmostafa EL FAHIME, Professeur à la Faculté de Médecine et de Pharmacie, UMVR / UATRS, CNRST

-11h10-12h35 : Discussions et questions. Autres perspectives de recherche
-12h35-12h45 : Synthèse et Clôture : Rajae El Aouad, Membre résidente de l'Académie

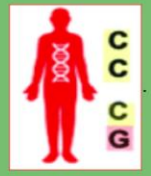
June 2020 : Based on the conclusions from the first webinar

4 themes of researchs were retained

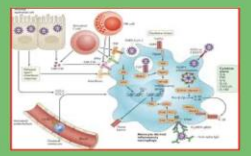
Viral Genomic



Host genetic

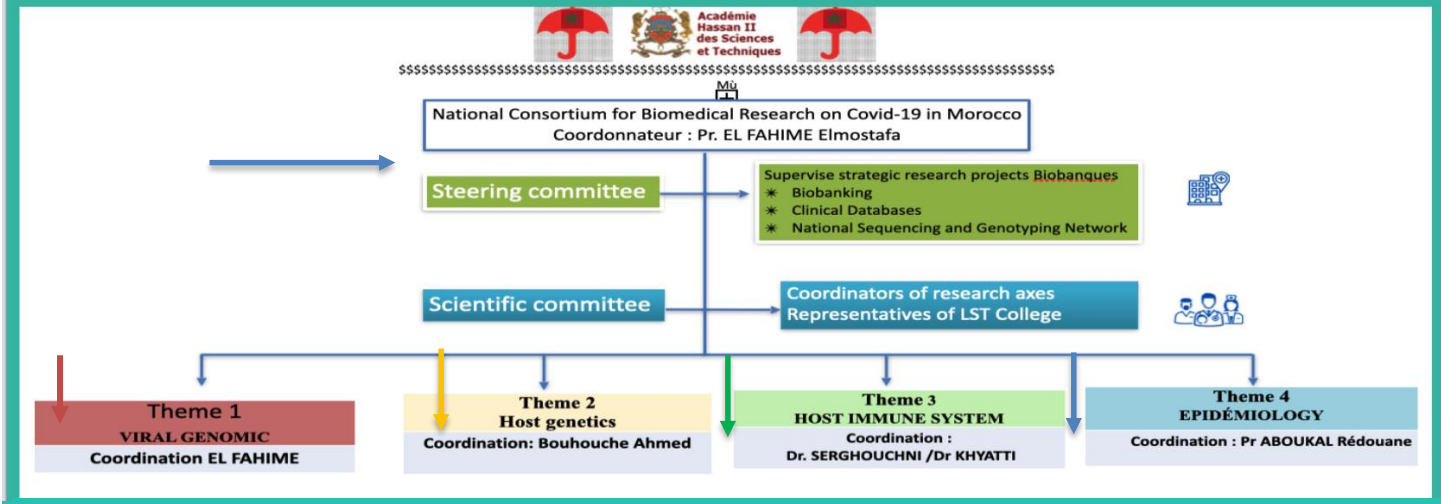


Host Immunology



Epidemiology

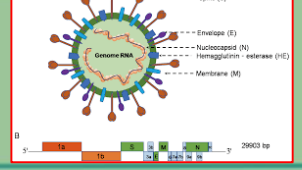
A structural organization the NCBM was retained



Each WG was given four weeks to provide a detailed proposal for the research activities to be done, including Rational behind proposal Methodologies, expected result, a time frame and specific needs.

Example of detailed proposal for the research activities retained for the viral Genomic theme of research

Work Package	Activités	INSTITUTIONS								
		A	B	C	D	E	F	G	H	I
		CNRST	CVMIT-HMIMV	LRAM	IPM	UIASS	UAE	BIOPHAR	IAV	CHU-RABAT
WP1	**SEQUENCING OF THE COMPLETE GENOMES OF SARS-COV2 VIRUSES CIRCULATING IN MOROCCO**									
Tache1.1	Séquençage des génomes complets du virus SARS-Cov2 circulant au Maroc (Technologies Ion torrent/ et Illumina)	X	X	X	X	X				X
Tache1.2	Séquençage d'un génome complet du Sar-Cov2 par la technologie Sanger (Génome de Référence de Sarc-Cov2 du Maroc)	X	X	X	X	X				X
Tache1.3	Étude des profile phylogénomique/phylogénétique et mutationnel et Cartographie des haplotypes viraux	X	X	X	X	X				X
WP2	**STUDY OF THERAPEUTIC TARGETS BY MOLECULAR MODELING AND DOCKING**									
Tache 2.1	Utilisation des séquences génomique des virus pour des Études in silico par la modélisation moléculaire, l'amarrage moléculaire, la simulation de la dynamique moléculaire du complexe protéine-ligand	X			X					
Tache 2.2	Déterminer la puissance inhibitrice des inhibiteurs potentiels par un Kit de transfert d'énergie par résonance de fluorescence (FRET).	X			X					
Tache 2.3	Déterminer l'impact des inhibiteurs potentiels sur la réplication du SRAS-cov-2 in vitro sur des cellules infectées par le virus	X	X	X	X					
WP-3	**IMPLEMENTATION: SYSTEM OF CELL CULTURE TO STUDY IN VITRO THE INFECTION BY SARS-COV2**									
Tache 3.1	Développement de VLPs SARS-CoV-2, utilisant le système BACMamm de production sur cellules d'insectes (BACculovirus) et de Mammifères		X	X	X			X		
Tache 3.2	Amplification des ORF du gène S par RT-PCR et Construction de vecteur de transfert et de «schuttle vectors» d'expression de protéines.	X						X		
Tache 3.3	Modèles animaux : Utilisation pour la simulation des manifestations cliniques et pathologiques de COVID-		X	X	X			X		
WP-4	**IMPLEMENTATION OF A REVERSE GENETIC SYSTEMS FOR SARS-COV 2: VLP production**									
Tache 4.1	Clonage des ADNc du SRAS-CoV-2 et Assemblage des cDNA pour la production des VLP (***(Virus Like Particles)***	X	X					X		
Tache 4.2	Test in vitro des VLP sur culture cellulaire	X	X	X	X			X		
Tache 4.3	Explorer et caractérisation de nouvelles Molécules thérapeutique sur les VLP		X	X	X			X		
Tache4.4	Test in Vivo chez l'animal des molécules thérapeutiques ayant données les meilleurs résultats in-Vitro							X	X	
WP-5	**IMPLEMENTATION OF DIAGNOSTIC TEST FOR THE RAPID SCREENING OF SARS-CoV-2 VOC**									
Tache-5.1	Conception de dispositifs des cassettes de test rapide de diagnostic sur la salive et validation (proof du concept)						X			
Tache-5.2	Fabrication des cassettes (Prototypes) et validation des résultats par comparaison avec les cassettes sérologiques						X			
Tache-5.3	Préparation des manuels d'utilisation						X			



IMPLEMENTATION A CELL CULTURE SYSTEM TO STUDY THE SARS-COV2 INFECTION IN VITRO

- Isolation of SARS-Cov2- VOC in BSL3 laboratory
- Sero-neutralisation and microneutrlisation assay
- Infectivity and replication study of VOC using common cell culture (Vero-E6)

Generate genomic data by NGS and ST. A workflow for bioinformatic analysis was implemented.
A reporting system to notify the health authorities about VOC introduction was implemented

SARS-COV-2 RAPID DIAGNOSIS TEST DEVELOPMENT

- Design and development of diagnostic assays using standard PCR
- Design and development of diagnostic assays using sthe HRM option of real-time PCR,
- Design and development of diagnostic assays using the CRISPR-CAS system.

GENOME SEQUENCING OF SARS-COV2 VIRUSES CURRENT IN MOROCCO

- WHole genome sequencing of the SARS-Cov2 virus circulating in Morocco
- Using Sanger technique, the whole Sar-Cov2 genome will be sequenced (to be used as a Reference genome of Sarc-Cov2 from Morocco)
- Phylogenomic/phylogenetic and mutational profile study and viral haplotype mapping

STUDY OF THERAPEUTIC TARGETS BY MOLECULAR MODELING AND DOCKING

- Development of a bioinformatic workflow for in silico screening of potential antiviral compounds
- Drug Repurposing (DR): An Emerging Approach in Drug Discovery
- Compounds that do well in the FRET experiment will be studied further in vitro.

IMPLEMENTATION OF A REVERSE GENETIC SYSTEM FOR SARS-COV 2: VLP PRODUCTION

- Cloning of the SARS-CoV-2 cDNAs and cDNA assembly for the generation of VLPs
- using VLPs to accelerate the discovery and characterisation of novel antiviral compounds
- In vivo assessment for candidate compounds that provide the best results on the VLP in vitro

The main Mitigation actions are built up with the use of genomic data.

T3 | Test. Treat. Track.

- **In order to reduce the risk of any pandemic, three major actions are built using genomic data.**

SARS-CoV2 strutural specificity

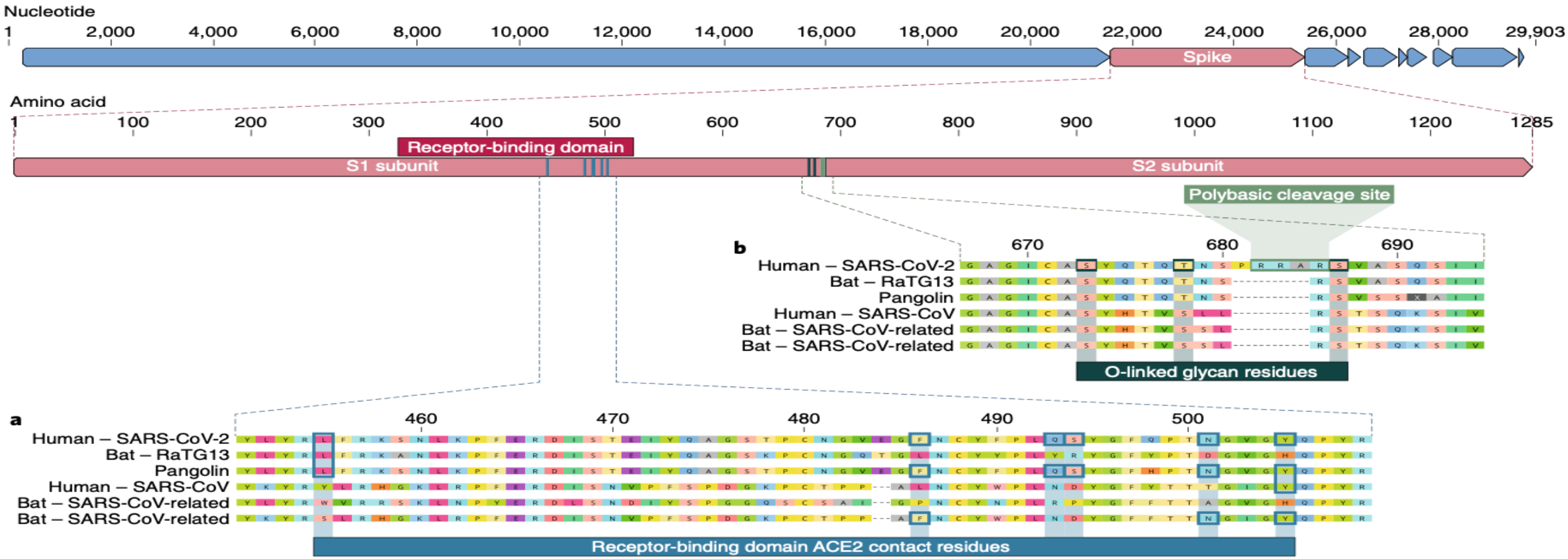


Fig. 1 | Features of the spike protein in human SARS-CoV-2 and related coronaviruses. a, Mutations in contact residues of the SARS-CoV-2 spike protein. The spike protein of SARS-CoV-2 (red bar at top) was aligned against the most closely related SARS-CoV-like coronaviruses and SARS-CoV itself. Key residues in the spike protein that make contact to the ACE2 receptor are marked with blue boxes in both SARS-CoV-2 and related viruses, including SARS-CoV (Urbani strain). **b**, Acquisition of polybasic cleavage site and O-linked glycans. Both the polybasic cleavage site and the three adjacent predicted O-linked glycans are unique to SARS-CoV-2 and were not previously seen in lineage B betacoronaviruses. Sequences shown are from NCBI GenBank, accession codes MN908947, MN996532, AY278741, KY417146 and MK211376. The pangolin coronavirus sequences are a consensus generated from SRR10168377 and SRR10168378 (NCBI BioProject PRJNA573298)[29,30].

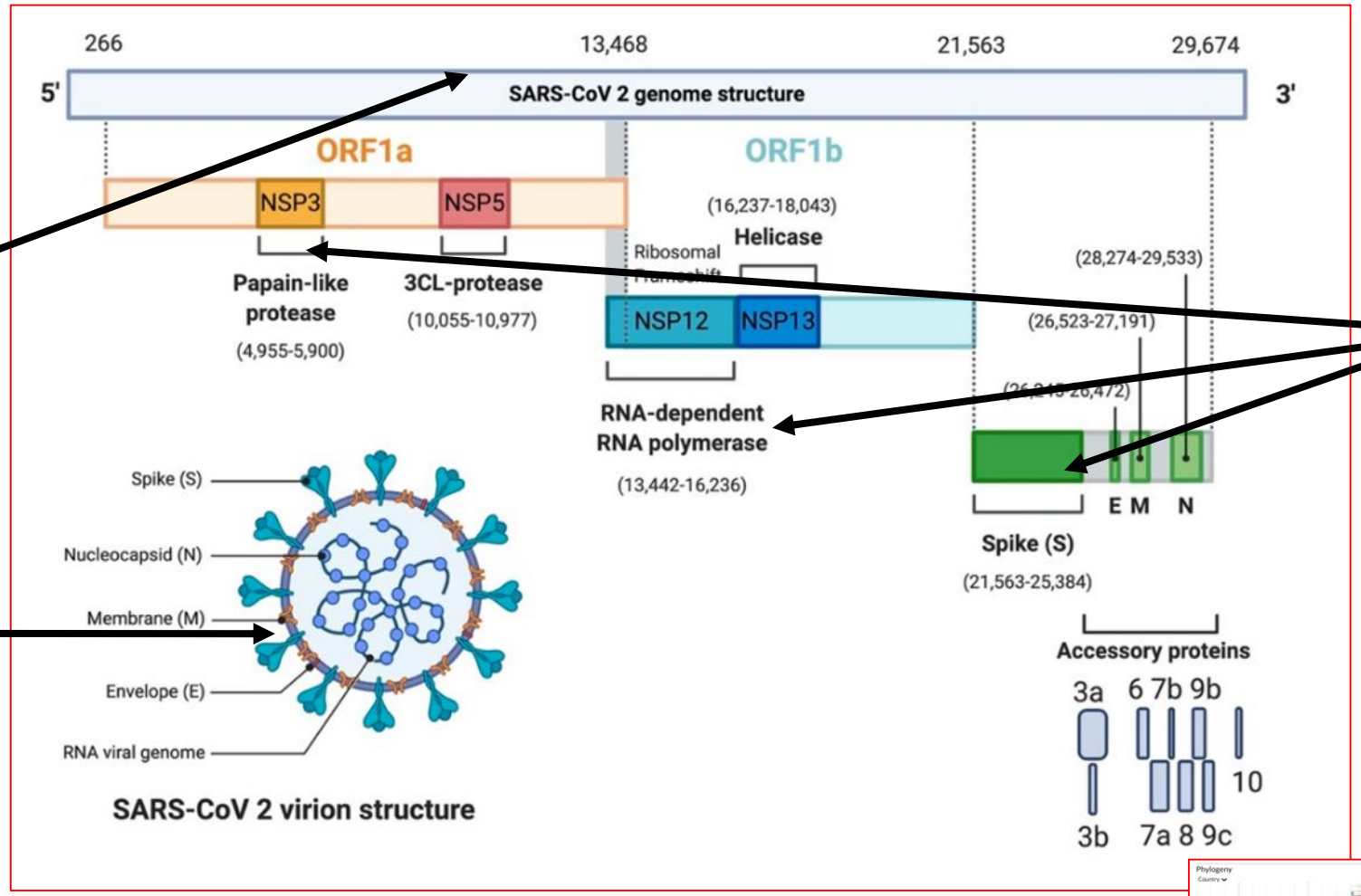
what does viral genomics enable?

Characterize the whole virus and Study its evolution

Study individual parts that make up the virus

Study changes over time

Study the spread of the virus in time and space (see data at https://nextstrain.org/)



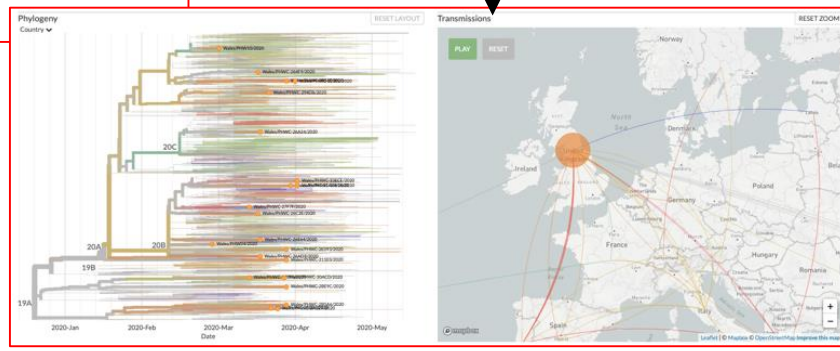
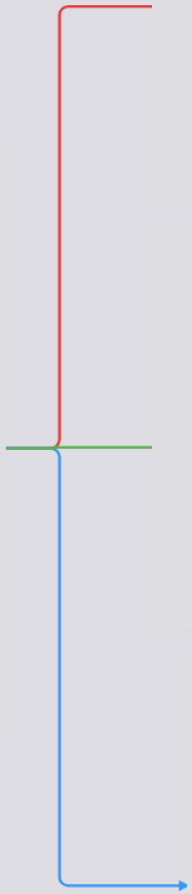


*Image from Alanagreh et al, Pathogens **2020**, ; https://doi.org/10.3390/pathogens9050331*

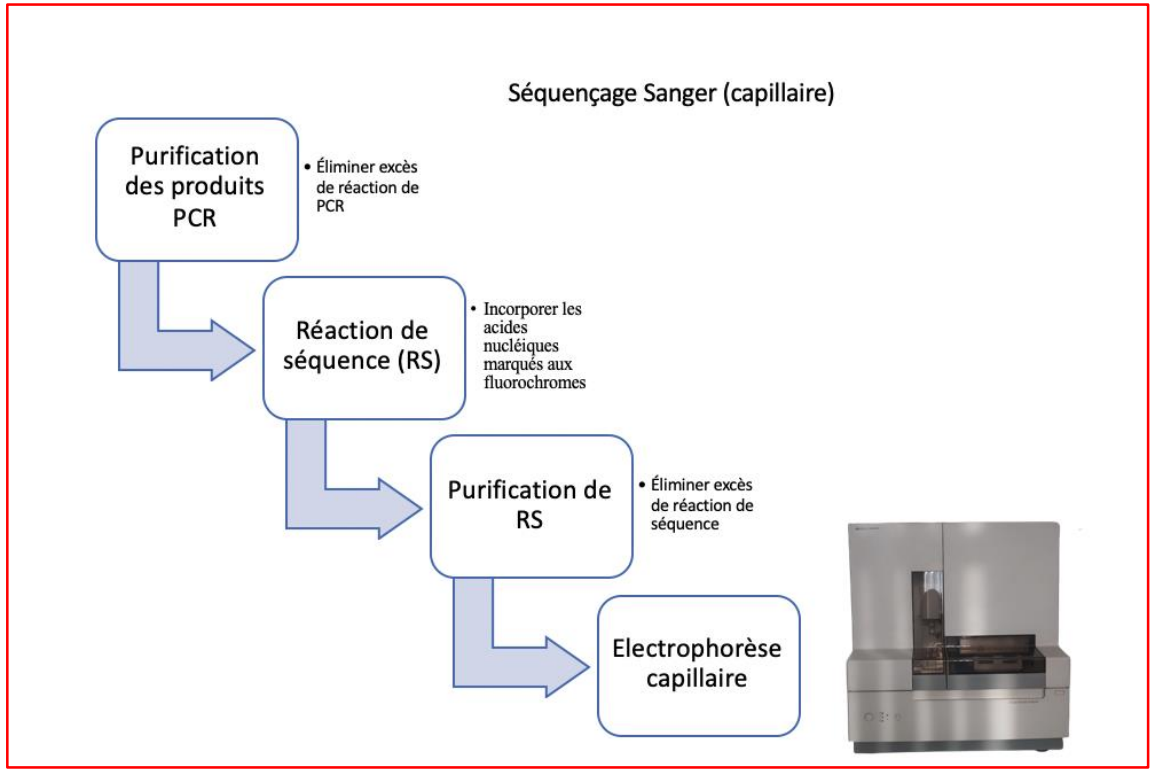
SARS_COV2 New variant genomic surveillance is a required activity for the sanitary authority.



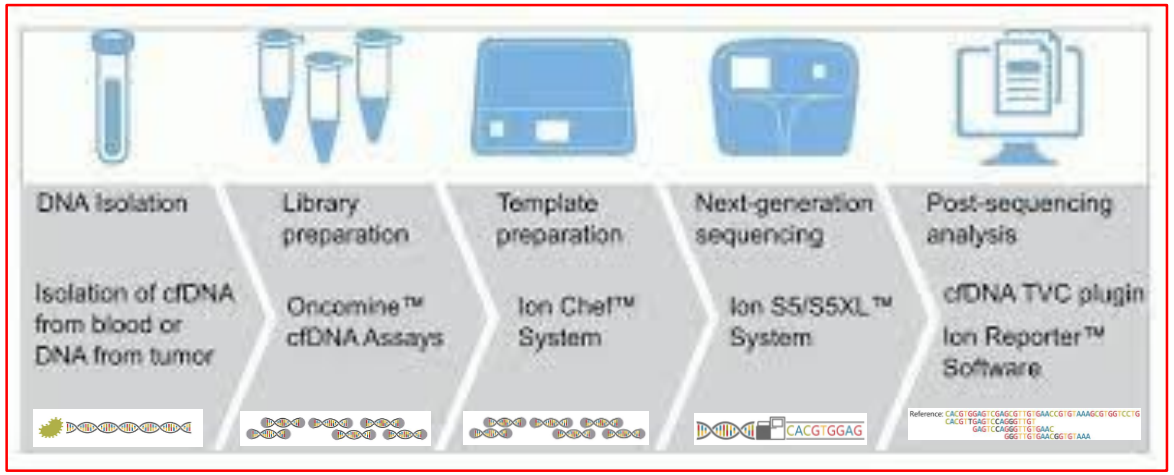
Utility of viral genomics data for Tracking and controlling the pandemic

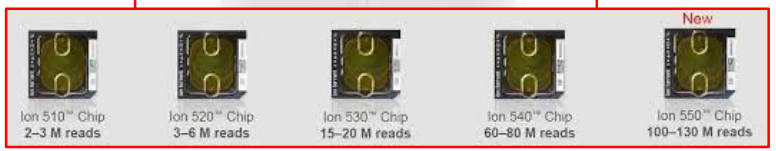
Sequencing Capacity in Morocco

Sanger Sequencing : Targeted sequencing



Sequençage NGS : Whole Génome sequencing





Digitalisation of The genomic and genetic data

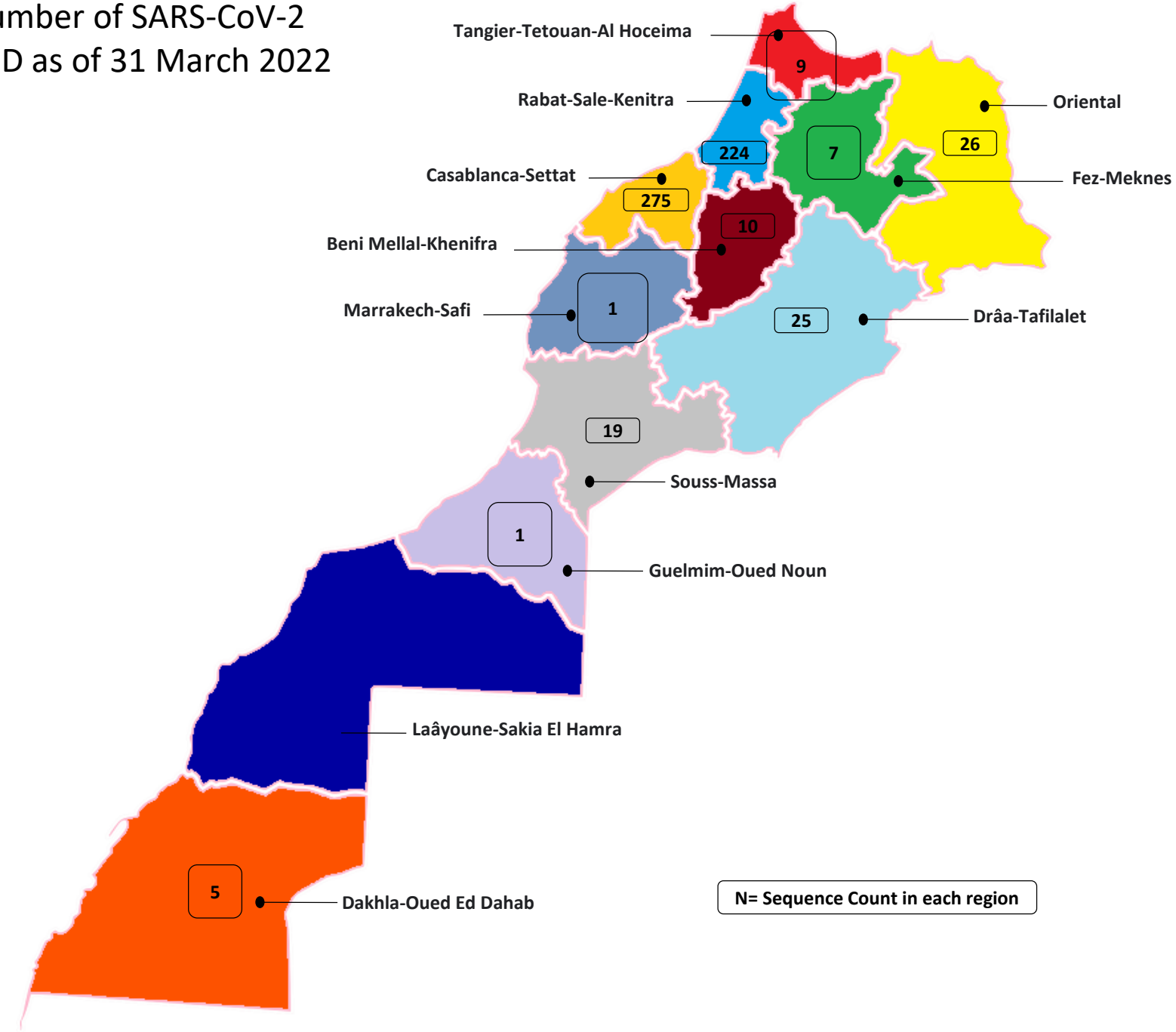
Institute	Query ref				List of mutations																							
GISAID	hCoV-19/Wuhan/WIV04/2019	DATE DE CO	lineage muta	Clade	NSP1	NSP2	NSP3	NSP4	NSP5	NSP6	NSP7	NSP8	NSP9	NSP10	NSP11	NSP12	NSP13	NSP14	NSP15	NSP16	Spike	NS3	E	M	NS6	NS7a	NS7b	NS8	N
IPM	hCoV-19/Morocco/6887/2020 EPI_ISL_459965|2020-03-03	3/3/2020	B.1.1	GR	0											P323L					D614G								R203K, G204R
IPM	hCoV-19/Morocco/6888/2020 EPI_ISL_459966|2020-03-15	15/3/2020	B.1.1	GR					V125I							P323L A449V			R257C		D614G								
IPM	hCoV-19/Morocco/6898/2020 EPI_ISL_459976|2020-03-16	16/3/2020	B.1	GH												P323L E922D					D614G	Q57H							
IPM	hCoV-19/Morocco/6891/2020 EPI_ISL_459969|2020-03-20	20/3/2020	B.1	GH												P323L													
IPM	hCoV-19/Morocco/6894/2020 EPI_ISL_459972|2020-03-20	20/3/2020		G			V1229F, T1830I									P323L													
IPM	hCoV-19/Morocco/6895/2020 EPI_ISL_459973|2020-03-20	20/3/2020		GR												P323L					D614G								R203K, G204R
IPM	hCoV-19/Morocco/6896/2020 EPI_ISL_459974|2020-03-20	20/3/2020		G			V1229F T1830I														D614G								
IPM	hCoV-19/Morocco/6897/2020 EPI_ISL_459975|2020-03-21	21/3/2020		G			P1292L														D614G								
CVMIT	hCoV-19/Morocco/HMIMV-Rabat102-03/2020 EPI_ISL_471456|2020-03	31/3/2020	B.1	G			V1229F T1830I									P323L					V6F D614G								
LNR	hCoV-19/Morocco/RMPS-06/2020 EPI_ISL_469054|2020-04-01	1/4/2020	B.1	GH		T85I										P323L E922D					D614G	Q57H							
LNR	hCoV-19/Morocco/RMPS-03/2020 EPI_ISL_469051|2020-04-03	3/4/2020	B.1	G			V1229F T1830I									P323L					D614G								
IPM	hCoV-19/Morocco/6906/2020 EPI_ISL_459984|2020-04-06	6/4/2020	B.1.1	GR												P323L					D614G								R203K, G204R
CVMIT	hCoV-19/Morocco/HMIMV-Rabat1025-04/2020 EPI_ISL_471457|2020-04-	13/4/2020	B.1.5	G												P323L	H290Y				V6F D614G								
LNR	hCoV-19/Morocco/RMPS-01/2020 EPI_ISL_469017|2020-04-13	13/4/2020	B.1	GH												P323L					D614G	Q57H							
IPM	hCoV-19/Morocco/6904/2020 EPI_ISL_459982|2020-04-18	18/4/2020	B.1	GH												P323L					V6F D614G	Q57H							
CVMIT	hCoV-19/Morocco/HMIMV-Rabat1429-04/2020 EPI_ISL_471458|2020-04-	19/4/2020	B.1.5						N142S							P323L	H290Y				V6F D614G								
CVMIT	hCoV-19/Morocco/HMIMV-Rabat1435-04/2020 EPI_ISL_471459|2020-04-															P323L	H290Y				D614G								
CVMIT	hCoV-19/Morocco/HMIMV-Rab 04/2020 EPI_ISL_4714															P323L	H290Y				D614G V6F L5F								
IPM	hCoV-19/ EPI_ISL		B.1	GH		T85I										P323L					D614G	Q57H							
IPM	hCoV-19/ EPI_ISL_45	19/4/2020	B.1.1	GR			A1819V									P323L					D614G M1237I								R203K, G204R
IPM	hCoV-19/Mo EPI_ISL_4599 -20	20/4/2020	B.1.1	GR			D218E									M196I, P323L			P65S		D614G								R203K, G204R
IPM	hCoV-19/Moro 6903/2020 EPI_ISL_459981|2020-04-19	20/4/2020	B.1	G												P323L		D324A			D614G								
IPM	hCoV-19/Morocco/6899/2020 EPI_ISL_459977|2020-04-21	21/4/2020	B.1.1	GR			D218E									P323L					D614G								R203K, G204R
IPM	hCoV-19/Morocco/6905/2020 EPI_ISL_459983|2020-04-21	21/4/2020	B.1.1	GR			D218E									M196I, P323L		D324A			D614G								R203K, G204R
LRAM	hCoV-19/Morocco/OUA677-19/2020 EPI_ISL_458287|2020-04-23	23/4/2020	B.1	G												P323L S647I		L157F			D614G								

dashboard for monitoring SARS-Cov 2 mutations and their location

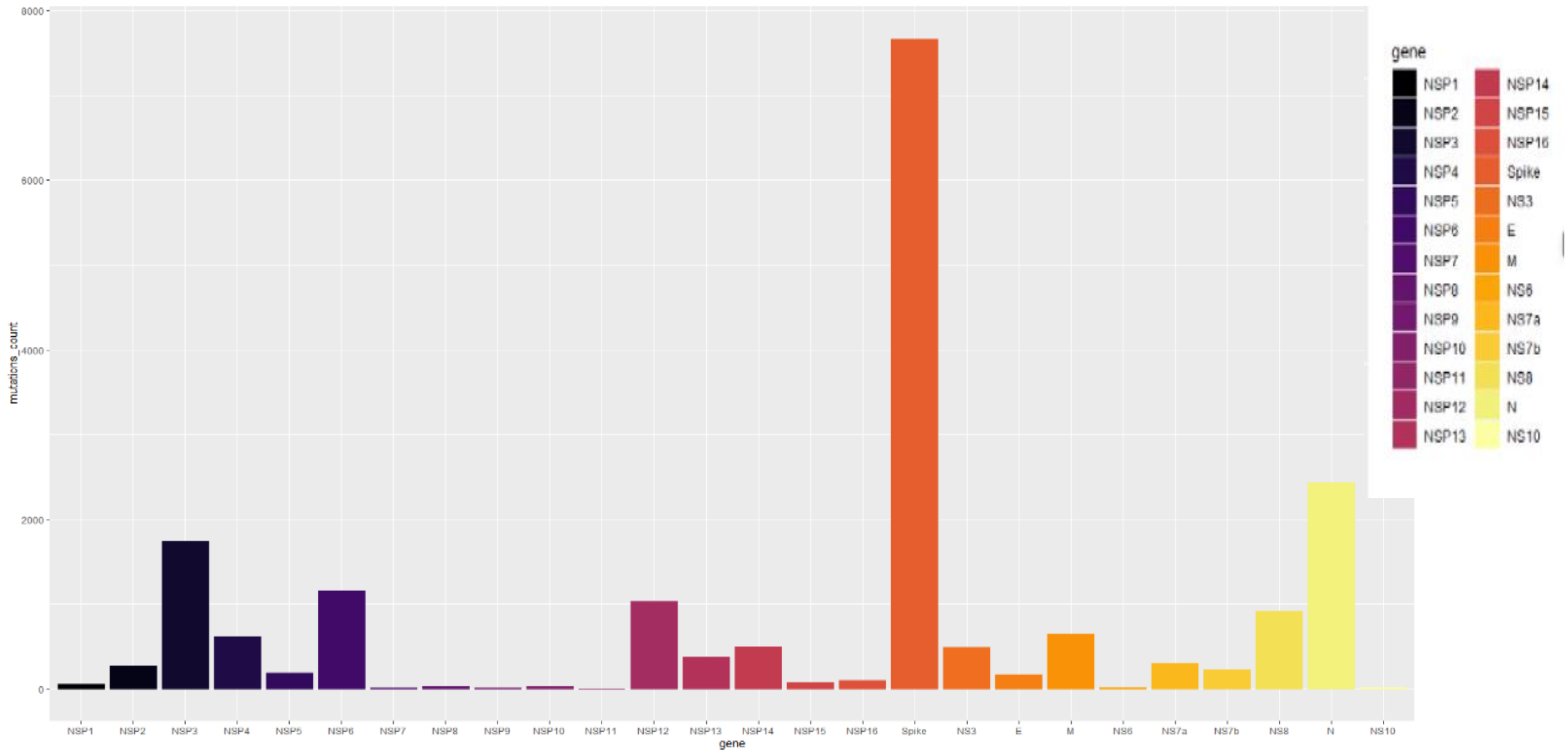
Digitalisation of The genomic and genetic data

Date	Mutations / Contacts	L5F	L18F	T19R	T22I	T29A	Q52R	L54F	Del	D80A	T95I	G142D	Del	Ins	Y145S	Y146N	E154K	E156G	Del 157F-Del 158R	V213L	D215G	R237K	Del	T250I	A262S	T299I	G339S	R346K	V367F	K417N	L452R	T478K	E484K	E484Q	P479S	F490S	N501Y	A570D	Q613H	D614G	Q677H	P681H	P681R	A701V	T716I	I882V	F888L	D950N	S981A	Q1071H	D1118H	VARIANT		
		Leu>Phe	Leu>Phe	Thr>Gln	Thr>Iso	Thr>Ala	Gln>Arg	Leu>Phe	69-70 (HV)	Asp>Ala	Thr>Iso	Gly>Asp	144-Y	144-T	Tyr>Ser	Tyr>Asn	Glu>Lys	Glu>Gly	-	Val>Leu	Asp>Gly	Arg>Lys	LAL 242-244	Thr>Iso	Ala>Ser	Thr>Iso	Arg>Ser	Arg>Lys	Val> Phe	Lys>Asn	Leu>Arg	Thr>Lys	Glu > Lys	Glu>Gln	Pro>Ser	Phe>Ser	Asp>Tyr	Ala>Asp	Gln>His	Asp>Gly	Arg>His	Pro>His	Pro>Ala	Ala>Val	Thr>Iso	Ile>Val	Phe>leu	Asp>His	Ser>Ala	Glu>His	Asp>His			
		21575 :C>T	21614: C>T	21618 :C>G	21627:C>T	21647: A>G	21717:A>G	21724: G>T	Del (21762-63-64) (21766/67) Del (21768/70)	21801: C>T	21846:C>T	21987:G>A	Del 21990/ 21991/ 21993	21989T/ 21991A/21992	21993: A>C	21995: T>A	22022: G>A	22029:-A>G 22030 :G>A	Del 22028:22029/ 22031-22034	22199: G>T	22206:G>A	22272 :T>C	Del 22281-89	22311:C>T	22346: G>T	22458:C>T	22577: G>A	22599: G>A	22661: G>T	22813:G>T	22917: T>G	22995: C>A	23012: G>A	23012:G>C	22997: C>T	22031 : T>C	23063:A>T	23271: C>A	23401: G>T	23403: A>G	23593: G>C	23604: C>A	23604: C>G	23664:C>T	23709: C>T	24206: A>G	24224: T>C	24410:G>A	24506: T>G	24775: A>T	24914: G>C			
23-Apr-21	CAS INDIEN-1	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	OUI	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
28-Apr-21	IPM273	NON	NON	NON	OUI	NON	OUI	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NIGERIA (VOI)	B.1.525	
	IPM274	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
	IPM275	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	ND	ND	ND	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
30-Apr-21	IPM276	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM277	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM278	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM279	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	Anglais (Voc)	B1.1.7	
6-May-21	IPM313	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	NON	P681R	NON	NON	NON	NON	NON	NON	OUI	NON	INDIA-1 (VOC)	B.1.617.1	
	IPM315	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM316	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	ND	ND	NON	NON	NON	ND	ND	ND	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM317	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
10-May-21	IPM318	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
	IPM319	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM320	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM321	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
	IPM325	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
	IPM326	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM327	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM328	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM329	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM330	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
	IPM331	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM332	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
31-May-21	IPM361	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	G142V	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	ND	NON	ND	Anglais (Voc)	B1.1.7	
	IPM367	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	ND	NON	ND	Anglais (Voc)	B1.1.7	
	IPM368	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	OUI	NON	ND	Anglais (Voc)	B1.1.7	
	IPM369	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	ND	NON	ND	Anglais (Voc)	B1.1.7	
	IPM370	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	ND	NON	ND	Anglais (Voc)	B1.1.7	
	IPM371	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	ND	NON	ND	Anglais (Voc)	B1.1.7	
	IPM376	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	OUI	NON	ND	Anglais (Voc)	B1.1.7	
	IPM380	NON	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	Afrique.S (VOC)	B.1.351	
4-Jun-21	IPM392	NON	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	Afrique.S (VOC)	B.1.351	
	IPM398	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	Anglais (Voc)	B1.1.7	
12-Jun-21	IPM406	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
	IPM408	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
19-Jun-21	IPM409	NON	NON	NON	NON	NON	NON	NON	ND	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	ND	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	ND	NON	ND	Anglais (Voc)	B1.1.7	
	IPM410	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	OUI	NON	OUI	Anglais (Voc)	B1.1.7	
	IPM411	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	ND	NON	NON	ND	NON	NON	NON	ND	NON	ND	Anglais (Voc)	B1.1.7	
	IPM412	NON	NON	ND	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	ND	ND	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	NON	NON	NON	NON	NON	OUI	NON	NON	P681R	NON	NON	NON	NON	OUI	NON	NON	NON	INDIA-2 (VOC)	B.1.617.2	
	IPM435	NON	NON	NON	NON	NON	NON	NON	OUI	NON	NON	NON	OUI	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	OUI	OUI	NON	OUI	NON	P681H	NON	NON	OUI	NON	NON	NON	ND	NON	OUI	Anglais (Voc)	B1.1.7	

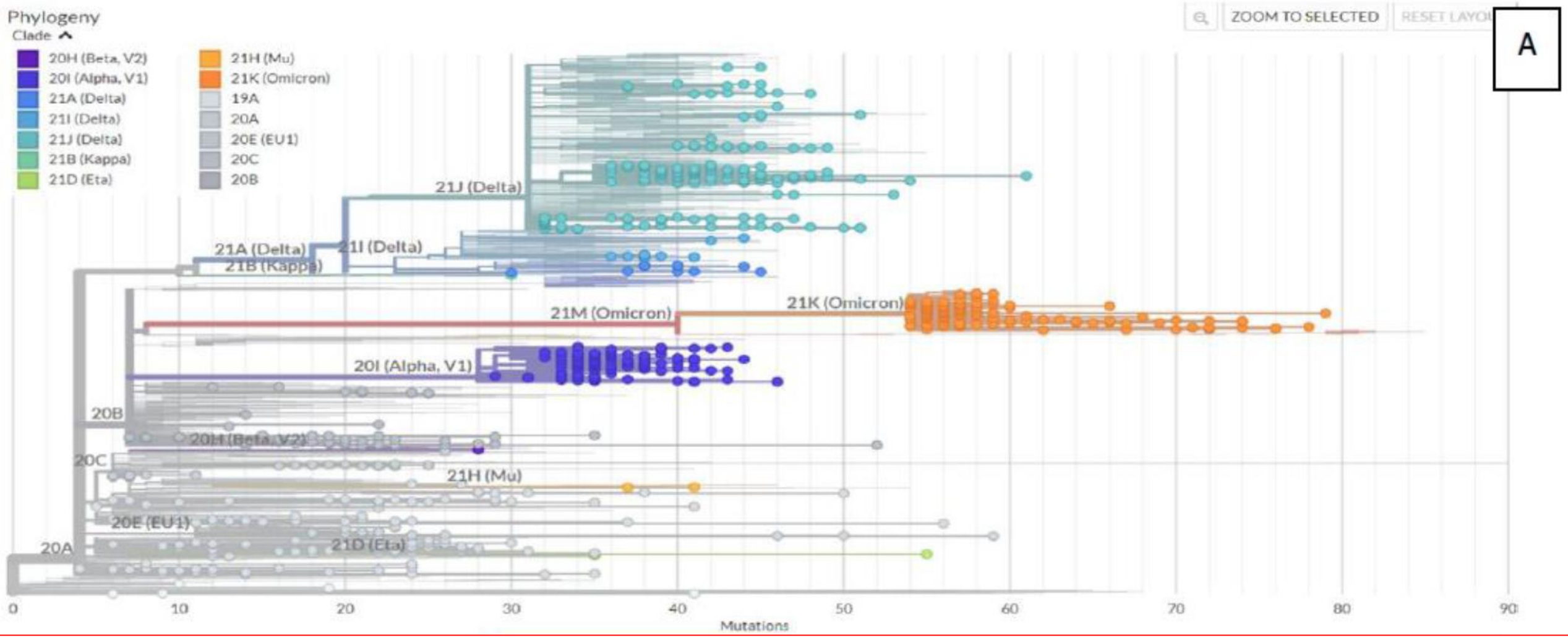
Map of Morocco with the number of SARS-CoV-2 sequences reflected in GISAID as of 31 March 2022



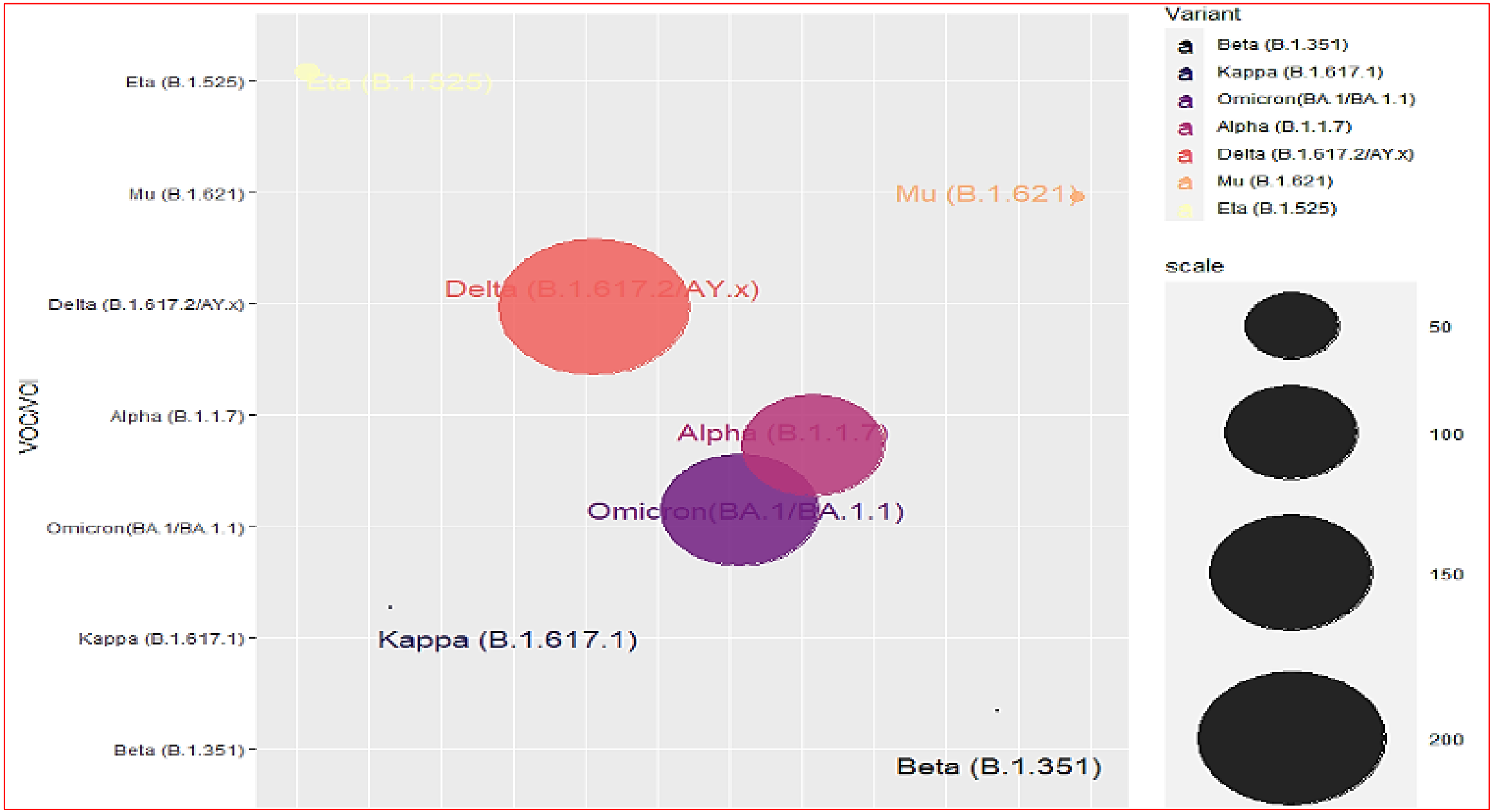
Deciphering the mutational landscape of SARS-CoV 2 in Morocco



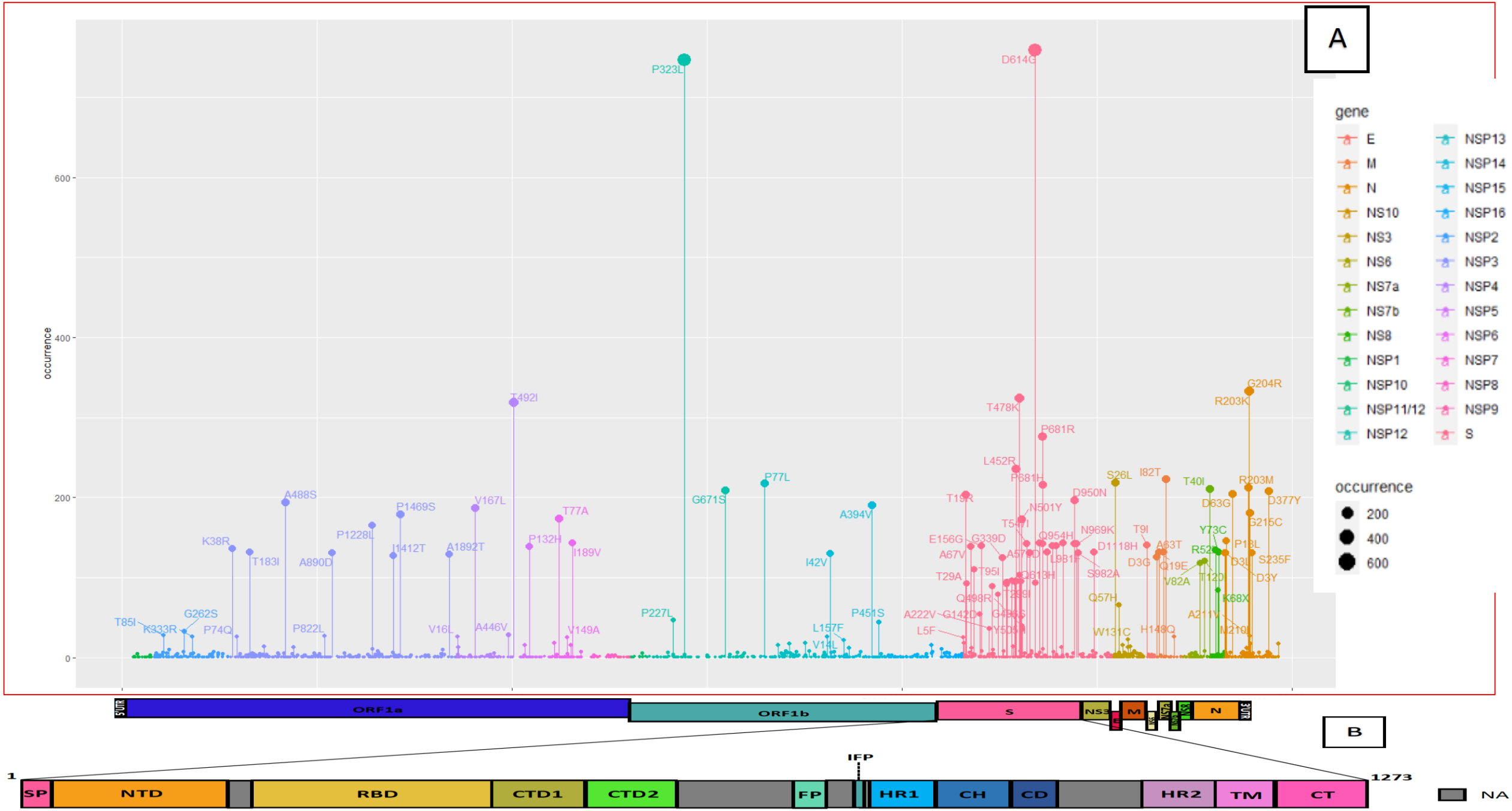
The genome of SARS-CoV-2 has rapidly acquired numerous mutations, giving rise to several Variants of Concern (VOCs) with altered epidemiological, immunological, and pathogenic properties



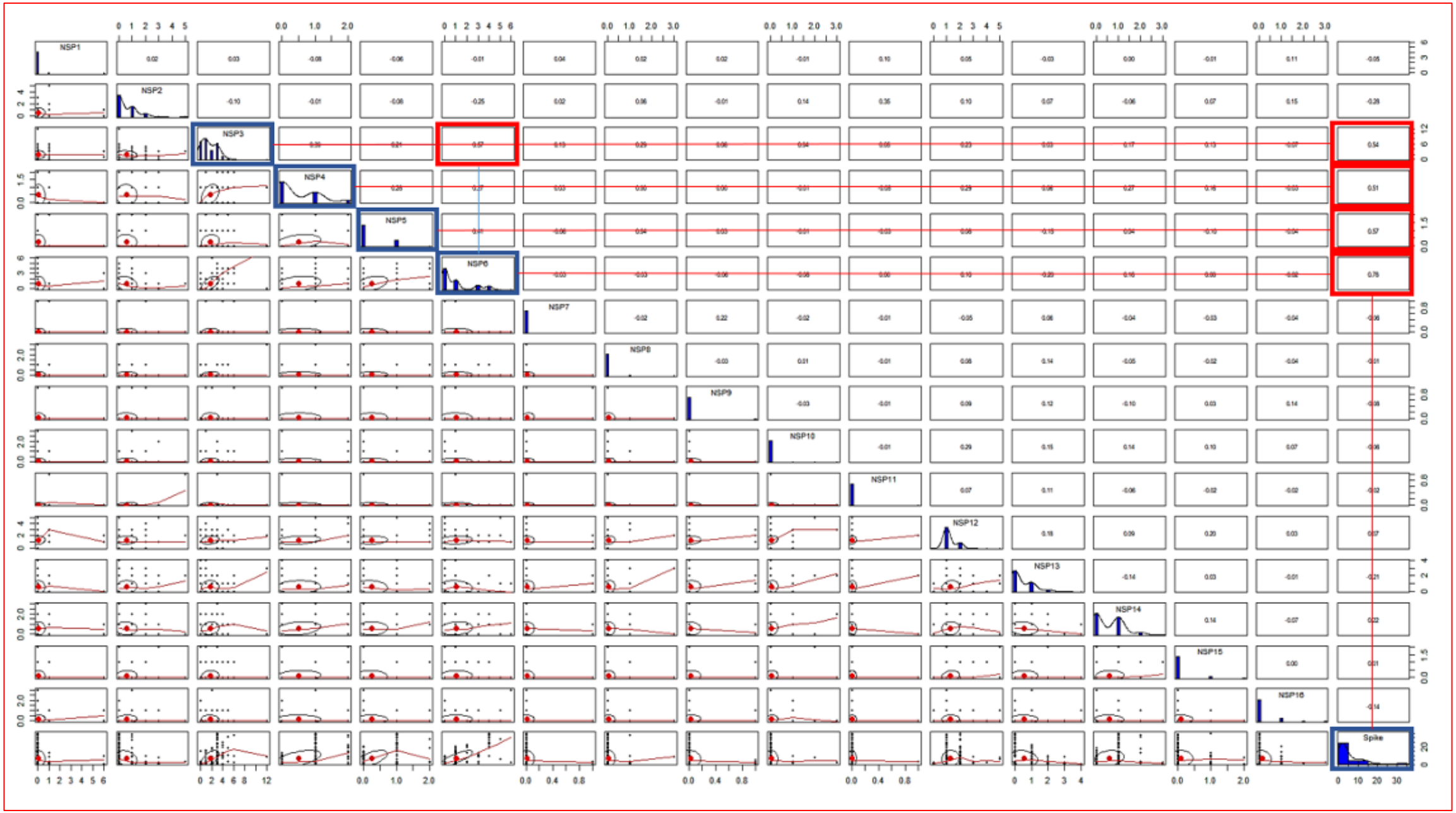
Proportions of VOI/VOC during The pandemic In Morocco



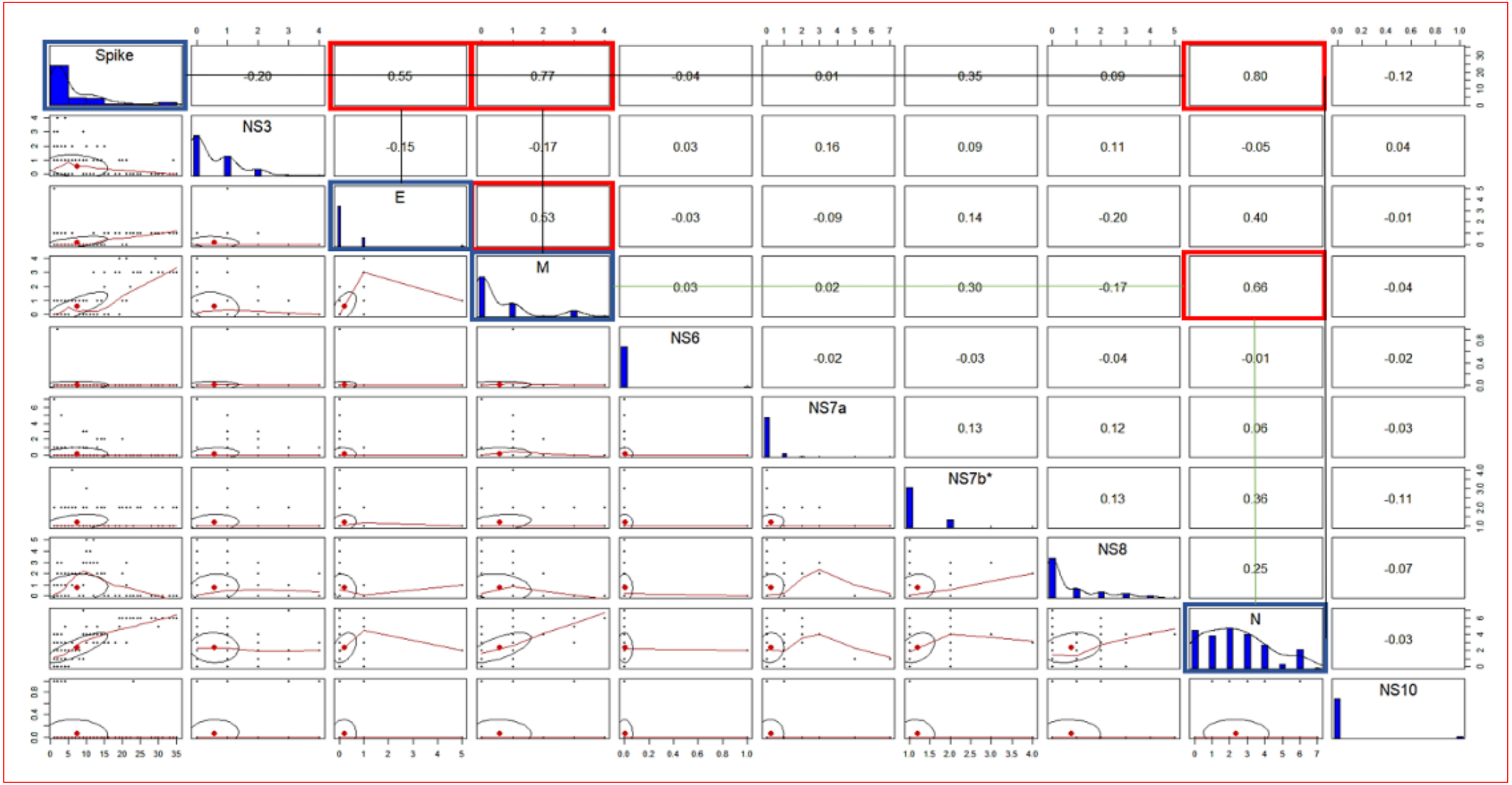
D614G located in the spike gene and P323L in NSP12 are the highest recorded mutations worldwide, that is also the case in Morocco



Pearson correlation test describing the relation between non structural protein and the Spike gene



Pearson correlation test describing the relation between structural protein and the Spike gene



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GENOME SEQUENCES
Month YYYY Volume XX Issue XX e00063-22
https://doi.org/10.1128/mra.00063-22

Coding-Complete Sequence of a SARS-CoV-2 Strain from an Omicron (B.1.1.529+BA.1) Variant Detected in Morocco

Taha Chouati[a,b], Mouhssine Hemlali[a,b], Marouane Melloul[a,e], Sanaa Alaoui-Amine[a,b], Safae Rhoulam[a], Hamza Ghamaz[a,b], Maha Ouarab[a,b], Omar Askander[f], Lamiae Belayachi[g], Nadia Touil[c], Bouchra El Mchichi[c], Hicham Elannaz[c], Abdelillah Laraqui[c], Mostafa Elouennass[d], Khalid Ennibi[c], Elmostafa El Fahime[a,b]

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GENOME SEQUENCES
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Coding-Complete Genome Sequences of a Delta Subvariant (AY.33) of SARS-CoV-2 Obtained from Moroccan COVID-19 Patients

Mouhssine Hemlali,[a,b] Taha Chouati,[a,b] Hamza Ghammaz,[a,d] Marouane Melloul,[a,d] Sanaâ Alaoui Amine,[a,b] Safaa Rhoulam,[a] Nadia Touil,[c,i] Khalid Ennibi,[h] Hicham Oumzil,[g] Rhajaoui Mohamed,[f] Aguenaou Hassan,[e] Elmostafa El Fahime[a,b]

AMERICAN SOCIETY FOR MICROBIOLOGY | Microbiology Resource Announcements
GENOME SEQUENCES
September 2021 Volume 10 Issue 39 e00727-21
https://doi.org/10.1128/MRA.00727-21

Genome Sequences of the Delta Variant (B.1.617.2) and the Kappa Variant (B.1.617.1) Detected in Morocco

Marouane Melloul[a,b], Taha Chouati[a], Mouhssine Hemlali[a,b], Sanaa Alaoui Amine[a,b], Nadia Touil[b], Hicham Elannaz[c], Khalid Ennibi[c], Mohammed Youbi[d], Mouad Merabet[d], Abdelkrim Meziane Bellefquih[d], Jalal Nourlil[e], Abderrahmane Maaroufi[f], and Elmostafa El Fahime[a,b]

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Complete Genome Sequence of a SARS-CoV-2 Strain Sampled in Morocco in May 2020, Obtained Using Sanger Sequencing

Abderrazak Rfaki,[a,b] Nadia Touil,[b,c] Mouhssine Hemlali,[a,b] Sanaâ Alaoui Amine,[a,b] Marouane Melloul,[a,b] Moulay Abdelaziz El Alaoui,[a,d] Hicham Elannaz,[c] Amine Idriss Lahlou,[c] Mostafa Elouennass,[c] Khalid Ennibi,[c] Elmostafa El Fahime[a,b]

2021: E Wilkinson, M Giovanetti, H Tegally, JE San, R Lessels, D Cuadros, …and al., [A year of genomic surveillance reveals how the SARS-CoV-2 pandemic unfolded in Africa.](#) **Science 374 (6566), 423-431**

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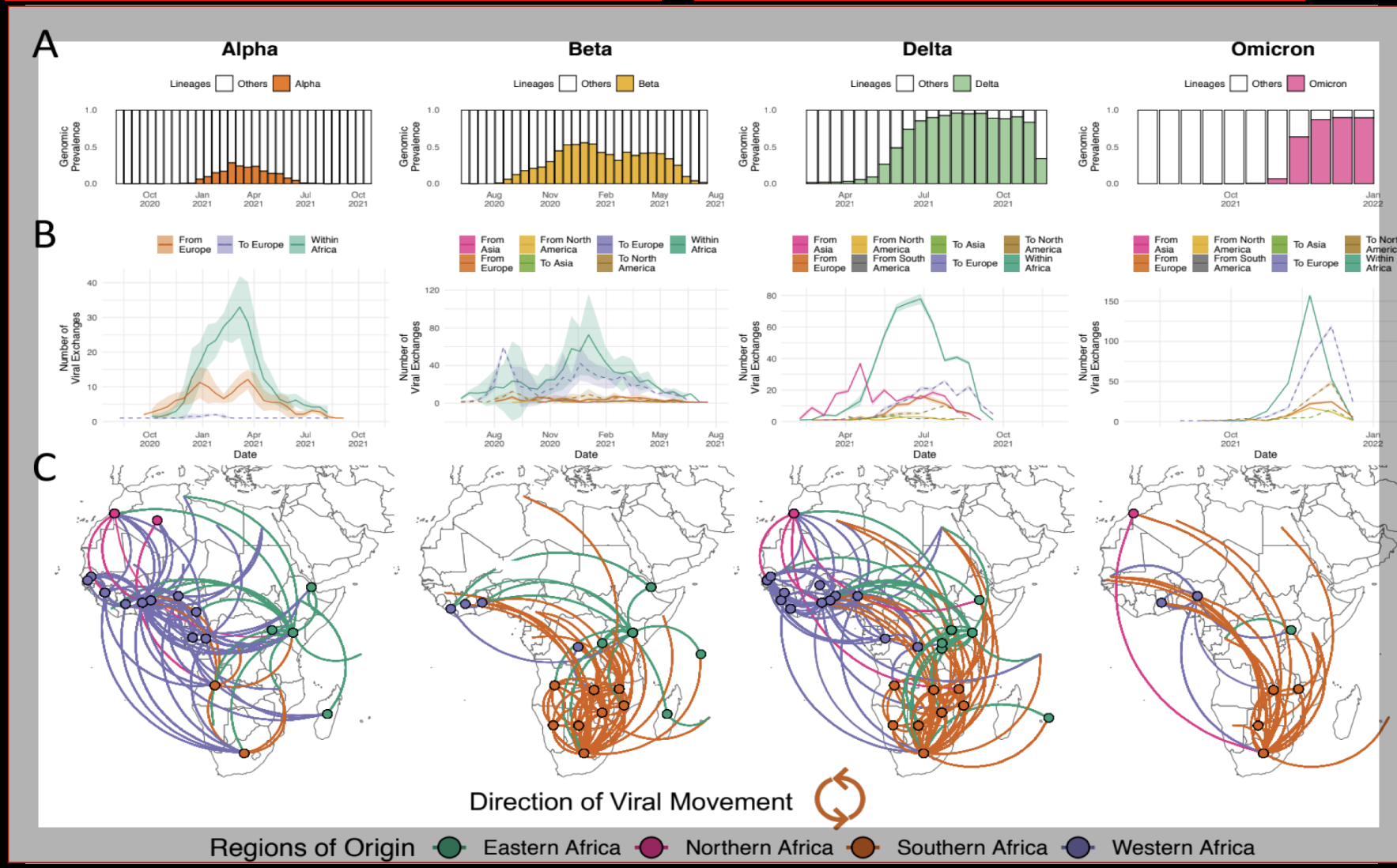
RESEARCH ARTICLE | CORONAVIRUS

A year of genomic surveillance reveals how the SARS-CoV-2 pandemic unfolded in Africa

EDUAN WILKINSON, MARTA GIOVANETTI, HOURIIYAH TEGALLY, JAMES E. SAN, RICHARD LESSELLS, DIEGO CUADROS, DARREN P. MARTIN, DAVID A. RASMUSSEN, ABDEL-RAHMAN N. ZEKRI, [...] TULIO DE OLIVEIRA +293 authors
Authors Info & Affiliations

SCIENCE • 9 Sep 2021 • Vol 374, Issue 6566 • pp. 423-431 • DOI: 10.1126/science.abj4336

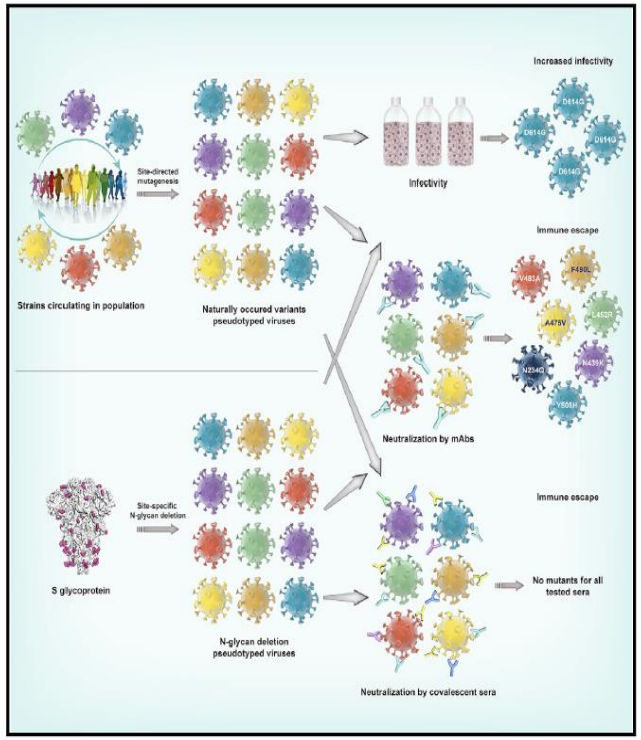


Cell

Article

The Impact of Mutations in SARS-CoV-2 Spike on Viral Infectivity and Antigenicity

Graphical Abstract



Highlights

- Over 100 mutations were selected for analyses on their infectivity and antigenicity
- The dominant D614G itself and combined with other mutations are more infectious
- Ablation of both N331 and N343 glycosylation at RBD drastically reduced infectivity

Authors

Qianqian Li, Jiajing Wu, Jianhui Nie, ..., Xuguang Li, Weijin Huang, Youchun Wang

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In Brief

Eighty natural variants and 26 glycosylation spike mutants of SARS-CoV-2 were analyzed in terms of infectivity and antigenicity using high throughput pseudovirus assay in conjunction with neutralizing antibodies.

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Article

The Impact of Mutations in SARS-CoV-2 Spike on Viral Infectivity and Antigenicity

Qianqian Li,[1,2,5] Jiajing Wu,[1,5] Jianhui Nie,[1,5] Li Zhang,[1,5] Huan Hao,[1] Shuo Liu,[1] Chenyan Zhao,[1] Qi Zhang,[3] Huan Liu,[1] Lingling Nie,[1] Haiyang Qin,[1] Meng Wang,[1] Qiong Lu,[1] Xiaoyu Li,[1] Qiyu Sun,[1] Junkai Liu,[1] Linqi Zhang,[3] Xuguang Li,[4] Weijin Huang,[1,*] and Youchun Wang[1,2,6,*]

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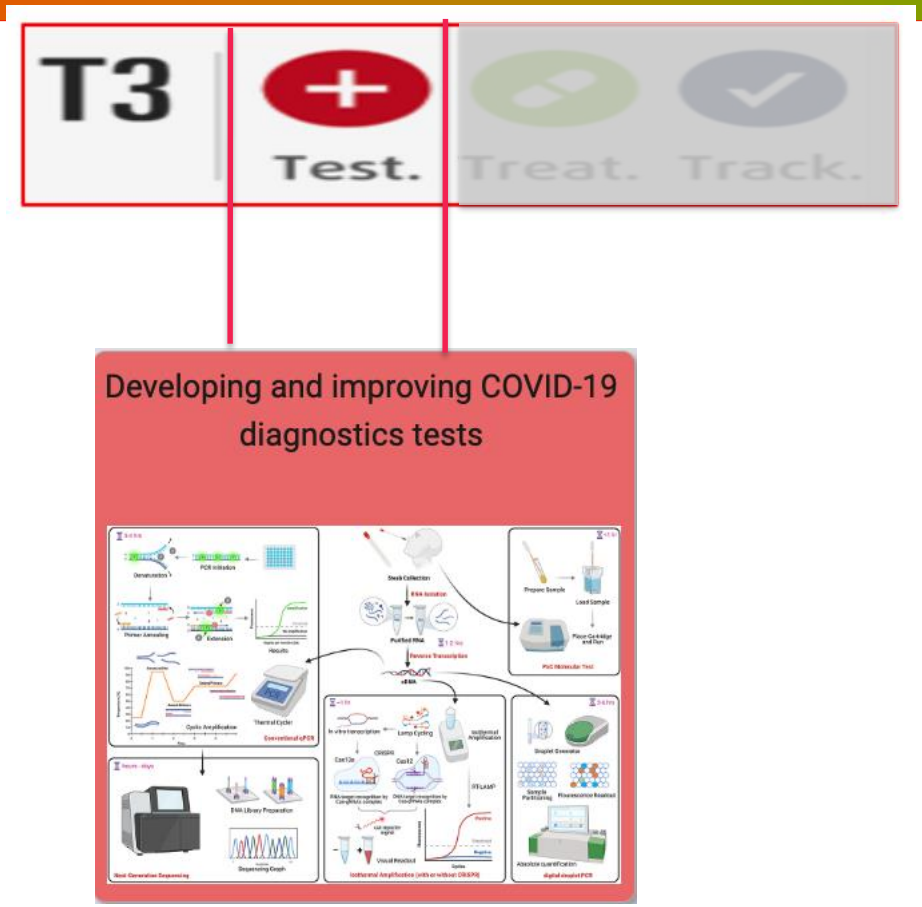
https://doi.org/10.1016/j.cell.2020.07.012

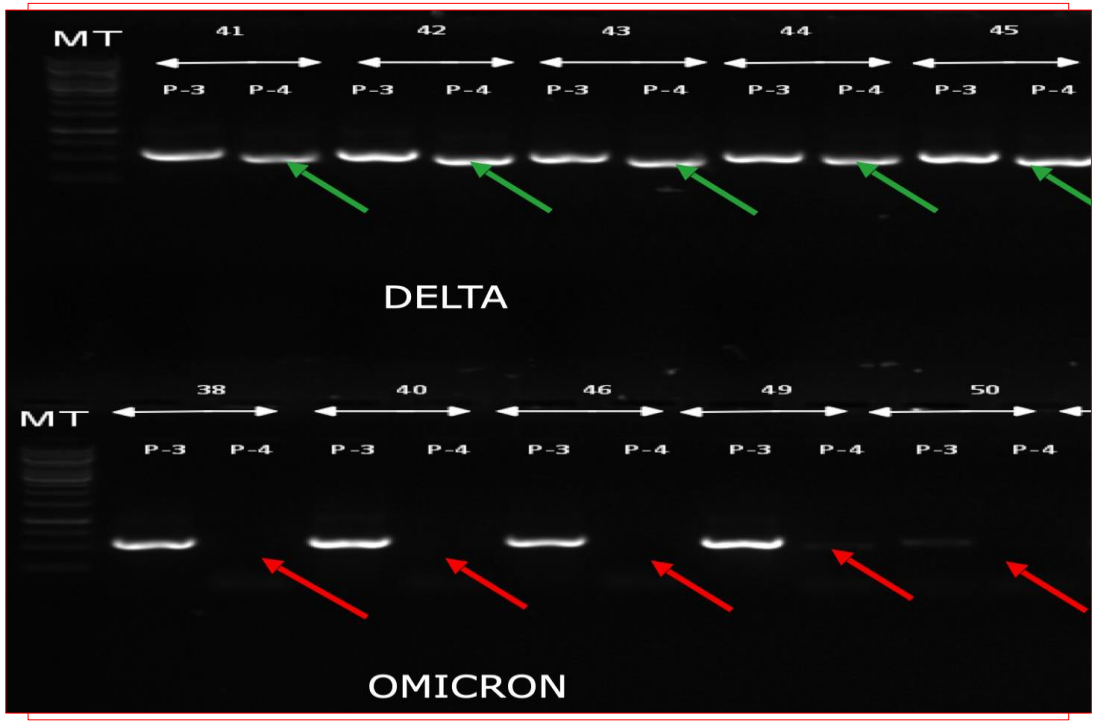
SUMMARY

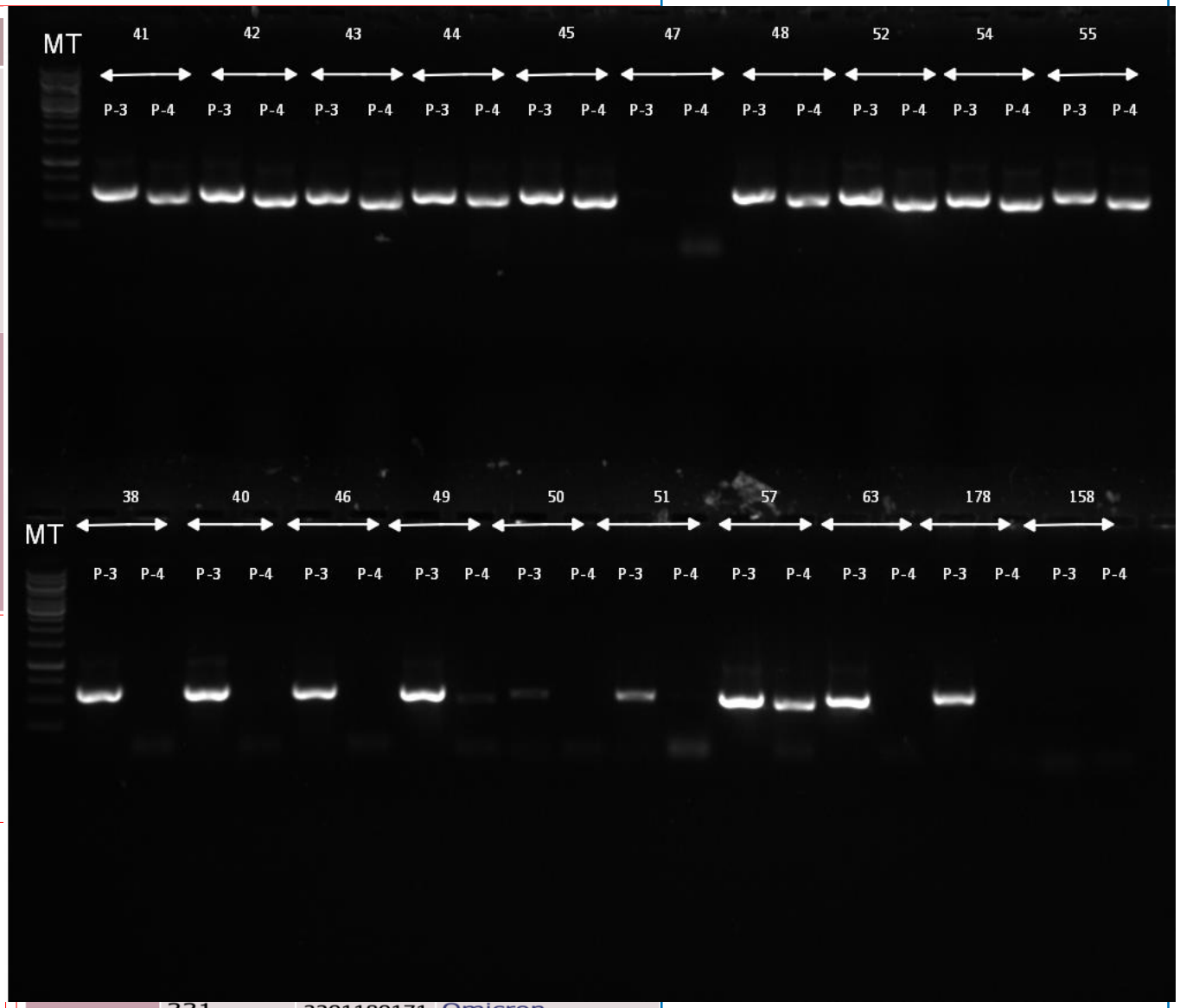
The spike protein of SARS-CoV-2 has been undergoing mutations and is highly glycosylated. It is critically important to investigate the biological significance of these mutations. Here, we investigated 80 variants and 26 glycosylation site modifications for the infectivity and reactivity to a panel of neutralizing antibodies and sera from convalescent patients. D614G, along with several variants containing both D614G and another amino acid change, were significantly more infectious. Most variants with amino acid change at receptor binding domain were less infectious, but variants including A475V, L452R, V483A, and F490L became resistant to some neutralizing antibodies. Moreover, the majority of glycosylation deletions were less infectious, whereas deletion of both N331 and N343 glycosylation drastically reduced infectivity, revealing the importance of glycosylation for viral infectivity. Interestingly, N234Q was markedly resistant to neutralizing antibodies, whereas N165Q became more sensitive. These findings could be of value in the development of vaccine and therapeutic antibodies.

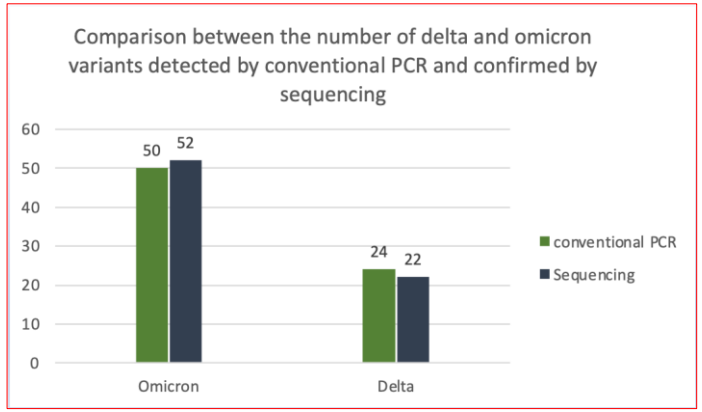


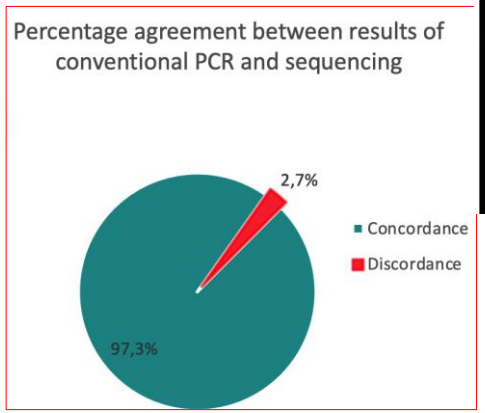
Utility of viral genomics data for the development of rapid diagnostic test

Data from viral genomes will be used to build rapid screening tools, which will be critical in the management and control of pandemics.

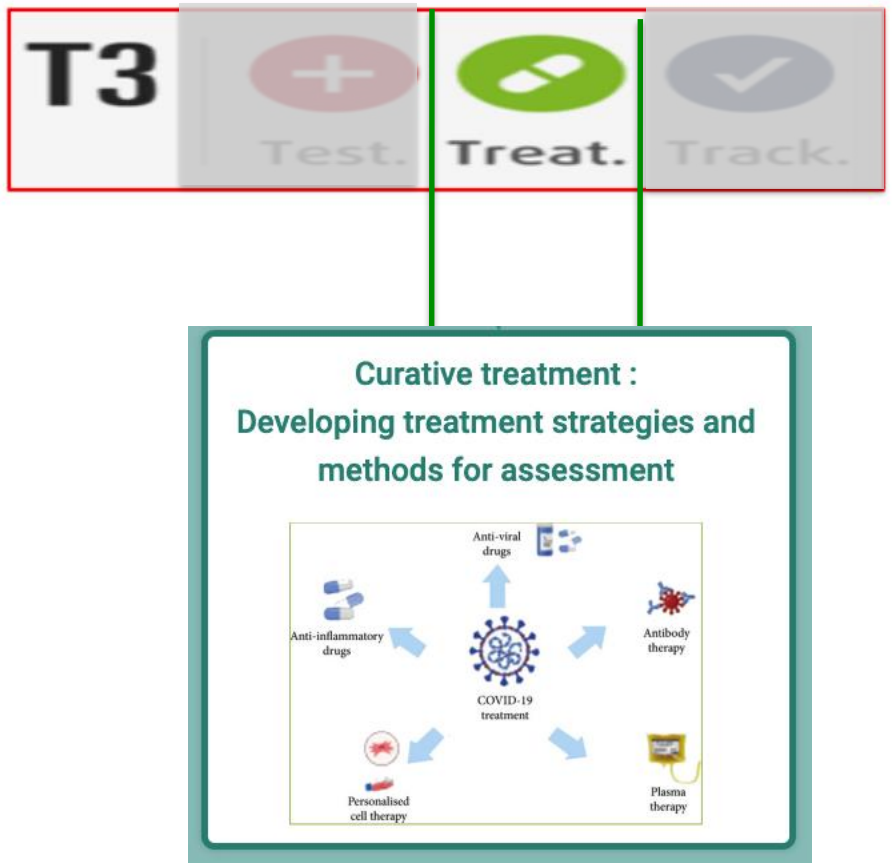








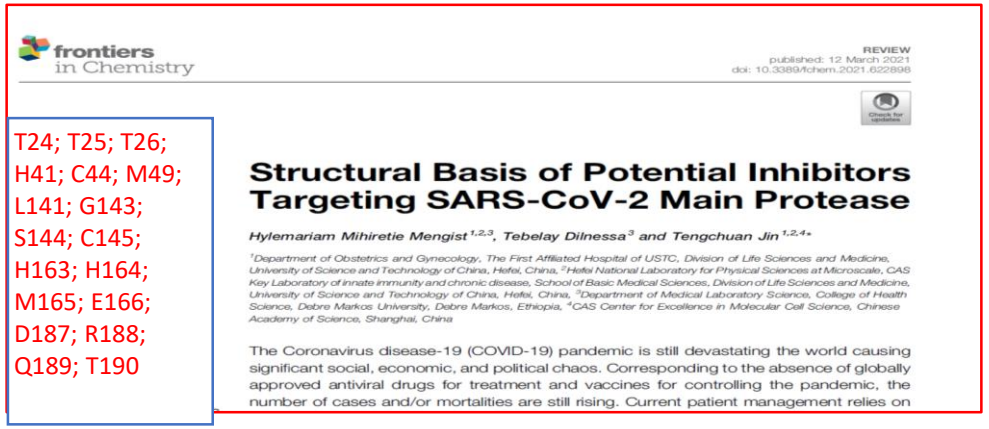
CHU Plaque 4	221	2201180171	Omicron
	222	2201180274	Omicron
	223	2201180447	Omicron
	224	2201180625	Omicron
	225	2201180628	Omicron
	226	2201180629	Omicron



Utility of viral genomics data for the development antiviral Treatments

Mpro: Potential therapeutic target for the creation of anti-SARS-CoV-2 treatment

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	ID	Date de collec	Région	Age	Sex	Lign	ade (Gl	de (Next	NSP1	NSP2	NSP3	NSP	NSP	NSP	NSP	NSP	NSP	NSP1	NSP1	NSP1	NSP1	NSP1	NSP1	NSP1	Spik	NS3	E	M	NS6	NS7	NS7	NS8	N	NS1	nomb
2	4899863	2/2/2020	Rabat	60	Male	B.1.221	G	20A			E195D	V293L								P323L	P300L	R163C			S98F	Q38R							A35V		1
3	4899863	2/2/2020	Rabat	60	Male	B.1.221	G	20A			H295Y										D583A				D614G	S74N							P199L		1
4	4899863	2/2/2020	Rabat	60	Male	B.1.221	G	20A			F1687L															G172R									1
5	4899863	2/2/2020	Rabat	60	Male	B.1.221	G	20A																		V202L									1
6	4899870	2/2/2020	Rabat	63	Female	B.1	G	20A						A166T						P323L					D614G	R134L							T205I		1
7	4899881	2/2/2020	Rabat	57	Female	B.1	G	20A		S36F		E310K								D67V					D614G		A36V			A55E		P30S			1
8	4899881	2/2/2020	Rabat	57	Female	B.1	G	20A												H39R					K1255I										1
9	4899881	2/2/2020	Rabat	57	Female	B.1	G	20A												P323L															
10	4899888	2/2/2020	Rabat	65	Male	B.1.221	G	20A		P129S	H295Y		A193V							P323L	D583A				S98F	Q38R							P199L		1
11	4899888	2/2/2020	Rabat	65	Male	B.1.221	G	20A			L1418I									P339S	A598V				D614G	G172R							A211S		1
12	4899888	2/2/2020	Rabat	65	Male	B.1.221	G	20A																		V202L									1
13	4899892	2/2/2020	Rabat	46	Male	B.1.160	GH	20A		S211F	D178Y	V293I	V296D			V34F				A185S		D48N	N163D		N148T	Q57H							S180R		1
14	4899892	2/2/2020	Rabat	46	Male	B.1.160	GH	20A		E292D		V294K	R298C							P323L		M153I			S477N								Q303E		1
15	4899892	2/2/2020	Rabat	46	Male	B.1.160	GH	20A												D358E					D614G								A376T		1
16	4899892	2/2/2020	Rabat	46	Male	B.1.160	GH	20A												V776L															1
17	4899898	2/2/2020	Rabat	55	Male	B.1.177	O	20E (EU1)		I251M	E1487K	V293L		H11N						P323L	T351I			K160R	A222V			F103L				A65V	A220V	V30L	1
18	4899898	2/2/2020	Rabat	55	Male	B.1.177	O	20E (EU1)			K1909N			L15I										H186D	F400L			A104S					P365S		1
19	4899898	2/2/2020	Rabat	55	Male	B.1.177	O	20E (EU1)						L16I										A192T	D614G								D371H		1
20	4899898	2/2/2020	Rabat	55	Male	B.1.177	O	20E (EU1)						N82K																			K373*		1
21	4899898	2/2/2020	Rabat	55	Male	B.1.177	O	20E (EU1)						M83T																					1
22	4899898	2/2/2020	Rabat	55	Male	B.1.177	O	20E (EU1)						Y85N																					1
23	4899903	2/2/2020	Rabat	76	Female	B.1.177	O	20E (EU1)		I251M	V1315I	R306K		A161T						P323L	T351I				A222V	T208A							A220V	V30L	1
24	4899903	2/2/2020	Rabat	76	Female	B.1.177	O	20E (EU1)		I296N	L1361I			Y253N											D614G	D210N							P365S		1
25	4899903	2/2/2020	Rabat	76	Female	B.1.177	O	20E (EU1)						M254I												E226G									1
26	4899911	2/2/2020	Rabat	62	Male	B.1.177	O	20E (EU1)	V54I	I251M	Q167R		A129G	M83K		I156T		T12N		P323L	T351I	F326L		E173G	A222V	T32A				C58*		H40N	P13L	V30L	1
27	4899911	2/2/2020	Rabat	62	Male	B.1.177	O	20E (EU1)		F455L	A338T		N221T							E436G					D614G	S117G						I76T	A220V		1
28	4899911	2/2/2020	Rabat	62	Male	B.1.177	O	20E (EU1)			L863I									Y867D					T723S	N119H							P365S		1
29	4899911	2/2/2020	Rabat	62	Male	B.1.177	O	20E (EU1)			T943I														M1229T	I179M									1
30	4899911	2/2/2020	Rabat	62	Male	B.1.177	O	20E (EU1)			G1433D																								1
31	4899917	2/2/2020	Rabat	66	Female	B.1	G	20A	H165Y		S650F									P323L	A296S	P297S			D614G								N8T		1
32	4899917	2/2/2020	Rabat	66	Female	B.1	G	20A														T472M			G769V								Q384R		1
33	476559	2/27/2020	unknown	unknown	unknown	B.1	G	20A												P323L					D614G										1
34	459965	3/3/2020	unknown	unknown	unknown	B.1.1	GR	20B												P323L					D614G								R203K		1
35	459965	3/3/2020	unknown	unknown	unknown	B.1.1	GR	20B																									G204R		1
36	459966	3/15/2020	unknown	unknown	unknown	B.1.1	GR	20B					V125I							P323L			R257C		D614G								R203K		1
37	459966	3/15/2020	unknown	unknown	unknown	B.1.1	GR	20B												A449V													G204R		1
38	459967	3/15/2020	unknown	unknown	unknown	B.1	G	20A												P323L					D614G										1
39	459976	3/16/2020	unknown	unknown	unknown	B.1	GH	20A												P323L					D614G	Q57H									1
40	459976	3/16/2020	unknown	unknown	unknown	B.1	GH	20A												E922D															1
41	459968	3/17/2020	unknown	unknown	unknown	B.1	G	20A												P323L					D614G										1
42	459971	3/18/2020	unknown	unknown	unknown	B.1.153	G	20A					V157L					R134S		P323L		Y420C		I169L	D614G										1
43	459971	3/18/2020	unknown	unknown	unknown	B.1.153	G	20A												M380I				K170*											1
44	459969	3/20/2020	unknown	unknown	unknown	B.1	GH	20A												P323L					D614G	Q57H									1
45	459972	3/20/2020	unknown	unknown	unknown	B.1	G	20A			V1229F									P323L					D614G										



frontiers in Chemistry

REVIEW
published: 12 March 2021
doi: 10.3389/fchem.2021.622898

T24; T25; T26;
H41; C44; M49;
L141; G143;
S144; C145;
H163; H164;
M165; E166;
D187; R188;
Q189; T190

Structural Basis of Potential Inhibitors Targeting SARS-CoV-2 Main Protease

Hylemariam Mihiretie Mengist[1,2,3], Tebelay Dilnessa[3] and Tengchuan Jin[1,2,4]

[1]Department of Obstetrics and Gynecology, The First Affiliated Hospital of USTC, Division of Life Sciences and Medicine, University of Science and Technology of China, Hefei, China, [2]Hefei National Laboratory for Physical Sciences at Microscale, CAS Key Laboratory of innate immunity and chronic disease, School of Basic Medical Sciences, Division of Life Sciences and Medicine, University of Science and Technology of China, Hefei, China, [3]Department of Medical Laboratory Science, College of Health Science, Debre Markos University, Debre Markos, Ethiopia, [4]CAS Center for Excellence in Molecular Cell Science, Chinese Academy of Science, Shanghai, China

The Coronavirus disease-19 (COVID-19) pandemic is still devastating the world causing significant social, economic, and political chaos. Corresponding to the absence of globally approved antiviral drugs for treatment and vaccines for controlling the pandemic, the number of cases and/or mortalities are still rising. Current patient management relies on

Total des séquences analysés	**506**
Avec mutation	93
Sans mutation	413
Mutations au niveau du site actif M-Pro	**1:** (FMP-82)/(M49I)

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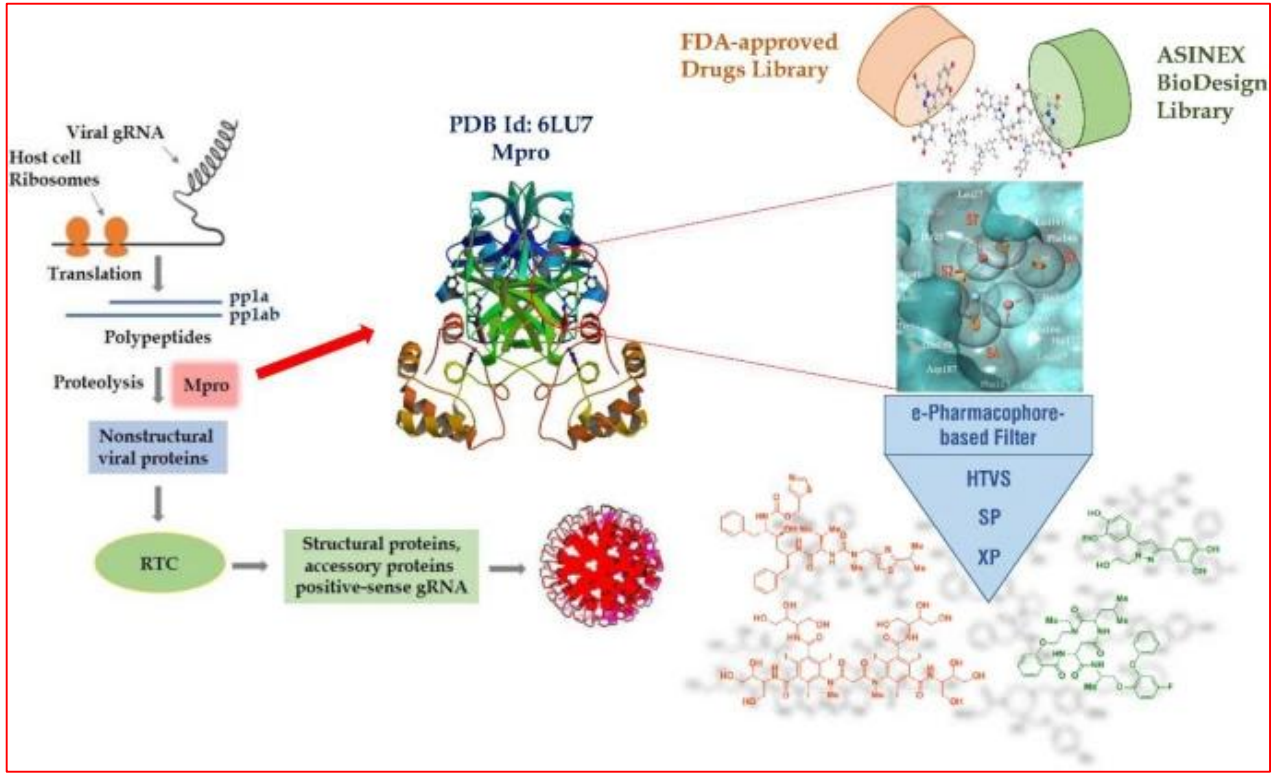
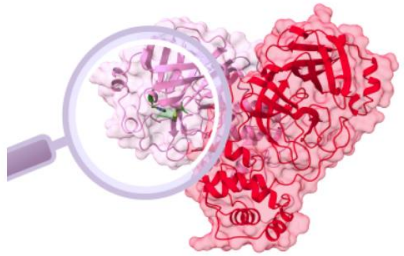
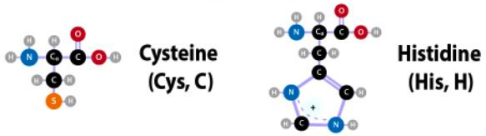
Mpro: A potential therapeutic target for anti-Sars-Cov-2 treatment development.

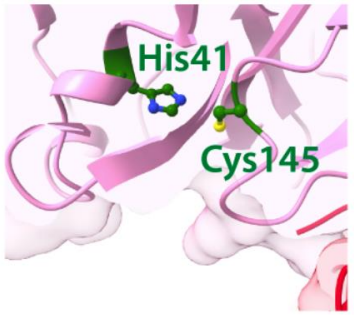




the main target for M^{Pro} inhibitor drug design is the **active site**

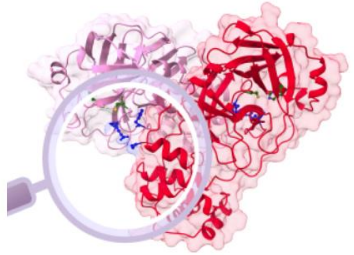
MPro is a **cysteine protease** - it gets its cutting power from a molecular duo of 2 amino acids (protein letters) - a Cysteine (Cys145) and a Histidine (His41)

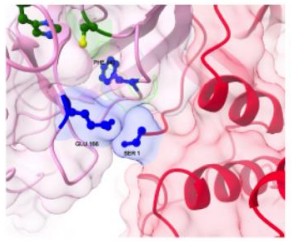




some inhibitors bind to this Cys through strong covalent bonds, making the inhibition "irreversible"

another potential target is the **dimer interface**





the protomers stabilize each other - so if you prevent them from pairing you prevent fully functional MPro production

so you prevent functional Nsp production

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RESEARCH ARTICLE

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SARS-CoV-2 Nsp5 Demonstrates Two Distinct Mechanisms Targeting RIG-I and MAVS To Evade the Innate Immune Response

Yongzhen Liu,[a] Chao Qin,[a] Youliang Rao,[a] Chau Ngo,[b] Joshua J. Feng,[b] Jun Zhao,[a,c] Shu Zhang,[a] Ting-Yu Wang,[a] essica Carriere,[a*] Ali Can Savas,[a] Mehrnaz Zarinfar,[a] Stephanie Rice,[a] Hanging Yang,[d] Weiming Yuan,[e] Julio A. Camarero,[f] Jianhua Yu,[g] Xiaojiang S. Chen,[d] Chao Zhang,[b] Pinghui Feng[a]

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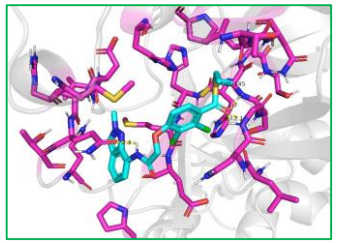
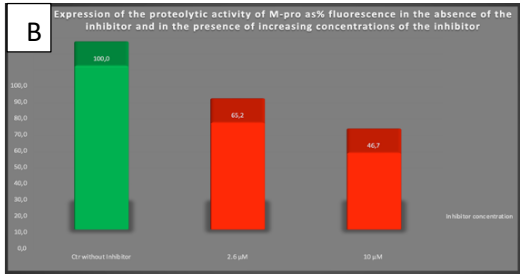
Molecular Docking

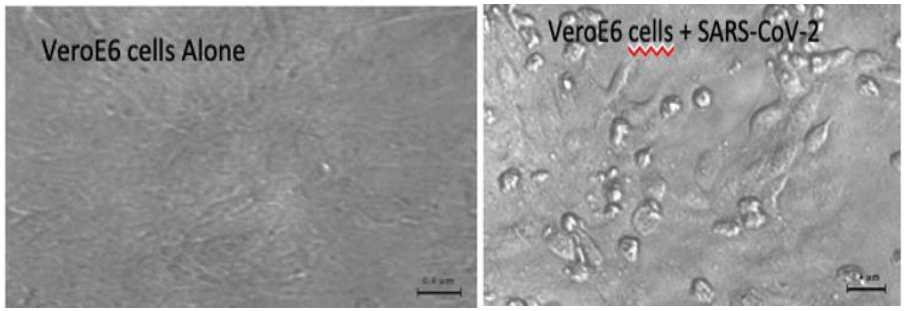
mode	affinity (kcal/mol)	dist from best mode rmsd l.b.	rmsd u.b.
1	-6.7	0.000	0.000
2	-6.5	3.621	9.359
3	-6.4	2.894	3.431
4	-6.1	4.456	9.595
5	-6.0	5.220	10.200
6	-6.0	3.254	4.029
7	-6.0	4.291	9.554
8	-6.0	4.377	9.533
9	-5.8	4.170	9.463

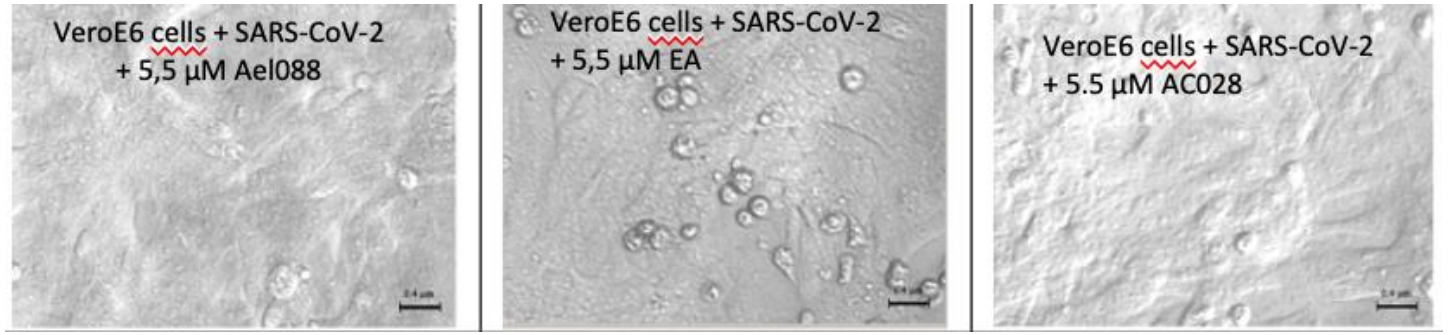


FRET protease assay

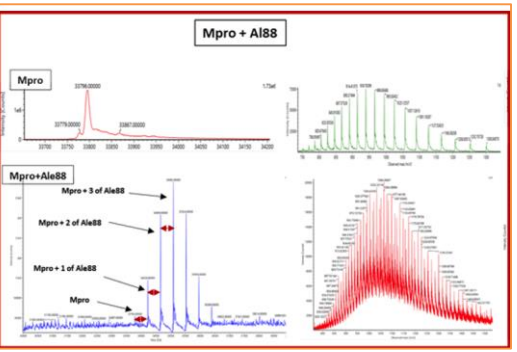


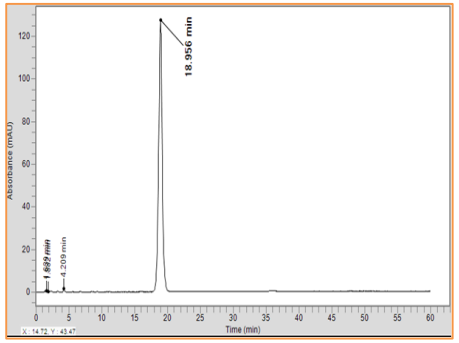
Cell culture microneutralization,

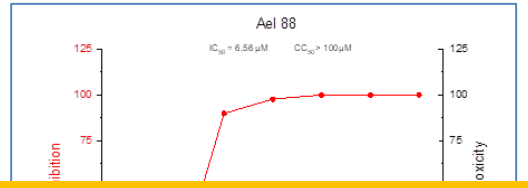




Mass spectra , RMN and HPLC analysis



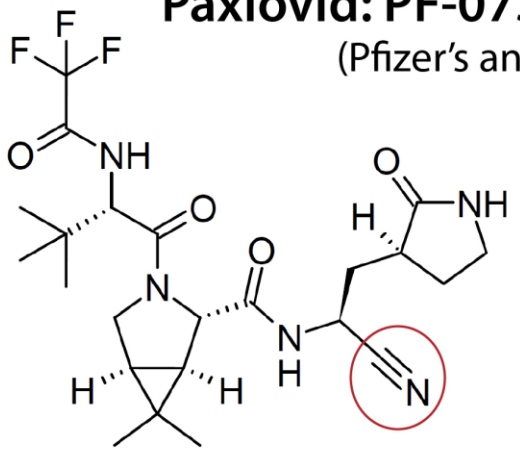




AC088 is a novel molecule that inhibits the main protease of SARS CoV2 and prevents viral replication.
These findings are covered by international patents,
and a scientific article will be published in a high-impact journal.

Paxlovid: PF-07321332 + ritonavir

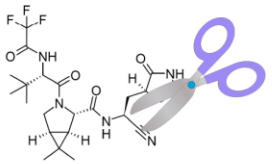
(Pfizer's antiviral pill for treating COVID-19)



PF-07321332

Main Protease (MPro) inhibitor that prevents the virus from separating its protein precursor (polyprotein) into individual proteins

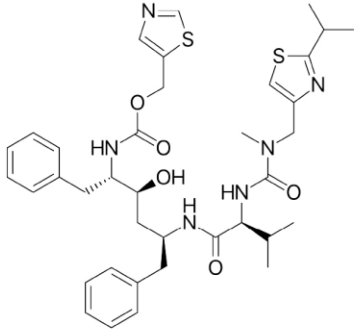
it gets covalently stuck on the scissors' blades



via formation of a thioimidate adduct between the drug's nitrile warhead and the enzyme's catalytic cysteine if you were curious

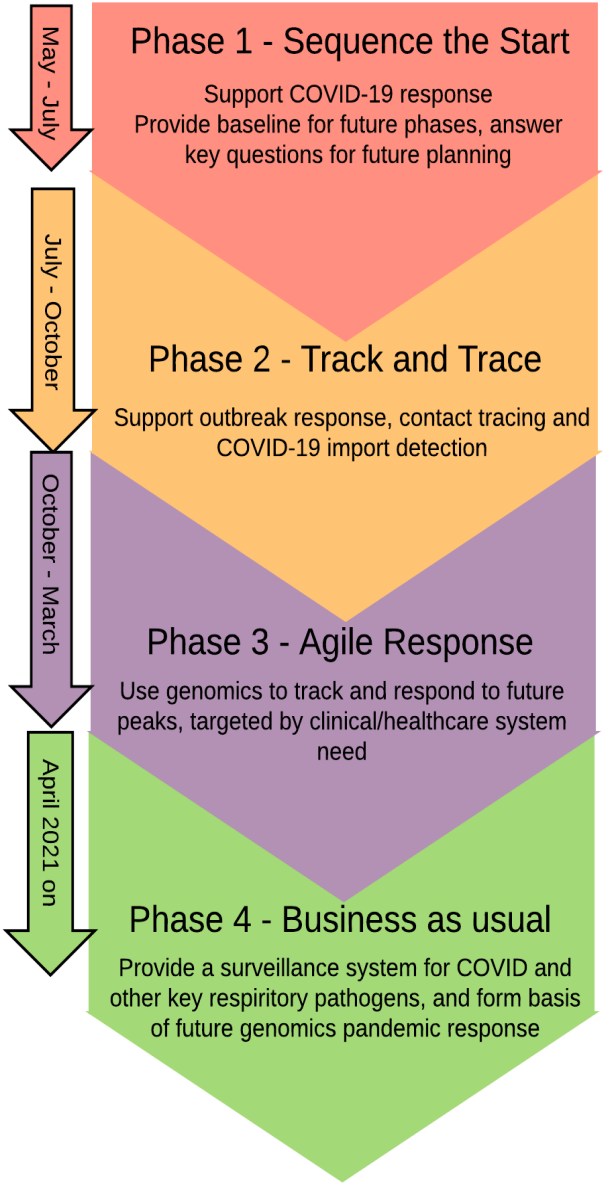
ritonavir

CYP inhibitor that prevents it from getting metabolized too quickly by CYP enzymes in our liver (keeps it from being modified in ways that make it more easily excreted)



chemical structures from Wikipedia

Conclusions



- We have built a National COVID-19 sequencing service in Morocco
- We have sequenced and shared genomics information at national , regional and international level
- We are sequencing samples in real time, and using this data to support every level of the pandemic response, from hospital outbreaks up to national scientific advice
- This is an extension of the work being done at the national level by Public Health authorities to include academic research institutions.

Acknowledgments

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INH

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AH2ST promotes scientific research to support our country's health sovereignty.

ON THE EPIGENETICS AS A TOXICOLOGICAL MECHANISM CAUSING HUMAN DEGENERATIVE DISEASES

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Faculty of Pharmacy and the Institute of Pharmaceutical Sciences (TIPS)
Tehran University of Medical Sciences, Iran

ABSTRACT

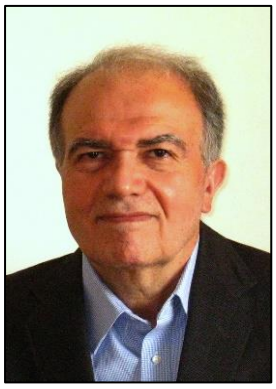
Epigenetics is one of the toxicology mechanisms usually seen by the environmental toxicants causing abnormal gene expression and cell dysfunction. Environmental toxicants may cause epigenetics toxicity through DNA methylation, histone modifications, and disturbance of microRNA expressions. These epigenetic effects can be tissue-type specific and positively associated with the level and duration of exposure. These alterations are identified in various diseases such as cancer, autoimmune disorders, and respiratory, cardiovascular, gastrointestinal tracts, and bone diseases.

Current investigations have helped find some histone deacetylase inhibitors and DNA methyltransferase blockers that can limit epigenetic effects. Some of these compounds are approved for clinical use, and some are in preclinical and clinical testing.
Besides medicines, dietary compounds can also be useful in the prevention of epigenetic - pathophysiological conditions.

THE ROLE OF ANTIOXIDANTS AND NUTRACEUTICALS IN PROMOTION OF LIFESTYLE AND HEALTH

ALI A. MOOSAVI-MOVAHEDI FIAS
Institute of Biochemistry and Biophysics
University of Tehran, Iran

ABSTRACT



Today, humanity needs a healthy lifestyle to be able to control and moderate abnormal industries and technologies with rationality and science. One of the most important aspects of a decent lifestyle is having a good diet. As famous ancient words: you say what you eat, I say who you are. Good food has medicinal and nutritional functions that meet all the cellular needs of the body and this food is called superfood. Some superfoods are molecules, and those called Nutraceuticals suchlike natural molecules as curcumin and gingerol. These molecules are antioxidants that can scavenge and remove the stress from the body. The molecular definition of stress is unbalanced free radicals. Another important antioxidant that is produced in good sleep is a generous molecule called melatonin. We need to identify and live with generous natural molecules and educate others to make a lifestyle for society. The root cause of many diseases, including type 2 diabetes and COVID-19, are stress and unbalanced free radicals, so recognizing antioxidants from different sources such as sleep, functional food, tranquility, nature and faith is known for health. Let us and others this kind of lifestyle that enculture for human society. This manner may play a role in personalized medicine that manages some of the medicines it needs through human inner and external nature.

Keywords: Antioxidant, Lifestyle, Nutraceuticals, Sleep, Functional food, Tranquility, Natural molecules, Nature, Inner nature, Health, Science, Rationality.

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بسم الله الرحمن الرحيم

The Role of Antioxidants and Nutraceuticals in Promotion of Lifestyle and Health

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Description

- Today, humanity needs a healthy lifestyle to be able to control and moderate abnormal industries and technologies with rationality and science. One of the most important aspects of a decent lifestyle is having a good diet. As famous ancient words: you say what you eat, I say who you are.
- Good food has medicinal and nutritional functions that meet all the cellular needs of the body and this food is called superfood. Some superfoods are molecules, and those called Nutraceuticals suchlike natural molecule as curcumin. This molecule is edible antioxidant that can scavenge and remove the stress from the body. The molecular definition of stress is unbalanced free radicals. Antioxidants are edible and nonedible.

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UBL University of Tehran

Description

- The important antioxidant that is produced in good sleep is a generous molecule called melatonin. We need to identify and live with generous natural molecules and educate others to make a lifestyle for society. The root cause of many diseases, including type 2 diabetes and COVID-19, are stress and unbalanced free radicals, so the antioxidants from different sources such as sleep, functional food, tranquility, nature and faith is important to know for health. Let us and others this kind of lifestyle that enculture for human society.
- This manner may play a role in personalized medicine that manages some of the medicines through human inner and external nature.

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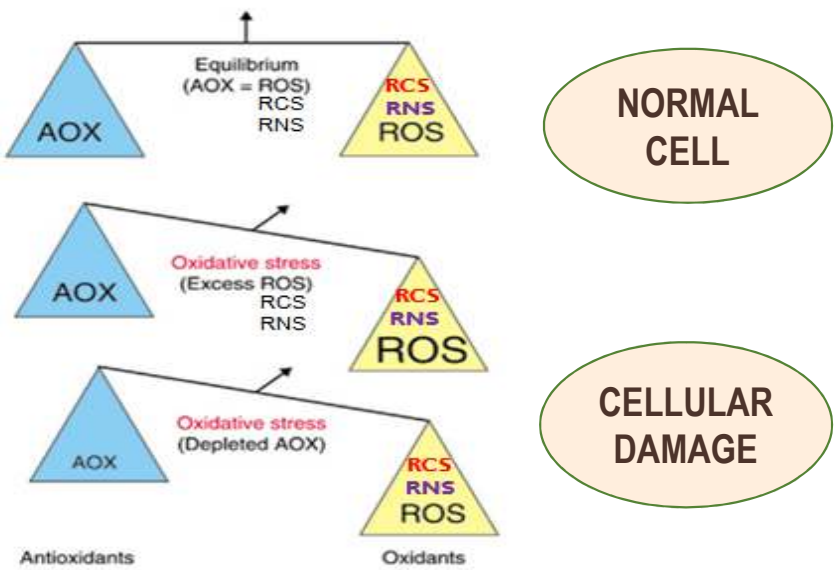
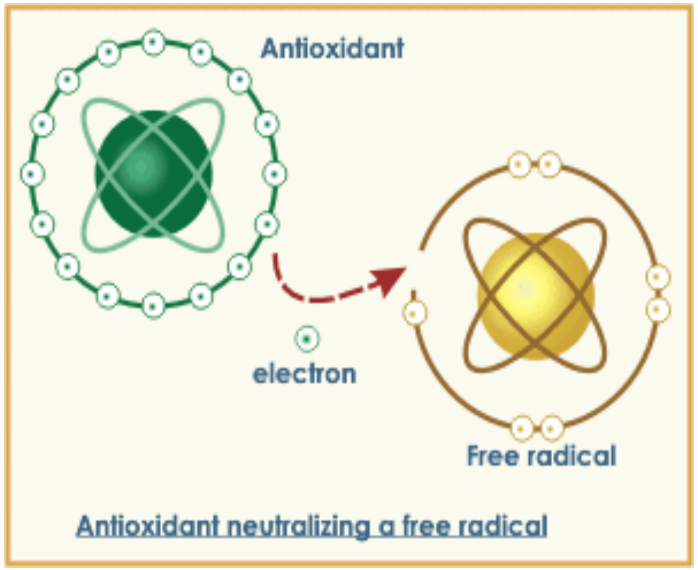
- The transmission of any external stress to the body's internal system produce oxidative stress
- The definition of molecular stress means penetrating free radicals in the body



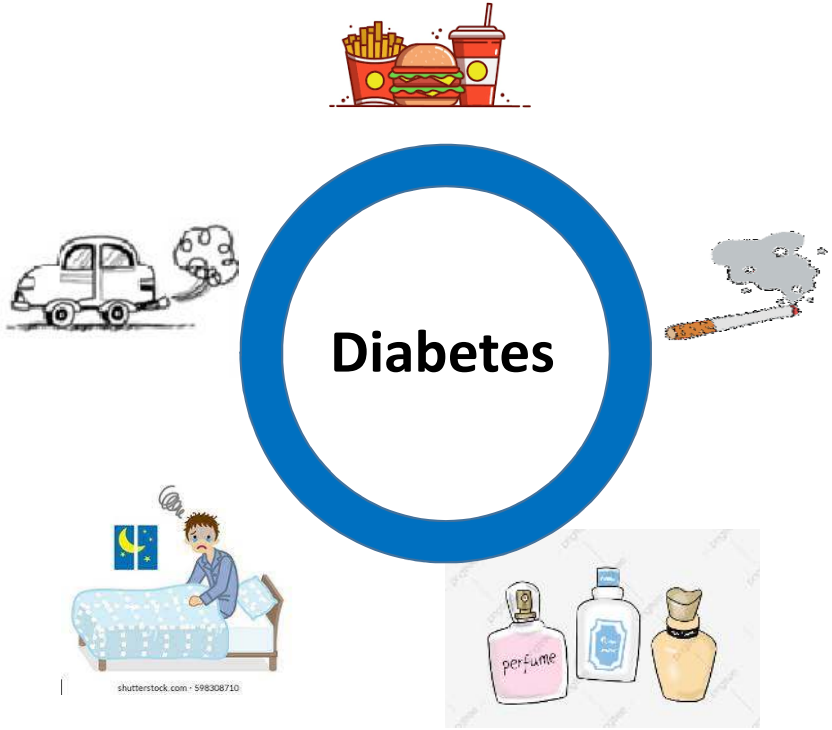
NORMAL CELL

CELLULAR DAMAGE



- Free radical: an uncharged molecule (typically highly reactive and short-lived) having an unpaired valence electron.
- Antioxidant neutralizes free radicals via donation or receiving one electron

Diabetes type-2 is a common disease in the industrial community. Diabetes complications are much more important than diabetes itself and causes dozens of other illnesses. One of the main reasons for diabetes type-2 is the consumption of industrial foods and industrial lifestyles that cause free radicals. Free radicals in the body to destroy biomacromolecules, cells and tissues. Reactive oxygen species (ROS) are most risky free radicals in the body to intensify diabetes and its complications. The generation of unbalanced free radicals is the source of any stress and molecular aspect of stress refers to the birth of free radicals.



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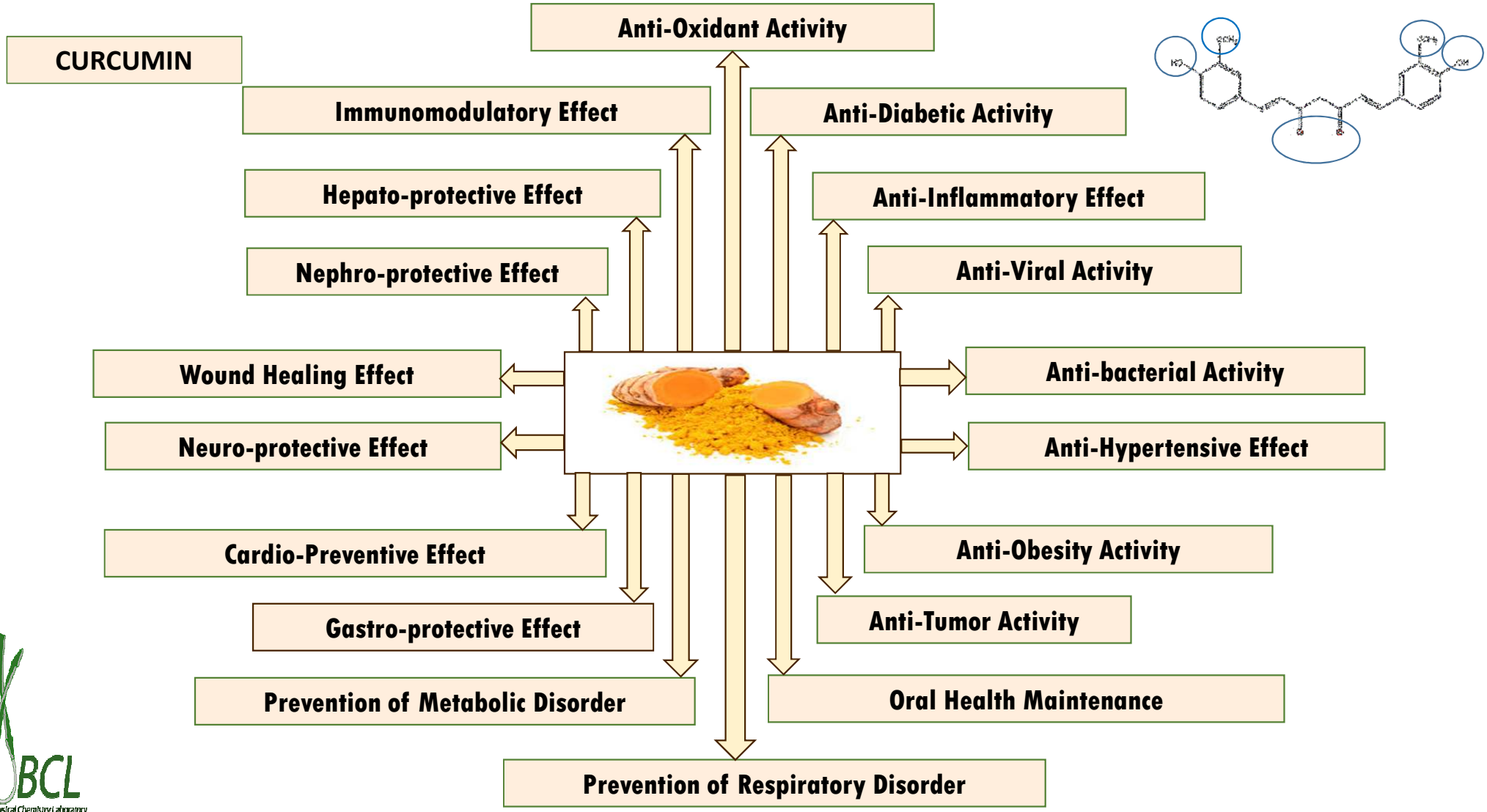
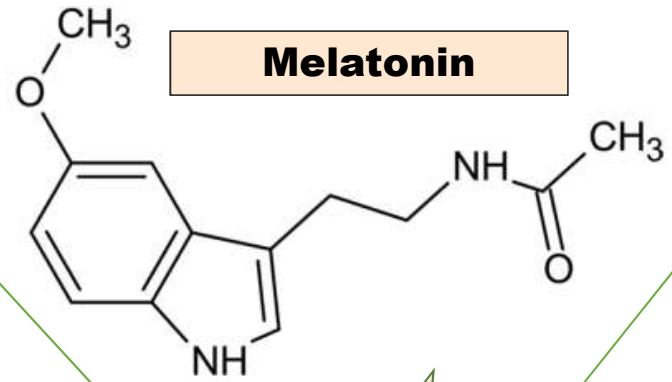

CURCUMIN
Anti-Oxidant Activity
Immunomodulatory Effect
Anti-Diabetic Activity
Hepato-protective Effect
Anti-Inflammatory Effect
Nephro-protective Effect
Anti-Viral Activity
Wound Healing Effect
Anti-bacterial Activity
Neuro-protective Effect
Anti-Hypertensive Effect
Cardio-Preventive Effect
Anti-Obesity Activity
Gastro-protective Effect
Anti-Tumor Activity
Prevention of Metabolic Disorder
Oral Health Maintenance
Prevention of Respiratory Disorder

Good quality sleep which is very important for health

Melatonin



Direct action
Scavenging free radicals

Indirect action
Synthesis of antioxidant enzymes

ROS

Anti-Inflammatory Effect

Anti-Cancer Activity

Anti-Diabetic Activity

Anti-Hypertensive Effect

Neuro-protective Effect

Anti-Aging

Prevention of Metabolic Disorder

The production of melatonin, which is made of tryptophan in the pineal gland, increases in the evening with the onset of darkness, which tells us that it is time to go to bed

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- **Sleep plays an important role in stabilizing and improving memory, effective productivity, maintaining hormonal balance, regulating temperature and heart rate, removing metabolic wastes from the brain, strengthening the immune system, healing wounds and reducing inflammation.**
- **Good sleep along with proper and healthy nutrition and continuous exercise are a triangle that ensures the health and well performance of individuals in community.**
- **Light pollution in the modern industrial societies, and physical and mental illnesses may severely affect sleep quality. It is essential that citizens are properly educated about sleep hygiene and the right ways to experience perfect sleep.**

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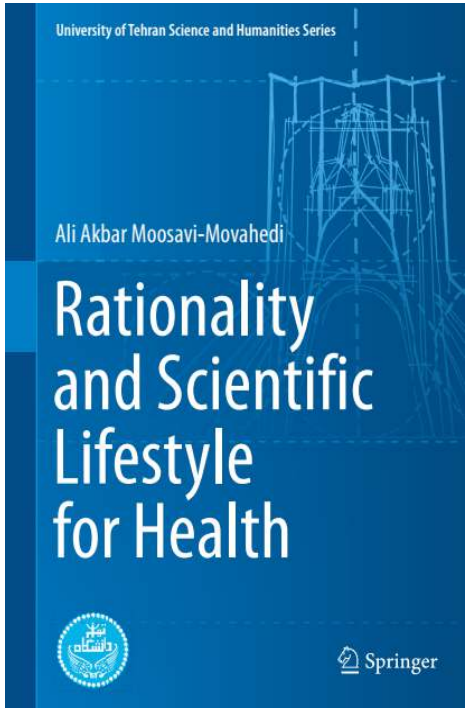
The End



- Human health is formed by a balance between external nature and human inner nature. Whatever man departs from his nature, approach to unbalanced diseases and make a balance, which is the principle of human health. Self-knowledge is thus the foundation of human health and happiness.
- Humankind has created technologies based on inferior knowledge, whereas it needs vast knowledge to produce healthy technologies. Today, a large part of man-made technologies is anomalous and create pollutants that produce unbalanced free radicals for humans and other creatures. This caused human disease and damage to the planet. Technologies must be linked to ethics, sustainable environment, bio-model, biomimetic and bioinspiration and health.

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APPENDIX A

CONFERENCE ORGANIZING COMMITTEE

ISLAMIC WORLD ACADEMY OF SCIENCES (IAS), JORDAN

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Ms. Taghreed Saqer	Executive Secretary.
Ms. Najwa F. Daghestani	Programs Manager.

HASSAN II ACADEMY OF SCIENCE AND TECHNOLOGY, MOROCCO

Prof. Omar Fassi-Fehri	Permanent Secretary.
Prof. Mostapha Bousmina	Chancellor.
Prof. Abdeslam Hoummada	Director of Sciences.

APPENDIX B

23rd Islamic World Academy of Sciences Conference

Science, Technology and Innovation Under Ever Changing Global Events

List of Participants
18-19 October 2022

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APPENDIX C
Patrons of the Islamic World Academy of Sciences

His Excellency the President of the Islamic Republic of Pakistan.
His Royal Highness Prince El-Hassan bin Talal of the Hashemite Kingdom of Jordan, Founding Patron.

Honorary Fellows of the Islamic World Academy of Sciences

(in alphabetical order)

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7. Prof. Umran S. **Inan,** The 2019 Mustafa Prize Laureate, Turkey.
8. Prof. Ali **Khademhosseini,** The 2019 Mustafa Prize Laureate, Iran.
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14. Prof. Ugur **Sahin,** The 2019 Mustafa Prize Laureate, Turkey.
15. Prof. Mohamed El-**Sayegh**, The 2021 Mustafa Prize Laureate, Lebanon.
16. His Excellency Mr. Mintimer **Shaimiev**, Former President of the Republic of Tatarstan/ Russian Federation.
17. Prof. M. Amin **Shokrollahi**, The 2017 Mustafa Prize Laureate, Iran.
18. Prof. Yahya **Tayalati**, The 2021 Mustafa Prize Laureate, Morocco.
19. His Excellency Sheikh Hamad Bin Jassim Bin Jabr Al **Thani**, Former Prime Minister of Qatar, Qatar.
20. Prof. Cumrun **Vafa,** The 2021 Mustafa Prize Laureate, Iran.

List of Fellows of the Islamic World Academy of Sciences
(February 2023)

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2.	Prof. Zakri **Abdul Hamid**	Malaysia	Genetics
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4.	Prof. Farhan Jalees **Ahmad**	India	Pharmaceutics
5.	Prof. Bobomurat **Ahmedov**	Uzbekistan	Physics
6.	Prof. Askar **Akayev**	Kyrgyzstan	Computer Engineering
7.	Prof. Liaquat **Ali**	Bangladesh	Medicine
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10.	Prof. Huda Saleh **Ammash**	Iraq	Biology
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12.	Prof. Muhammad **Asghar**	France	Physics
13.	Prof. Muhammad **Ashraf**	Pakistan	Botany-Salt Tolerance
14.	Prof. Allaberen **Ashyralyev**	Turkmenistan	Mathematics
15.	Prof. Saleh A **Al-Athel**	Saudi Arabia	Mechanical Engineering
16.	Prof. Ahmad Abdullah **Azad**	Bangladesh/ Australia	Biochemistry
17.	Prof. Agadjan **Babaev**	Turkmenistan	Geography
18.	Prof. Adnan **Badran**	Jordan	Biology
19.	Prof. Shah Nor Bin **Basri**	Malaysia	Mechanical Engineering
20.	Prof. Elias **Baydoun**	Jordan	Biochemistry
21.	Prof. Farouk **El-Baz**	USA	Geology
22.	Prof. Kazem **Behbehani**	Kuwait	Immunology
23.	Prof. Azret **Bekkiev**	Balkar/Russia	Physics
24.	Prof. Rafik **Boukhris**	Tunisia	Medicine
25.	Prof. David (Mohamed Daud) A. **Bradley**	UK	Physics
26.	Prof. Noor Mohammad **Butt**	Pakistan	Physics
27.	Prof. Mohamed Thameur **Chaibi**	Tunisia	Agriculture/ Climate Technologies
28.	Prof. Muhammad Iqbal **Choudhary**	Pakistan	Organic Chemistry
29.	Prof. Abdallah **Daar**	Oman/ Canada	Medicine
30.	Prof. Ali Al-**Daffa'**	Saudi Arabia	Mathematics
31.	Prof. Mamadou **Daffe**	Mali/France	Biochemistry
32.	Prof. Ramazan **Demir**	Turkey	Biology
33.	Prof. Oussaynou Fall **Dia**	Senegal	Geology
34.	Prof. Dilfuza **Egamberdieva**	Uzbekistan	Biology
35.	Prof. Mehmet **Ergin**	Turkey	Chemical Engineering
36.	Prof. Sehamuddin **Galadari**	UAE	Biochemistry

37. Prof. Nesreen **Ghaddar**	Lebanon	Metallurgical Engineering
38. Prof. Mehdi **Golshani**	Iran	Physics
39. Prof. Kadyr G **Gulamov**	Uzbekistan	Physics
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42. Prof. Kemal **Hanjalic**	Bosnia-Herzegovina	Mechanical Engineering
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44. Prof. Tasawar **Hayat**	Pakistan	Mathematics
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47. Prof. Aini **Ideris**	Malaysia	Veterinary Medicine
48. Prof. Asma **Ismail**	Malaysia	Biotechnology
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50. Prof. Mohammad Qasim **Jan**	Pakistan	Geology
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52. Prof. Hamza **El-Kettani**	Morocco	Physics and Chemistry
53. Prof. Idriss **Khalil**	Morocco	Mathematics
54. Prof. Hameed Ahmed **Khan**	Pakistan	Physics
55. Prof. Mostefa **Khiati**	Algeria	Medicine
56. Prof. Hala **El Khozondar**	Gaza/ Palestine	Physics
57. Prof. Abdelhafid **Lahlaidi**	Morocco	Medicine
58. Prof. Zohra Ben **Lakhdar**	Tunisia	Physics
59. Prof. Malek **Maaza**	Algeria	Neutronics
60. Prof. Ahmed **Marrakchi**	Tunisia	Electronic Engineering
61. Prof. Akhmet **Mazgarov**	Tatarstan/ Russia	Petrochemistry
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63. Prof. Shaher **Al-Momani**	Jordan	Mathematics
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72. Prof. Gulsen **Oner**	Turkey	Medicine
73. Prof. Ilkay Erdogan **Orhan**	Turkey	Pharmacognosy
74. Prof. Ramdane **Ouahes**	Algeria	Chemistry
75. Prof. Munir **Ozturk**	Turkey	Biology
76. Prof. Iqbal **Parker**	South Africa	Biochemistry
77. Prof. Syed Muhammad **Qaim**	Germany	Nuclear Chemistry
78. Prof. Atta-ur-**Rahman**	Pakistan	Chemistry

79. Prof. Hussein Samir **Salama**	Egypt	Entomology
80. Prof. Eldar Yunisoglu **Salayev**	Azerbaijan	Physics/ Mathematics
81. Prof. Jawad A. **Salehi**	Iran	Electronic Engineering
82. Prof. Boudjema **Samraoui**	Algeria	Biology
83. Prof. Lorenzo **Savioli**	Italy	Medicine
84. Prof. Mohammed Musa **Shabat**	Gaza/ Palestine	Biology
85. Prof. Muhammad Raza **Shah**	Pakistan	Nanotechnology
86. Prof. Misbah-Ud-Din **Shami**	Pakistan	Chemistry
87. Prof. Ali **Al-Shamlan**	Kuwait	Geology
88. Prof. Ahmad **Shamsul-Islam**	Bangladesh	Botany
89. Prof. Muthana **Shanshal**	Iraq	Chemistry
90. Prof. Zabta Khan **Shinwari**	Pakistan	Biology
91. Prof. Ahmedou M **Sow**	Senegal	Medicine
92. Prof. Mahmoud **Tebyani**	Iran	Electronic Engineering
93. Prof. Ahmet Hikmet **Ucisik**	Turkey	Materials Science
94. Prof. Gulnar **Vagapova**	Tatarstan/ Russia	Medicine
95. Prof. Omar M. **Yaghi**	Jordan/USA	Chemistry
96. Prof. Jackie **Ying**	Singapore/USA	Chemical Engineering
97. Prof. Bekhzad **Yuldashev**	Uzbekistan	Physics/ Mathematics
98. Prof. Khatijah Mohd **Yusoff**	Malaysia	Microbiology
99. Prof. Salim **Yusuf**	Canada	Medicine
100. Prof. Mikhael **Zalikhanov**	Balkar/Russia	Glaciology/Biology

APPENDIX D

LAUREATES OF THE IAS-COMSTECH IBRAHIM MEMORIAL AWARD

Prof. Ugur **Dilmen**	1996	Turkey.
Prof. Mohammad **Abdollahi**	2005	Iran.
Prof. Mohammed Manna **Al-Qattan**	2007	Saudi Arabia.
Dr Faris **Gavrankapetanovic**	2009	Bosnia.
Dr Saima **Riazuddin**	2011	Pakistan.
Prof. Liaquat **Ali**	2013	Bangladesh.
Prof. Jackie **Ying**	2015	Singapore.
Prof. Ameenah **Gurib-Fakim**	2017	Mauritius.

APPENDIX D

THE COUNCIL OF THE ISLAMIC WORLD ACADEMY OF SCIENCES (2023-2027)

President:	**Adnan Badran**	Jordan
Vice-President:	**Khatijah Yusoff**	Malaysia
Vice-President:	**Abdelhafid Lahlaidi**	Morocco
Vice-President:	**Zabta Shinwari**	Pakistan
Treasurer:	**Elias Baydoun**	Jordan
Secretary General:	**Tasawar Hayat**	Pakistan
Member:	**Malek Maaza**	Algeria
Member:	**Farhan Jalees Ahmad**	India
Member:	**Mohammad Abdollahi**	Iran
Member:	**Aini Ideris**	Malaysia
Member:	**Dilfuza Egamberdieva**	Uzbekistan

IAS EXECUTIVE STAFF

Dr. Abdullah Al Musa	Director General.
Ms. Taghreed Saqer	Executive Secretary.
Ms. Najwa F. Daghestani	Programs Manager.
Mr. Ahmad Nassar	Finance Officer.
Mr. Hamdi Bader Ahmad	Driver.

APPENDIX E

PUBLICATIONS OF THE ISLAMIC WORLD ACADEMY OF SCIENCES

CONFERENCE PROCEEDINGS

- *The Islamic Academy of Sciences.* Proceedings of the Founding Conference (1986). Published by the Islamic Academy of Sciences, **Editor: A. Kettani (Morocco).**
- *Food Security in the Muslim World.* Proceedings of the first international conference, Amman (Jordan) (1987). Published by the Islamic World Academy of Sciences, **Editor: S. Qasem (Jordan).**
- *Science and Technology Policy for Self-Reliance in the Muslim World.* Proceedings of the second international conference, Islamabad (Pakistan) (1988). Published by the Islamic World Academy of Sciences, **Editors: F. Daghestani (Jordan), H. El-Mulki (Jordan), and M. Al-Halaiqa (Jordan).**
- *New Technologies and Development of the Muslim World.* Proceedings of the third international conference, (Kuwait) (1989). Published by the Islamic World Academy of Sciences, **Editors: F. Daghestani (Jordan), and S. Qasem (Jordan).**
- *Technology Transfer for Development in the Muslim World.* Proceedings of the fourth international conference, Antalya (Turkey) (1990). Published by the Islamic World Academy of Sciences, **Editors: F. Daghestani (Jordan), A. Altamemi (Jordan), and M. Ergin (Turkey).**
- *Science and Technology Manpower Development in the Islamic World.* Proceedings of the fifth international conference, Amman (Jordan) (1991). Published by the Islamic World Academy of Sciences, **Editors: F. Daghestani (Jordan), A. Altamemi (Jordan), and H. El-Mulki (Jordan).**
- *Environment and Development in the Islamic World.* Proceedings of the sixth international conference, Kuala Lumpur (Malaysia) (1992). Published by the Islamic World Academy of Sciences, **Editors: S. Al-Athel (Saudi Arabia), and F. Daghestani (Jordan).**
- *Health, Nutrition and Development in the Islamic World.* Proceedings of the seventh international conference, Dakar (Senegal) (1993). Published by the Islamic World Academy of Sciences, **Editors: N. Bor (Turkey), A. Kettani (Morocco), and Moneef R. Zou'bi (Jordan).**

- *Water in the Islamic World: An Imminent Crisis.* Proceedings of the eighth international conference, Khartoum (Sudan) (1994). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), H. Dogan Altinbilek (Turkey), and Moneef R. Zou'bi (Jordan).**
- *Science and Technology Education for Development in the Islamic World.* Proceedings of the ninth international conference, Tehran (Iran) (1999). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), M. Doruk (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 9957-412-7).**
- *Information Technology for Development in the Islamic World.* Proceedings of the tenth international conference, Tunis (Tunisia) (2000). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), M. Doruk (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 9957-412-03-5). Online.**
- *Biotechnology and Genetic Engineering for Development in the Islamic World.* Proceedings of the eleventh international conference, Rabat (Morocco) (2001). Published by the Islamic World Academy of Sciences, **Editors: A. S. Majali (Jordan), M. Ergin (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 9957-412-07-8). Online.**
- *Materials Science and Technology and Culture of Science.* Proceedings of the twelfth international conference, Islamabad (Pakistan), (2002). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 9957-412-06-x). Online.**
- *Energy for Sustainable Development and Science for the Future of the Islamic World and Humanity.* Proceedings of the thirteenth international conference, Kuching, Sarawak (Malaysia), (2003). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 9957-412-08-6). Online.**
- *Science Technology and Innovation for Socioeconomic Development of OIC-Member Countries Towards Vision 1441.* Proceedings of the fourteenth international conference, Kuala Lumpur (Malaysia), (2005). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 9957-412-11-6). Online.**
- *Higher Education Excellence for Development in the Islamic World*. Proceedings of the fifteenth international conference, Ankara (Turkey), (2006). Published by the Islamic World Academy of Sciences, **Editors:**

M. Ergin (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 978-9957-412-18-0). Online.

- *Science, Technology and Innovation for Sustainable Development in the Islamic World: The Policies and Politics Rapprochement*. Proceedings of the Sixteenth international conference, Kazan (Tatarstan), (2008). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 978-9957-412-19-7). Online**.
- *Towards the Knowledge Society in the Islamic World: Knowledge Production, Application and Dissemination,* Proceedings of the seventeenth international conference, Shah Alam *(Malaysia),* (2009). Published by the Islamic World Academy of Sciences, **Editors: M. Ergin (Turkey), and Moneef R. Zou'bi (Jordan) (ISBN 978-9957-412-22-7). Online.**
- *The Islamic World and the West: Rebuilding Bridges through Science and Technology,* Proceedings of the eighteenth international conference, Doha (Qatar), (2011)**.** Published by the Islamic World Academy of Sciences, **Editor: Moneef R. Zou'bi (Jordan) (ISBN 978-9957-412-24-1). Online.**
- *Science and Technology in Muslim World: Achievements and Prospects,* Proceedings of the IAS Symposium, Astana (Kazakhstan), (2012). Published by the Islamic World Academy of Sciences, **Editor: Moneef R. Zou'bi (Jordan)**. **Online**.
- *Achieving Socioeconomic Development in the Islamic World through Science, Technology and Innovation,* Proceedings of the nineteenth international conference, Dhaka (Bangladesh), (2013). Published by the Islamic World Academy of Sciences, **Editors: Moneef R. Zou'bi (Jordan), and Najwa F. Daghestani (Jordan) (ISBN 978-9957-412-25-8). Online.**
- *Science, Technology and Innovation: Building Humanity's Common Future,* Proceedings of the twentieth international conference, Tehran (Iran), (2015). Published by the Islamic World Academy of Sciences, **Editors: Moneef R. Zou'bi (Jordan), and Najwa F. Daghestani (Jordan) (ISBN 978-9957-412-26-5). Online.**
- *Science, Technology and Innovation for Global Peace and Prosperity,* Proceedings of the twenty-first international conference, Konya (Turkey), (2017). Published by the Islamic World Academy of Sciences, **Editors: Moneef R. Zou'bi (Jordan), and Najwa F. Daghestani (Jordan) (ISBN 978-9957-412-27-2). Online.**
- *Landscape of Science, Technology and Innovation in the Islamic Countries,* Proceedings of the twenty-second international conference,

Amman (Jordan), (2020) *Virtual Conference*. Published by the Islamic World Academy of Sciences, **Editors: Abdullah Al Musa (Jordan), and Najwa F. Daghestani (Jordan). Online.**

- *Biodiversity Conference*, Proceedings of the IAS conference on Biodiversity, Amman (Jordan), (2021) *Virtual Conference*. Published by the Islamic World Academy of Sciences, **Editors: Abdullah Al Musa (Jordan), and Najwa F. Daghestani (Jordan). Online.**
- *Science, Technology and Innovation Under Ever Changing Global Events*, Proceedings of the twenty-third international conference, Rabat (Morocco), (2022). Published by the Islamic World Academy of Sciences, **Editors: Abdullah Al Musa (Jordan), and Najwa F. Daghestani (Jordan). Online.**
- *Challenges to Promote Science and Technology for Socio-Economic Development in OIC Countries*, Proceedings of the twenty-fourth international conference, Karachi (Pakistan), (2023). Published by the Islamic World Academy of Sciences, **Editors: Adnan Badran (Jordan), and Najwa F. Daghestani (Jordan). Online.**

BOOKS

1) *Islamic Thought and Modern Science* - Published by the Islamic World Academy of Sciences (1997) - **Author: Mumtaz A. Kazi**.

2) *Qur'anic Concepts and Scientific Theories* - Published by the Islamic World Academy of Sciences (1999) – **Author: Mumtaz A. Kazi.**

2) *Personalities Noble* **Editor: Hakim Mohammed Said**, Second Revised Edition, Published by the Islamic World Academy of Sciences (2000), **Editor: Moneef R. Zou'bi** (Arabic-English). **(ISBN: 9957-412-01-6).**

3) *Declarations of the Islamic World Academy of Sciences* – Published by the Islamic World Academy of Sciences (2005), **Editor: Moneef. R. Zou'bi (ISBN: 9957-412-09-4)**.

4) *Islamic World Academy of Sciences Outreach*, – Published by the Islamic World Academy of Sciences (2005), **Editor: Moneef R. Zou'bi (ISBN: 9957-412-10-8)**.

5) *Intellectual Property Rights: An Introduction for Scientists and Technologists* – Published by the Islamic World Academy of Sciences (2006), **Author: Mohamed B. E. Fayez (ISBN: 978-9957-412-18-0)**.

6) *Reverse Engineering: The Permissible but not Well-Recognized* - Published by the Islamic World Academy of Sciences (2010), **Author: Mohamed B. E. Fayez (ISBN: 978-9957-412-20-3)**.

7) *The Discoveries in the Islamic Countries* – Arabic Edition Published by the Islamic World Academy of Sciences (2012), **Author: Ahmed Djebbar (ISBN: 978-9957-412-23-4)**.

8) *The Essentials of Science, Technology and Innovation Policy* – Published by the Islamic World Academy of Sciences (2013), **Author: Tan Sri Dr Omar Abdel Rahman (ISBN: 978-983-9445-95-4).**

9) *Overview*. Published by the Islamic World Academy of Sciences (2021).

PERIODICALS

1) *Medical Journal of the Islamic World Academy of Sciences* (ISSN 1016-3360) – quarterly. Responsible Editor: **Dr. Nedim Aytekin**.

2) *Newsletter of the Islamic World Academy of Sciences* – quarterly. Responsible Editor: **Najwa Daghestani.**

3) *Islamic Thought and Scientific Creativity* (in Arabic) - quarterly Journal of the Organisation of the Islamic Conference (OIC) Standing Committee on Scientific and Technological Co-operation (COMSTECH). Arabic version published by the IAS with the support of the Royal Academy for Islamic Civilisation Research (Al-Albait Foundation) (publication ceased in 1996).

APPENDIX G

IAS SUPPORTERS

The Hashemite Kingdom of Jordan
The Islamic Republic of Pakistan
The State of Kuwait
The Republic of Turkey
Malaysia
The Republic of Senegal
The Republic of Sudan
The Islamic Republic of Iran
The State of Qatar
The Republic of Tunisia
The Kingdom of Morocco
The State of Sarawak/Malaysia
The Republic of Indonesia
The Republic of Tatarstan/ Russian Federation
The State of Selangor/Malaysia
The Sultanate of Oman
The Republic of Kazakhstan
The People's Republic of Bangladesh

The OIC Standing Committee on Scientific and Technological Co-operation (COMSTECH), Pakistan.
The Islamic Development Bank (IDB), Saudi Arabia.
The OPEC Fund for International Development, Vienna, Austria.
Arab Fund for Economic and Social Development (AFESD), Kuwait.
Arab Potash Company, Jordan.
United Nations Educational Scientific and Cultural Organisation (UNESCO), France.
Islamic Educational Scientific and Cultural Organisation (ISESCO), Morocco.
The World Bank, USA.
The United Nations Environment Programme (UNEP), Kenya.
Kuwait Foundation for the Advancement of Sciences (KFAS).
Turkish Scientific and Technical Research Council (TUBITAK).
The Royal Scientific Society (RSS), Jordan.
Pakistan Ministry of Science and Technology.
Ministry of Science, Technology and the Environment, Malaysia.
University Cheikh Anta Diop, Dakar, Senegal.
Ministry of Higher Education and Scientific Research, Sudan.
National Centre for Research, Sudan.
Ministry of Culture and Higher Education, Iran.
Iranian Research Organisation for Science and Technology (IROST).
The Academy of Sciences, Tehran, Iran.
The Academy of Medical Sciences, Tehran, Iran.
Saudi Arabian Oil Company, Saudi Arabia (ARAMCO).

Ihlas Holding, Turkey.
Arab Bank, Jordan.
Jordan Kuwait Bank, Jordan.
Rafia Industrial Company, Jordan.
Secretariat of State for Scientific Research and Technology, Tunisia.
Academy of the Kingdom of Morocco.
Petra Private University, Jordan.
Higher Council of Science and Technology (HCST), Jordan.
Pakistan Academy of Sciences.
Majlis Islam Sarawak, Malaysia.
Tabung Baitulmal Sarawak, Malaysia.
Sasakawa Peace Foundation, Japan.
Perdana Leadership Foundation, Putrajaya, Malaysia.
Royal Jordanian Airlines, Jordan.
Arab Jordan Investment Bank, Jordan.
National Centre for Human Resources Development, Jordan.
Al Bukhary Foundation, Malaysia.
Bilkent University, Turkey.
US National Academy of Sciences, USA.
International Islamic Charity Organisation, Kuwait.
Islamic Organisation of Medical Sciences, Kuwait.
Arab Gulf Programme for Development (AGFUND), Saudi Arabia.
Fouad Alghanim & Sons Group of Companies, Kuwait.
Saudi Basic Industries Corporation (SABIC), Riyadh, Saudi Arabia.
Tatarstan Academy of Sciences, Tatarstan, Russian Federation.
World Islamic Call Society, Tripoli, Libya.
Jordan Phosphate Mines Company, Amman, Jordan.
International Islamic Academy of Science and Biotechnology (IAB), Malaysia.
University of Industry of Selangor (UNISEL), Malaysia.
Ministry of Foreign Affairs of Qatar: The Permanent Committee for Organizing Conference, Qatar.
Doha International Centre for Interfaith Dialogue (DICID), Qatar.
R.B. Suleimenov Institute of Oriental Studies, Kazakhstan.
Prime Ministry of Bangladesh, Bangladesh.
Foreign Ministry of Bangladesh; Bangladesh.
University Grants Commission of Bangladesh, Bangladesh.
Bangladesh Academy of Sciences, Bangladesh.
Sheikh Mohammed bin Hamad Al Thani, Qatar.
Eng. Awni Shaker Al Aseer, Saudi Arabia.
Eng. Amjad Abu Aisheh, Jordan.
Jordan Islamic Bank, Jordan.
Dr Mahmood Abu Shairah, Jordan.
Necmettin Erbakan Üniversitesi, Turkey.
Turkish Academy of Sciences (TÜBA), Turkey.
Hikma Pharmaceuticals, Jordan.
Dr Ahmed Saif Balhasa, UAE.

Dr Adnan Mjalli, USA.
Mr Ahmed Abu Ghazaleh (Arab Wings), Jordan.
Cairo Amman Bank, Jordan.
The Inter-Islamic Network on Water Resources Development and Management (INWRDAM), Jordan.
Hassan II Academy of Science and Technology, Rabat, Morocco.
International Center for Chemical and Biological Sciences (ICCBS), University of Karachi, Karachi, Pakistan).