THE ENTREPRENEURIAL SCIENTISTS SERVING SCIENCE AND SOCIETY

By
RahmatUllah
Dr. Rashida R. Zohra

ISBN # 978-969-9011-09-2

A digital
publication by
Satha
South Asian Triple Helix Association

Acknowledgement

The authors are highly thankful to their institutions, families and friends for their overwhelming support during the research of this book. Without their support and facilitation, this challenging task may not have been possible.

Special thanks to the scientists presented in the case studies. Their support and willingness to participate was the important component of this study over a long period of time.

We are very thankful to the World Intellectual Property Organization (WIPO) because the data of international entrepreneurial scientists has been taken from WIPO Database.

Dedication

Dedicated to Mr. Abid H K Shirwani, President SATHA/ DG, UMT/CEO IRP, and Mr. Wajeeh Uddin, Chancellor, Jinnah University for Women, for their kind support of the authors.

President's Message

This is an incredible effort to inspire young scientists on how to serve society along with their academic pursuits. I always advocate entrepreneurship in teachers, researchers, faculty members and students. A person who thinks beyond the routines and brings about an innovative way of doing the assigned job actually possesses entrepreneurship and innovativeness. These entrepreneurial scientists are real heroes as they transform novel ideas into practical products and services. This book will inspire young scientists to become hybrid scientists to serve science and society.

Abid H K Shirwani
President
South Asia Triple Helix Association

Mr. Wajeehudin
Chancellor, Jinnah University for Women-JUW

I am highly pleased to see this smart book showcasing successful case studies of the scientists who serve academia and society. My university has also started journey on the track of entrepreneurial university with the support of IRP. We offer our full commitment and support to the faculty aiming to adopt hybrid role of serving science and society. This book is very helpful for our university also.

Dr. Muhammad Ashraf
Chairman, Pakistan Science Foundation

The world is indebted to the great scientists who produced theories and went to discover new areas of knowledge and wisdom. Similarly, we are grateful to those scientists who develop real life solutions for the problems confronting society and industry. My extensive science career includes more than five hundred publications presenting new theories and ideas for the next phase of technology development. The dual role of scientists to serve science and society is very credible and must be promoted. This smart book on entrepreneurial science with hybrid character of science and society will promote this culture of entrepreneurship and innovation in Pakistan.

Dr. Mirza Habib Ali
Ex-Director Research
Pakistan Science Foundation

The world we live in belongs to entrepreneurial science and exploitation of existing knowledge. Particularly, a developing country like Pakistan has no choice but to strategize and prioritize converting developed science into solutions of local problems. The entrepreneurial science discussed in this book is very much related to the local industry of Pakistan. The industry is looking for efficiency and innovativeness in existing products and processes. The entrepreneurial scientists can improve life of local society and contribute in industry growth. The literature on this subject is of high importance.

CONTENTS

Executive Summary

The current era of the knowledge economy is based on scientific discoveries and their implications inhuman life. Scientific endeavors have substantially changed the course of human history and led to exponential growth. The change in human life is fast and diversified; so is the magnitude of the problems.

This development is largely based on entrepreneurial scientists working in academia, industry, and government institutions. They thought beyond the human limits and solved problems which were considered unsolvable. This study defines an entrepreneurial scientist as an academic person who publishes research and develops products to be marketed by the organizations. The entrepreneurial scientist in this study is one who has not only contributed to the body of knowledge but also given new products and services to improve the human life experiences.

The study is being conducted by two researchers and is a continuousresearch project spanning many years. The project includes case studies of more than100 scientists who made a significant contribution to the improvement of human life experience. It also includes the scientists who are listed in the WIPO (World Intellectual Property Organization) website as model case studies showing technology impact.

This work consists of 20 casestudies thoroughly selected after a detailed study of around 300 cases from the WIPO website and other sources. The selected scientists are presented in this book and more will be included in the forthcoming versions.

This study starts with an introductory chapter based on existing literature review on the subject of entrepreneurial scientists. The second chapter includes 20 case studies of academic professors with a focus on improving the human life experiences of the real world. The third chapter includes thematic highlights of the study extracted from the cases and literature. This is the most significant part of the study. A total of four themes are presented as a PESE framework for entrepreneurial scientists along with summary discussion for each theme. The PESE framework includes components as such as personality, environment, scientific and enterprising skills of the entrepreneurial scientists. The fourth chapter presents a critical discussion, scholarly review, and conclusion of the entire study presented in the book.

These are the scientists who published their research which became the bases of many products in the market. The study findings help individuals, institutions and policy planners in developing impact making entrepreneurial scientists. The institutions can devise policies, plan interventions and take actions to foster a culture of academic entrepreneurship based on the findings of this book.

1 – Introduction to Entrepreneurial Scientists

Entrepreneurial science is an active research field and well-published phenomena for the past few years. Earlier, academic role was identified as the teacher followed by the creator of new knowledge. Knowledge is meant to lead towards publication for the purpose of its dissemination and advancement. Commercialization aspects need protection, confidentiality and secrecy; therefore, it is appreciated less by academics. This situation has changed and a new breed of scientists has started emerging. They believe in the creation of knowledge for economic growth and commercialization. They believe in publishing but also in patenting and licensing out the technology to solve human problems through products and services which they invent. This commercialization is usually done by new startups or through licensing the technology to established firms. This has also led to contract research where scientists engage with industry with target problem to invent a solution (Jain, S., George, G., & Maltarich, M., 2009; Lam, A., 2010; Etzkowitz, H., 1998; Murray, F., 2004).

One aspect of this entrepreneurial scientist journey is traveling from single identity to hybrid identity which reflects the social psychology of the scientists (Jain, S., George, G., & Maltarich, M., 2009). Scientists used to identify themselves as academicians with focus on teaching and new knowledge creation. This identity in its rigid level prevents interaction with the outer world of industry and society. The number of factors like legal change, the culture of university and involvement of scientists in industry interaction changed this single identity into hybrid identity with dual role. This hybrid identity is best reflected in biotechnology as the scientists invented new solutions, published, patented and commercialized. This role of scientists created a big economy of biotechnology (Jain, S., George, G., & Maltarich, M., 2009).

Lam, A. (2010) conducted a study in UK research universities comprising of 36 interviews and 734 sampled surveys of academic scientists. He presented the variation in norms, behaviors, and approaches of scientists toward entrepreneurial activities. He also endorsed the birth of hybrid model reporting that a class of scientists has emerged to utilize science for commercial interest and sell technologies.

Science for profit was perceived as sin in the early days of the evolution of academic entrepreneurship. Literature was published and is still being published reporting how commercialization is damaging academic freedom to think, research and publish independently. However, this transition from pure academics to academic entrepreneurship has started and this new role is now widely accepted (Stuart, T. E., & Ding, W. W., 2006). A number of factors influenced this transition and facilitated the shift towards science for economics and science for profit. The study by Stuart, T. E., & Ding, W. W. (2006) concluded that human capital in the form of patents, knowledge, and scholarship and institutional position like position and level of the university largely influence academic entrepreneurship largely. Peer influence is found very effective in the entrepreneurial research. They found that co-authorship with entrepreneurial scientists develops commercial interest. Similarly, they found that established scholars are more likely to be trusted for industry contract research due to their reputation, patents, and level of exposure in the field. Workplace norms driving commercialization are also found effective in the study of Stuart, T. E., & Ding, W. W. (2006).

The findings of a study by Louis, K. S. et.al. (1989) also presents similar findings. They concluded that individual characteristics and group norms highly affect the capability and attitude of a scientist to do science for economics.

The scientist is a central point in the process of academic entrepreneurship and therefore is highly discussed in the literature. The scientist brings human capital like knowledge, experience, patents, etc. which surely leads to commercialization of newly developed products and services. The scientist also carries social capital in the form of the good scientist as friends, laboratory network, and influence to gain other resources for commercial science (Murray, F. (2004).

2 – Cases Studies of Entrepreneurial Scientists

Case No. 1: Dr. Abdul Hameed, University of Management & Technology, Lahore: "Propagating Inclusive Education in Pakistan for Special Children"

Personal Information:

- **Name:** Dr. Abdul Hameed
- **Born:** Pakistan
- **Nationality:** Pakistani
- **Institutional Affiliation:** Dean School of Social Science and Humanities, University of Management and Technology, Lahore, Pakistan
- **Alma Mater:** Ph.D. in education from Ohio State University, Columbus, Ohio, U.S.A

Problem Background:

The term inclusive captures in one word, an all-embracing societal ideology. Regarding individuals with disabilities and special education inclusion secures opportunities for students with disabilities to learn alongside their non-disabled peers in general education classrooms. In Pakistan, several initiatives have been taken by the governments and NGOs for addressing the special education needs of children with disabilities.

Some researchers have demonstrated successful models of special and inclusive education, however a comprehensive analysis of these initiatives has not been undertaken in Pakistan. Teachers, researchers, professionals and parents are aware of the concept of inclusive education in Pakistan but are not sure how it's implemented in an ordinary setting. In some places teachers or school directors refuse to accept a child with moderate disability for these types of reasons. Hence in Pakistan it was difficult to find the good practice models for the inclusive education of special children.

Research and Development:

Dr. Abdul Hameed has spent 14 years of his career in special education. He has been the chairman of the department of special education in University of the Punjab where he started work on special education. He started social work for special children from his own children's. He then make his passion and mission that disable children's should also get education at higher level and should also participate in different jobs. He pulled all resources available for introducing the M.A in special education in University of the Punjab and for this purpose Vice Chancellor of PU at that time Lt. Gen. (R) Arshad Mahmood gave incentives and full support for launching MPhil and PhD degrees for disabled students. After a few years this degree become most popular in Pakistan as students from India, Sri Lanka and Iran also come here for special education. The major challenge that he faced during his career is to find the out of school children and to educate them. Pakistan is the top second country after Nigeria, where the number of out of school children increases day by day. Dr. Abdul Hameed then joined UMT and introduced first ever B.S. 4 year program for deaf students. This program was first introduced in America very early and now feasts in all west.

The integrating of deaf students with normal student is the major challenge that he think. But he found very good response, after three months of launching the program all students are friends and comparatively they performed well. Now he is working to implement this inclusive education all other departments of UMT such as computer science, business management and commerce to include UMT worldwide known top inclusive universities of the world. His prominent contributions are;

- Introduction of B.S 4 years program for deaf students
- Introduction of MPhil and PhD degrees for disabled students
- Launching and promoting inclusive education in Pakistan

Social Impact:

The inclusive education is important because now Higher Education of Pakistan developed policy to include special children into education. The inclusive education serves many advantages to the society because through diversity we certainly add to our creativity. If you don't have a diverse classroom or a diverse world, you don't have the same creative levels and I think our strength as a whole lies in our diversity.

Scholarly Impact:

- The initiative of inclusive education for special children has generated many jobs and the research opportunity for MPhil and Ph.D. researchers.
- Published 53 papers in national and international journals and presented 50 plus papers in national and international conferences.

- He has been reviewed PhD thesis as external examiner and supervised 14 doctoral dissertations.

Case No. 2: Dr. Abdul Rauf, University of Azad Jammu Kashmir: "Capacity Building and Sensitization of Barbers and Beauticians of Muzaffarabad for Prevention of Hepatitis"

Personal Information:

- **Name:** Dr. Abdul Rauf
- **Born:** Pakistan
- **Nationality:** Pakistani
- **Institutional Affiliation:** Assistant Professor, University of Azad Jammu and Kashmir, in collaboration with Human Appeal International-Pakistan and Department of Health, Government of AJ&K
- **Alma Mater:** Ph.D. from University of the Punjab, Lahore.

Problem Background:

Hepatitis B, C and HIV/ AIDS have become an ever-increasing health problem for Pakistan. Almost 10% of the total population has been infected with one of these viruses.

These diseases not only inflict heavy human loss but also a huge capital loss which drains from the country during the import of medicines for treatment. According to some recent estimates, an amount of 60 billion US$ is required to treat the existing disease burden, which will further increase as there is no effective vaccine against hepatitis C an HIV. Unfortunately, no effective prevention policy at the state level has been adopted to halt the spread of these diseases. This situation demands the adoption of precise preventive steps by blocking the transmission routes of these viruses. Barbers and beauticians are among the major but yet ignored disease transmitters in the society. They are quite ignorant of the fact that they may be the source of hepatitis and HIV transmission from one customer to the other.

Research and Development:

Dr. Rauf planned and executed the current project which focused on educating and sensitizing the barbers/beauticians about their role in the spread of disease, and measures which they could take to stop disease proliferation in order to save the lives of hundreds and thousands of their customers as well as the masses of Muzaffarabad city and catchment areas. Dr. Rauf, representing the University of AJK, in collaboration with Human Appeal International- Pakistan and Department of Health, Government of AJ&K, took the pioneering initiative of sensitizing and training of the barbers/ beauticians of Muzaffarabad. They were also taught practices which could eliminate the transmission of these deadly diseases. A practical demonstration of sterilization was also performed by the participants. At the end of the training workshops, 50 state-of-the-art sterilizers were distributed among participants through a lucky draw. A total of 50 personal hairdressing kits were also distributed among the students of UAJK to promote the trend of personal hairdressing kit among customers.

Social Impact:

A total of about 600 barbers/ hairdressers and beauticians of Muzaffarabad City were included in the project. They were divided into a group of 50 individuals in each workshop. During the workshop, they were educated regarding hepatitis and AIDS as well as their role in transmitting these diseases. These 600 barbers cater for the needs of 1.2 million catchment population of AJK along with half a million tourists per year.

Their unhygienic practices were exposing customers to deadly infectious diseases, but this risk has now been minimized through this project.

This cost-effective intervention at the country level can be very helpful in the prevention of deadly hepatitis and AIDS in Pakistan.

The key outcomes of the project are:

- In-time diagnosis and treatment of the barbers/ beauticians who were suffering from hepatitis and AIDS, which is helpful in saving their lives.
- During the awareness sessions, more than 2000 students and teachers of the University were also educated as an added benefit of the project.
- Government health department extended an extraordinary support towards the project by allocating funds for the complete diagnostics including treatment of all the suspects of the disease and vaccination of all the disease-free cases, which has made the project a completely comprehensive healthcare intervention.
- Training certificate has been announced mandatory for all the shops by the government agencies which will ensure safe hairdressing practice in future.
- This activity will reasonably increase the business of hairdressing/ beautician industry in the city by attracting tourists and other catchment populations due to risk-free practices.
- A sense of community service was inculcated among the university students at large, turning them into responsible and active citizen in line with the University's mission.

- Unhygienic practices of barbers were exposing 1.2 million catchment population of AJK alongwith half a million tourist customers, to deadly infectious diseases, but this risk has now been minimized through this project.
- **Muzaffarabad** is on its way to becoming the **first hygienic hairdressing city of the country**.

Scholarly Impact:

- The project generated the research opportunity for two M.S and four B.S researchers.

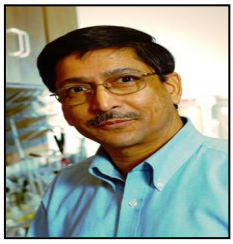
Publications:

- Abdul Rauf, Muhammad Shahid Nadeem, Nuzhat Shafi, Maher un Nisa Awan, Sumayya Aziz, Jahnanzeb Khurshid, Nisar Ahmed, Khushi Muhammad and Bibi Nazia Murtaza. Beauticians and barbers with high prevalence of HBV, HCV and HIV infections: a serious health threat to the population of Kashmir, Pakistan. International Journal of Infectious Diseases (Submitted)

- Abdul Rauf, Syed Ayaz Kazmi, Madiha Khalid, Tasleem Akhtar, Jahnanzeb Khurshid, Khushi Muhammad, Muhammad Shahid Nadeem and Nuzhat Shafi. Impact of preventive training on the practices of beauticians and barbers of Muzaffarabad: A cost-effective disease control intervention in Pakistani perspective (Under Preparation)

Case No.3: Dr. Abul Hussam, George Mason University: "Saving millions of Bangladeshi from Drinking Polluted Water"

Personal Information:



- **Name:** Dr. Abul Hussam
- **Born:** Kushtia, Bangladesh
- **Nationality:** Bangladeshi, American
- **Institutional Affiliation:** George Mason University, Georgetown University, Case Western Reserve University
- **Alma mater:** University of Dhaka, University of Pittsburgh

Problem Background:

Naturally occurring arsenic in nature is found to be polluting groundwater at higher concentrations, especially in the areas with deep tube wells. The presence of arsenic pollution is a menace in Bangladesh where 61 districts out of 64 have crossed the permissible limit and caused chronic arsenic poisoning to about 77 million people. Environmental activists, government, and academic institutions have been putting efforts on developing an easy to use and market a cost-efficient technology for safe water.

Adversity of the situation was addressed remarkably by Dr. Abul Hussam, a Bangladeshi chemist at George Mason University in the United States. He developed a cost-effective, simple and zero energy input system for arsenic removal from water. From 2001 to 2010, about a million of Bangladeshis have been benefitting from this SONO filtration system.

Research and Development:

Dr. Hassam graduated from University of Dhaka, Bangladesh, in the field of chemistry and earned Ph.D. in analytical chemistry from University of Pittsburgh in the United States. He had a great understanding of automated electrochemical methods for water toxicity analysis which triggered his mind for development of a method to combat the arsenic pollution in Bangladesh during the 1990s.

He established an automated lab at a heavily arsenic polluted area "Kushtia" of Bangladesh with the help of his brother and began screening water samples from tube wells of different areas. Side by side, he worked on developing filtration system to provide safe drinking water. It took him two years to produce a marketable version of the prototype of a system utilizing zero energy, cheap raw material, and long-term process efficiency.

Dr. Hussam devised a very easy, two-step filtration process using a composite iron matrix along with wood charcoal, river sand, and brick chips. The first step removed arsenic and the second step removed all other fine particles, producing safe potable water.

The invention was patented as "Arsenic Removal Filter" (Patent No. 1003935, 2002) by Dr. Hussam in Bangladesh along with two international patent applications which have been made under the Patent Cooperation Treaty (PCT).

Economic Impact:

The licensed NGO has commercially produced about 160,000 SONO filters up till 2010 being used in Bangladesh as well as in India and Nepal.

Scholarly Impact:

- More than 100 scientific publications and conference proceedings.
- Awarded highest engineering prize, the 2007 Grainger Challenge Prize for Sustainability from the US National Academy of Engineering (NAE) for the SONO arsenic filter.
- Reclaimed in TIME Magazine, Global Heroes of the Environment 2007.

- The Outstanding American by Choice, awarded by US Citizenship and Immigration Services in 2008.
- Distinguished Alumni Award for "Creativity, Leadership, and Accomplishments" by the Department of Chemistry, University of Pittsburgh.
- Director, Center for Clean Water and Sustainable Technologies, George Mason University
- Professor, Department of Chemistry and Biochemistry, George Mason University
- Visiting research scholar at Georgetown University and at Case Western Reserve University.

Case No. 4: Dr. Adalberto Noyola, National Autonomous University of Mexico: "Innovative Research Solutions in Waste Water and Sludge Treatment Using Biological Processes"

Personal Information:

- **Name:** Dr. Adalberto Noyola
- **Born:** May 25, 1956, San Luis Potosí, México
- **Nationality:** Mexican
- **Institutional Affiliation:** Senior Researcher, National Autonomous University of Mexico, UNAM, Institute of Engineering
- **Alma Mater:** Ph. D. in Environmental Engineering (1985)

Problem Background:

Adalberto Noyola is a Mexican environmental scientist, with specialization particularly in the field of waste water treatment engineering (France). His main focus had been in developing innovative research solutions in wastewater and sludge treatment using biological processes.

As a result of collaborations, he developed patents, wrote books, supervised researchers and also advocated enabling policies at various societies and associations he chaired. Mr. Adalberto Noyola, UNAM researcher and entrepreneur, described patenting and licensing the technology as a good stance for technology development.

After World War II, Mexico was failing to provide treated water as per the need of the nation and support economic development. In the late 1980s, driven by higher attention to the significance of clean water and the North American Free Trade Agreement (NAFTA) settlements, Mexico fortified its ecological performance, bringing about expanded interest in water treatment plants.

To address the rising issue of polluted water, Metropolitan Autonomous University (UAM) and the Institute of Research for Development (IRD), a French open research organization working for the advancement of Southern nations, formed a research team. They started to work on procedures to recycle and reduce water consumption. Engineering Institute of the National Autonomous University of Mexico (UNAM) joined the team after a year.

Research and Development:

As a result of fruitful collaboration of these three institutions, with the help of the Center for Technological Innovation (CIT) of UNAM, two patents were registered. One is related to the production process of seed sludge for up-flow anaerobic sludge blanket (UASB) reactors and the second one is regarding down-flow reactor for anaerobic or anoxic wastewater treatment. Registered trademarks included BIODAAR® in 1991, BIOIMA® and BIODAN® in 1992, and BIOSOLAR® in 1993.

The UNAM's Engineering Institute and the CIT authorized their technologies to nine Mexican organizations. The long term non-exclusive license not only includes patented technologies but also different computer software, manuals for technology usage, trademark as well as technological assistance for the application of starting projects. In early 1994, it was observed that the companies, to whom technologies were being licensed, were not promoting technology much effectively. So it was decided to start a new method for commercialization. This resulted in creation of Integración Biotecnológica S.A. de C.V. (IB Tech®), which was led by some entrepreneurs and Mexican academies. The company's name was protected through a Mexican trademark registration. At the initial stages, it was operating in the Incubator System for Technology and Science-based Companies (SIECyT) of the UNAM but later, after signing the first project it started its operations outside the university. IB Tech has its specialty in water treatment from industrial sources. They hired engineers from UNAM and also utilized the technology which they invented.

Economic Impact:

IB Tech has emerged as an engineering and project management company not only in Mexico but in technologically advanced states such as in Latin American countries including Argentina, Chile, Honduras, Nicaragua and Colombia. Right now IB Tech has its engineers specialized in Environmental, Chemical and Civil Engineering. And among many of its customers "Grupo Bimbo" (the largest Mexican food corporation and the largest bakery in the world), FEMSA -Coca Cola, Compañía Cervecerías Unidas, the largest brewery in Chile, and several Mexican states and municipalities are most important.

Scholarly Impact:

Notable Awards and Associations:

He has been awarded various notable awards such as Distinction National University for Young Academics 1991, the Prize CIBA for Technological Innovation in Ecology 1993, and the University Prize Leon Biálik, on two occasions, 1992 and 1998. He has recognitions granted by associations of engineering in Colombia and Venezuela.

Not only that, he has academic awards but also exhibits leadership and team building qualities by serving at different societies. He has served as Vice President and President of the Mexican Society of Biotechnology and Bioengineering AC, and of the Mexican Federation of Sanitary Engineering and Environmental Sciences (FEMISCA) AC. He has served as President of the Inter-American Association of Sanitary and Environmental Engineering (AIDIS) in 2006-2008.

Publications:

- 36 peer reviewed journal papers
- 5 patents
- 24 book chapters
- 50 papers in international congresses
- 52 papers in national congresses
- 24 papers in national journals
- More than 200 oral presentations in national and international congresses
- 5 national academic prizes

Supervisor of Master and PhD Students:

He has supervised 5 PhD and 16 Master thesis.

Professional Background:

- 1985 – 1987 Associate Professor, Dept. of Biotechnology, UAM, México.
- 1987 to 1990 Associate Researcher, Institute of Engineering, National University of Mexico (UNAM)
- 2001 to 2005: Deputy Director, Institute of Engineering, National University of Mexico (UNAM)
- 2008 to date: Director, Institute of Engineering, National University of Mexico (UNAM)
- 1990 to date, Senior Researcher, Institute of Engineering, National University of Mexico (UNAM)

Case No. 5: Albert Cheung-Hoi Yu, Peking University, Beijing: "Utilization of Biotechnology for the Cure of Living Beings"

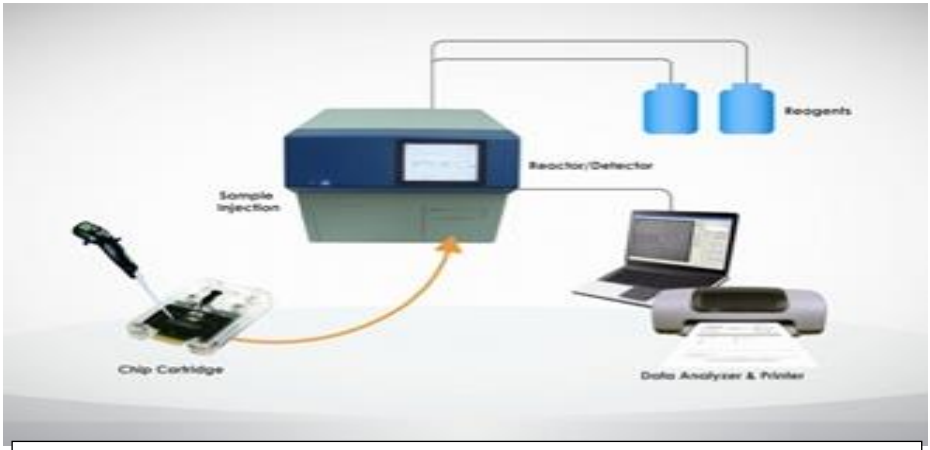
Personal Information:

- **Name:** Albert Cheung-Hoi Yu
- **Born:** China
- **Nationality:** Chinese
- **Institutional Affiliation:** Peking University, Beijing, PRC
- **Alma mater:** Ph.D. from the University of Saskatchewan, Canada

Problem Background:

In this world of technology, the healthcare sector is facing issues which can be addressed by combining medical sciences with rapid and highly sensitive detection tools. The common aging problems, epidemics, endemics and zoonotic diseases have to be dealt with technologies which are easy to use, cost-effective and rapid. The delayed medical checkups, and high healthcare cost are a nuisance for the common man in this fast-paced world.

A reclaimed neuroscientist, expert of infectious diseases and neurology at Peking University, Beijing, China, and Professor Yu aimed to work for ensuring better quality of life for mankind, and established a company named Hai Kang Life Corporation (HK-Life) in 1999.



HK-Life's LOAC system and EFADchip technology is mobile, easy to carry and highly precise and has thereby revolutionized the IVD market (Image: HK-Life)

By utilizing state-of-the-art equipment, Professor Yu launched the first biotech product H5 Avian Influenza Virus Detection Kit (H5 Kit) in 200. Since then, HK-Life is continuously driving a global healthcare market to secure lives of millions of humans and other living species. The groundbreaking technology of HK-Life is the Electric Field Assisted Diagnostic chip (EFADchip).

Research and Development:

In order to carry out research on infectious diseases and develop remedies, the company initially received grant from Innovation and Technology Fund (ITF) – a resource established by the Innovation and Technology Commission, a department of the Commerce and Industry Bureau of the Hong Kong Government, which also helped in development of diagnostic kits of other Flu strains.

The company continued product development with the help of its partners and rapidly growing a network of fully owned subsidiaries. It developed subsidiaries which supported its research platform and industrial linkages, successfully transformed them into commercial technology. Beijing Hai Kang DNA Chips Limited (BHK Ltd) helped in penetrating Asian and other international markets. Utilization of cutting-edge technologies and expertise in clinical, veterinary, food, health and environment sciences has given a boost to its market competitiveness. Due to its high-value research content, local linkages and implementation of internationally recognized quality standards and processes; it got easy for HK-Life to get international partnerships for product development and export. HK-Life not only focused on state-of-the-art R&D practices but also on popularization and awareness of the said, with brilliant science communication strategies. The research publications were sent to international scientific journals like *Lancet,* etc., training of clients on new products and services, exhibiting new products at national, international corporate fairs and exhibitions. The company not only approached top-notch business officials for clientage but also ministers and government officials of various Asian states like Dhaka, India, Bangladesh, and of course China, which resulted in brand recognition and development of new business avenues.

Economic Impact:

From 2001 to date, the company has filed numerous patents via Patent Cooperation Treaty (PCT) System managed by the World Intellectual Property Organization (WIPO), in USA, via the United States Patent and Trademark Office (USPTO), Hong Kong Intellectual Property Department via the State Administration for Industry and Commerce of the People's Republic of China, and the like worldwide.

With patent protection, trademark registrations, the IP and human assets of HK-Life have allowed the company to expand on massive national, international levels. HK-Life has 04 fully owned subsidiaries, e.g., Angenomics Limited (for marketing and international sales of molecular 37diagnostics, DNA-Tech Limited (for prenatal 37diagnostics), and Food Safety Laboratories Limited (food testing and certifications) which generates handsome financial output.

Scholarly Impact:

- He devoted more than two decades to neuroscience and infectious disease research, and contributed significantly to molecular neurobiology and molecular diagnosis
- Vice-Director of Neuroscience Research Institute of Peking University
- Chief of the Laboratory of Translational Medicine at the Institute of Systems Biomedicine of Peking University
- President of the Chinese Neuroscience Society
- Served as Chairman and Professor
- Around 50 high impact publications
- Published several books
- Around 100 conference papers
- 17,299 Citations
- Director and Vice Chairman of 10 plus professional and public-sector bodies

Case No. 6: Dr. Alessandro Ferretti, Polytechnic University of Milan: "Satellite-Based Technique to Measure Ground Movement"

Personal Information:

- **Name:** Dr. Alessandro Ferretti
- **Born:** January 27, 1968
- **Nationality:** Italian
- **Institutional Affiliation**: Polytechnic University of Milan
- **Alma mater:** Ph.D. degree in electrical engineering from POLIMI, in 1997

Problem Background:

Alessandro is an electronic engineer graduate from Politecnico di Milano (Polimi) University, with over 20 years' experience in satellite radar data. He is the co-inventor of the first advanced InSAR technique, namely PSInSAR™, and of the latest industry standard algorithm SqueeSAR™. In 2000, he created, with professors Rocca and Prati, Tele Rilevamento Europa, TRE, as a spin-off company of POLIMI to market PSInSAR™. In 2000, he created, with professors Rocca and Prati, Tele Rilevamento Europa, TRE, as a spin-off company of POLIMI to market PSInSAR™.

In 2000, he created, with professors Rocca and Prati, Tele Rilevamento Europa, TRE, as a spin-off company of POLIMI to market PSInSAR™. In 2016, he became CEO of the TRE ALTAMIRA group, when the Spanish ALTAMIRA INFORMATION was merged with TRE, under the acquisition process by the French group CLS. Throughout his career, Alessandro has driven the development of different monitoring solutions using radar data and their applications in the market. Keen for innovation, he strongly believes that satellite radar data can reduce risks, make people safer and help optimize operations in different market sectors, while respecting the environment.

In the world of new technologies Polytechnic University of Milan, (Polimi), is well known for its research and development groups, which always come up with new ideas of technological development. Professor Fabio Rocca also established a developmental group along with Claudio Prati in 1985. The main purpose was to explore the maximum possible uses of information obtained through Synthetic Aperture Radar, (SAR), a satellite system used to develop surface maps for detection of abnormality in the ground. In the beginning, the data was only accessible from an American satellite but afterwards, more satellites were launched and Professor Fabio Rocca's group became the leader in the field of satellite-based interferometric synthetic aperture radar techniques ("InSAR") to measure ground movement.

Alessandro Ferretti joined the SAR group of Politecnico in 1994 as an electronic engineer and teamed up genuinely with professors Fabio Rocca and Claudio Prati on the detailed study of digital elevation models (DEM) and satellite radar interferometry.

Heco-invented the first adavancedlnSAR technique: PSlnSAR™, patented in 1999 at Politecnico, and the latest algorithm SqueeSAR™; he now serves as CEO of TRE ALTAMIRA. The company offers satellite monitoring of surfaces and helps in analyzing data, interpreting and evaluating the risks of instabilities.

Research and Development:

Within three years of joining the group, Dr. Alessandro made Polimi file an Italian patent application for the PS Technique in 1999, and start the process for international patent grant in Canada, the European Union, Japan and the United States via the Patent Cooperation Treaty (PCT) system.

In March 2000, a spin-off was created by Polimi named "Tele-Rilevemento Europa (TRE)" which had sole license to commercialize the technology. The strategy worked very well for all the stakeholders; university, researchers, Spin-off Company and the producer industry. The industrial partner had the responsibility to deal with the marketing and commercialization of technology, the researchers had the benefit to gain royalty from university and spin-off firm, the university shared exploitation of the patent by industrial partner and the spin-off firm had all the liberty to use university as brand name, delivering supreme quality services and working on new projects with Polimi by procuring research funds.

The spin-off TRE became a benchmark as how IP cycle works; PS technology creation, protection via Intellectual Property Rights and commercialization by a spin-off company leading to financial gains for inventors and institutes and persuading them to explore further new technologies creation. Successful PS technique management by TRE led to the creation of SqueeSAR™ and the whole IP cycle came into action.

Economic Impact:

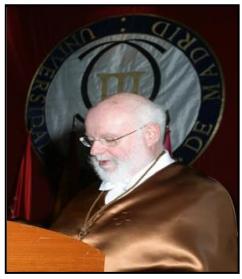
As it was a new approach, it didn't face direct competition; rather it was a very cost effective solution. The market value of PS technique led TRE to grow in 10 years from seven to twenty two employees. TRE has expanded business clientage across continents and has academic as well as corporate collaborations. It has collaborations with University of California, Berkeley, and organizations such as the Norway Geological Survey. It has ongoing businesses in Canada, North America, European municipal governments, Italy, France, Japan and Indonesia for provision of consultancy and new R&D solutions.

Scholarly Impact:

He has been cited approx. 9500 times with an H-index of 39 as per Google scholar.

Case No. 7: D. Antonio LuqueLópez, Polytechnic University of Madrid: "Bifacial Solar Cell by"

Personal Information:



- **Name:** D. Antonio LuqueLópez
- **Place of Birth:** Malaga
- **Date of Birth:** 15 August 1941
- **Nationality:** Spanish
- **Institutional Affiliation:** Polytechnic University of Madrid
- **Alma mater:** Ph.D.Technical University of Madrid

Problem Background:

Prof. Antonio Luque is a Dr. Engineer in Telecommunication at the Polytechnic University of Madrid. His core expertise is in system engineering and photovoltaic equipment's development. He is founding Chairperson of the Institute of Solar Energy in 1979. To harvest the full potential of sunrays, Prof. Antonio Luque invented the bifacial cell and commercialized it from the platform of self-created company "Isofoton" in 1982.
The company currently operates in more than 50 countries. He also chairs the Scientific Advisory Board and in Silicon ultra-purification research as CEO of the university-industry joint company CENTESIL for a pilot plant in this sector.

Research and Development:

Solar Photovoltaic systems are the source that can convert energy obtained from sun into electricity. Sun emits over a thousand times more energy than we can ever utilize. PV systems are not new, they were first invented in 1839 and advancements were made during the period till 1950s. But unfortunately, due to high cost of production its commercial application was very low. In 1990, grid connected PV systems were developed and from that point its industry started to grow further, which led to the world's fastest growing energy technology; its average production increased by 48% per year.

Patented bifacial-solar-cell was invented by Professor Antonio Luque. It collects energy from both sides i.e. front and back. This Spanish company was originally formed in 1981 as a turn off company of Polytechnic University of Madrid. Now Isofoton is serving commercially over 60 countries providing a wide range of solar cells, PV modules (immobilized and integrated solar cells), solar trackers, inverters, regulators, lighting, batteries and pumping systems, and develops new products and processes for attracting, transforming, storing and using the sun's power.

The main focus of Isofoton's R&D was to secure the know-how of technology rather than protecting its process/procedure and it costs less as well. This helped the company to bring more innovations and research ideas on the basis of their technological know-how. As Isofoton had become a pioneer in solar energy technology, they divided their strategic market into two segments. One was the market of PV application in major countries like Japan, Europe and The United States.

And the second segment represented the market for isolated PV installation. This was a quickly developing business sector where Isofoton aimed to conquer before anyone else in the market.

The company has filed eight regional applications with the European Patent Office (EPO) and eleven national applications with the Spanish Patent and Trademark Office (SPTO). Isofoton owns a registered trademark of its name and logo as well as various product names. In addition, it holds six trademark registrations with the SPTO and one registration with the Trademarks and Designs Registration Office of the European Union (OHIM) for its name and logo. As it has a growing and effective R&D, Isofoton partners with colleges, universities and research centers. In September 2009, it entered into a partnership with another Israel based solar energy company to build up a solar power yielding solution that will increase the power generation to the maximum level in addition to cost reduction.

Isofoton also served underdeveloped areas to provide electricity. It installed over 34,000 PV energy systems in remote villages in Morocco, a PV powered water plant to a rural community in Senegal as well as electricity supply to 17,000 homes, schools and health centers in Bolivia and Ghana.

Economic Impact:

In its struggling era, Isofoton nearly went bankrupt twice but with the passage of time, it made its way and name in the world of solar technology. A 3 megawatt PV power plant, which was expected to generate 3.1GWh of electricity per year, was completed in 2010 in Miltenberg, Germany.

After a lot of struggling, Isofoton managed to become one of the top ten PV solar cells producers in the world, enjoying increase in revenues each year since 1997. Moreover, in 2007, it produced 180 megawatts of PV solar cells and recorded nearly 300 million Euros in total sales.

Scholarly Impact:

Supervision:

Prof. Lukue has supervised over 30 doctoral theses, including those of several researchers who were to become prominent in the fields of systems engineering and photovoltaic equipment, such as Gabriel Sala, Eduardo Lorenzo, Juan Carlos Miñano, GabinoAlmonacid, Juan Carlos Jimeno, and Antonio Martí.

Publications:

- 165 articles in international scientific journals
- 269 at international conferences
- 2 books in Spanish and 5 books in English including "Handbook of Photovoltaic Science and Engineering"
- Holds 22 patents
- He is also on the editorial panel of 4 international scientific journals.

Achievements/Awards:

- Leonardo Torres Quevedo National Research Prize (1987)
- Alexandre-Edmond Becquerel prize awarded by the European Commission (1992)
- Academician of the Spanish Royal Academy of Engineering (1994)

- King Jaime I Prize for environmental protection (1999)
- Juan de la Cierva National Research Prize for applied technology (2003)
- IEEE William Cherry prize for research in solar energy (2006)
- Einstein prize awarded by the German photovoltaic company Solar World (2008).
- Karl W. Böer Solar Energy Medal (2015).

Case No. 8: Dr. Azmat Ali Awan, Pakistan Oilseed Development Board: "Development of Olive Industry in Pakistan"

Personal Information:

- **Name:** Dr. Azmat Ali Awan
- **Born:** Peshawar, Pakistan
- **Nationality:** Pakistani
- **Institutional Affiliation:** Pakistan Oilseed Development Board under the ministry of National Food Security and Research
- **Alma Mater:** Ph.D. from University Agriculture, Peshawar.

Problem Background:

Pakistan being an agricultural country still relies on import of edible oil. Its import comes next to petroleum products. Edible oil has been one of the major economic expenses of our country. The main issue underlying this situation was the unprofitable production of olives. Even after having the most favorable conditions for olive cultivation in various parts of Pakistan, the demand for local production was not met and that ended in importing olive oil at heavy expense.

In previous attempts to develop the olive cultivation, lack of knowledge among local farmers and selection of unsuitable regions for cultivation had rendered it unsuccessful.

Pakistan being an agricultural country still relies on import of edible oil. Its import comes next to petroleum products. Edible oil has been one of the major economic expenses of our country. The main issue underlying this situation was the unprofitable production of olives. Even after having the most favorable conditions for olive cultivation in various parts of Pakistan, the demand for local production was not met and that ended in importing olive oil at heavy expense. In previous attempts to develop the olive cultivation, lack of knowledge among local farmers and selection of unsuitable regions for cultivation had rendered it unsuccessful.

Research & Development:

Realizing the resources, Dr. Azmat developed an idea to make Pakistan self-sufficient in producing olive oil or at least meet 50% of total country need. For this purpose he took training on "Olive Propagation Techniques" at Izmir Olive Research Institute Turkey in 2006. Afterwards in 2009 a project was sponsored by Italy in which Dr. Azmat worked as a local coordinator. In the project, Promotion of Production and Commercialization of Olive Oil in Pakistan, he trained the local farmers regarding olive grafting and planting using local language and communication so information could easily be disseminated. Sessions on olive pruning and orchard management were specially designed to increase the productivity.

Dr. Azmat worked under different projects for the propagation of olive planting and grafting. During this work he, along with his teams identified approximately 870,000 hectares area suitable for olive plantation in Pakistan, among which 60% were in FATA region, 17% in KPK and 21% in Baluchistan region. KP and Baluchistan belt specially included Bajur Agency, Kurram Agency, Waziristan, Bannu, Buner, Lower Dir, Malakand, Mardan, Swat, Khyber Agency, Swabi, Barkhan, Loralai, Musa khel and KillaSaifullah. To increase the farmer's learning output; demonstration on plantation of olives was also made the part of training.

Economic Impact:

With the help of these campaigns olive plantation has remarkably been increased in the regions of Balochistan, Potohar and KPK. Local market of olives in Pakistan is also growing gradually and its by-products including olive oil, Olive pickle, jam, olive Murabba and green tea are also being made at larger extent. The main target is to achieve at least up to 50% of the total requirement of olive in the country which is only possible when we start promoting it. During year 2001 to year 2009 following areas were established for olive cultivation which have been properly functioning till now:

- Olive Model Farm Sangbhatti , Swabi: 170 Acres
- Olive Farm Pirsabak, Nowshera: 125 Acres
- Olive Orchard Tarnab Farms: 25 Acres
- Izhar Farms, Chakwal: 400 Acres
- PACIFIC Farms, Nowshera: 80 Acres

Economically, development of Olive industry, its local production, processing produced a strong and positive impact on our economy. It'stotal plantation per hector is approx. 250 and its total oil yield is about 1750 Litreswith total olive yield per plant of about 50 KG attained. These figures point that promotion of olive cultivation in suitable areas of Pakistan will contribute significantly in creating a healthy environment; both economically and socially.

Scholarly Impact:

He has completed his Ph.D in Horticulture (Olives) from University of Agriculture, Peshawar in 2014. Dr. Azmat has been Nominated as Productive Scientist of Pakistan by Pakistan Council of Science and Technology (Discipline: Agricultural Sciences, Nomination Code: 741) And also has the privilege to have written a article on Olive Oil in Pakistan in an International Book published in Italy titled "A Guide to the World of Extra Virgin Olive Oil" By Marco Oreggia and Laura Marinelli, pp: 739-741, 2015. He completed 7 months consultancy with PPAF on olive value edition.

He is a member of Editorial Board of International Journal Agricultural and Environmental Research (IJAAER) and also holds the honor to receive 11th Ambassador Award in the field of Olive from Brazilian ambassador at Pakistan on 4th November, 2017 at Islamabad. .He has 06 impact factor publications as well as 25 HEC recognized publications. Also he has been a co advisor of 14 MSc (H) thesis and BSc (H) students.
He attended many national and international conferences/workshop/trainings in the country and abroad. He also imparted training to different organizations regarding olive nursery production, orchard management, pruning and training and harvest and post-harvest of olive.

Case No. 9: Dr. Faisal Khan, Institute of Integrative Biosciences, CECOS University, Peshawar: "Initiating Multiple Entrepreneurial Ventures"

Personal Information:

- **Name:** Dr. Faisal Khan
- **Born:** Riyadh, Saudi Arabia
- **Nationality:** Pakistani
- **InstitutionalAffiliation:**Director, Institute of Integrative Biosciences, CECOS University, Peshawar; Cofounder and CEO, Peshawar 2.0
- **Alma Mater:** DPhil in Systems Biology, University of Oxford, UK

Problem Background:

Dr. Faisal Khan is an entrepreneurial scientist with tremendous passion to convert science into solutions that can address local problems and help us in driving sustainable development and economic growth. Dr. Faisal took the difficult path of testing his own ideas and experimenting with innovative models. He is undoubtedlydemonstrating new ways of how a scientist can contribute tosociety and catalyze economic development.

After his training at Oxford, Dr Faisal Khan returned back to Peshawar, Pakistan, and decided to serve his nation. He found existing institutions very constraining for new ideas and thoughts, both by scientists and students who otherwise have a lot of potential. He spent his first year in a one of the largest public sector universities, but failed to face the inertia and create any change. This is when he decided to test out his ideas by exploring newer avenues, especially in the private sector. The biggest problem in his view was the absence of an institution which combines academic excellence and entrepreneurial flair to accelerate economic growth and bring prosperity to the society. But this was his chance to prove that it is possible.

Research and Development:

Since his return in November 2013, Dr. Faisal Khan has undertaken three substantial initiatives which are noteworthy.

Firstly, he pitched the idea of a cross-disciplinary biology institute to a 30 years old private engineering university in Peshawar. Within two weeks, they signed the papers and the Institute of Integrative Bioscience (IIB) was born. IIB was meant to be world-class (zero compromise on quality), lean (purposefully frugal and devoid of extravagance) and agile (extremely quick on keeping up with the latest trends). These principles found a lot of leverage in the private sector and these could not be afforded in large, older institutions that are sources of inertia. IIB now has 100+ students and a start-studded team of biologists in its faculty. The institute takes a lot of pride in the curriculum it has developed for the BS and MS programs in Biotechnology, and the laboratory resources it offers to its researchers and students alike.

The institute takes a lot of pride in the curriculum it has developed for the BS and MS programs in Biotechnology, and the laboratory resources it offers to its researchers and students alike. The faculty is engaged in undertaking cutting edge research in areas such as Nano biotechnology, molecular biology, synthetic biology and systems biology. The Institute is also very popular for the Bio-Entrepreneurship course it offers (also developed and taught by Dr Khan), the first ever Startup Weekend event for Biologists and a remarkable STEM Outreach program that has reached over 20,000 school children across the country – from Chitral to Karachi.

Secondly, Dr Khan established Peshawar 2.0 (P2) – a social enterprise that is working really hard to engineer and foster the local startup ecosystem in Peshawar. P2 has organized some of the largest technology events in the country, runs one of the oldest co-working spaces in the country (Basecamp), and a unique incubator accelerator program (Revolt) for local startups. Since 2013, Peshawar 2.0 has successfully mobilized different stakeholders including the Government of KP, the World Bank, UNDP, all 13 universities in the City, and their student bodies to promote innovation and entrepreneurship on the City.

Finally, Dr. Faisal Khan successfully demonstrated how public-private partnerships can work in science in a Pakistani context. Faisal designed and spearheaded a new science project under the annual development budget of the Government of KP. The project called 'Propagation of Synthetic Biology' (abbreviated SynBioKP) was intended to initiate and propagate activity in the emerging new area of Synthetic Biology and bring it to Pakistan. This was carried out through different training, activities, conferences and more important participation in the IGEM Competition that takes place in Boston, USA.

IGEM started at MIT in 2004, and the IGEM Peshawar was the first ever team that took part in it in 2016. The pioneering team of undergradswas selected from all across the country and hosted by Dr. Faisal Khan's lab at IIB to conduct synthetic biology research. The team developed a biosensor for the detection of poisonous gases like carbon monoxide and oxides of nitrogen. They took the project to Boston for Pakistan's maiden participation and surprised everyone in the country with a Bronze medal. This was a major achievement in its validation of 1) local talent and 2) local capacity, and demonstrated that cutting-edge science can actually be carried out in our circumstances in Pakistan if the right will and direction are there.

The IGEM Peshawar 2017 team worked on a reporter fish and grabbed a Silver Medal in the 2017 finals in Boston, USA.

Economic Impact:

Through Peshawar 2.0, the Bio Entrepreneurship course and SynBioKP, Dr. Faisal Khan has helped catalyze more than a 100 startups in Peshawar's ecosystem and trained more than 26,000 students in business, science, and technology.

After its pilot stage worth 12.5 million rupees, SynBioKP has recently received an approval of 300 million rupees from the Government of KP, which promises to further scale all the activities under the project.

Scholarly Impact:

Dr. Faisal Khan got his Masters in Integrative BioscienceandDPil in Systems Biology from the University of Oxford, United Kingdom. He also attended the Saïd Business School as the SIP Fellow to study strategy and innovation.

He held the HEC Overseas Scholarship during his studentship and won the Oxford Noon and the St. Anne's College Domus Award. His most recent awards include the Yong Development Leader Award by the Federal Planning Commission, two annual SATHA innovation awards in a row, the P@SHA Tertiary Student Project Award for the IGEM project, and the Government Innovation Award for SynBioKP by the Pakistan Innovation Foundation. Dr. Khan has more than a dozen articles, abstracts, and conference posters, and has been invited to 60+ talks and guest lectures nationally and internationally. Dr. Khan also advises the federal and provincial government. He is part of numerous boards and task forces in the areas of Science and Technology, Education, Higher Education, Information Technology, Industries and Youth Policy.

Case No. 10:Dr. Ghulam Hussain, Govt. Postgraduate College Toba Tek Sing: "Developing Local Technologies of Leather Dyes for SRC"

Personal Information:

- Name: Dr. Ghulam Hussain
- Born: Jhang, Punjab Pakistan
- Nationality: Pakistan
- Institutional Affiliation: Assistant Professor of chemistry, Govt. Postgraduate College Toba Tek Sing
- Alma mater: University of Punjab, Pakistan

Problem Background:

Pakistan presents huge trade deficit due high import volume and less production of exportable goods and services. Almost 30% imports are contributed by chemicals as the big share of the pie after fossil fuel and edible oil. The import of dies in leather and textile also contribute major share of import. Pakistan needs to do R&D in import substitution and production local dies. SRC (Shafi Reso Chem) is among the companies which import dies and need local technologies.

Research and Development:

Dr. Ghulam Hussain a college professor in chemistry having fire in belly and dream in eyes to do something applied and significant in life. He was in search of any opportunity to exploit his chemistry knowledge and research for the benefit of the industry and society. He did his MPhil research study with Sandal Dyestuff Industry and developed Syntansas outcome of his research. Finally, Dr. Ghulam Hussain got connected with SRC a company thirsty for innovation.

Dr. Ghulam Hussain got the opportunity to substitute imported leather dies in partnership with SRC. It took him initial 2-3 years to do basic research and develop some formulations. Shortly his R&D brought fruits and he was able to install first pilot then commercial plant of leather dyes. This plant substituted significant amount of imported dues and saved country foreign reserves.

He took up the assignment of second plant and succeeded after next 2-3 years of R&D. His R&D based two commercial level plants are working successfully in SRC.

Economic Impact:

Developed two locally fabricated plants of dyes production leading to import substitution and great economic impact worth billions.

Scholarly Impact:

- He has produced 14 research publications published in high repute journals

Case No. 11: Dr. G. Sarwar Markhand, Shah Abdul Latif University, Khairpur, Sindh: "Developing Tissue Culture Technology for Date Palm Growers Industry"

Personal Information:

- **Name:** Dr. G. SarwarMarkhand
- **Born:** Pakistan
- **Nationality:** Pakistani
- **Institutional Affiliation:** Director,Date Palm Research Institute, Shah Abdul Latif University, Khairpur,Sindh
- **Alma Mater:** Ph.D. Molecular Genetics (UK)

Problem Background:

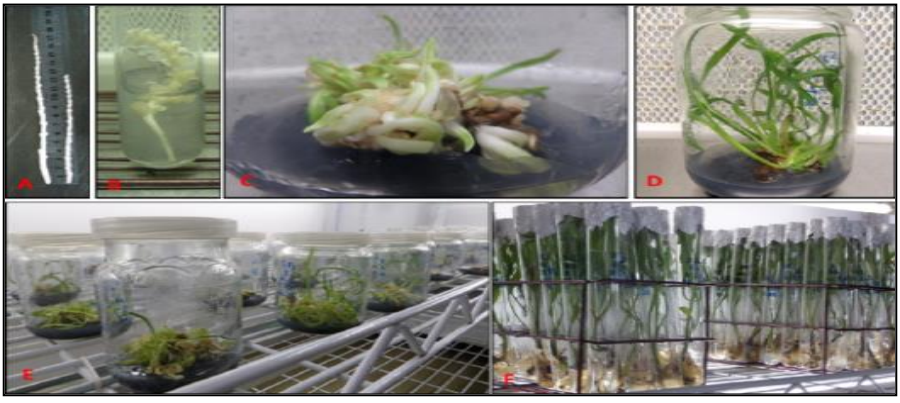
District Khairpur is located in remote part of Sindh, Pakistan, with a rural economy heavily dependent on the date palm industry. The date palm plants cultivated and planted conventionally take 4-5 years to bring fruits.

The mortality rate is generally high and sometimes offshoots bring diseases with them which eventually become the source of the problem for the whole area. If the variety has little occurrence then not many offshoots can be available at a time. There is also no chance to cultivate high-value varieties that can fetch high prices for farmers.

Research and Development:

Dr. Markhand being an active and challenge accepting scientist, got an opportunity to establish Date Palm Research Institute (DPRI) through a project funded by the Higher Education Commission (HEC). He took the opportunity with great zeal and benefitted society with good quality, rapidly growing date palm trees. The specialized science work was then ready to impact the rural economy.

Around 1000 plants of different date palm varieties produced through tissue culture were distributed free of cost as a gift to the local farmers in September 2014. Some of these plants have given fruit this year. These plants are disease free, uniform in age, availability in terms of quantity, very low rather next to nil mortality rates, easy to transport, fruiting in third year, etc. These plants are quarantine free and boundaries less.



Economic Impact:

DPRI now sells plants ready to cultivate on the subsidized rate of Rs.1000 and few thousand plants have already been sold to the local community. Science has done magic for the rural community. Instead of waiting 4-5 years and facing high mortality, they will start enjoying the fruits in three years' time only with nearly no mortality.

Scholarly Impact:

- Ph.D. from Institute of Grassland and Environmental Research (IGER), Aberystwyth, UK, Post Doctorate from University of Reading, UK
- Won Commonwealth Scholarship
- Published more than twenty research papers
- Widely presented his research work in the country and abroad
- Supervised MPhil and PhDs

Case No. 12: Dr. Irfan Ahmed Shiekh, College of Earth and Environmental Sciences, University of the Punjab: "Developing Water Treatment Technology"

Personal Information:

- **Name: Dr. Irfan Ahmed Shiekh**
- **Born:** Pakistan
- **Nationality:** Pakistani
- **Institutional Affiliation:** Assistant Professor

  College of Earth and Environmental Sciences,
  University of the Punjab.
- **Alma Mater:** Ph.D. from University of Punjab, Lahore.

Problem Background:

The generation of wastewater and excess usage of fresh water in industrial production is very serious issue all over the world as well as in The Entrepreneurial Scientists-Serving Science and Society Pakistan. The environmental problems and water scarcity is a very serious concern caused by industrial wastewater. It contributes a lot of hazardous chemicals into the main water stream and ground water.

Research and Development:

Dr. Irfan Shiekh took this challenge in his Ph.D. study to develop technology which can reduce water consumption in textile dying process. His thesis title was Development of AOPs based Novel Technology for Water Conservation and Pollution Reduction in Textile Dyeing. A total of seven (7) international patents have been awarded on the novel research work, which reduced pollution load and water consumption in textile dyeing process for cotton knits.

Dr. Irfan has assigned his Ph.D. students (Miss Nabeela Firdus and Mr. Azhar Ali) to work withSRC Pvt. LTD (Shafi Reso Chemicals). The aim of the project was the reduction of water consumption through reuse /recycling, and wastewater treatment by adopting Zero Liquid Discharge (ZLD) approach. The group has succeeded in implementing recycling system of chromium in Basic chromium sulphate (BCS) unit. 100 % recycling of chromium-contaminatedwastewater inside the BCS helped to control its discharge in mainstream (Zero Discharge approach) as well as save its treatment cost and freshwater consumption (45 T/Month).

Economic Impact:

- Signed a contract with German Company, Thies GmbH & Co. KG, for commercialization of patented technology, worth US$0.50 million, in 2009
- SRC project resulted in 50% of wastewater reduction and 30% water consumption saving, leading to economic benefits for millions.
- Dr. Irfan has provided consultancy to the industry for water treatment, water recycling and water saving giving economic benefits to millions.

Scholarly Impact:

- Dr. Irfan has 30 research publications, 07 patents, 13 books and 18 years academic and industrial experience.
- He has produced 15 M.Phil. Graduates and is supervising many PhDs.

- Dr. Irfan Ahmed Shaikh is a truly an entrepreneurial scientist with hybrid skills of moving between science and practice. He teaches in the university and provided consultancy to the industry, particularly textile dyeing and finishing companies. He publishes research papers and solves industry problems by assigning his PhDs for industrial research.

Team of Dr. Irfan Ahmed Shiekh:

- **Name: Mr. Azhar Ali**
  PhD. Scholar

- **Name: Miss. Nabeela Firdous**
  PhD. Scholar

Case No. 13: Dr. Maurice Iwu, University of Nigeria: "Proliferating and Supporting Nigeria's Biological and Human Resources across the Globe"

Personal Information:

- **Name:** Dr. Maurice Iwu
- **Born:** 21 April 1950 in Umuezeala, Nigeria
- **Nationality:** Nigerian
- **Institutional Affiliation:** University of Nigeria, University of Oxford, Ohio State University.
- **Alma Mater:** Ph.D. in Pharmacy from University of Bradford (1978)

Problem Background:

Since its independence in 1960, Nigeria has been striving to build a stable economy. Although its GDP is a bit higher than other countries in the fast developing Sub-Saharan region, it is of little use. Unemployment, illiteracy, poverty, poor health and sanitation, neglected self-production of goods, and no initiatives for industrialization hamper its shift of status from underdeveloped, developing to developed nations.

The pain of the nation was felt by a patriot named Dr. Maurice Iwu, who in 1992, developed a non-profit, non-governmental platform (NGO) as Bioresources Development and Conservation Programme (BDCP). Its role is to collaborate with local and foreign partners on traditional health practices, medicinal plant varieties, and their effective utilization. By doing so, it aims to proliferate and support Nigeria's biological and human resources.

Research and Development:

To unify Nigeria's repertoire of biodiversity with the pharmaceutical industry, the major challenge was to develop trustworthy relationship among government, business sector, and local traditional healers. To gain the trust of the local community, they were assured of their strengthened position and share from the benefits derived from these collaborations. For that, Shaman Pharmaceuticals Inc. USA (Shaman PI), founded by Lisa Conte (a scientist – drug manufacturer) and African branch of the International Cooperative Biodiversity Groups (Africa ICBG) and various departments of Nigerian government were taken on board by BDCP. African ICBG is an organization which works for biodiversity conservation and sustainable economic growth and drug discoveries. This teaming up with THPs resulted in a benefits-sharing agreement between THPs, Nigerian scientists and the pharmaceutical company in 1991.

The R&D on local flora started with the help of THPs in the identification of exact varieties having medicinal potential instead of screening huge numbers otherwise. Once the plant species were identified, taxonomically pharmacopeia (a list of medicinal drugs with their effects and usage directions) were developed.

Species were then transferred to high-tech laboratories in Shaman PI's R&D facility in the USA to investigate further. The varieties having promising results were processed to study the active compound (which actually alters biological system upon intake). The drugs were manufactured by Shaman PI using these active ingredients and the profit sharing went with all stakeholders.

Apart from the profitable ventures, at initial levels, "access fees" were paid to THPs by Shaman PI. It was to get access to the traditional repertoire of medicines via THPs and also for facilitation in plant specimen collections and other on the ground help. These short-term payments to THPs were managed by an independent organization established by BDCP called the Fund for Integrated Rural Development and Traditional Medicine (the Fund). These agreements were legal and were based in part on the Convention on Biodiversity (CBD), a global treaty sponsored by the United Nations (UN) to deal with biodiversity and the equitable sharing of benefits. It also helped THPs to set up their small-scale ventures for selling herbal medicinal cures.

Apart from Shaman PI, BDCP also partnered with organizations around the world to explore and share the R&D facilities for biological samples analysis. It included universities from UK, USA, Cameroon and South Africa.

Economic Impact:

BDCP understood the importance of IP assets. It filed various patents on drugs manufacturing with Shaman PI and other partners to the United States Patent and Trademark Office (USPTO) and also secured international markets by filing international patent applications via the Patent Cooperation Treaty (PCT) System.

Due to the unfavorable global economic climate in the late 2000s, the collaboration between Shaman PI and BDCP ended. BFCP set up two successful spin-offs, Axxon Biopharm Inc. (Axxon), Maryland USA, and Inter CEDD Health Products (IHP), Nsukka, Nigeria. These two ventures are based on production and marketing of natural pharmaceutical products.

Scholarly Impact:

- Published more than 100 research articles
- Author of four books
- Senior Research Associate at the Division of Experimental Therapeutics of Walter Reed Army Institute of Research, Washington D.C.
- WHO Visiting Scholar to Dyson Perrins Laboratory, University of Oxford (1980)
- Fulbright Senior Scholar, Ohio State University
- Won the U.S National Research International Prize for Ethnobiology in 1999
- Professor of Pharmacognosy at the University of Nigeria, Nsukka (1984–1993)
- Member, Board of Directors, Axxon Biopharm Inc.
- Member, Board of Inter CEDD, Fund for Integrated Rural Development and Traditional Medicine, and Center for Economic and Social Justice
- United Nation's Lead Consultant for the development of Nigeria's National Biodiversity Strategy and Action Plan

Case No. 14: Micheal Wilson, University College London: "Non-Invasive, Safe Treatment of Periodontics"

Personal Information:

- **Name:** Micheal Wilson
- **Institutional Affiliation:** Professor of Microbiology in the Faculty of Biomedical Sciences at University College London. Director of the Eastman Centre for Microbial Diseases within this university.
- **Alma Mater:** PhD in Microbiology from University College Galway, Ireland

Problem Background:

Periodontitis is characterized by inflamed gums and teeth caused by poor oral hygiene ultimately results in loss of infected tooth. Existing treatment methods for oral infections such as periodontitis involve tooth scaling, curettage, root planning and use of antibiotics and antiseptics to target biofilms. The physical treatments are intensive and invasive. Therefore, there was a need for new antibacterial approaches that will not only effectively treat oral infections such as periodontitis in a shorter duration but also won't add to the emerging problem of antibiotic resistance.

Professor Wilson, Emeritus Professor, and a microbiologist, is working at the Eastman Dental Institute in the Faculty of Medical Services of University College London (UCL). He was the first to successfully treat complex biofilm infections using antimicrobial Photodynamic Therapy PDT, demonstrating the potency of this technology against multidrug-resistant pathogens.

Research & Development:

Professor Michael Wilson along with his research team conducted a research on the use of light-activated antimicrobial agents (LAAAs) for the treatment of oral infections at University College London's Eastman Dental Institute (EDI). These drugs would show no activity in the absence of light but would be activated when they were illuminated by a laser that emitted light of specific wavelength for maximum absorbance by the drug. Upon activation, the drug would disrupt and damage metabolic mechanisms and cell membrane of bacteria and neutralize the toxin.

With this Periowave™ non-invasive, safe and a sixty second treatment utilizing Methylene blue for photosensitizing came into existence. The system is antimicrobial in nature and is useful adjunctive treatment to standard SRP (Scaling & Root-planning). Different parameters affecting the working were optimized and the product was finally commercialized in 2006 by licensee OndineBiopharma. It procured IPRs in the form of patents and trademarks. The patent of the technology was filed by Denfotex, a company licensing technology developed by staff at UCL. Owing to the ground breaking results of PDT, more than 300,000 patients have been treated globally.

Economic Impact:

The PDT technology producing Periowave™ has been marketed in Canada, Mexico and South East Asia. FDA approval is in process. Approximately, 92,000 treatment kits have been sold and 313,000 patients have been treated worldwide through the commercialization of this technology.

Scholarly Impact:

At the 16th International Photodynamic Association (IPA) World Congress in Coimbra, Professor Michael Wilson was recipient of the 2017 Lifetime Achievement Award in antimicrobial PDT research. He has also filed application for 13 patents for his contribution in the field of light-activated antimicrobial agents and water purification. He has received various awards for his efforts including National Westminster/British Petroleum Innovation (1990) and the Toshiba "Invention of the Year" Award for inventing a low-technology method of sterilizing water for use in developing countries, (1991). His book "Bacteriology of Humans: an ecological perspective") was awarded first prize in the Royal Society of Medicine and Society of Authors Medical Book Awards, 2008.

- Published 334 peer-reviewed papers
- 11 books
- Supervision of 35 PhD students
- 46 M.Sc. Students

Case No. 15: Dr. Muhammad Zubair, Khushhal Khan Khatak University Karak: "Development of Olive Growing Industry in Karak"

Personal Information:

- **Name:** Dr. Muhammad Zubair
- **Born:** Pakistan
- **Nationality:** Pakistani
- **Institutional Affiliation:** Assistant Professor,
  Khushhal Khan Khatak University Karak
- **Alma Mater:** Ph.D from Dalian University of Technology, China.

Problem Background:

The Karak District presents a very high potential for olive industry but it never grew as an olive industry due to local obstacles. The Pakistan Oil Seed Development Board, Agriculture Department, and some donor agencies started olive plantation and top work during 2002. It failed in District Karak due to reservations of the communities about forest conversion into commercial varieties due to fear of deforestation and lack of awareness about the benefits of olive.

Research and Development:

Dr. Zubair representing Khushal Khan Khattak University, Karak, in collaboration with SMEDA and PODB, revitalized efforts and initiated a comprehensive community mobilization program. The notables from communities, after having exposure visits to edible olive bearing districts, were motivated to start the olive top working in their groves. Olive Pruning and Orchard Management trainings were conducted. This resulted in a very positive change in the community and started demanding olive grafting and plantation. The Agriculture Research GoKP joined and by June 2017, a total of 1000 plants were grafted at TarkiKhel and Speena of District Karak. Till date, 80% success has been reported. Additionally, the olive orchards were initiated and around 1000 plants were planted at Latamber area, Khushal Khan Khattak University, Karak. Plantation at other areas of District Karak are in process.

Economic Impact:

The program will, therefore, improve the income level and create more employment opportunities in District Karak.

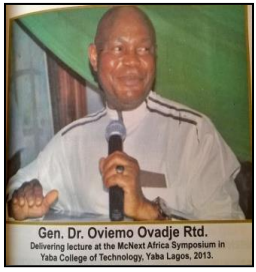
Major program beneficiaries will be the farming community, whose living standards will be improved, resulting in poverty alleviation. Additionally, CPEC is focused and this program will bring a major contribution by exporting olive oil and value addition of different olive products such as green tea, pickles, dry fruits, etc.

Scholarly Impact:

- Assistant Professor, Ph.D. in Computer Science and Ex Director ORIC
- Published 09 research papers and presented in many national and international conferences
- Technical reviewer of Impact Factor journals
- Established BIC and ORIC in KKKU

Case No. 16: Dr. Out Oviemo Ovadje, West African College of Surgeons: "Emergency Blood Auto-Transfusion Set"

Personal Information:


Gen. Dr. Oviemo Ovadje Rtd.
Delivering lecture at the McNext Africa Symposium in Yaba College of Technology, Yaba Lagos, 2013.

- **Name:** Dr. Otu Oviemo Ovadje
- **Born:** 20 December 1954
- **Nationality:** Delta State, Nigeria
- **Institutional Affiliation:** Member at,
    - Fellow, West African College of Surgeons
    - Life Member of the Association of Military Surgeon of the United States (AMSUS)
    - Member, Association of Military Surgeons of the Federal Republic of Austria
    - Member of the Technical Working Committee of the International Congress of Military Medicine
- **Alma mater:** Lagos University Teaching Hospital, University of Benin Teaching Hospital

Problem Background:

Brigadier General (Dr) Out Oviemo Ovadje (Rtd) is a veteran military doctor and inventor of famous emergency blood auto-transfusion set called EAT-SET. He received training from Lagos University Teaching Hospital and University of Benin Teaching Hospital. The invention EAT-SET is a lifesaving equipment to transfuse blood, especially in injuries due to accidents and childbirth.

Dr. Oviemois a well-known public speaker and has been awarded various national and international medals and awards owing to his social contributions. He has been serving in distinguished positions of notable organization.

Many problems had arisen from ruptured ectopic pregnancy in the past years. Many deaths were caused by internal hemorrhage/ bleeding during the pregnancy period because the facilities and process of blood transfusion had not been easy before the great and remarkable invention of Emergency Auto transfusion Set (EAT-SET) by Dr. Out Oviemo Ovadje, who was working as a medical doctor in the Nigerian Army. Getting blood from the laboratories was an expensive process for people who have low incomes, while EAT-SET was cost saving and used more advanced technology as compared to previously used methods.

Research and Development:

Realizing this health problem, Dr. Otu Oviemo Ovadje started his research in Lagos at a military hospital. He discovered that there is no need to depend on other donors, patient's own blood can also be reused after treating it with EAT-SET. In this process, blood was obtained from the body and made reusable through filtration.

After successful trials of the device in 1996, in Geneva under the directions of the World health Organization (WHO) and three Nigerian Hospitals, it was declared safe to use within 24 hours after obtaining it from the body. The most important advantage of this invention was availability of the blood at the moment. No further diseases were transferred to the patient as it was his own blood.

Initially, the project was started with limited funds but the government of Nigeria provided Dr. Otu OviemoOvadje with all necessary research equipment and facilities. Financial resources were sponsored by the United Nations Development Program (UNDP) and World Health Organization (WHO) to help in the execution of the idea.

EAT-SET industries were set to help in promoting medical devices. Many private and public financiers offered to finance the company and amount was estimated around 1 lac USD and further investment of approximately 1 million USD was expected from potential investors. The basic purpose of the company is to facilitate the market with low cost medical devices that are easily affordable by lower class patients.

Dr. Out Oviemo Ovadje filed a patent for his invention i.e. (patent no. 40893) at African Intellectual Property Organization (OAPI), with strong support of the United Nations Development Program (UNDP). It is now protected by patents in nine African countries. Realizing the importance of patents and IP protection, Dr. Out Oviemo Ovadje also acquired a trade mark for his invention in African countries.

Economic Impact:

By the end of 2006, around 3000 units of EAT-SET device were produced by an Indian company and commercialized with the combined efforts of EAT-SET industries and First Medical and Sterile Products. Per unit price was 30 USD.

Scholarly Impact:

The EAT-SET device has saved lives of many patients and is considered a great invention by
Dr. Otu Oviemo Ovadje. He has won different international awards on behalf of his invention. World Health Organization (WHO) awarded him Sasakawa Health Prize in 2000. He also won World Bank Institute Award (2000), and J.P. Morgan Chase Health Award (2002). Receiving WIPO/OAU Gold medal in 1995 and the title of the Best African Scientist were among his major achievements.

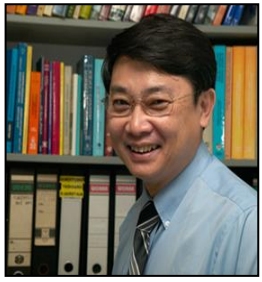
Achievements:

- Promex Silver Medal in Geneva, Switzerland, 1998
- First African Winner of WHO SASAKAWA Award, Geneva, Switzerland, 2000
- World Bank institute award in February 2000
- ARCO Gold Medal, Blood Transfusion Society of England Award, London, UK, 2001
- P. Morgan Chase Health Award at the Tech Museum Awards, California, USA, 2002
- Two-time winner of Chief of Army Staff Award of the Nigerian Army for professional excellence
- Army Council Medal, Nigerian Army, Abuja, Nigeria
- 100 distinguished Nigerians Centenary Awards

- Member of Order of the Niger, MON
- Member of the Order of the Federal Republic, OFR

Case No. 17: Teoh Swee Hin, National University of Singapore (NUS): "Tissue Regeneration Technology"

Personal Information:



- **Name:** Professor Teoh Swee Hin
- **Born:** Perak, Malaysia
- **Nationality:** Malaysian
- **Institutional Affiliation:** National University of Singapore (NUS).
- **Alma Mater:** Ph.D. from Materials Engineering Department, Monash University, Australia (1978)

Problem Background:

The patients having cranial fractures and injuries pass through a life-saving preliminary treatment called "burr hole" to prevent pressure building up in the enclosed skull and avoid the risk of hemorrhage. These holes are later repaired by fusing some external bones over it (usually hip bone parts) or titanium plates. These methods have limitations like being unable to find a suitable self-bone for grafting, infections due to improper grafts or fixing of plates, and the high cost of titanium implants. The poor and low-resolution diagnostic imaging techniques in underdeveloped countries make the problem worsen where doctors bore more than one hole in search of a suitable pressure relief point.

In 1999, a team of 06 persons comprising of scientists and doctors from National University of Singapore (NUS) and National University Hospital (NUH) led by Professor Teoh Swee Hin united to develop some tissue regeneration technology to address this problem.

Research and Development:

With four years rigorous R&D, the team successfully developed a biocompatible and degradable plug to be inserted into holes which were convenient to use, cheaper than previous technologies and was more effective in healing the wounds.

The substance used for the plug was a US Food and Drug Administration (FDA) approved polymer called polycaprolactone (PCL). PCL has characteristics like absorbable, slowly degradable, malleable, and exhibits mechanical strength like that of trabecular bone. The invention was named "Osteoplug™". With this remarkable invention, National University of Singapore (NUS) set up a spinoff company to market the product effectively. With continuous R&D efforts, now the company offers two main products in the worldwide market. The plug and bio absorbable mesh which works on the same principle as a plug but offers a large surface area for muscles, large bones regeneration. Along with that, the company also offers customized mesh scaffolds to support bone regeneration in knees, spine, eye socket, cranial and facial bones. To protect the invention, Osteopore filed patent applications at various time intervals after the first invention for bio absorbable plug implants and method for bone tissue regeneration in Intellectual Property Office of Singapore (IPOS), and Patent Cooperation Treaty (PCT) system. The company also registered trademarks for its own name *Osteopore* and its *Osteoplug*and*Osteomesh*, the two main products.

The IP protection and registered trademarks have given a competitive edge to the company in national and international markets where it operates via distributors. Osteopore is led by R&D experts and a team understands business strategies, market demands and focus on regulatory issues aswell. The wide range of functional products developed in tissue regeneration technology by Osteopore has given it a globally leading position, highlighted in the eyes of venture capitalists worldwide.

Economic Impact:

Osteopore International Pvt. Ltd. was initially established for exclusive sale and marketing of Osteology and mesh by NUS but later to expand R&D operations, the company partnered with Institute of Innovative Oral Surgery and Medicine Center for Tissue Engineering in Tampere, Finland in 2007. The partnership is focused on oral tissue regeneration technology by utilizing Finnish technology. Since tissue regeneration and modeling are one of the revolutionary areas of recent medical research, its global market was around 100 US$ in 2010 and annual growth rate AGR of about 8-20%.

Scholarly Impact:

- Ph.D. from Materials Engineering Department, Monash University, Australia in 1978
- Professor Nanyang Technological University (NTU)
- Supervised more than 60 graduate students, filed 9 patents, authored 02 books, contributed 12 book chapters, given 45 keynote/invited lectures, and published more than 300 technical papers. He has been cited approx. 7000 times with an H-index of 119 as per Google Scholar.

- Completed 15 funded research projects and 12 as collaboration projects with ongoing projects as well.
- Executive Member of the NUS Tissue Engineering Program, National University of Singapore (NUS)
- He received the prestigious Golden Innovation Award, Far East Economic Review, and the Institute of Engineers Prestigious Engineering Achievement Award in 2004, for development of the platform technology for scaffolds in bone tissue engineering.
- Chairman, Singapore Academy, Asia Regulatory Professional Association (ARPA)
- He sits in as board of editors Tissue Engineering, Journal of Tissue Engineering and Regenerative Medicine, Journal of Mechanical Behavior of Biomedical Materials, Journal of Oral & Maxillofacial Research and Proceedings of the Institution of Mechanical Engineers Part H: Journal of Engineering in Medicine.

Case No. 18: Dr. Waheed Noor, University of Balochistan: "Developing Application Software for University and Industry"

Personal Information:

- **Name:** Dr. Waheed Noor
- **Born:** Paksitan
- **Nationality**: Pakistani
- **Institutional Affiliation:** Assistant Professor, University of Balochistan
- **Alma Mater:** PhD. from Asian Institute of Technology, Thailand

Problem Background:

Dr. Waheed Noor joined University of Balochistan as alecturer in computer science and completed his Ph.D. in machine learning from Asian Institute of Technology, Thailand. He saw his university troubled in multiple crises which could be partially solved through process automation. UoB could not afford billions for process automation of the largest institution of the province which was already crippled with financial crises. He decided to help UoB and initiated in-house development of many software applications.

Research and Development:

The opportunity of serving as department head enabled Dr. Waheed to exercise his entrepreneurial capabilities. Dr. Waheed and his team developed an excellent local system of distance education. This system integrates teachers, students and university management for a number of educational activities. They won the project of developing internal examination system for the University of Baluchistan. This system saved millions in cost and also saved billions by preventing corruption done through the conventional system. His team is working on a system to integrate all the matters of students including hostels. This project will automate all the matters of students and things will be recorded, tracked, updated and accessed within a short time.

Dr. Waheed won FAO project worth 0.85 million and delivered it successfully. He delivered on 60%-70% cost of the market-saving lot of money for FAO. Dr. Waheed is working with a number of other organizations for short and long-term projects.

Economic Impact:

He saved minimum 15 million of UoB through in-house development. In-house development has been providing IT services to Public and Private sectors and contributing to Revenue generation.

Scholarly Impact:

- Currently serving as Assistant Professor at Department of Computer Science, University of Balochistan, Quetta, Pakistan
- He has an additional charge of Director, Office of the Research, Innovation & Commercialization (ORIC) and Directorate of Distance Education, University of Balochistan.

- Obtained Ph.D. from Asian Institute of Technology, Thailand, in 2013 in “Learning Predictive Models for Optimization”, Computer science.
- He is an approved HEC supervisor, technical reviewer of IEEE journals and has published in impact factor journals.

Case No. 19: Yoshiyuki Sanka, University of Tsukuba: "Human Assistive Limb"

Personal Information:

- **Name:** Professor Yoshiyuki Sanka
- **Born:** Japan
- **Nationality:** Japanese
- **Institutional Affiliation:** University of Tsukuba
- **Alma mater:** Ph.D. University of Tsukuba

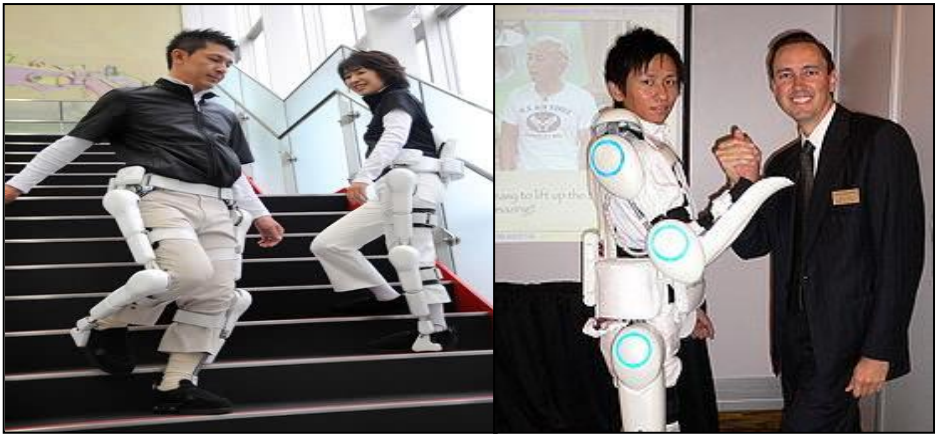
Problem Background:

In 1968, it was a book "I, Robot" by Isaac Asimov that inspired a young boy to make robots. Unlike others, he didn't let go of this childhood dream; rather, it grew with his own self. He shaped his interest in robots, electronics, and engineering to serve humans. After getting an engineering degree, he chose academic profession at the University of Tsukuba in Japan to shape his dream into reality. With sheer dedication and futuristic approach, Prof. Yoshiyuki Sankai presented his invention robot suit, dubbed HAL™ for "Hybrid Assistive Limb" in 2005. A cyborg-type strap-on robot suit designed to aid elderlies, disabled to perform daily tasks like climbing, walking, bending, lifting heavy objects which would otherwise be cumbersome.

The invention not only has potential in the biomedical industry but also in factory operations requiring intensive labor, entertainment industry and also in rescue operations by teams.

Research and Development:

Prof. Sankainoticed that the barrier in tech development is intolerance of the human body to any external object injected/inserted in it. His invention "Hybrid Assistive Limb" worked on sensing the nerve impulses on the skin which were analyzed by integrated computer on the device which eventually helps movement. Though device engineering was a tough task, its integration with the human body was more difficult. Timing to move motors of the device with the user's intentions, the discomfort of wearing an external device, different body shape/sizes, weight and durability of the device were some of the major challenges. Prof. Sankai felt that in order for the invention to work, an interactive knowledge of fields like engineering, behavioral sciences, physiology, psychology, neurosciences along with ethical, social, safety and legal considerations had to be developed.



He proposed an entire academic system "cybernetics", which is now taught worldwide, for development of his invention. The robotic suit HAL is the proud product of cybernetics by the University of Tsukuba.

Cyberdyne® Inc., Professor Sankai's company, manufactures and commercializes the HAL robot suits that have a tremendous potential not only for medical use but also for rescue support operations, the entertainment industry, labor-intensive factory operations and related businesses.

To assess functionality of HAL, Cyberdyne signed agreement with Odense municipality (Denmark) which tested it in rehabilitation unit run by the city's Elderly and Handicapped care agency. MoU with Karolinska Institute and Karolinska Institute Danderyds Hospital were also signed for R&D collaborations.

Economic Impact:

For the commercialization of Prof. Sankai's R&D products, a university spin-off venture firm named Cyberdyne Inc. was set up in 2004. It facilitated the production, leasing and sales of the HAL suits.The company works for "Research Projects for Promoting University-Industry Cooperation" and "Projects for Supporting University Spin-offs".

From 2008, Cyberdynewent into mass production, marketing and distribution of the HAL robot suit nationwide and from 2010, it reached global sales aswell.

The invention has been patented in Japan, USA, Europe with "Robot Suit" and "Robot Suit Hal" names. Cyberdyne also filed Patent Cooperation Treaty (PCT) application for the robot suit.

Prof. Sankai has a number of other inventions and international applications through the PCT system established by the World Intellectual Property Organization (WIPO) which generates revenue for the researcher.

Scholarly Impact:

- CEO of the cyborg-robot maker Cyberdyne
- Professor of the Graduate School of Systems & Information Engineering at the University of Tsukuba
- Visiting professor at Baylor College of Medicine, Houston, Texas, US
- One of the richest persons in the world. He is a Japanese billionaire
- Awarded numerous national, international awards for pioneering new fields in robotics and mechatronics like the World Technology Award in 2005, Edison Award (2014), SII2012 Best Paper Award(SI), The Capek Award, etc.
- Published more 25 high quality papers, above 20 books, presented 100 plus conference papers and holds more than 30 patents
- Member, Director and Advisor of 20 plus professional, government and academic bodies.

Case No. 20: Dr. Zafar Iqbal, University of Peshawar: "Initiating Multiple Pharmaceutical Ventures"

Personal Information:

- **Name:** Dr. ZafarIqbal (Tamgha-e-Imtiaz)
- **Born:** Mardan, Pakistan
- **Nationality:** Pakistan
- **Institutional Affiliation:** Meritorious Professor

  Department of Pharmacy, University of Peshawar
- **Alma Mater:** Ph.D. Dept. of Pharma.Sci. University ofStrathclyde, Glasgow, Post.doc. Pharma. Sci. Institute of Pharmacy and Biomed. Science, University of Strathclyde, Glasgow. U.K.

Problem Background:

Mr. Ashfaq Ahmed Paracha was a banker by profession with vast international exposure. While living in Peshawar, he got interested in setting up a pharmaceutical plant in KP. He had zero knowledge about pharmaceuticals. However, he was driven by the high spirit to serve the country with economical and affordable drugs supply.

Another lesson that he learned from his global exposure was that university scientists can help him to set up his dream unit of pharmaceuticals. This belief brought him to the University of Peshawar where he met Dr. Zafar Iqbal, an entrepreneurial scientist serving the Pharmacy Department.

Dr. Zafar Iqbal has been In-charge of Research in Sibro Pharma Ltd. Nowshera, Production In-charge at Redex Drug House Labs., Faisalabad, and Head, Production & Quality in Wellcome Pakistan, Karachi. He set up many laboratories for pharmaceutical industriesand helped many industries for drug registration. His research group developed two fast released ant-emetic formulations and these are patented research products in Pakistan. He has applied for 4 other patents.

Research and Development:

The university-industry collaboration took birth between the Pharmacy Department, University of Peshawar and Delta Pharma. Dr. Zafar took it as a challenge to convert his science into economical drugs for the community. He identified, formulated and set up production with high quality and assured compliance with local and international standards. Delta Pharma, which has been running successfully, was the outcome of the entrepreneurial approach of Dr. Zafar Iqbal. The project was successfully completed with support and trust of a businessman on the university research skills.

This is not the single case of the entrepreneurial zeal of Dr. Zafar. He served many other industries, set up quality labs, designed production process and helped industries for drug registration. He is the scientist equally known to academia and industry with patents, publication and production consultancy to his credit.

Scholarly Impact:

- Ph.D. and Post Doc. from Dept. of Pharma Science University of
- Strathclyde, Glasgow, U.K.
- He has 135 research paper publications to his credit
- Supervised more than 30 MS and PhD theses
- Chief Editor of a journal and member editorial board of more than 10 journals.
- Won and managed funded projects worth millions (PKR).
- He organized five conferences and contributed chapters in two books
- He got two patents in Pakistan

3-PESE Framework of Entrepreneurial Scientists

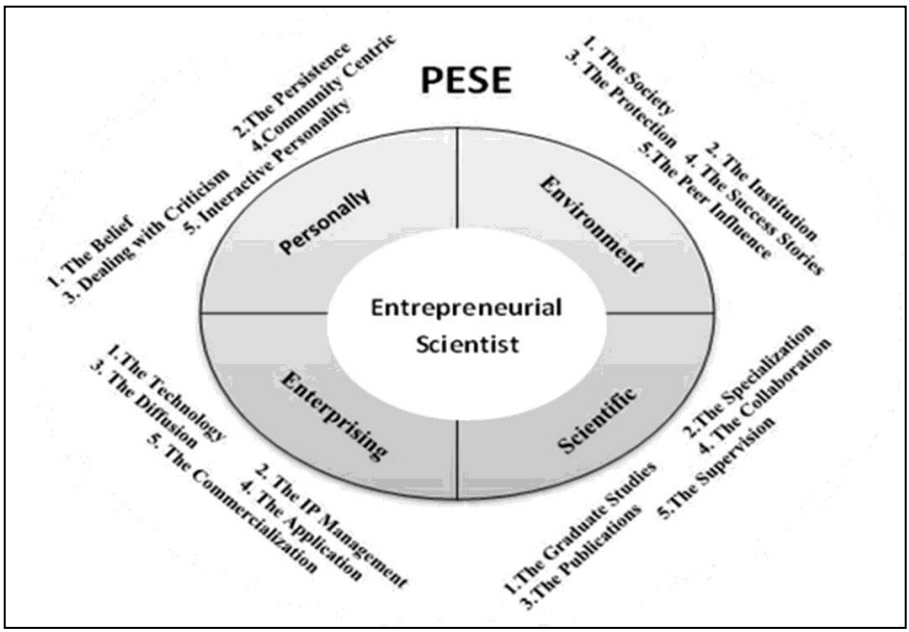
The findings of the case studies are formed into the conceptual framework presented below. The entrepreneurial scientists are primarily characterized as having four components: The Personality, The Environment, The Scientific and The Enterprising. The four components contribute to the buildup of the entrepreneurial scientists. Each component has five further indicators that explain how the component is formed.

The personality component further includes five indicators as the belief, the persistence, dealing with criticism, community centric, and interactive personality. These indicators together constitute the personality of the entrepreneurial scientist. **The environment** also affects the person to be an entrepreneurial scientist. This component has five indicators as the society, the institution, the protection, the success stories, and the peer influence. These indicators together constitute the environment component of the study. The third study component is **the scientific** dimension of the entrepreneurial scientist. This component includes five indicators comprising of the graduate studies, specialization, publications, collaboration, and the supervision. The fourth component is **the enterprising** which includes indicators as technology, IP management, commercialization, application, and diffusion. The framework is the theoretical extract of the case studies of the entrepreneurial scientists who have served both academia and society.

3.1 Personality of Entrepreneurial Scientists

The people with the genes to come up with innovations are known as creative geniuses. They may be known as cat lovers, music lovers, lonely, messy, having bad hand-writing and the tendency to think differently. Similarly, there are personality features which are well researched about successful people.

Figure 01 – PESE Framework



They are humble, hard-working, outreaching, driving, team-builders, planners and exceptional executors. The entrepreneurial scientists are another rare breed in this world who give different meaning to success and science. Our study findings are an extract of the work of more 100 such scientists but the findings presented in this book represent only 20 case studies.

3.1.1 Belief

The entrepreneurial scientist means science for the benefit of society; they utilize science to solve problems of the community and industry. All the entrepreneurial scientists are found with firm belief to find solutions of human problems from the scientific discoveries. They use the power of belief to see what is not seen by others.

Their strong belief in the capacity of science to solve human problems helps them travel the tough road of turning impossible into possible. The people of Bangladesh would have been facing the consequences of using contaminated water (carcinogenic), if Prof. Hussam had lost his belief in using science to come up with a cost effective solution. His belief to produce scientifically viable water purification solution turned into reality.

3.1.2 Persistence

All the entrepreneurial scientists embarked on the difficult journey full of ups and downs. Failure was expected more than the success. They kept on searching for the ultimate solution which they had envisioned to be the great innovation. Their ability to stay firm and keep on moving brought success for them. They were quite persistent in the long term and demonstrated persistence even when the unexpected happened. Persistence is crucial in innovation as more than the planned time and resources are consumed. Prof. Markhand maintained his persistence for many years to establish a biotechnology lab and transfer date palm plants to the farmers. This success would not have been possible if he had lost his patience during the long R&D work, ups and downs and unexpected occurrences.

3.1.3 Dealing with Criticism

Criticism is common and overwhelming when your planned innovation is expected to break the status quo. The early stage of failures and low performance also invite a lot of criticism by those who doubt the innovation. The scientists advocating for the ban of CFC were simply labeled as 'Russian Agents Killing American Industry.' The scientist who tried to develop innovative ecosystem for natural products to improve the economy of rural people was criticized as "The Fake Scientist."

The study shows that these scientists are never demotivated by criticism and negative experiences. They successfully manage the criticism by not being reactive or demotivated.

3.1.4 Community Centric

The community centric people are grounded in the passion to serve social causes for the benefit of the society. The entrepreneurial scientists must have borrowed some gene from the social centric breed. Most of the scientists have chosen their technological innovations due to negative impact of target problems on the community. Dr. Waheed Noor helped in eradication of corruption worth millions by automating systems and processes of the university. His passion to end corruption led to the development of a series of applications and software which resulted in saving millions for his university.

3.1.5 Interactive Personality

The ability to develop a solution requires deep understanding of target problem. This deep understanding of problems requires extensive interaction of scientists to understand the issue from different dimensions. The highly interactive personality interacts with all the stakeholders concerned with the problem, understands its magnitude, and comes up with the solution which is the best fit in the context. The entrepreneurial scientists in the study are found to be very interactive and they reached out to the community. They worked in close coordination with the community to propose and test the developed solutions for target problems.

3.2 Environment for Entrepreneurial Scientists

A great deal of academic literature discusses what drives people to accomplish outstanding achievements.

Money, religion, cast, traditions, passion and many other factors drive people. There is discussion about system, policies and rewards to drive scientists to come up with more publications and innovations. This study of entrepreneurial scientists reveals interesting factors in the environment that drive a scientist to act as an entrepreneurial scientist.

3.2.1 Society Appreciating Entrepreneurial Activities

The saying that the human is a product of the environment holds true in the case of entrepreneurial scientists. The healthy characteristics of a society like encouraging risk taking, rewarding failures, appreciating out of the box thinking and facilitating new ventures inspire the scientists to take unusual moves in life. The entrepreneurial society presents high probability to produce the entrepreneurial scientists. Therefore, most of the scientists in our sample study are trained in the USA followed by Germany, Japan and the UK. The political and social leadership should cultivate the means and the environment to inculcate entrepreneurial societal components. Society will feed the breed of entrepreneurial scientists who ultimately convert science into solutions and improve the human life experiences.

3.2.2 Institution Providing Enabling Environment

The institution is like a second home to the people and often they spend more time in the organization as compared to the home. The entrepreneurial spirit that exists in the institution will determine the birth of entrepreneurial scientists. The entrepreneurial institutional culture is characterized as having freedom of expression, encouraging diversity, inspiring creative and independent thinking, rewarding societal services, facilitating scientific endeavors, appreciating out of the box moves, inspiring faculty to outreach and interact with the outside environment, and including innovativeness in the

faculty and students. The institutional culture is very much responsible for producing entrepreneurial scientists. The case of the study reflects this thesis as most of the scientists are trained in such kind of academic environment. The institutions of these scientists present great degree of diversity and creative thinking.

3.2.3 Protection of Entrepreneurial Interventions

A strong IP environment guarantees reward of long term scientific discoveries and developments. The fear of not being rewarded or associated risks kills the spirit needed for discovering the right solutions of the problems. The protection in the form of IP not only rewards the inventors and institutions but also ensures that innovations are rightly treated and saved from poor quality copying. Dr. Hussam wanted to make his Sono Filter invention public without patent so that a large number of people can produce, use and improve life through purified drinking water.

The IP office of his institution advocated for patenting and licensing to the producers for genuine reasons. Through IP, the invention was saved from falling into the wrong hands that could copy or destroy the invention. Similarly, non-patented inventions are less likely to bring good revenue from the licensing fee and other modes of commercialization. The developing economies have very weak IP regime and poor law enforcement which discourages inventors to invest their life in great discoveries. The scientists in the study utilized patents to protect their inventions and earn rewards including high level of satisfaction.

3.2.4 Success Stories of Seniors by Selling Technologies

Success breeds success proves true in the case of the upbringing of entrepreneurial scientists. The rumors about entrepreneurial scientists and their success stories create a culture of inspiration for everyone to become an entrepreneurial scientist. Especially, the success stories of professors narrated in the class inspires faculty and graduates to solve the dominating problems of the world through new innovations. The respect, financial earnings, satisfaction, high regard in the society, and recognition of entrepreneurial scientists in the academic circles drives everyone in the academia to develop great solutions, new ventures and amazing innovations.

3.2.5 Peer Influence on Entrepreneurial Activities

The old saying that a person is like the company he keeps best reflects in the case of entrepreneurial scientists. The academic literature and observations during the research of presented cases in this study confirm the thesis that university peers largely influence others. A university having good number of faculty doing entrepreneurial activities presents higher likelihood that more entrepreneurial scientists will emerge. The entrepreneurial scientists start observation of academic life at graduate study level. The peers in the universities ignite their hidden spirit, help to find a potential problem, and facilitate to frame a good study to develop the solution. The colleagues who are involved in entrepreneurial interventions add fuel to the fire and cause the birth of more entrepreneurial scientists. Universities must bring entrepreneurial scientists in the campuses to produce more entrepreneurial scientists and earn the repute of being entrepreneurial.

3.3 Scientific Skills of Entrepreneurial Scientists

3.3.1 Graduate Studies Incubate Scientific Entrepreneurship

The study of entrepreneurial scientists also leads us to an important question: when do the scientists develop the germs of entrepreneurship? Academic literature and observation of study cases reveal that graduate study period is the incubation of entrepreneurial germs. The scientist who shared the Nobel Prize for CFC discovered harmful effects of CFC on ozone during PhD work. He developed passion and continued the investigation in the later academic career. The universities with rigorous graduate programs present higher probability to produce entrepreneurial scientists. The professors, university, environment and topic of graduate study reinforce the spirit of solving great human problems through scientific solutions. This thesis is backed by large number of cases of students and professors whose ventures and startups of graduates stemmed from the institutions. The study finds that graduate studies rightly planned on the issues of industry and society incubate scientific entrepreneurship in the minds and hearts of students. These students, when they join the academia, contract research, serve industries and contribute to the knowledge based economy. This has become a virtuous circle in the advanced world and the developing world is striving to embark on it as well.

3.3.2 Specialization in the Area of the Target Problem

Scientific entrepreneurship demands a great deal of expertise, intellectual thoroughness and scientific rigor. This does not come from generalized level of expertise. Scientific entrepreneurship also means developing the competitive solution crossing the limits of offered solutions until now.

The solution may come from combination of existing offering or by employing some management design. The faculty spends great amount of time thinking and passes through extensive experimentation in a focused field which presents greater possibility of developing a unique solution of the target problem. This demands in-depth understanding of the phenomena and scientific possibilities to respond to the challenge. Specialization is also required to convert academic results into some prototype and then the final acceptable product. Therefore, many great products belong to the specialized areas of the inventors.

3.3.3 Collaboration with other Experts of the Field

The standalone voyage through the sea of scientific discoveries is a known historical fact. Solo flight in the field of scientific entrepreneurship is seldom experienced. In order to convert basic results of experimentations into some useable product, 8-10 diverse expertise are required. The scientist needs to work with engineers, designers, finance people, marketing people and supply chain experts to develop a useful product. Therefore, entrepreneurial scientists are always those who believe in collaborative works and team support. There is also need to consult peer scientists for input at all stages from theory to experiment and product development. The cases of the study show that scientists with high capability for partnership and collaboration are more likely to become entrepreneurial scientists and develop great innovative products.

3.3.4 Publications in the Related Field

Academic publication and industry contract research have been academically presented in contrast to each other. The academic freedom to publish is threatened when results are not disclosed and codified for business secrets.

Industry research is mostly seen unworthy of publications. Based on the presented case studies, this study found this debate a myth for number of reasons. The publications always reinforce and endorse the claims of the product, and therefore contribute towards awareness, promotion and consumer trust on the product. The competitive industry product always demands more than what is offered in the market and known to the world. This extra creation of knowledge leads to good patents and worthy publications. The entrepreneurial scientists who offer great products to the market also publish well in reputable journals. The publications of entrepreneurial scientists are more grounded in real data, offer new knowledge and are more valid. The entrepreneurial scientists gain two impacts after being published in impact journals and making some impact on society. Therefore, they yield more citations.

3.3.5 Supervision of Research in the Related Field

The entrepreneurial scientists hold another great secret and that is their graduate students doing great research. The entrepreneurial scientists offer better quality supervision of graduate research as compared to pure academic professors. They present greater understanding of application to the students and help them do meaningful work. The entrepreneurial scientists assemble variety of students' work and convert them into some useful solutions. Entrepreneurial science work requires large amount of surveys, experimentations, prototyping and product design. This extensive input is possible only through quality research supervision. Therefore, the entrepreneurial scientists are better supervisors in their focused area of research.

3.4 Enterprising Skills of Entrepreneurial Scientists

3.4.1 Technology Skills to Convert Academic Results into Product Solution

The academic scientists are very good in designing and conducting experiments. They are less trained in thinking about academic results in terms of business. The entrepreneurial scientists have touch of this enterprising skill. They prefer to patent first and then publish. They have the ability to choose topics and design their experiments that can respond to a particular problem. They also go for technological way of doing research which means finding new ways to produce solutions in a low cost and high yield manner. This becomes a transferable technology which is well understood by the community and the industry. The entrepreneurial scientists think in terms of solutions, products and technology avoiding academic jargons of significance and P value. The technology development skill requires the scientific ability to produce better solutions than those offered by the existing players and are easy to be adopted by the end user community.

3.4.2 IP Management for Technology Spread

The historical traditional academic style is to publish what is written well, produced through scientifically sound experimentation, is repeatable and qualifies standard validity. The new regime of entrepreneurial science is to adopt IP route to register social and economic impact of research work and then publish also. Therefore, it is advisable that research which produces significant solutions to a high prevalent problem must be patented first and then published. The patent is an excellent tool to spread value of your technology to maximum stakeholders without fear of loss or theft.

Research can be published, presented, negotiated and promoted through press and social media after securing IP. The entrepreneurial scientists develop the art of managing successful IP which leads to better utilization and implementation of technology. They also develop understanding of financial returns from IP, and strategize accordingly with the university, investors, technology offices and legal experts.

3.4.3 Commercialization Skills to Convert Research into Business Results

Entrepreneurial scientists believe in working with technology transfer offices (ORIC in Pakistan) to better plan monetization of their research. IP managers and the scientist jointly plan the transfer of academic research into business value through IP management. This involves careful drafting of patent documents, careful disclosure of technology, finding the right partners to invest and working with consumers of technology to adopt and use. Commercialization skills also include ability to interact with large number of people, present technology, negotiate terms, enter into various contracts, and ensure ultimate production and sale of technology in the form of a product. The commercialization journey of academic results also requires a lot of piloting and prototyping before commercial scale production is started. The entrepreneurial scientists need to work with engineers, marketers, financial experts, legal experts and business investors. This develops complex phenomena as every player involved has its own role and reward share in the technology. Commercialization is mostly managed by technology offices and requires celebrative working between the scientists, technology managers and the investors.

3.4.4 Application Skills to Fit Technology in the Problem Environment

Application is the most critical stage for academic results in the cycle of technology development. Large number of projects fail in the implementation stage. The biggest challenge of application is the integration of the product with other tools, gadgets, machines and instruments available in the working environment. The second big challenge is consistence performance or reliability in terms of repeated production with the same quality. The third big challenge at application stage is qualification of industry standards like STM standards. The entrepreneurial scientists are very comfortable with application challenges and work to get their technology through. The entrepreneurial scientists also understand the complexity of this stage and keep on improving, revising, and modifying the product till it qualifies the requirements. This phase also demands the ability of the entrepreneurial scientists to work in different environments and deal with people of diverse expertise having supporting roles in their technology application.

3.4.5 Diffusion Skills to Ensure Technology Adoption by the Masses

The ultimate success of technology is acceptance by the end users. The return of efforts of all the technology stakeholders like donors, the university, inventor, investors and support staff depends on user acceptance of the technology. The success of technology is determined by the appreciation of end users to buy and refer it to other consumers. Unfortunately, large numbers of outstanding technologies fail the adoption and diffusion test. Successful entrepreneurial scientists understand this diffusion challenge and work with the end user along with technology development.

They make the end user part and partner of their development. They keep on presenting and sharing new technology developments to get feedback. The entrepreneurial scientists develop an outstanding ability to adjust their technologies with the end user requirements. The end user does not always demand technologically superior product. In fact, large numbers of technologically superior products have failed, and simpler and convenient products have been marketed. There are a number of factors which influence technology adoption like culture, government regulations, convenience, comfort, knowledge about usage, local values and traditions and most importantly, user perception towards technology.

4-Conclusion

The antithesis of our study is fear of the death of academic independence to investigate and publish. The critique presented by scholars comprises variety of arguments including growing academic slavery to the corporations under the umbrella of academic entrepreneurship. The academic entrepreneurship phenomena emerged in the USA and spread over the developed world, followed by the developing world now. USA and Japan are leading fronts of university entrepreneurship. The study by Walsh, J. P., & Huang, H. (2014) on USA and Japan confirms delay in publications and growing secrecy of academic results in the race of patenting. Public money funded academic results are becoming trade secrets of corporations in the name of licensing and patenting.

The advocates of academic entrepreneurship argue more powerfully that this growing phenomenon of academic entrepreneurship has genuine reasons to grow and become an active part of human life. The guru of this field, Henry summed up growth factors of these phenomena. According to Etzkowitz, H. (1983), public sector funding has reduced substantially and made more objective too. This causes the presidents to find more avenues of funding from the market and resultantly, industry contract research has grown. There is phenomenal change in the belief of university faculty from pure academic research in the pursuit of knowledge to application of knowledge for the benefits of the society. There is a technology transfer industry as a third economy has emerged recently and grown up to great heights. Every university has a technology transfer office and there are large numbers of allied services in the private sector.

There are scientists like Gulbrandsen, M. (2005) who are publishing the moderate way of academic entrepreneurship. He suggests scientists not to get extremely grounded inside of both industry and academic pursuits.

The entrepreneurial scientists may serve both the sectors by staying in the boundaries of both. The findings of Shichijo, N., Sedita, S. R., &Baba, Y. (2015) are very good contribution in response to this debate. They concluded as "*that entrepreneurial scientists make a relatively large contribution to furthering the scientific frontier by not relying on conventional research traditions. The two-way interaction between science and technology provides scientists with the opportunity to extend their scientific research into unexplored areas, and it is the type of entrepreneurial scientists that benefits mostly from such opportunities".*

The commercialization of university knowledge is founded on the principles of economics and new market realities. The world can no more afford investment of trillions ending up in the form of academic theses and reports while the people continue suffering with diseases, poverty and social ills. The entrepreneurial zeal in scientists is mostly found either through family background or peer influence. Scientists like Dr. Waheed served the society successfully by employing his academic expertise. He believes that science is the best tool to solve problems and generates more economic activities and financial reward. He has set the example for others to sell their technology and build career as entrepreneurial scientists.

The study offers insight on how scientists get engaged in entrepreneurial activities. The era of scientific entrepreneurial is not very old and emerged recently. According to Kenney, M., &Goe, W. R. (2004), this phenomena is best explained by the term "Nested Embeddedness". The scientist is influenced by peer, his institution and overall environment. It is also learned from literature and above case studies that entrepreneurial activities in early career also help the scientists to adopt the career of hybrid entrepreneurial scientists.

The following factors mostly influenced the faculty to be entrepreneurial scientists:

1. Entrepreneurial research experience during PhD studies by solving some real problems
2. Success stories of seniors by selling technologies
3. Influence of the peer by observing peer doing entrepreneurial activities
4. Enabling environment in the institution
5. Inspiring culture and appreciation in society for entrepreneurial activities
6. Involvement in technology transfer process

The common characteristics of entrepreneurial scientists include:

1. Belief in science for economic generation
2. Passion for involvement in entrepreneurial activities
3. Deep understanding of the problem and orientation
4. Keen interest to solve significant problems of the community
5. Love to interact with stakeholders
6. Focusing more on science and technology application

In developing countries like Pakistan, the breed of entrepreneurial scientists is emerging. The academic community is slowly losing its belief on only science to science and its application. Scientists having frequent interaction with community and society will be able to develop the needed technology and earn through licensing.

Academics like Krabel, S., Siegel, D. S., &Slavtchev, V. (2016) term this "mobility of the scientists", which causes the incubation of entrepreneurship in the scientists. This mobility includes interaction with industry and society, education abroad, and foreign-citizenship.

They also described few personality features of mobile scientists as "*the tolerance of risk and uncertainty, high degree of human and social capital, as well as high entrepreneurial commitment*". This scientists' mobility issues is endorsed by Moog, P., Werner, A., Houweling, S., &Backes-Gellner, U. (2015) who have also advocated for diverse experiences of the scientists and interaction with outside diverse environment. They concluded that variety of experiences and interaction with multiple environments develop faculty as entrepreneurial scientists. Similarly, Bienkowska, D., Klofsten, M., & Rasmussen, E. (2016) pointed out very important role of PhD students which is currently missed in the academic studies of entrepreneurship literature. The graduate students as found in our study are critical to perform a great part of foundation work and experiments for a target problem. The sharing of information with PhD students about commercialization opportunities, networking and funding possibilities will promote culture of entrepreneurship in the university. The culture of new venture creation by students also demands access to university resources, counseling from faculty and peers, industry interaction, investor interaction, and mentoring by technology offices for the students (Rasmussen, E., & Wright, M., 2015).

There is another antithesis by scholars who have presented a critique that industry research undermines academic publications. This objection leads to a healthy academic discussion and research on relationship between paper publication and entrepreneurial science.

Shichijo, N., Sedita, S. R., &Baba, Y. (2015) compared the publication output of various scientists of material science in Japan and found as "*(i) entrepreneurial scientists (Pasteur and Edison scientists) publish more papers than traditional scientists (Bohr and Other scientists) do; (ii) the papers published by Bohr scientists demonstrate better citation performance than those published by Pasteur scientists, do on average; (iii) the prestige of high-impact papers is favored by the authorship of Pasteur scientists; and (iv) the degree of the multi/inter-disciplinarily of the papers authored by Pasteur scientists is higher (more diverse) than that of Bohr scientists. The general trend of scientific performance – that is, although the quantity of research output is larger for entrepreneurial scientists, the overall citation performance of Pasteur scientists is not as good as that of Bohr scientists*".

Our cases of entrepreneurial scientists and these academic researchers do not support the antithesis that publications are negatively impacted by entrepreneurial activities. The study of Oliver, A. L. (2004) reports biotechnology scientists on average having 15 patents, around 50 publications, 1-2 academic collaborations and 1-2 industry collaborations. Oliver, A. L. give all the credit for the growth of the biotechnology industry to biotechnology scientists and wrote; "*The biotechnology industry in Israel was initially founded primarily by academic scientists. In1990, Israel boasted only 30 biotechnology companies, employing 600 employees, but by 2000 there were 160 companies employing more than 4000 employees. In order to ease the commercialization of academic research, the government set three initiatives in the 1990s. These included: the creation of incubator units for fledgling companies, the supply of high-tech resources for academic and start-up companies, and the creation of links between academia and industry*".

We would like to conclude the discussion by quoting the study of Huyghe, A., &Knockaert, M. (2015) advocating for developing culture of entrepreneurship by creating successful role models of entrepreneurial scientists on the university.

About the Authors

Rahmat Ullah

Rahmat Ullah, Chief Coordinator, Institute of Research Promotion (IRP), Secretary General South Asia Triple Helix Association (SATHA), Manager ORIC-UMT. Mr. Rahmat is a research scholar in management with specialized focus on innovation and technology development. He moved into management profession by setting up his own enterprise, managing marketing and sales for national firms. After management and business administration education, he joined the research organization-IRP to promote R&D culture in Pakistan. Mr. Rahmat has published in academic journals and presented many papers in national and international conferences. He has diversified experience of providing training, managing survey projects, developing online portals, initiating academic publishing, and executing funded projects of development nature.

Dr. Rashida R. Zohra

Dr. Rashida Rahmat Zohra, is a biotechnologist with specialization in Industrial Biotechnology. Her research interests are in developing biotech based technologies and commercialization of biological research. She is serving as Director, Office of Research Innovation and Commercialization (ORIC) and Assistant Professor in Department of Biotechnology at Jinnah University for Women, Karachi. She has been associated with Institute of Research Promotion (IRP), Lahore, Pakistan's largest R&D network, as In-charge of Invention to Innovation Summit and leads the annual activities.

Team of Entrepreneurial Scientist

Naveed Ul Haq

Research Associate
Office of Research Innovation and Commercialization
University of Management and Technology, Lahore

Rafia Iqtadar Mirza

Manager Research & Development, ORIC,
Jinnah University for Women, Karachi
Phone: 021-36620856 Mobile: 0334-1890590
Email: **rafiamirza@irp.edu.pk**

References

1. Bienkowska, D., Klofsten, M., & Rasmussen, E. (2016). PhD Students in the Entrepreneurial University-Perceived Support for Academic Entrepreneurship. *European Journal of Education*, *51*(1), 56-72.
2. Etzkowitz, H. (1983). Entrepreneurial scientists and entrepreneurial universities in American academic science. *Minerva*, *21*(2), 198-233.
3. Etzkowitz, H. (1998). The norms of entrepreneurial science: cognitive effects of the new university–industry linkages. *Research policy*, *27*(8), 823-833.
4. Gulbrandsen, M. (2005). "But Peter's in it for the money"--the liminality of entrepreneurial scientists. *VEST: Journal of Science & Technology Studies*, *18*.
5. Huyghe, A., &Knockaert, M. (2015). The influence of organizational culture and climate on entrepreneurial intentions among research scientists. *The Journal of Technology Transfer*, *40*(1), 138-160.
6. Jain, S., George, G., &Maltarich, M. (2009). Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity. *Research policy*, *38*(6), 922-935.
7. Kenney, M., &Goe, W. R. (2004). The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science at UC Berkeley and Stanford. Research Policy, 33(5), 691-707.
8. Krabel, S., Siegel, D. S., &Slavtchev, V. (2016). The internationalization of science and its influence on academic entrepreneurship.

9. Lam, A. (2010). From'ivory tower traditionalists' to'entrepreneurial scientists'? Academic scientists in fuzzy university-industry boundaries. *Social Studies of Science*.
10. Louis, K. S., Blumenthal, D., Gluck, M. E., &Stoto, M. A. (1989). Entrepreneurs in academe: An exploration of behaviors among life scientists. *Administrative Science Quarterly*, 110-131.
11. Moog, P., Werner, A., Houweling, S., &Backes-Gellner, U. (2015). The impact of skills, working time allocation and peer effects on the entrepreneurial intentions of scientists. *The Journal of Technology Transfer*, *40*(3), 493-511.
12. Murray, F. (2004). The role of academic inventors in entrepreneurial firms: sharing the laboratory life. *Research Policy*, *33*(4), 643-659.
13. Oliver, A. L. (2004). Biotechnology entrepreneurial scientists and their collaborations. *Research Policy*, *33*(4), 583-597.
14. Rasmussen, E., & Wright, M. (2015). How can universities facilitate academic spin-offs? An entrepreneurial competency perspective. *The Journal of Technology Transfer*, *40*(5), 782-799.
15. Shichijo, N., Sedita, S. R., & Baba, Y. (2015). How does the entrepreneurial orientation of scientists affect their scientific performance? Evidence from the Quadrant Model. *Technology Analysis & Strategic Management*, *27*(9), 999-1013.
16. Stuart, T. E., & Ding, W. W. (2006). When do scientists become entrepreneurs? the social structural antecedents of commercial activity in the academic life sciences 1. *American Journal of Sociology*, *112*(1), 97-144.
17. Walsh, J. P., & Huang, H. (2014). Local context, academic entrepreneurship and open science: Publication secrecy and commercial activity among Japanese and US scientists. *Research Policy*, *43*(2), 245-260.
18. http://www.manythings.org/voa/0/12093.html

19. http://www.speciation.net/News/Bangladeshi-scientists-get-prestigious-award-for-arsenic-filter-;~/2007/02/02/2640.html
20. http://www.post-gazette.com/health/2007/08/07/Fighting-arsenic-News-of-chemistry-professor-s-water-filter-is-spreading-around-the-world/stories/200708070198
21. https://scholar.google.fr/citations?user=qkP1U2UAAAAJ&hl=ru
22. https://www.researchgate.net/profile/Adalberto_Noyola
23. http://en.acnnewswire.com/press-release/english/6920/hai-kang-life%27s-efadchip-technology-featured-in-science-magazine
24. https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=52959522
25. https://patents.justia.com/inventor/alessandro-ferretti
26. http://ieeexplore.ieee.org/search/searchresult.jsp?searchWithin=%22Authors%22:.QT.Alessandro%20Ferretti.QT.&newsearch=true
27. https://scholar.google.com/scholar?q=Alessandro+Ferretti+scholarly+impact&hl=en&as_sdt=0&as_vis=1&oi=scholart&sa=X&ved=0ahUKEwjDlPabi-_VAhWQmbQKHfjSBMYQgQMIJTAA
28. http://www.isofoton.com/
29. http://www.renewableenergyworld.com/articles/2010/03/isofoton-delivers-3-mw-german-pv-plant.html
30. http://www.wipo.int/wipo_magazine/en/2008/03/article_0003.html
31. http://iib.cecos.edu.pk
32. http://www.peshawar2.org
33. http://www.synbiokp.com
34. http://plants.jstor.org/stable/10.5555/al.ap.upwta.1_1200

35. http://saharareporters.com/2011/05/19/maurice-iwu-and-sale-nigeria%E2%80%99s-collective-inheritance
36. http://www.napopharma.com/
37. http://impact.ref.ac.uk/CaseStudies/CaseStudy.aspx?Id=21768
38. http://www.ucl.ac.uk/news/news-articles/0309/dentofex-product
39. https://www.prnewswire.com/news-releases/professor-michael-wilson-receives-ipa-lifetime-achievement-award-in-antimicrobial-pdt-research-300479859.html
40. https://bbbagro.com/leadership/dr-otu-oviemo-ovadje/
41. http://www.wipo.int/ipadvantage/en/details.jsp?id=2545
42. https://scholar.google.com.sg/citations?user=kAUsFTkAAAAJ&hl=en
43. http://research.ntu.edu.sg/expertise/academicprofile/Pages/StaffProfile.aspx?ST_EMAILID=TEOHSH
44. http://www.osteopore.com/history.html
45. https://www.asianscientist.com/2016/06/features/sg50-pioneers-teoh-swee-hin-biomaterials-spin-doctor/
46. http://lemelson.mit.edu/
47. http://www.tsukuba.ac.jp/news/20100223120415.html
48. https://www.cyberdyne.jp/english/products/HAL/index.html