A booklet on

# POPULAR WOMEN IN SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICAL SCIENCE
P.K.M. COLLEGE OF EDUCATION, MADAMPAM

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# POPULAR WOMEN IN SCIENCE & TECHNOLOGY

*Focal theme of National Science Day 2020 –*
**WOMEN IN SCIENCE**

**KERALA STATE COUNCIL FOR SCIENCE, TECHNOLOGY AND ENVIRONMENT**
***Sasthra Bhavan, Pattom P O***
***Thiruvananthapuram***

- **E K Janaki Ammal (1897-1984):**

D.Sc. (1931, Michigan), Founder Fellow of the Indian Academy of Sciences. Winner of Padmashri Award.

Was a renowned botanist and plant cytologist who made significant contributions to genetics, evolution, phytogeography and ethnobotany. Her two innings in Michigan were crucial in determining the choice of her specialization in plant science: she chose cytology which in those formative years of the science was concerned primarily with the nucleus and the chromosomes. The early decades of the last century saw a great deal of pioneering work in genetics, notably on wheat and on sugarcane. At the Sugarcane Breeding Institute at Coimbatore, in the early decades of the last century, C. A. Barber and T. S. Venkataraman initiated research in sugarcane breeding. Venkataraman developed the internationally famous Coimbatore canes such as Co 419 with qualities of drought-resistance, disease-resistance, etc. The Co varieties were grown in all parts of India and were also preferred for cultivation in other countries where sugarcane was an important crop. Dr. Janaki Ammal was thoroughly Indian in attire and habits, selfless and Gandhian in her lifestyle. The honorary LL.D. which the University of Michigan conferred on Ammal in 1956 in recognition of her contributions to botany and cytogenetics said: *Blessed with the ability to make painstaking and accurate observations, she and her patient endeavours stand as a model for serious and dedicated scientific workers*. She lived up to her own definition of greatness which combined virtue in life and passion in the pursuit of her science.

- **B Vijayalakshmi (1952-1985):**

PhD (1982, Madras). For her research she studied relativistic wave equations and their proportions. She was diagnosed with widespread cancer of the stomach and the abdominal region at an early stage of life but her major aim was to make some substantial research contribution and be recognised as a physicist. She was involved in the studies of relativistic equations of higher spin in external electromagnetic and gravitational fields. She attempted to look for suitable ways in which 6 interacting higher spin theories could be constructed. In 1978, she started her work on characterizing a spinning particle in non-relativistic quantum mechanics. This was a novel idea of the interplay of geometry and topology. This also produced an interesting dual relation between massless particles and the monopoles of electromagnetic theory. This work was published and this particular contribution laid the foundation for many interesting developments later. She was always aware of the race with time. Continuing research for the next couple of years she wrote five publications on the relativistic wave equations in external fields and completed her requirements for PhD. The study of higher spin wave equations and their interactions were important issues which had engaged the minds of physicists and mathematicians. In her thesis work, she identified large classes of relativistic equations which were not equivalent to already known equations describing single mass and spin. This study in which she obtained interesting new results involved many conceptually difficult issues in group theory, which she mastered successfully. She expired on 12th May 1985 at the age of 33 due to cancer. She had 11 papers to her credit in international journals.

- **Asima Chatterjee (1917-2006):**

First woman D.Sc. (1944, Calcutta), FASc, FNA, Khaira Professor of Chemistry, Calcutta University. Recipient of the Padma Bhushan. The numerous awards she won include S S Bhatnagar award, C V Raman award of the UGC, P C Ray award, Sisir K Mitra Lectureship and Dr G P Chatterjee Lectureship. First lady president of the Indian Science Congress, member of Rajya Sabha. She worked with L.M. Parks University of Wisconsin, USA (1947) on naturally occurring glycosides, with L. Zechmeister, California Institute of Technology, Pasadena, USA (1948–49) on Carotinoids and provitamins and with Paul Karrer, N.L. University of Zurich (1949–50) on biologically active alkaloids, which became her life-long interest ever since. After her return to India in 1950, she vigorously pursued investigations on the chemistry of Indian medicinal plants, particularly alkaloids and coumarins. Chatterjee successfully developed the anti-epileptic drug, Ayush-56 from *Marsilia minuta* and the anti-malarial drug from *Alstonia scholaris, Swrrtia chirata, Picrorphiza kurroa* and *Ceasalpinna crista*. The patented drugs have been marketed by several companies. She made significant contributions in the field of medicinal chemistry with special reference to alkaloids, coumarins and terpenoids, analytical chemistry, and mechanistic organic chemistry. She published around 400 papers in national and international journals and more than a score of review articles in reputed serial volumes. Her publications have been extensively cited and much of her work has been included in several textbooks.

- **Anna Mani (1918-2001):**

FASc, FNA, Ph.D. (submitted 1945, Madras). The only woman scientist to work with C.V. Raman, is well known for her work in atmospheric physics and instrumentation. She contributed to the study of radiation, ozone and atmospheric electricity, both on the surface and in the upper air using special sounding techniques. Joining the India Meteorological Department in 1948, she rose to become the Deputy Director General of Observatories in Delhi. Anna Mani had wanted to study medicine, but when that was not possible she decided in favor of physics because she happened to be good in the subject. Anna Mani enrolled in the Honors program in physics at the Presidency College in Madras (now Chennai). In 1940, a year after finishing college, Anna Mani obtained a scholarship to do research in physics at the Indian Institute of Science and was accepted in C.V. Raman's laboratory as a graduate student. In Raman's laboratory, Anna Mani worked on the spectroscopy of diamonds and rubies. During this period Raman's laboratory was immersed in the study of diamonds because of Raman's ongoing controversies with Max Born on crystal dynamics and with Kathleen Lonsdale on the structure of the diamond. He had a collection of three hundred diamonds from India and Africa and practically all his students worked on some aspect of diamonds. Anna Mani recorded and analyzed fluorescence, absorption, and Raman spectra including the temperature dependence and polarization effects of over thirty different diamonds. The experiments were long and painstaking: the crystals were held at liquid air temperatures, and the weak luminescence of some of the diamonds required fifteen to twenty hours of exposure time to record the spectrum on photographic plates. Anna Mani spent long hours in the laboratory, sometimes working through the night. Between 1942 and 1945, she published five papers single authored on the luminescence of diamonds and rubies. In August 1945, she submitted her Ph.D. dissertation to Madras University and was awarded a government scholarship for an internship in England. It is no surprise that Anna Mani's is a success story to which few women (or men) could aspire. She transcended the limited cultural spaces available to her and not only created a room of her own, and a laboratory of her own but a whole workshop, a mini factory of her own.

- **Kamal Ranadive (1917-2001):**

Ph.D.(1949, Bombay), FNA. This recipient of the Padmabhushan established the first tissue culture laboratory in India at the Indian Cancer Research Centre (presently Cancer Research Institute). She got Watumal Foundation Award for her work in the field of leprosy. She founded the Indian Women Scientist Association (IWSA). After a post doctoral stint in the laboratory of George Gey who developed the HeLa cell line at Johns Hopkins University Hospital, Kamal Ranadive returned to India and established the first tissue culture laboratory at the Indian Cancer Research Centre. In the early 1960s tissue culture media and other reagents had to be prepared in the laboratory. To fulfil these needs, Dr Ranadive recruited a team of biologists and bio chemists. Quick to recognize talent, sincerity and integrity in her 25 colleagues and students, Kamal Ranadive encouraged them to work in various areas of cancer biology. She strongly believed that scientists who went abroad for postdoctoral work should return to India and develop new areas of research in their perspective laboratories. A staunch nationalist, she instilled the same spirit in her colleagues, enough that most of them returned to work in India, making Cancer Research Institute a renowned centre for cancer research. Her unique quality for allowing individual scientific talents to bloom, in fact resulted in the formation of three new divisions, carcinogenesis, cell biology and immunology besides tissue culture. Her work on animal models for understanding patho- physiology of cancer was extremely important. She was among the first to recognize the connection between cancer susceptibility and interaction between hormones and tumor virus. The so called Indian Cancer Research Institute (ICRC) mouse studied by her group turned out to be an excellent model for work on leukemia, breast cancer and cancer of oesophagus. In addition to this she continued her work on leprosy bacteria, which eventually led to the preparation of a Leprosy vaccine. A strict disciplinarian, she instilled the spirit of hard work in her students; her lab was busy till late in the night! She was the recipient of many awards including Padma Vibhushan and the Watumal Foundation award for her work in the field of leprosy.

- **Darshan Ranganathan (1941-2001):**

Ph.D. (1967, Delhi), FASc, FNA. Her honors include a Senior Research Scholarship of the Royal Commission for the Exhibition of 1851, A.V. Rama Rao Foundation Award, Jawaharlal Nehru Birth Centenary Visiting Fellowship, Third World Academy of Sciences Award in Chemistry and Sukh Dev Endowment Lectureship. Was Deputy Director, IICT, Hyderabad. She passed away from metastasis of cancer. She was the most prolific organic chemist in India, having, in the last five years, a dozen publications in The Journal of the American Chemical Society, six in the Journal of Organic Chemistry and dozens in others. Her monumental contribution to the Accounts of Chemical Research was published, as well as many other papers, posthumously. She was elected Fellow of the Indian Academy of Sciences, Indian National Science Academy and the recipient of many honors the last of which was The Third World Academy of Sciences Award in chemistry for her outstanding contributions to bio-organic chemistry, particularly supramolecular assemblies, molecular design, chemical simulation of key biological processes, synthesis of functional hybrid peptides and synthesis of nanotubes, in 1999. All these achievements assume special significance, particularly for young women aspiring scientists in India, when viewed from the fact that at every turn in her life she felt the impact of male chauvinism that so controls the scientific world. She fended them all with the invincible armour of obsession for scientific research.

- **Kamala Sohonie (1911-1996):**

Ph.D. (1939, Cambridge). Recipient of the Rastra-pati award for best scientific research. Life time achievement felicitation by ICMR. Assistant Director, NRI, Cunnoor, India. Retired as First Lady Director, Institute of Science, Mumbai. At the Institute of Science, Bangalore, she worked very hard under her teacher, Shri Sreenivasayya. He was very strict, demanding and at the same time eager to impart knowledge to deserving students. After observing her for a year, Raman was satisfied about her sincerity and discipline. She was allowed to do regular research in Bio-chemistry. He was impressed enough to admit lady students to the institute from then on. This was another victory for Kamala, and through her for other aspiring Indian women scientists. Here she worked on proteins in milk, pulses and legumes, which in fact had important implications for nutritional practices in India. In 1936, Kamala, then only a graduate student, was the first person to work on pulse proteins. She submitted her research to Bombay University and received her MSc degree. She went then to Cambridge University and first worked in the laboratory of Dr Derik Richter who offered her a spare table to work during the day, where he himself would at night when she left. When Dr Richter left to work elsewhere, Kamala continued her work under Dr Robin Hill, who was doing similar work, but on plant tissue. Here, working on potatoes she found that every cell of plant tissue also contains the enzyme "cytochrome C" and that cytochrome C is involved in oxidation of all plant cells. This was an original discovery embracing the entire plant kingdom. Kamala sent a short thesis describing her finding of cytochrome C in respiration of plant tissue, to Cambridge University for her PhD degree. Her PhD degree is remarkable in many ways. Her research and writing of the thesis was done in less than 14 months since arriving at Cambridge. It consisted only of 40 typewritten pages. Those of others sometimes contained more than thousands of pages. She was the first Indian woman "on whom the title of PhD degree was conferred".

- **Dr. Tessy Thomas :**

Born in 1963. **Distinguished Scientist**, has taken over as **Director General (Aeronautical Systems)** w.e.f 01-Jun-2018. She obtained her B.Tech in Electrical Engineering from Calicut University, ME in Guided Missiles from Institute of Armament Technology (now Defence Institute of Advanced Technology), Pune and PhD in Missile Guidance from Jawaharlal Nehru Technological University (JNTU), Hyderabad. She obtained MBA in Operations Management from Indira Gandhi National Open University (IGNOU), New Delhi. Dr. Tessy Thomas Joined IAT Pune as a faculty member in Guided Missiles in the year 1986. She joined DRDL, Hyderabad in 1988. She was associated with Agni Programme right from its developmental flights. She has **designed the guidance scheme for long range missile systems which is used in all Agni missiles**. An energy management guidance scheme was designed and developed for the first time in the country for an all – solid propelled long range systems for which she was conferred with **Agni self reliance award in the year 2001**. She has contributed in various fields such as Guidance, Control, Inertial Navigation, Trajectory Simulation and Mission Design. She lead a major project **AGNI-4** as **Project Director**, for a state-of-art system with many new technologies for the first time and successfully flight tested and proven. She was also **Project Director (Mission)** for the long range **AGNI-5 system**, which was successfully flight tested and proven. As **Director, Advanced Systems Laboratory**, DRDO, she held multi-dimensional roles and responsibilities and lead the development of strategic missile system from 2014 to 2018. Dr. Tessy Thomas is the recipient of many prestigious awards

including Lal Bahadur Shastri National Award for Excellence in Public Administration Academics and Management-2012; DRDO Agni Award for Excellence in Self-Reliance – 2001; DRDO Award for Path breaking Research/Outstanding Technology Development-2007; DRDO Scientist of the Year Award-2008; DRDO Performance Excellence Award for Agni-4 in 2011; DRDO Performance Excellence Award for Agni-5 in 2012; Suman Sharma Award by The Institution of Engineers (India), National Design and Research Forum for Engineering Design in 2009; Madam Marie Curie Mahila Vijnana Puraskar-2012; Dr. Y. Nayudamma Memorial Award for the Year 2014 for Outstanding Contributions in the field Missile Technology, "Bharat Ratna Sir Mokshagundam Visvesvaraya Award-2016" towards outstanding contributions in the field of Engineering towards design, development and realization of indigenous missile systems by The Institution of Engineers (India), Telangana State Centre, Hyderabad, "Distinguished Woman Scientist Award" in 2016 for her contributions in the field of Missile Technology by Andhra Pradesh Science Congress, Andhra Pradesh Academy of Sciences.

- **Ritu Karidhal:**

Ritu Karidhal is a proud contributor to The Mars Orbiter Mission launched by the Indian Space Research Organisation. Leading the team behind the success of 'Mangalyaan', Ritu has been involved in a lot of revolutionary space operations with ISRO. A proficient alumnus of the Indian Institute of Science, she completed her Masters in Aerospace Engineering with a clear aim of working towards a change. Ritu comes from a middle-class family, in Lucknow, where the major importance has always been given to the education. She always had the fascination about space, an urge to do something different from a normal trend. Collecting news articles related to any space activities by ISRO or NASA was one of her hobbies. The dream of joining the space agency came true in 1997, November. She has worked for many prestigious missions of ISRO, handled responsible position of Operations Director for many missions. Being the mother of two kids, she finds her inspiration and motivation to manage between work and home from the support given by her family all the times. She has been referred to as a "Rocket Woman" of India. Ms Ritu Karidhal has published more than 20 papers both in International and National Publications. She has been the recipient of many awards including "Young Scientist Award in 2007 by Shri Abdul Kalam , the then President of India , ", "ISRO Team Award for MOM in 2015 " , "ASI Team Award ", "Women Achievers in Aerospace, 2017" by SIATI(Society of Indian Aerospace Technologies & Industries (SIATI), " Birla Sun Achievement Award " by Bank of Baroda. She supervised the Chandrayaan 2 mission as the mission director.

- **Marie Curie (1867-1934):**

Marie Curie was the first woman to win a Nobel Prize, in Physics, and with her later win, in Chemistry, she became the first person to claim Nobel honours twice. Her efforts with her husband Pierre led to the discovery of polonium and radium, and she championed the development of X-rays. The famed scientist died in 1934 of a plastic anaemia likely caused by exposure to radiation. Marie Skłodowska was born in Warsaw, Poland, to a family of teachers who believed strongly in education. She moved to Paris to continue her studies and there met Pierre Curie, who became both her husband and colleague in the field of radioactivity. The couple later shared the 1903 Nobel Prize in Physics. Marie was widowed in 1906, but continued the couple's work and went on to become the first person ever to be awarded two Nobel Prizes. During World War I, Curie organized mobile X-ray teams. The Curies' daughter, Irene, was also jointly awarded the Nobel Prize in Chemistry alongside her husband, Frederic Joliot. The 1896 discovery of radioactivity by Henri Becquerel inspired Marie and Pierre Curie to further investigate this phenomenon. They examined many substances and minerals for signs of radioactivity. They found that the mineral pitchblende was more radioactive than uranium and concluded that it must contain other radioactive substances. From it they managed to extract two previously unknown elements, polonium and radium, both more radioactive than uranium. After Marie and Pierre Curie first discovered the radioactive elements polonium and radium, Marie continued to investigate their properties. In 1910, she successfully produced radium as a pure metal, which proved the new element's existence beyond a doubt. She also documented the properties of the radioactive elements and their compounds. Radioactive compounds became important as sources of radiation in both scientific experiments and in the field of medicine, where they are used to treat tumours.

- **Rosalind Franklin (1920-1958):**



Born in 1920 in London, England, Rosalind Franklin earned a Ph.D. in physical chemistry from Cambridge University. She was best known for her contributions to the discovery of the molecular structure of deoxyribonucleic acid (DNA), a constituent of chromosomes that serves to encode genetic information. Franklin also contributed new insight on the structure of viruses, helping to lay the foundation for the field of structural virology. She learned crystallography and X-ray diffraction, techniques that she applied to DNA fibres. In 1951, Franklin joined the Biophysical Laboratory at King's College, London, as a research fellow. There she applied X-ray diffraction methods to the study of DNA. When she began her research at King's College, very little was known about the chemical makeup or structure of DNA. However, she soon discovered the density of DNA and, more importantly, established that the molecule existed in a helical conformation. Her work to make clearer X-ray patterns of DNA molecules laid the foundation for James Watson and Francis Crick to suggest in 1953 that the structure of DNA is a double-helix polymer, a spiral consisting of two DNA strands wound around each other. One of her photographs provided key insights into DNA structure. Other scientists i.e. Maurice Wilkins, James Watson and Francis Crick used it as evidence to support their DNA model and took credit for the discovery. Franklin died of ovarian cancer in 1958, at age 37. In 1962, the Nobel Prize in Physiology or Medicine was awarded to James Watson, Francis Crick, and Maurice Wilkins for solving the structure of DNA. The Nobel committee does not give posthumous prizes.

- **Barbara McClintock (1902-1992):**

Barbara McClintock grew up in Connecticut and New York in the United States. Her family had little money, so her interest in research was viewed with scepticism. It was more important for her to marry, her family thought. Despite this, with her father's support, Barbara began studying at Cornell's College of Agriculture in 1919, and her studies are where her interest remained. She never married, choosing to devote her life to research instead. She was shy and anything but a careerist, but at the same time she also realized the importance of what she had achieved, not least of all in her role as an example for other women. Many characteristics of organisms are determined by heredity - that is, by their genes - which are stored in the chromosomes inside their cells' nuclei. Barbara McClintock studied corn's hereditary characteristics, for example the different colours of its kernels. She studied how these characteristics are passed down through generations and linked this to changes in the plants' chromosomes. During the 1940s and 1950s Barbara McClintock proved that genetic elements can sometimes change position on a chromosome and that this causes nearby genes to become active or inactive. She won the Nobel Prize in Physiology or Medicine 1983 for her discovery of mobile genetic elements.

- **Rachel Louise Carson (1907-1964):**

Rachel Carson was an American biologist well known for her writings on environmental pollution and the natural history of the sea. Perhaps the finest nature writer of the Twentieth Century, Rachel Carson is remembered more today as the women who challenged the notion that humans could obtain mastery over nature by chemicals, bombs and space travel than for her studies of ocean life. Her sensational book 'Silent Spring' (1962) warned of the dangers to all natural systems from the misuse of chemical pesticides such as DDT, and questioned the scope and direction of modern science, initiated the contemporary environmental movement. Disturbed by the profligate use of synthetic chemical pesticides after World War II, Carson reluctantly changed her focus in order to warn the public about the long-term effects of misusing pesticides. Carson was attacked by the chemical industry and some in government as an alarmist, but courageously spoke out to remind us that we are a vulnerable part of the natural world subject to the same damage as the rest of the ecosystem. Testifying before Congress in 1963, Carson called for new policies to protect human health and the environment. Rachel Carson died in 1964 after a long battle against breast cancer. Her witness for the beauty and integrity of life continues to inspire new generations to protect the living world and all its creatures.

- **Maria Goeppert-Mayer (1906-1972):**

The German physicist and mathematician, Maria Goeppert-Mayer is prominent for her numerous contributions to the field of physics which earned her a Nobel Prize in Physics in 1963. She was the first woman to win the Nobel Prize for theoretical physics and second woman in history to win a Nobel Prize— the first being Marie Curie. She is most famous for proposing the nuclear shell model of the atomic nucleus. Maria Goeppert-Mayer was born in Katowittz, which was then part of Germany. Her father became a professor at the university in Göttingen, from which Goeppert-Mayer also received her PhD in 1930. After marrying, Goeppert-Mayer migrated to the US where regulations prohibited her from accepting employment at the same university as

her husband. She was affiliated with several universities, however, and worked on the American atom bomb project during World War II. Maria Goeppert-Mayer was later made a professor at the University of California in San Diego. The Goeppert-Mayers had two children. According to modern physics, an atom consists of a nucleus made up of nucleons - protons and neutrons - surrounded by electrons distributed within shells with a fixed number of electrons. It became apparent that atomic nuclei in which the number of nucleons corresponded to full electron shells are especially stable. In 1949 Maria Goeppert Mayer and Hans Jensen developed a model in which nucleons were distributed in shells with different energy levels. The model reflected observations of directions in which nucleons rotated around their own axes and around the centre of the nucleus.

- **Irène Joliot-Curie (1897-1956):**

Irène Curie was born in Paris as the daughter of Pierre and Marie Curie, who went on to become Nobel Laureates in Physics and Chemistry. Irène Curie worked together with her mother to provide mobile X-ray units during World War I. She resumed her studies at the university in Paris after the war and later worked at the institute that her parents had founded. It was there that she conducted her Nobel Prize-awarded work together with Frédéric Joliot, whom she married in 1926. The couple was politically active and worked to combat fascism and Nazism. They had two children. Radiation from radioactive substances also became an important tool in investigating atoms. When Irène Joliot-Curie and Frédéric Joliot bombarded a thin piece of aluminium with alpha particles (helium atom nuclei) in 1934, a new kind of radiation was discovered that left traces inside an apparatus known as a cloud chamber. The pair discovered that the radiation from the aluminium continued even after the source of radiation was removed. This was because aluminium atoms had been converted into a radioactive isotope of phosphorus. That meant that, for the first time in history, a radioactive element had been created artificially. She won the Nobel Prize in Chemistry 1935 "in recognition of their synthesis of new radioactive elements."

- **Tiera Fletcher (Guinn):**


Born and raised in a small town near Atlanta, Georgia, Tiera Fletcher (Guinn) has had a passion for aerospace engineering since the tender age of eleven. Before then, she had aspirations of being a scientist, inventor, architect, mathematician, and many other careers within the field of STEM. It was not until she became introduced to the field of aerospace engineering that she realized her true dream. Tiera graduated from the Massachusetts Institute of Technology (MIT) with a Bachelor's of Science in Aerospace Engineering in June 2017. During her time at MIT, she was also a part-time Rocket Structural Design and Analysis Engineer at The Boeing Company, specifically working on NASA's Space Launch System. She's received the 2017 Good Housekeeping's Awesome Woman Award, which recognizes women who are impacting the world for the better by overcoming social constraints and influencing the world around them. She is one of the lead engineers and designers working on the Space Launch System for NASA which aims to put humans on Mars. She has a strong interest in helping upcoming generations to realize and achieve their dreams. Tiera enjoys speaking to youth to not only encourage them to become more involved in science, technology, engineering and mathematics (STEM), but to reach their goals in any field they wish to pursue.

- **May-Britt Moser:**

May-Britt Moser was born in Fosnavåg, Norway in 1963. After studying psychology at the University of Oslo, where she met her future husband and co-recipient of Nobel Prize Edvard Moser, she received her doctorate in neurophysiology in 1995. After stays at the University of Edinburgh and University College London, the couple moved to the Norwegian University of Science and Technology in Trondheim. May-Britt Moser is a professor of neuroscience and the director of the university's Center for Neural Computation. The awareness of one's location and how to find the way to other places is crucial for both humans and animals. In 2005 May-Britt Moser and Edvard I. Moser discovered a type of cell that is important for determining position close to the hippocampus, an area located in the center of the brain. They found that when a rat passed certain points arranged in a hexagonal grid in space, nerve cells that form a kind of coordinate system for navigation were activated. They then went on to demonstrate how these different cell types cooperate. She was one of the recipients of Nobel Prize in Physiology or Medicine in 2014 "for the discovery of cells that constitute a positioning system in the brain."

- **Frances H. Arnold:**

Frances Arnold was born and raised in Pittsburgh, Pennsylvania in the United States. She studied mechanical and aerospace engineering at Princeton University. She then continued her studies at the University of California, Berkeley, where she earned a doctorate in chemical engineering in 1985. She has subsequently worked at the California Institute of Technology. She became interested in energy technology early and formed a company in 2005 to produce renewable fuels. Evolution – the adaption of species to different Environments – has created an enormous diversity of life. Frances Arnold has used the same principles – genetic change and selection – to develop proteins that solve humankind’s chemical problems. In 1993, Arnold conducted the first directed evolution of enzymes, which are proteins that catalyze chemical reactions. The uses of her results include more environmentally friendly manufacturing of chemical substances, such as pharmaceuticals, and the production of renewable fuels. She won the Nobel Prize in Chemistry 2018 “for the directed evolution of enzymes”.

- **Donna Strickland:**

Donna Strickland was born in Guelph, Ontario, Canada. She became interested in laser and electro optics early and studied at McMaster University in Hamilton, Ontario. She pursued her doctoral studies in the U.S. at the University of Rochester, where she did her Nobel Prize awarded work. She obtained her PhD in 1989. She subsequently has worked at Princeton University and since 1997 at the University of Waterloo in Canada. The sharp beams of laser light have given us new opportunities for deepening our knowledge about the world and shaping it. In 1985, Gérard Mourou and Donna Strickland succeeded in creating ultrashort high-intensity laser pulses without destroying the amplifying material. First they stretched the laser pulses in time to reduce their peak power, then amplified them, and finally compressed them. The intensity of the pulse then increases dramatically. "Chirped pulse amplification" has many uses, including corrective eye surgeries. She won the Nobel Prize in Physics 2018 "for developing a method of generating high-intensity, ultra-short optical pulses."

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