# INDIAN NUCLEAR SOCIETY

# INS News Letter

Vol 21 Issue 1 February 2021




## Contents



## Dear Honorable Members of INS,

On behalf of INS and my own behalf it gives me great pleasure to wish you and your family **"A VERY HAPPY , PROSPEROUS, AND PROFESSIONALLY ACTIVE NEW YEAR"** .You are aware of the various unexpected situations that happened during the last more than five years in the functioning of INS. This got further complicated due to COVID 19, that is still lingering on. During this period, the members who took the responsibility of managing the day to day affairs of INS did a creditable job and steered the election electronically successfully. Credit goes to the INS members for their cooperation .

The elected EC (Executive Committee) members have a mission and commitment to re-establish INS professional status to international level. With the help of EC members, the office bearers are steadily making progress to sort out the pending issues and take initiative to promote interaction with the members. In this direction you may be aware that with the dedication and involvement of our Treasurer, Sh. G.D.Mittal, the backlog in financial matters are being sorted out. At the same time with the initiative of Vice President, Dr V.K.Manchanda, and the editorial committee members, News letter is being published regularly. It is our attempt to keep the members well informed about the technical activities and associated developments in the nuclear field within the country as well as globally. We have been seeking inputs from various units of DAE. We do seek your involvement and cooperation through your technical inputs. EC is making efforts to activate the local units of INS and we are hopeful of reestablishing contacts with these units and seeking their valuable inputs on regular basis.

The working of the various INS activities are being streamlined by our Secretary Sh. S.K. Malhotra and his team, which is essential for the proper functioning of the INS.

Due to COVID 19 and the associated uncertainties, our future activities may have to be restricted to on-line for quite some time. We are therefore strengthening our Website and Webinar activity for on-line technical presentations and other activities like GB meeting. **It gives me immense pleasure that Padma Vibhushan Dr Anil Kakodkar has kindly agreed to deliver the first INS Webinar Series talk .** Certainly we will try to have physical seminars / symposia and other activities as permitted by the prevailing situation.

Myself and my colleagues shall keep you informed periodically about the details of the future events. We are open to your suggestions and be assured that your valuable input is important to us .

With very best wishes and kind regards

**S.K.Mehta**
**President, INS**

## From Editor's Desk

Let me at the outset wish all honorable INS members a very prosperous and productive year ahead. As we enter New Year, there is good news on the sharply declining trends in the rate of registration of new cases as well as of the fatalities due to COVID 19 in the country. Vaccinologists globally worked very hard to develop a range of vaccines within a record time. Vaccination program using Covishield / Covaxine is reassuring the countrymen that they can look ahead with positivity in 2021 leaving the memory of gloomy days of 2020 behind. DAE along with other national laboratories contributed significantly to meet the challenges of COVID 19, and these activities were shared with the members in the previous issues of NL. In this issue, you will find a glimpse of the way AERB faced the challenge of COVID 19. Chairman AEC, Shri K.N.Vyas in his New Year message has presented a very positive outlook of the road ahead in 2021 for nuclear program. He made particular reference to the upcoming 700 MWe PHWRs at Kakarpar , Rawatbhata and Gorakhpur and 1000 MWe LWRs at Kudankulam. Kakrapar 3, the forerunner of 700 MWe PHWR was synchronised with the grid at 11.37A.M. on 10 January 2021, which is the first in a series of 16 such reactors being set up in the country. Globally nuclear reactor additions and subtractions to the power grid in 2020 mirrored the trend from the past 20 years. 443 reactors are in operation around the world today, and 52 more are under construction .

Director BARC was kind enough to share his address on Founder's day with President INS. Some of his thoughts are reflected in the present issue. Steps towards setting up of a medical research reactor in public-private-partnership (PPP) mode have been taken by DAE. Steady progress has been made in the societal programs dealing with health, food, industry and environment. Many of us may not be aware that 49 varieties of different Radiation Induced Crop Mutants have been released and notified by Govt. of India for commercial cultivation. While explaining the impact of these mutants in everyday life, I vividly remember hearing the then Chairman AEC mentioning that one out of two Idlis we take has the mutant variety of ingredients (developed at BARC). Dr B.K.Das of NA &BTD, BARC discusses in this issue these mutant crop varieties. The FAO/IAEA Mutant Variety Database, includes more than 3346 officially released mutant varieties in more than 73 countries throughout the world. Over 1,000 mutant varieties of major staple crops, cultivated on tens of millions of hectares enhance rural income, improve human nutrition and contribute to environmentally sustainable food security in the world .

You will find in the present issue the review by Dr P.R.V.Rao of a recently published book "Ionising Radiation and Mankind" edited by Dr D.V.Gopinath and Dr N.Ramamoorthy and an interesting article on the role nuclear energy plays globally to protect environment by former DG, WNA, Ms. Agneta Rising. **I hope that the readers will find Cross Word Puzzle (introduced for the first time) an interesting brain teaser. Please send your solution as soon as you crack it to insvkmeditor@gmail.com. First 10 correct solutions will be acknowledged in the next issue of NL.**

INS will like to congratulate Indian Physicist and Padmashri awardee Prof. Rohini Godbole of IISc, Bengaluru who has been conferred with the Ordre National du Merite, one of the highest distinctions granted by France . She is best known for her work on High Energy Physics at CERN, the European Organisation for Nuclear Research.

**Vijay Manchanda**

INS holds its First Webinar Talk
on Feb 5, 2021
Speaker : Dr. Anil Kakodkar
Pl see the poster on Page 23

## DAE News Brief

### Development of Ruthenium (Ru-106) Plaque for eye cancer therapy at BARC

**In a major breakthrough, a team of scientists from BARC, has developed the first indigenous Ruthenium (Ru-106) plaque for eye cancer therapy.** Ruthenium is a fission by-product with a typical yield of ~0.4%. As the fission reaction produces several other components, it is important to harvest radio-chemically pure Ru-106 for medical applica-

tions through a series of separation steps . Pure Ru-106 thus obtained is electro-deposited over silver discs and is subsequently sealed under controlled atmosphere to produce the plaques.

The plaques are extensively tested as per the specifications approved by the Atomic Energy Regulatory Board (AERB) and are supplied to hospitals through the Board of Radiation and Isotope Technology (BRIT), an industrial unit of DAE.The first batch of Ru-106 plaques, with round configuration, has been evaluated by leading ophthalmic centres like Dr. Rajendra Prasad Centre for Ophthalmic Sciences, New Delhi, AIIMS Centre for Sight Hospital, Hyderabad and Sankara Eye Hospital, Bengaluru. Ophthalmic surgeons have confirmed that the handling of BARC plaque is surgeon-friendly and is at par with the international standards in all aspects. Availability of indigenous Ru-106 plaque as an import substitute will reduce the cost of treatment and help to save vision of a large number of patients.

## Indigenous NPCIL Reactors

**Kakrapar 3, the forerunner of 700 MWe PHWR was synchronised with the grid at 11.37A.M. on 10th January 2021.** This is the first in a series of 16 such indigenous reactors being set up in the country. Continuing with the trend of setting records in long operation by Indian nuclear power reactors, NAPS-2 (Narora Atomic Power Station-2) continued to operate during the year, registering 851 days of continuous operation as on December 23, 2020.

## Societal Programs

BARC has developed a super-absorbent polymeric hydrogel using radiation technology. The hydrogel can soak up about 400 times its own weight of water and thus act as a water reservoir in the soil, releasing the stored water upon plant/root demand. One Trombay crop variety TKR Kolam (Trombay Karjat Kolam) has been released and gazette notified for commercial cultivation by Ministry of Agriculture & Farmers Welfare. Two rice varieties, Vikram-TCR and CG Trombay Jawaphool were released by State Variety Release Committee (SVRC), Chhattisgarh. Breeder seed production of Trombay crop varieties was carried for groundnut (332 quintals), rice (15 quintals) and pulses (20 quintals).

In pursuance of the policy of setting up a research reactor for the production of medical isotopes in PPP mode , M/s A.T.Kearney have been appointed as Strategic Consultant and Transaction Advisor.

## Proton Therapy treatment at the Tata Memorial Centre's (TMC) ACTREC Kharghar

Proton Therapy treatment, one of the world's most sophisticated forms of cancer treatment, will be provided at the Tata Memorial Centre's (TMC) ACTREC Kharghar centre by mid-2021. The installation of the proton beam therapy machine is almost complete and the TMC expects about 800 patients to be treated every year, of whom 50 per cent will be treated free of cost. The treatment modality, called 'Proton Therapy', will be the first of its kind in the public sector in India. The ambitious project is being executed in association with the IBA, Belgium. The Proton Beam Therapy machine provides sub-millimetre precision in destroying cancer cells. **It ensures precision tumour targeting, with minimal collateral damage to normal and vital tissues. The accelerator at Kharghar facility is the largest medical accelerator in the country** and it had been commissioned in a record time of six months, during the peak of the pandemic. At present, only a private hospital in Chennai, Tamil Nadu, has such facility. Since TMC works under the Department of Atomic Energy, the cost of treatment will be subsidised for economically weaker sections. Children will get priority for treatment. The total cost of the project is around Rs 550 crore. Proton therapy is used for cancers of the skull base, prostate, spine, brain, liver, breasts, head and neck, among other types of cancers. It can also be used for tumours that recur in areas previously treated with standard radiation.

## AERB Functioning during COVID-19 Pandemic *(Dr. Avinash Sonawane, DRA&C, AERB)*

In the wake of COVID-19 pandemic, AERB used virtual medium extensively for conducting regulatory oversight activities like licensing, regulatory inspections (RI) and document development. The in-depth multi-tier safety review was carried out by discussions through video conferencing. A dedicated Remote Inspection Centre was set-up in AERB Headquarters (Mumbai) and virtual RIs were carried out by devising special methodology. AERB staff remained in constant communication with each other as well as with the licensee organisation. Site Observer Teams (SOTs) of AERB at various Nucle-

ar Power Plants / Projects under construction and in operation continued to function from the respective sites and kept AERB staff at Headquarters informed.

The first ever virtual meeting of the Board of AERB was organised on July 07, 2020 to review the commissioning of Kakrapar Atomic Power Project Unit-3 (KAPP-3) and its readiness for First Approach to Criticality (FAC). The Board recommended clearance for FAC on July 17, 2020. **KAPP-3 achieved first criticality on July 22, 2020 making it the first reactor in the world to achieve criticality during the pandemic.** The criticality was witnessed by AERB observers on site and by AERB experts at headquarters through live streaming from KAPP-3 Control Room. In the second virtual meeting of the Board of AERB held on November 13, 2020, AERB granted consent for 'First Pour of Concrete' for Pressurized Heavy Water Reactors (PHWRs) of Gorakhpur Haryana Anu Vidyut Pariyojna.

With regard to control over ionizing radiation applications, the web based system for facilitating e-Licensing of Radiation Applications (eLORA) system enabled AERB's staff to continue performing the regulatory functions from home /office unhindered.

AERB extensively used virtual platforms for public awareness and safety promotional activities by conducting Webinars on selected topics. AERB ensured periodic website updates for information to the general public. An Action Plan adopted by NPPs worldwide to manage Risks Related to COVID-19, prepared by International Atomic Energy Agency (IAEA), was shared with utility organisation for comparing with their own action plans and the measures taken by Indian utilities were shared with IAEA.

On the international front, the preparatory meeting for hosting the follow-up Integrated Regulatory Review Services (IRRS) Mission of IAEA was held remotely with participation of experts from different countries. AERB also participated in IAEA activities such as Annual General Conference and the meeting of Commission on Safety Standards (CSS) virtually.

**Compiled by Vijay Manchanda**

## Radiation Induced Mutations in Crop Breeding

**Introduction**: Variability is the most important requirement for any plant breeding program. Mutations (sudden heritable changes) spontaneous or induced are the source of variability. In nature, while the frequency of spontaneous mutations occurs at extremely low rate (~ one in million), mutagens (chemical or physical) can enhance the mutation frequency several hundred fold (~ one in thousands). It is observed that induced mutations are not essentially different from the natural variability.

**Historical:** The first successful mutation induction using X-rays for crop improvement was achieved by Lewis Joh Stadler (in 1928) in barley and maize. Soon after that, radiation induced mutagenesis started providing economically important mutants in barley, wheat, oats, flax, mustard, lupin etc. The use of induced mutations for crop improvement is known as radiation induced mutation breeding (or simply mutation breeding). Now a days there is renewed interest to induce mutations using different types of mutagens and to use those in plant breeding for crop improvement, and many scientists are entering this field.

**Mutagens** are the agents that can bring about permanent alterations/changes to the genetic material (DNA) in a living organism that is inherited from one generation to next. Mutagens are broadly two types viz. physical and chemical . Physical mutagens consist mainly of radiations such as gamma rays, X-rays and particulate radiations such as alpha -particles, beta particles, and fast and thermal neutrons, ion beams, etc. Among these, gamma-rays emanating from ($^{60}$Co/ $^{137}$Cs), have been extensively used, due to convenience in handling and better penetration power. Gamma rays can penetrate deep in biological tissues. For irradiation of the seeds and stem cuttings, use of gamma rays is the best choice. X-rays have similar penetration and interaction like gamma rays but differ in their origin. Beta radiations from radioisotope, $^{32}$P can be used for seed treatments. Alpha radiation is particulate in nature and has low penetration power and hence is not commonly used in plant mutation breeding experiments. Neutrons (fast and thermal) having higher energy can be used in plant mutagenesis experiments. Exposure to neutrons results in neutron acti-

vation or induced radio activity and therefore materials cannot be handled immediately. Physical mutagens except neutrons do not leave any radioactivity in the treated materials and hence do not need any special procedures to be followed while handling and are therefore convenient to use.

**How do the mutagens cause mutation?** Mutagens interact with biological materials (viz. DNA which is the genetic material) directly or indirectly (radiolysis of water) and bring about alterations. Gamma radiations bring about mutations by causing chromosomal deletions, inversions and translocations or by causing single or double strand breaks leading to transitions, transversions or frame shifts in the DNA.

**Materials that are used for mutagenesis**: Usually for seed propagated crops, seeds are used for irradiation since these are easy to handle and convenient for transportation. Other tissues (viz. stem cuttings, bulbs, rhizomes in vegetatively propagated or horticultural crops) which can give rise to next generation can also be used. Chimera formation is a major drawback in mutation induction in vegetatively propagated crops.

**Appropriate dose for mutation induction**: The amount of mutagens (dose) to be used for inducing mutations varies between crop species and type of mutagen(s) used. To start mutation breeding work using a particular mutagen (say Gamma-rays), the appropriate dose needs to be standardised. A wide variation in radio-sensitivity is seen among different crop plants. The dose that causes 50% reduction in growth (GR50) can be taken as an index of radio sensitivity. The dose that causes 30% growth reduction (GR30) is also worked out at seedling stage. Then dose between GR30- GR50 is selected for inducing mutations.

**When and where mutation breeding approach will be successful**? Mutation breeding technique supplements other conventional methods of plant breeding. It helps breeders to create genetic variability in crop plants, increases efficiency of selection, and allows use of mutants either directly or in recombination breeding. Mutation breeding is useful under two circumstances: (i) for improvement of one or two desirable traits (characters) in an otherwise elite and well adapted crop variety without altering its original properties and (ii) to increase the frequency and the spectrum of variability in those crops in which less natural variability exists. Therefore, for getting desired success, R&D work should be carried out systematically with clear-cut and specific objectives.

**Mutation breeding process**: Using appropriate dose, a large mutagenized population (M1) is raised. Then in the next generation (M2), useful/ desired mutants are selected from a large number of mutations in M2 population. Then these are forwarded to subsequent generations (M3 to M7/8). The stable mutants can be directly released (through state and national trials) as varieties or use in recombination breeding to develop improved varieties.

**Mutation breeding scenario in the world:** Mutation breeding is pillar of modern plant breeding as it plays an important role to deal with the global nutritional and food security. In the past few decades, several superior crop varieties have been developed through induced mutagenesis by various countries, which made significant impact on food production and consumption. By 2020, ~ 3364 cultivated mu-

**Table 1: Country wise and crop wise status of crop mutants in the world**

| S. No. | Top 10 countries that have developed the highest number of crop mutants | | Top 10 crops having highest number of crop mutants | |
|---|---|---|---|---|
| | Country | Number of Mutants | Crop | Number of Mutants |
| 1 | China | 817 | Rice | 852 |
| 2 | Japan | 479 | Barley | 306 |
| 3 | India | 341 | Chrysanthemum | 285 |
| 4 | Russian Federation | 216 | Wheat | 265 |
| 5 | Netherlands | 176 | Soybean | 181 |
| 6 | Germany | 171 | Maize | 89 |
| 7 | United States | 139 | Groundnut | 78 |
| 8 | Bulgaria | 76 | Rose | 67 |
| 9 | Bangladesh | 75 | Common bean | 57 |
| 10 | Viet Nam | 58 | Cotton | 48 |

**[Source: https://mvd.iaea.org(MVD, database 2020 FAO/ IAEA, Vienna, Austria) searched on 16-Dec-2020]**

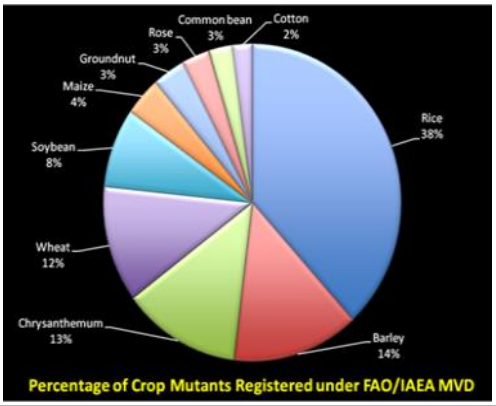


Fig.1a. Pie chart representing the percentage contribution top ten countries for crop mutant variety development.

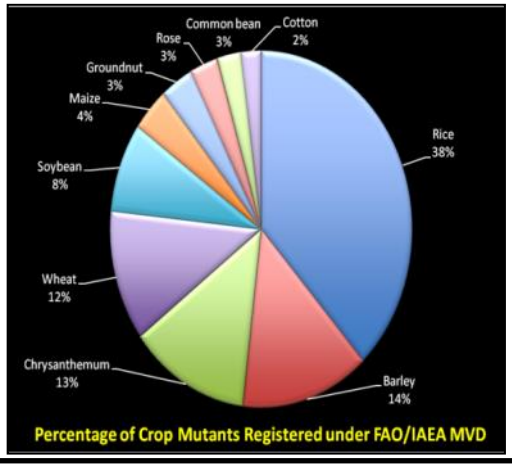


Fig.1b. Pie chart representing the percentage contribution of the top ten officially registered mutant crop varieties. The [Data from FAO/IAEA MVD, 2020 accessed on 16-Dec-2020]

tant varieties in about 228 crop plants have been developed and their information is uploaded in the FAO/IAEA Mutant Variety Database (http://https://mvd.iaea.org). The Asian countries have developed largest numbers of mutant varieties especially in the small grain cereal crops (FAO/IAEA, MVD, 2020). China, the leading country has developed highest number of crop mutant varieties followed by Japan and India. About 50% crop mutants of the total were developed by China, Japan and India **(Table 1 & Fig 1a)**. In the world, maximum number of mutants were developed for rice crop followed by Barley and Chrysanthemum. More than 70% crop mutants belong to cereal crops **(Table 1 & Fig 1b).**

**Mutation breeding in India:** India ranks in 3rd position next to China and Japan on the list of release of mutant varieties. In India, BARC has played a leading role in mutation breeding research and development of crop varieties. The other leading institutes and universities in India pursuing mutation breeding research are: Indian Agricultural Research Institute (IARI), New Delhi; National Botanical Research Institute (NBRI), Lucknow; Tamil Nadu Agricultural University (TNAU), Coimbatore; Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur; Assam Agricultural University, Jorhat; Dr. Punjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola and many State Agricultural Universities. In India, total 341 varieties have been released, highest number of mutants in rice (60) followed by chrysanthemum (48). Details about number of mutant varieties in India are given in **Table- 2 & Fig.2. (Source: https://mvd.iaea.org (MVD, database 2020 FAO/IAEA, Vienna, Austria; searched on 16-Dec-2020)**

**Table-2: Top 10 crops having highest number of mutants in India and their percentage**

| S. No. | Crop | No. of Mutants |
|---|---|---|
| 1 | Rice | 60 |
| 2 | Chrysanthemum | 48 |
| 3 | Groundnut | 26 |
| | Mung bean | 16 |
| 5 | Rose | 15 |
| 6 | Barley | 13 |
| 7 | Dahlia | 11 |
| 8 | Bougainvillea | 10 |
| 9 | Cowpea | 9 |
| 10 | Black gram | 8 |

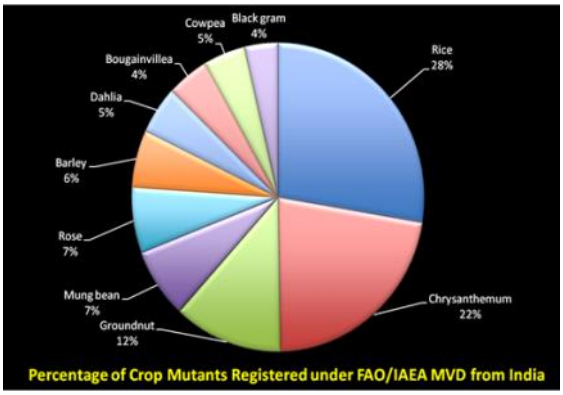


Fig.2: Percentage of crop mutants from India registered under FAO/IAEA -MVD data

**Mutation Breeding at BARC**: BARC has a strong programme and expertise on crop improvement using radiation induced mutation breeding along with recombination breeding; and has made substantial and significant contributions in terms of developing and popularizing new varieties of crops. This crop improvement programme is being carried out in collaboration with State Agricultural Universities and ICAR research institutes. In this journey of five decades, BARC has developed 49 varieties in eleven crops(**Table-3**) viz. oilseeds (groundnut, mustard, soybean, linseed and sunflower), pulses (uradbean, mungbean, pigeon pea, and cowpea), rice and jute; which have been released and notified for commercial cultivation across the country. List of the crop varieties along with their special characters and state for which it is released is given in **Table-4**.

**Table-3: Crop wise the number of Trombay Varieties released & notified (up to 2020)**

| Sr. No | Crop | No. of varieties released |
|---|---|---|
| 1 | Groundnut | 15 |
| 2 | Soybean | 2 |
| 3 | Mustard | 4 |
| 4 | Sunflower | 1 |
| 5 | Linseed | 1 |
| 6 | Mungbean | 8 |
| 7 | Urdbean | 5 |
| 8 | Pigeon pea | 5 |
| 9 | Cowpea | 2 |
| 10 | Paddy | 5 |
| 11 | Jute | 1 |
| | **Total** | **49** |

Fig. 4: Green gram (Mungbean) variety TMB-37 (tolerant to yellow mosaic disease) released for summer sowing of North east plain zone of India.

Fig. 3: Popular Trombay Groundnut varieties TG-37A & TG-51

Some of the desirable traits in these varieties include higher yield, larger seed size, improved agronomic and quality traits, early maturity and resistance to biotic and abiotic stresses. Several of these varieties have high patronage from the farming community and are extensively grown in the country. Some of the groundnut varieties viz. TAG-24, TG-37A, TG-39, TG-51 (**Fig. 3**), are very popular among the farmers. Among the pulse varieties, TAU-1 and TU-40 (black gram), TMB-37 (green gram) (**Fig.4**), TC-901 (cow pea), TT-401, TJT-501 and PKV-TARA (pigeon pea) are gaining popularity among the farmers.

BARC varieties released & notified for commercial cultivation in a Chronological manner are given in **Table-4.**

**Mutation breeding for improvement of rice**: BARC has a strong programme on rice improvement using radiation induced mutation breeding. In collaboration with Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth (DBSKKV), Dapoli, rice variety 'TKR Kolam' (Trombay Karjat Kolam) has been released and notified for commercial cultivation in the year 2020. For improvement of traditional rice varieties for their revival, with a view to improve these landraces and bring them into main-stream farming, joint collaborative R&D project has been undertaken with Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur. Three mutant varieties have been released so far.

1) 'TCDM-1' (Trombay Chhattisgarh Dubraj Mutant–1) (**Fig.5a and Fig.5b**) was released for the state of Chhattisgarh which has a yield advantage of 35% with non-lodging and mid-early maturity. (2) Vikram TCR (mutant of Safri-17; Vikram name has

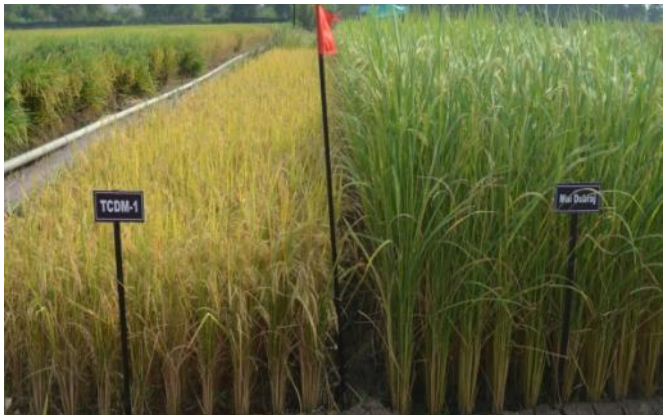


Fig. 5 (a) : Field view of TCDM-1 (mutant) along with parent variety (Mai Dubraj)


Fig 5b : Breeders seed production of TCDM-1

been given to this variety in honour of Prof. Vikram Sarabhai, Ex-Chairman, AEC in his birth centenary year 2019-20) and (3) CG Jawaphool Trombay (a mutant of Jawaphool) has been released for commercial cultivation in 2020.In view of the success and potential of radiation induced mutagenesis for rice improvement, BARC and IGKV, have envisioned a large scale mutation breeding programme for more than 50 traditional landraces of Chhattisgarh state. This will benefit the rice farming community in the state of Chhattisgarh and nation as a whole.

## Current priorities in agriculture in India : How radiation induced mutation breeding can help?

Radiation induced mutation breeding will continue to play an increasing role in creating crop varieties with traits that can tolerate climate change and address current issues in Indian Agriculture. Priorities areas are the development of crop varieties a) with less water requirement; b) that can withstand high salinity or heavy metal contamination ; c) which are herbicide and green house gas emission tolerant; d) that can withstand high temperature and low light intensity .

**Conclusions:** The application of nuclear techniques and research efforts are highly relevant in increasing productivity and production in India where the number of marginal and small-land holding farmers are more. Bhabha Atomic Research Centre (BARC) has developed new mutant varieties, improved materials which need large scale field testing. Active collaboration between BARC and State Government Departments & State Agricultural Universities need to be expanded further which will open new avenues for development in agriculture in many states as well as in the country. Our experience has shown that use of radiations for crop improvement is an efficient plant breeding method complementing the conventional methods. The nuclear technologies have benefited farmers, traders and end-users and will continue to play a significant role in addressing food and nutritional security of the country.

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**Dr. B. K. Das**
bkdas@barc.gov.in

**Dr. B. K. Das is Research Group Leader of Mutation Breeding Section, NA&BTD, Bioscience Group of BARC. He is the National Project Co-ordinator for IAEA RCA-RAS5077 and Chief Scientific Investigator for IAEA-CRP- D23032 Project**

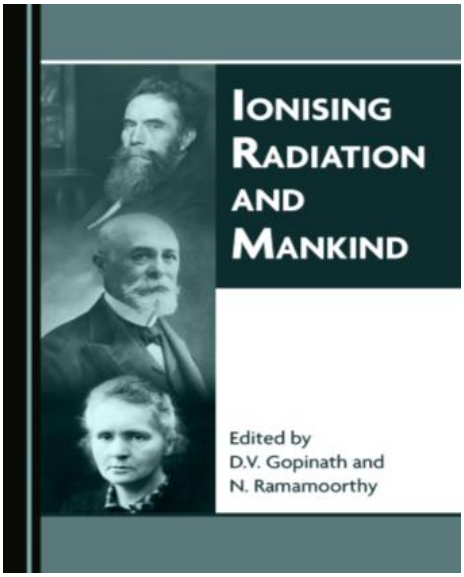
**Tasble 4 : List of BARC varieties released & notified for commercial cultivation (Chronologically)**

| Sr. No | Variety | Crop | Year of release | States | Special features |
|---|---|---|---|---|---|
| 1 | TG 1 | Groundnut | 1973 | All India | High yield, large seed, more branches, 50 days seed dormancy |
| 2 | TKJ-40 (Mahadev) | Jute | 1983 | Orissa | High yielding |
| 3 | TAP-7 | Mungbean | 1983 | Maharashtra, Karnataka | Tolerant to powdery mildew |
| 4 | TT-6 | Pigeon pea | 1983 | MP, Maharashtra, AP, Gujarat, Karnataka, Kerala | Large seed |
| 5 | TG 17 | Groundnut | 1985 | Maharashtra | No secondary branches, 30 days seed dormancy |
| 6 | TAT-10 | Pigeon pea | 1985 | Maharashtra | Early maturing |
| 7 | TAU-1 | Urdbean | 1985 | Maharashtra | Large seed |
| 8 | TG 3 | Groundnu | 1987 | Kerala | High Yield |
| 9 | TM 2 | Mustard | 1987 | Assam | Appressed pod |
| 10 | TM 4 | Mustard | 1987 | Assam | Yellow seed |
| 11 | Hari | Rice | 1988 | Andhra Pradesh | Slender grain type |
| 12 | Somnath (TGS 1) | Groundnut | 1991 | Gujarat | Large seed (70-80 g/100 seeds), Semi-runner type |
| 13 | TAG 24 | Groundnut | 1992 | Maharashtra, Orissa, Karnataka, West Bengal, Rajasthan | Semi-dwarf, Small dark green thick leaves, Earliness (95-100 days), high harvest index, high partitioning %, wider adaptability |
| 14 | TARM-2 | Mungbean | 1992 | Maharashtra | Resistant to powdery mildew |
| 15 | TPU-4 | Urdbean | 1992 | Maharashtra, MP | Large seed |
| 16 | TAU-2 | Urdbean | 1992 | Maharashtra | High yielding |
| 17 | TG 22 | Groundnut | 1994 | Bihar | Medium large seed (55-60g/100 seeds), 50 days seed dormancy |
| 18 | TARM-1 | Mungbean | 1995 | Maharashtra, Gujarat, MP, AP, Kerala, Orissa, Karnataka, Tamil Nadu | Resistant to powdery mildew |
| 19 | TARM-18 | Mungbean | 1995 | Maharashtra | Resistant to powdery mildew |
| 20 | TKG 19A | Groundnut | 1996 | Maharashtra | Large seed (70-75g/100 seeds), 30 days seed dormancy |
| 21 | TG 26 | Groundnut | 1996 | Gujarat, North Maharashtra, Madhya Pradesh | Earliness (95-100 days), high harvest index, 20 days seed dormancy, Smooth pods, Salinity tolerance |
| 22 | TU 94-2 | Urdbean | 1999 | Andhra Pradesh, Kerala, Karnataka, Tamil Nadu | Resistant to yellow mosaic virus |
| 23 | TG 37A | Groundnut | 2004 | Haryana, Rajasthan, Punjab, UP, Gujarat, Orissa, West Bengal, Bihar, North Eastern states | High yield, smooth pods, collar rot and drought tolerance, wider adaptability |
| 24 | TPG 41 | Groundnut | 2004 | All India | Large seed (75-80g/100 seeds), Medium maturity (120 days), 20 days seed dormancy, High oleic acid (60%). |
| 25 | TMB-37 | Mungbean | 2005 | Uttar Pradesh, Bihar, Jharkhand, Assam, WB | Tolerant to yellow mosaic virus |
| 26 | TAMS 38 | Soybean | 2005 | Maharashtra | Early maturing, resistant to bacterial pustule, *Myrothecium* leaf spot |
| 27 | TG 38 | Groundnut | 2006 | Orissa, West Bengal, Bihar, North Eastern states | High shelling % (78%), more 3-seeded pods, more round seeds |

| | | | | | |
|---|---|---|---|---|---|
| 28 | TLG 45 | Groundnut | 2007 | Maharashtra | Large seed (75-80g/100 seeds), Medium maturity (115-120 days) |
| 29 | TJM-3 | Mungbean | 2007 | Madhya Pradesh | Resistant to powdery mildew, Yellow mosaic virus and *Rhizoctonia* root –rot diseases |
| 30 | TM-96-2 (*Trombay Pesara*) | Mungbean | 2007 | Andhra Pradesh | Resistant to powdery mildew and *Corynespora* leaf spot |
| 31 | TPM 1 | Mustard | 2007 | Maharashtra | Yellow seed, Tolerant to powdery mildew |
| 32 | TAMS 98-21 | Soybean | 2007 | Maharashtra | Resistant to bacterial pustules, *Myrothecium* leaf spot, soybean mosaic virus diseases |
| 33 | TAS-82 | Sunflower | 2007 | Maharashtra | Black seed coat, tolerance to necrosis disease |
| 34 | TRC-77-4 (Khalleshwar) | Cowpea | 2007 | Chhattisgarh | Suitable for rice based cropping system |
| 35 | TT-401 | Pigeon pea | 2007 | Madhya Pradesh, Maharashtra, Gujarat, Chhattisgarh | High yielding, tolerant to pod borer and pod fly damage |
| 36 | TG 51 | Groundnut | 2008 | Orissa , West Bengal, Bihar, North Eastern states | Early maturity (90 days), medium large seed (50-55g/100 seeds), high shelling% (78%), more 3-seeded pods. |
| 37 | TBG 39 (Trombay | Groundnut | 2008 | Rajasthan | Large seed (75-80g/100 seeds), Medium maturity (115-120 days), high oleic acid (59%), more number of branches |
| | TDG 39 (TGLPS 3) | | 2009 | Karnataka | |
| 38 | TJT-501 | Pigeon pea | 2009 | MP, Maharashtra, Gujarat, Chhattisgarh | High yielding, tolerant to *Phytophthora* blight, early maturing |
| 39 | TM-2000-2 (Pairy mung) | Mungbean | 2010 | Chhattisgarh | Suitable for rice fallow and resistant to powdery mildew |
| 40 | TG 47 (Bheema, (RARS-T-1) | Groundnut | 2011 | Andhra Pradesh | Large seed (65-70g/100 seeds), Maturity of 110-115 days, more 3 seeded pods |
| 41 | PKV-TARA | Pigeon pea | 2013 | Maharashtra | Resistant to wilt and sterility mosaic |
| 42 | TU-40 | Urdbean | 2013 | AP, Karnataka, Orissa, TN | Suitable for rice fallows and resistant to powdery mildew |
| 43 | TC 901 | Cowpea | 2018 | Bihar, Gujarat, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh | High yielding, Early and Synchronous maturity, Resistant to cowpea mosaic virus |
| 44 | TCDM 1 | Rice | 2019 | Chhattisgarh | Semi-dwarf, medium slender, Aromatic, High yielding |
| 45 | TBM-204 | Mustard | 2019 | West Bengal | Yellow seed, high yield |
| 46 | TL-99 | Linseed | 2019 | UP, Bihar, Jharkhand, West Bengal, Assam & Nagaland | Low linolenic acid, high yield and oil content |
| 47 | TKR Kolam | Rice | 2020 | Maharashtra | Fine grain, high yielding and lodging resistant |
| 48 | Vikram TCR (Trombay Chhattisgarh | Rice | 2020 | Chhattisgarh | High yielding, lodging resistant, early maturing, drought tolerant, Good murmura making |
| 49 | CG Jawaphool Trombay | Rice | 2020 | Chhattisgarh | High yielding, Short slender grain, aromatic rice, good for kheer making |

## Review of Ionising Radiation and Mankind; Cambridge Scholars Publishing ; ISBN-13:978-1-5275-5581-5; Date of Publication: 01/10/2020; Pages : 349 Price:£64.99

It was a pleasure reading the book **"Ionising Radiation and Mankind",** edited by **D.V.Gopinath and N.Ramamoorthy**. Indeed, the book has been brought out at a correct point of time. The year 2020 marked the 125 years of the discovery of X-rays by Roentgen, and the year 2021 marks 125 years of the discovery of radioactivity by Henry Becquerel. Mankind has indeed reaped enormous benefits from the discovery and applications of radiations and radioactivity. It is indeed appropriate that the title of the book itself underlines the importance of ionising radiations (and radioactive isotopes) for mankind.




The book is divided into 11 chapters, each written by author(s) who are experts of eminence in the particular domain. The excellent choice of authors has made it possible to deal with the topics in a concise manner and at the same time provide a wide coverage of theoretical as well as practical aspects. Medical applications part I and part II (together 98 pages) form a large part of the book, rightly highlighting the extent of applications in medical fields. The large number of figures and illustrations serve to explain the concepts to the reader more clearly.

**Chapter 1** authored by **D. V. Gopinath** provides an overview of the impact of ionising radiations on mankind, serving also as an introduction chapter

**Chapter 2** authored by **K. N. Govinda Rajan** deals with the applications of radiation in radiation oncology. Starting with a historical background, the author discusses the principles of radiation therapy, treatment modalities including external beam therapy as well as brachytherapy and also dwells briefly on the radiological basis of cancer treatment, before elaborating advanced treatment modalities. This chapter would be of special value to students on the way to becoming a Radiation Safety Professional. The author rightly points out the frivolous manner in which radioactivity and radiation were handled in early years.

**Chapter 3** authored by **N. Ramamoorthy** deals with nuclear medicine and radiopharmaceuticals. The longest chapter in the book, it starts with a historical perspective, and goes on to discuss principles behind use of radiopharmaceuticals for diagnostics, therapy with radioisotopes/ radiopharmaceuticals, imaging applications of radiopharmaceuticals, and a discussion on various radionuclides available for different applications. The author has summarised the extensive data available on applications of radiopharmaceuticals in tables, providing data on a variety of radiopharmaceuticals, targeting mechanisms, imaging instrumentation, etc.

**Chapter 4** authored by **B. Venkatraman and M. Menaka** deals with industrial applications of radiation. The authors have covered a wide range of applications, focusing on non-destructive examination of various objects such as castings, columns, pipelines and even art objects. The applications of X-ray diffraction and X-Ray fluorescence are discussed with interesting examples.

**Chapter 5** authored by **Dinara Abbasova and Sunil Sabharwal** deals with the radiation processing of materials. The chapter begins with a brief discussion on interaction of radiation with matter, following which, a variety of applications of radiation in processing of materials, are discussed. The sterilisation of medical products, an important application of gamma radiation, is discussed as also the hygienisation of sewage sludge. One would have also expected some description of ISOMED facility at BARC, which has been a success story

with regard to sterilisation of healthcare products.

**Chapter 6** authored by **(late) Stanislaus F. D'Souza and Krishna B. Sainis** deals with the use of radiation technology in agriculture. After an elaborate introduction on the role of ionising radiation in developing mutant varieties, the chapter provides impressive data on the global trends in utilisation of radiation for realising better crop varieties. It is also obvious that India has taken great strides in harnessing the power of ionising radiation for developing crop varieties, that will benefit the large Indian population. The chapter also deals with the use of radiation in controlling the population of insects harmful to crops, and the role of radiation in research related to soil fertility and related subjects.

**Chapter 7:** authored by **Arun Sharma** deals with the use of ionising radiation for food preservation. The introduction provides a good emphasis on the need for food preservation, conventional methods for food preservation and a history of radiation based technology, before discussing the applications. Various aspects such as sources used, packaging and safety aspects are discussed, as also impressive progress made in the country in the application of this technology. The author, however, points out, rightly so, that increase in acceptance level has been suboptimal, even globally.

**Chapter 8** authored by **H.Pant** deals with applications of radiotracers in industry, environment and research. The chapter begins with a description of the pioneering work of George de Hevesy, which is appropriate. Various applications such as leak detection, flow rate measurement and material inventory measurement are discussed. Lastly, the chapter deals with applications in water bodies, and in research.

In contrast to earlier chapters that deals with societal and industrial applications of ionising radiation, **Chapter 9** authored by **S.Kailas** deals with ionising radiation as a tool in various research domains, with particular emphasis to physics driven basic research. A list of epoch making discoveries utilising ionising radiation is presented, such as the discovery of element 118 and the solution of the structure of ribosome. The chapter describes use of different types of ionising radiation in static and dynamic studies on materials, applications in astrophysics, high energy physics, geophysics and allied fields.

**Chapter 10** authored by **A. Dhanasekaran, M. T. Jose and S. A. V. Satya Murty** deals with radiation instrumentation. It provides an introduction to various fundamental concepts regarding radiation detection such as detection efficiency, energy resolution, and describes various types of detectors. Circuit diagrams and schematic diagrams used are simple enough to be comprehended even by those readers who may not be specialists in electronics.

**Chapter 11** authored by **D.V.Gopinath** provides an overview of radiation safety, discussing fundamental features of safety practices and units of radiation exposure. The author has put radiation exposure in the proper perspective by deliberating on natural background radiation and giving a brief account of experience with regard to exposures from manmade sources.

The book is directed at a wide range of readers including professionals in radiation medicine, industrial processes, food preservation and agriculture. Each chapter is self-sufficient in itself, with introduction, discussion of basic principles and to some extent safety aspects, all available in each chapter. This has the advantage that the reader can go through selected chapters of the book depending on his domain of interest. However, this also has the disadvantages that some of the concepts , units etc., have been repeated in different chapters, and one finds some concepts, that may usually find a place in initial chapters, coming in a later chapter, e g. interaction of radiation with matter.

One interesting element of the production of this book is the inclusion of the color pictures and figures together at the end, and providing the black and white versions in the body of the chapters. Obviously, this would optimise the cost of the book, a welcome measure. There are a few other minor issues, such as the excessive use of abbreviations in some of the chapters, particularly in titles of sections.

These comments and suggestions, however, do not take away the high value of the contents of the chapters that can serve as reference material for professionals working in the concerned domains. The book has also been written in such language that a common reader with some knowledge of radioactivity and ionising radiation can easily appreci-

ate the subject. To that extent, I believe that the authors have indeed done yeoman service to the nuclear community by providing such reading material to a broad cross section of people that will go a long way in creating awareness of the usefulness of radiation and radioactivity for the mankind.

**Reviewer : Dr P.R. Vasudeva Rao , VC, HBNI, Mumbai and former Director IGCAR, Kalpakkam**

## We must cross the bridges that divide us (Reproduced from World Nuclear News, 27 October 2020)

**"In many ways, the future of nuclear energy is much brighter than it has been for many years. We are evermore recognised and valued for the unique services that nuclear energy offers humanity, and I am immensely proud to have served and lead our industry through these exciting times," writes Agneta Rising, outgoing director general of World Nuclear Association.**

As I reflect upon my many years in the world of nuclear, paradoxically I find that many important personal developments have closely followed the changes that have resulted from nuclear accidents. I took over as Director General of the World Nuclear Association in 2013, when the nuclear industry was struggling to regroup following the Fukushima

***Agneta Rising, the outgoing director general of World Nuclear Association***

Daiichi accident.

I left university in 1980, merely a year after the Three Mile Island accident, a year when my native Sweden was voting on its own nuclear future. At this point, people had already been fed misconceptions about radiation. Before I went to university, I thought that something must be wrong with nuclear. However, even after spending five years at university, I failed to uncover what was 'wrong' with nuclear, so I continued to dig further and deeper.

The first 10 years of my career were spent working on radiation protection, computer models and examining different designs for radiation safety. However, it was in the aftermath of Chernobyl that my career forever changed.

I was given the opportunity to speak to communities, both in my native Sweden and further afield, about radiation and the environment. As a scientist by background, I had been given no formal training in communication, but had to learn by doing as I went along. I found that few people combine scientific expertise with an ability to communicate science to the public.

After Chernobyl, people obviously got more worried about nuclear, but they were never given a chance to react in any other way than from fear. Not enough effort was made to talk to people outside the realms of sciences, in everyday language, and to put radiation in perspective. With radiation, we should compare radiation from a nuclear power plant with natural radiation, and other risks, to provide proper perspective.

Nevertheless, questions about Chernobyl, radiation and accidents were those most commonly asked for a number of years. People would come to public meetings visibly worried, asking if the berries they had picked, or the meat in their freezers back home, were safe to eat. I would usually tell the audience that if they didn't want their berries or meat, then I would gladly have them! That definitely made people think!

I believe that I helped make Sweden more pragmatic towards nuclear. I spent much time in the 1980s and 1990s briefing every single Swedish Member of Parliament about the facts of nuclear, and helped to bring science into what was a very political debate.

One recurring topic in the Swedish debate was uranium and the perceived impacts of uranium mining. These were unfounded claims about serious health impacts on local and native populations, which for lay audiences was easy to believe, but difficult to

check. These claims clearly had no scientific basis, but as a part of my work at Vattenfall, I inspected uranium mines around the world, and helped develop frameworks for best practice – frameworks which remain in place today. One thing was very clear: uranium mines are extremely well-kept, especially in comparison with mining of other products, and should be a source of pride.

In 1999 I became the first woman elected chairman of the Uranium Institute, which in many ways was a club for uranium miners and buyers with little engagement with the nuclear energy debate. However, I believed there was much potential, and during my chairmanship I set out to convince the members about the importance of the Uranium Institute talking about nuclear energy and the importance of developing nuclear energy worldwide. It required considerable efforts to overcome the inertia that parts of the organisation had, which resisted the changes proposed. Together with the Board, we managed to secure the unanimous support of the members, and I was delighted to preside over the transformation of the Uranium Institute into the World Nuclear Association which we all know today.

A few years earlier, I co-founded Women in Nuclear (WiN) Global. Women generally fear radiation much more, having huge concerns for future generations. We, the nuclear industry, need to be better at listening to people's concerns – it is crucial that female nuclear professionals speak to women outside the industry about their work. Founding WiN was part of this effort. I chaired the first meeting of Women in Nuclear Energy – the predecessor of WiN - and later served as WiN's second president. Under my presidency, WiN was transformed from a European to an international organisation and grew its membership fourfold. It gives me great pleasure to see how this organisation has continued to grow and flourish, continuing its important mission across the globe.

My time at university, and my general background in science, helped me realise the advantage of having a deep knowledge in natural science and its applications in every part of life. In presentations to audiences I would usually say that 'you cannot argue with the laws of nature'. This obviously extends to the world of energy as well. It is clear that we will need more electricity in order to power everything that we do, and everything that we want to do. Energy efficiency will play a role, but we need to power so much more, and so many more people will require power for the electric future. We need to keep the bigger picture in our mind, and not focus on the small parts of the puzzle.

Humanity faces many serious problems – people need electricity, people need clean power, and we need to address climate change. Electricity is required every second of a day, regardless of time or weather. We simply cannot be without it. However, we need to find solutions, and technology is central to this – we cannot talk our way out of the problems!

As things are now, nuclear is respected, but not wanted. Nuclear really is an essential part of the climate change solution – but nuclear is still not allowed to be part of the conversation in the EU, even if the IEA, several UN bodies and the OECD are more urgently emphasising its importance. Every policy should be technology-neutral – if it were, then we would be making so much more progress than we are. Germany is a prime example of how huge investments, when misplaced, bring no real decrease in emissions.

However, the picture is changing, thanks in large part to the vision that the Harmony goal provides. People are coming to the nuclear family, wanting nuclear energy to meet their needs and to power their dreams and aspirations. We need to change the image of the industry – both outside and inside the industry itself – and so I am especially proud of the outcome of the Harmony goal, which has been seized upon by the nuclear industry as well as being a reference for policy makers.

If you take a holistic approach to energy, you can see the entirety of society, and why reliable, round-the-clock nuclear electricity is so important. The nuclear industry delivers clean and low-cost power whenever we need it – in many ways, it is the lifeblood of society. As well as being affordable, nuclear has such a small environmental footprint it can be placed just about anywhere people need it.

Over the last few years, there have been more and more discussions around cost, cost and cost, despite the fact that nuclear is the most cost-effective energy source for society. However, we need to ask our-

selves – if we build short-term solutions, like solar panels or wind turbines, which are not effective for the societal system, what will happen to the system itself? They are small-scale, and cannot resolve the large-scale problems we face. Solar and wind are by nature very dispersed energy forms, which makes it more costly to harvest the energy from them and it cannot be stored (easily). Hydropower is clearly a much more efficient energy source, as the raindrops are concentrated into streams and rivers by nature.

Being the most concentrated energy form, nuclear is the most intelligent way to generate electricity and other services. We achieve huge output from nuclear, with very little input. Renewable energy is like a bicycle, it can take you places, and can play a role; however, it also has limitations – it is impossible to build an advanced society based on bicycles. For that task, you will need nuclear, or to follow the transport metaphor – railways – where you can transport huge amounts, but for a small effort. This is how we build a stronger tomorrow, by ensuring that we use the most efficient, most intelligent, energy systems that are currently available to us.

It is important that political decisions are made on the basis of what is actually important, and what we should invest in. Post-pandemic, long-term investments into the systems that build society must take place, and nuclear investments are the ultimate ones, lasting for 80-100 years. We need new nuclear power plants to be built, and new countries to join the nuclear family. I am particularly proud of the many *Spotlight* events we have undertaken around the world, bringing together governments and the nuclear community to share the many benefits that a nuclear power programme brings.

One of the great parts of my time at World Nuclear Association has been the fact I have been able to engage and enthuse people regarding the nuclear cause. Engaging people – especially those outside the nuclear industry – is crucial, as is helping them find the vocabulary to talk to others about nuclear energy and to explain why it matters.

I feel very positive about the future of nuclear, and this makes it so hard to step down from my position as director general of the World Nuclear Association. It has been a fantastic time, and I am grateful for the mandate and all the support I have received from the Association's Board, members and Secretariat. I now look forward to being able to spend more time with my beloved family.

Moving forward, the nuclear industry must stop focusing on convincing the public about its safety. The first 20 years of my career were spent on convincing people that nuclear is not a threat to the environment. Now we should focus on why in fact the environment needs nuclear energy, as well as on its societal benefits, its economic strengths, clean air and reliability. It is also important that we give people time to understand and reflect. We must take the time and make the effort to cross the bridges that divide us, bringing the nuclear conversation to people and places where we have never been before - and carry them with us into the nuclear future."

**Remarks in the Indian Context by Dr M.R.Iyer**

The contents of the article by Ms. Agneta Rising are all the more pertinent for our country for carrying the message to the people why nuclear is the cleanest and safest option for energy production. If she considers electric power is important in her native Sweden with a per capita electricity generation of 13,500 KWh, it is all the more crucial for the very existence of a country like India where the per capita electricity generation is only 1208 KWh. She narrates her experience and tryst with nuclear energy and correctly says that she failed to understand what is wrong with nuclear energy when the word had started crying hoarse about its risks. Another point in her article pertinent to India is how the education systems makes good scientists today but not concentrate on training them how to communicate. This is in stark relation to our own system where this aspect is woefully lacking. I think this is a good tip for our own institutions to take care of this aspect.

She correctly mentions that we should compare the radiation from nuclear power plant with natural radiation and other risks to provide the right perspective. It is significant to note the absence of ill effects on the people living in the high natural radiation background areas in the West Coast of India. People here live for generations in an average radiation exposure of 28 mSv which is nearly 30 times more than the safe exposure of radiation levels for the public from the operation of nuclear power plants prescribed by the regulatory authorities. This

is also more than the occupational exposure limit of 20 mSv per year for occupational workers. The detailed microbiological and epidemiological investigations carried out by Scientists on the population there showed no ill effects of radiation. The article also mentioned as to how the uranium mining areas are far safer than the proximity of chemical plants. This hype of fears of local representatives faced by our government in starting mining operations in the North east of India is a point in context.

Kerala is another example. While they assert for their share of nuclear power from Kudankulam they do not want any nuclear plant in their state. These hyped up fears about radiation are not based on scientific facts. It is wrong to frighten people on imaginary fears of nuclear power telling that the whole of Kerala would be unsafe to live due to Kudankulam nuclear power station. This is what transpired while dealing with the anti-nuclear lobby at Kudankulam. Around 250 persons die of electrocution in Tamil Nadu every year. How many have died in the use of nuclear power in India? NONE at all!

## Enrico Fermi, an Italian Physicist and 1938 Nobel Laureate

Enrico Fermi received Nobel Prize for physics in 1938 at the age of 37 for his work "demonstrations of the existence of new radioactive elements produced by neutron irradiation, and for his related discovery of nuclear reactions brought about by slow neutrons"

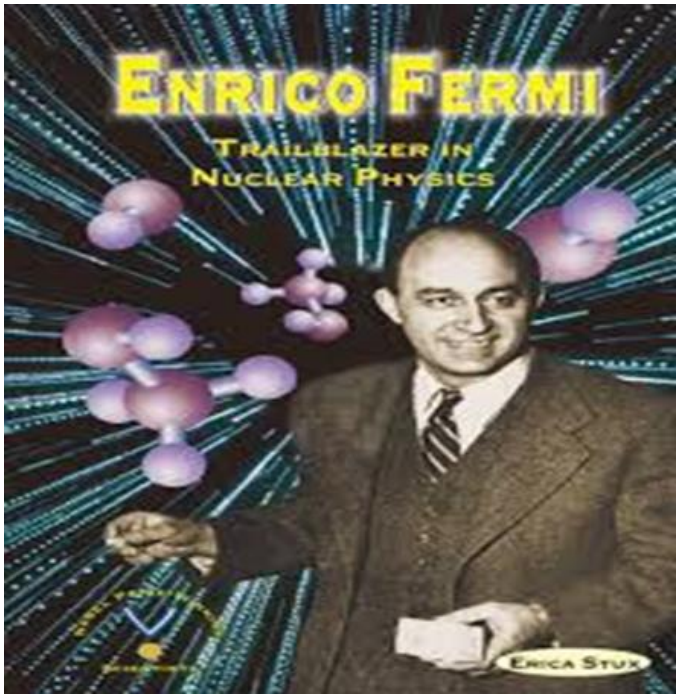
Apart from this Nobel prize winning work, Fermi made many more significant contributions in several important areas of science and to name a few: statistical mechanics (Fermi Statistics),quantum theory, nuclear and particle physics. beta-decay theory, and nuclear chain reactions. In fact Femi was the creator of the world's first nuclear reactor, the Chicago Pile-1, and he is also known as the **"Architect of the nuclear age"** He was one of the very few physicists to excel in both theoretical physics and experimental physics.

Fermi was born on 29th September 1901, in a middle class civil servant's family in Italy. He was spotted by many of his peers as mathematics prodigy. Even at very early age, he studied books on trigonometry, calculus, and theoretical mechanics and solved many complicated problems by himself, however he developed immense liking for fundamental physics and pursued physics instead of mathematics. After schooling he went to the University of Pisa for higher education and received his doctoral degree at the age of 20, for the thesis "**A theorem on probability and some of its applications"**. Fermi was the first to point out the potential nuclear energy behind the famous Einstein equation ($E = mc^2$). Fermi did his post-doctoral work, with Prof. Max-Born at the University of Göttingen, on the prestigious Italian Ministry of Education Fellowship, where he met Werner Heisenberg and Pascual Jordan. With Rockefeller Foundation Fellowship , Fermi studied in Leiden, Netherlands, where he met Hendrik Lorentz and Albert Einstein. In 1925, after the discovery of Pauli's exclusion principle, Fermi applied the exclusion principle to an ideal gas and published a paper **"On the quantization of the perfect monoatomic gas"**. The paper was especially notable for Fermi's statistical formulation. Later, Paul Dirac, a British scientist too developed this theory independently, and the duo's work became the most famous Fermi–Dirac statistics , which was related to the already established Bose–Einstein statistics. Accordingly, now the particles that obey the exclusion principle (having half- integer spin) are called "Fermions", while those that do not obey the exclusion principle (having integer spin) are called "Bosons"

In 1926, when he was only 24 years, he was appointed as Professor at University of Rome. He set up his own experimental physics laboratory and attracted many young physicists like Franco Rasetti, Edoardo Amaldi, Bruno Pontecorvo, Ettore Majorana and Emilio Segrè, Fermi and his group made important contributions to many practical and theoretical aspects of physics. In 1928, he published his famous book "*Introduction to Atomic Physics*" and also conducted public lectures and wrote popular articles for scientists and teachers. The German physicist Hans Bethe, too worked in his lab as Rockefeller Foundation Fellow.

Soon after the discovery of neutrons by Chadwick, and artificial radioactivity by Irene and Joliot, Fermi initiated experiments to study artificial radioactivity in several elements using neutrons (generated from a Radon-Beryllium source) and the group published nearly ten important papers in a short

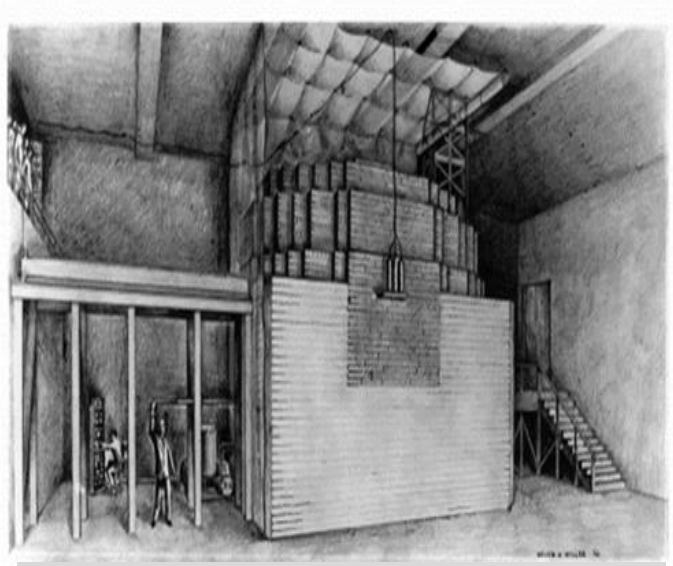
span. Of 67 elements investigated, 37 showed an easily detectable radioactivity identified by three important reactions viz., (n, g), (n,p) and (n, a) reactions. This work got him Nobel Prize for Physics in 1938. Fermi made many significant contributions to nuclear science and explained the moderation of neutron energy by low Z materials, estimated neutron cross sections of elements like Cd, B etc. However with the idea of preparing an element with atomic number 93, when his group bombarded the




elements, U and Th with neutrons, they failed due to the dominant fission reaction and formation of many fission products that too was discovered by Otto Hahn, Meitner and Strassman around the same time.

In 1939, due to the unrest in Europe, Fermi moved to USA. At that time, after the discovery of nuclear fission, it was confirmed that more than one neutron is emitted during fission process, many scientists started to think of possible chain reaction in nuclear fission, in a sustained manner to explore nuclear energy as alternate energy source . As a part of this, Fermi and his group, in collaboration with Szilard, successfully demonstrated the sustenance of the nuclear chain reaction in the first nuclear reactor, known as Chicago Pile-1, using graphite as the moderator and natural uranium as fuel. They used a pile of uranium oxide blocks interspersed with graphite bricks. Construction of this Chicago Pile-1 began on 6 November 1942, and the reactor went critical on 2 December, 1942 with power of less than 0.5 W. The shape of the pile was proposed to be roughly spherical, but due to Fermi's advanced calculations criticality could be achieved without finishing the entire pile as planned.

Subsequent to these discoveries, followed the process of making deadly nuclear weapons to counter the Nazi Forces, where Fermi played a key role. As a part of this a nuclear test known as Trinity test was conducted on July 15, 1945 at Alamogordo us-



**Chicago Pile 1, World's First Reactor**

ing the plutonium separated from the above reactor. Fermi watching this test from a distance of 14 km calculated the liberated energy during this explosion and shock waves by a simple paper displacement experiment.

After World War II, Fermi became a member of the US atomic energy commission and continued as a Professor at University of Chicago and trained many students. He was very popular among his students for his novel ideas, lucid explanations and simple presentations.

In 1954, Fermi was diagnosed with stomach cancer and died on 29 November 1954 at a very early age of 53. He was survived by his wife Laura Fermi, and two children: Nella, and Giulio. Laura Fermi described the life of Enrico Fermi in her book "Atoms in family", which by itself is a master piece.

Even though scientific community lost a great scientific genius very early, his contributions to science, in particular to nuclear science, remain forever. Several institutions were named after him like Fermi National Accelerator, under Department of Energy, and The Enrico Fermi Institute at the Uni-

versity of Chicago. The US Government instituted "Enrico Fermi Award", which is one of the most prestigious awards in science and technology. The 100th element in periodic table is named as Fermium.

**Dr K Indira Priyadarsini, DAE Raja Ramanna Fellow at UM-DAE Centre for Excellence in Basic Sciences, University of Mumbai ; email:indirapriyadarsini08@gmail.com**

## Nuclear News Snippets

### China starts building second CFR-600 fast reactor

Construction work has started on the second CFR-600 sodium-cooled pool-type fast-neutron nuclear reactor in Xiapu County, in China's Fujian province. Also known as the Xiapu fast reactor demonstration project, the CFR-600 is part of China's plan to achieve a closed nuclear fuel cycle. Construction of unit 1 started in late 2017. The fuel will be supplied by TVEL, a subsidiary of Russia's Rosatom, according to an agreement signed in 2019 with CNLY, which is part of China National Nuclear Corporation (CNNC).

https://www.world-nuclear-news.org/Articles/China-starts-building-second-CFR-600-fast-reactor

### UK and Japan partner on new nuclear decommissioning tech

The UK and Japan are working together to develop new technologies for the nuclear industry, including long-reach robotic arms to assist with the decommissioning of retired nuclear power plants. This £12m 'LongOps' project is supported by UK Research and Innovation, the UK Nuclear Decommissioning Authority, and Tokyo Electric Power Company (TEPCO) – which owns Japan's disabled Fukushima plant – in equal parts over four years. Long-reach robotic arms developed through this research partnership will be deployed at the Sellafield site in Cumbria and at the Fukushima Daiichi reactors.

https://eandt.theiet.org/content/articles/2021/01/uk-and-japan-partner-on-new-nuclear-decommissioning-tech/

### UAE's ENEC expects all four nuclear reactors to be operational in 4 years:

The UAE's Emirates Nuclear Energy Corp., which in 2020 started one of the four nuclear units, expects all reactors to be operational in four years as OPEC's third largest producer seeks to diversify its energy mix. ENEC's first 1.4 GW nuclear power reactor reached 100% power capacity in December after being connected to the power grid in August. It plans to generate half of its energy from clean and renewable energy, including nuclear power, by 2050. ENEC may in the future produce green hydrogen from its nuclear reactors

https://www.spglobal.com/platts/en/market-insights/podcasts/platts-future-energy/011921-repsol-energy-transition-oil-renewables-carbon-energy-hydrogen-luis-cabra

### Full radioactive operations to begin at Salt Waste Processing Facility at SRS

Full radioactive operations at the Salt Waste Processing Facility at the Savannah River Site are set to begin, as testing at the one-of-a-kind plant recently wrapped without incident, according to the Department of Energy. The Salt Waste Processing Facility has already handled more than 320,000 gallons of nuclear waste at the Savannah River Site; the first batch, thousands of gallons siphoned from the H Tank Farm, was sent to the plant late last year. Up to 6 million gallons of radioactive waste – a significant environmental threat, could be processed in its first year up and running.

https://www.postandcourier.com/aikenstandard/news/full-radioactive-operations-to-begin-at-salt-waste-processing-facility-at-srs/article_aaa33464-5b35-11eb-a335-735bf94d4316.html

### Developing Nuclear Power Infrastructure in Newcomer Countries

Around 30 countries are currently considering or embarking on nuclear power and working with the IAEA to introduce this reliable, low carbon energy source in a safe, secure and sustainable way. The IAEA supports these nuclear newcomers with advice and capacity building under the Milestones Approach, a three-phase method that enables countries to develop a national infrastructure for a nuclear power programme.

https://www.iaea.org/10-years-pui/developing-nuclear-power-infrastructure-in-newcomer-countries

**Nuclear stands out as clean, dispatchable firm power, says UK Energy Minister**

UK Energy Minister Kwasi Kwarteng said he looks forward to "a year of delivery" in 2021, following the publication of the Energy White Paper on 14 December. In an interview with the Westminster Energy Forum, Kwarteng said it is very difficult to "see anything better than nuclear power" in terms of low-carbon and dispatchable firm power, which will be a key part of the UK's energy system in 2050.

https://www.world-nuclear-news.org/Articles/Nuclear-stands-out-as-clean-dispatchable-firm-power

**Japanese industry leaders call for nuclear restarts**

Japan will need nuclear power if it is to realise the government's carbon neutrality goal and should therefore restart idled nuclear reactors as soon as possible, as well as work to extend their operating lifetimes and build new nuclear capacity, the heads of the Japanese Atomic Industry Forum (JAIF) and the Japan Iron and Steel Federation (JISF) have said in separate New Year messages.

https://www.world-nuclear-news.org/Articles/Japanese-industry-leaders-call-for-nuclear-restarts

**Belarus unit starts pilot operation**

Unit 1 of the first nuclear power plant to be built in Belarus started pilot operation yesterday, Russia's Rosatom has announced. Pilot operation is the final and longest check of a power unit before commissioning. The unit is the first of the VVER-1200 design to be built outside Russia.

https://www.world-nuclear-news.org/Articles/Belarus-unit-starts-pilot-operation

**Adequate uranium to meet demand, latest Red Book concludes**

Sufficient uranium resources exist to support the long-term, sustainable use of nuclear energy, according to the latest edition of the OECD Nuclear Energy Agency (NEA) and International Atomic Energy Agency (IAEA) joint report on uranium resources, production and demand. Known as the Red Book, published on 23 December, 2020

https://www.world-nuclear-news.org/Articles/Adequate-uranium-to-meet-demand-latest-Red-Book-co

**Hybrid systems could lead to clean energy paradigm shift, study finds**

The simultaneous use of diverse energy generators including nuclear to provide power, heat, mobility and other energy services could lead to paradigm shifts in clean energy production, according to a paper recently published by researchers from the US DoE's applied energy laboratories.

https://www.world-nuclear-news.org/Articles/Hybrid-systems-could-lead-to-clean-energy-paradigm

**Nuclear electricity costs set to decrease, study finds**

The levelised costs of electricity generation of low-carbon generation technologies are falling and are increasingly below the costs of conventional fossil fuel generation, according to a report by the OECD Nuclear Energy Agency (NEA) and the International Energy Agency (IEA). Nuclear electricity is expected to have lower costs in the near future, the report says.

https://www.world-nuclear-news.org/Articles/Nuclear-electricity-costs-set-to-decline,-study-fi

**US looks to nuclear propulsion systems to achieve space ambitions**

The US government announced on 9th December, 2020 the release of the National Space Policy, which advocates for developing and deploying nuclear power and propulsion systems on US space missions. The document specifies who, or which government agency, is responsible for various aspects of their development and deployment.

https://www.world-nuclear-ews.org/Articles/US-looks-to-nuclear-propulsion-systems-to-reach-sp

**French President stresses importance of nuclear energy for France**

French President Emmanuel Macron while speaking during a visit to Framatome's Le Creusot facility, said on December 8, 2020 that France's energy and ecological future depends on nuclear power.

https://www.world-nuclear-news.org/Articles/Macron-stresses-importance-of-nuclear-energy-for-F

**Malfunction triggers emergency shutdown at Finnish reactor**

An automatic shutdown on December 10, 2020 of

unit 2 at the Olkiluoto nuclear power plant in Finland was caused by a fault in the purification system for the reactor cooling water, which led to a temporary increase in radiation levels in the circuit, Finnish utility Teollisuuden Voima (TVO) said.

https://www.world-nuclear-news.org/Articles/Malfunction-triggers-emergency-shutdown-at-Finnish

**How Nuclear Science helps Countries Guarantee Basic Rights to Water, Food and Health**

While commemorating Human Rights Day on 10 December, 2020, Rafael Mariano Grossi, IAEA Director General said "As we mark Human Rights Day with a hopeful look towards the end of the COVID-19 pandemic, it strikes me as a good time to highlight the often-underappreciated ways the atom supports the attainment of our fundamental human rights.

https://www.iaea.org/newscenter/news/human-rights-day-how-nuclear-science-helps-countries-guarantee-basic-rights-to-water-food-and-health

**Preparations begin for Canadian borehole**

Canada's Nuclear Waste Management Organisation (NWMO) has begun preparations for the drilling of two boreholes in the South Bruce area prior to site selection for a deep geological repository for the country's used nuclear fuel. The first borehole will be drilled in Spring 2021.

https://www.world-nuclear-news.org/Articles/Preparations-begin-for-Canadian-borehole

**First-of-its-kind 3Dprinted nuclear fuel component to enter use**

Framatome has announced that 3D-printed fuel assembly channel fasteners manufactured at the US Department of Energy's Oak Ridge National Laboratory (ORNL) in a joint project with Tennessee Valley Authority are to be loaded into a US commercial reactor for the first time. The four components will be loaded into TVA's Browns Ferry nuclear power plant in early 2021.

https://www.world-nuclear-news.org/Articles/First-3D-printed-nuclear-fuel-components-to-enter

**Head of EDF calls for Europe to include nuclear in Green Deal**

The European Commission should include nuclear among the clean energy technologies that will be financed under the Green Deal low-carbon policy, EDF chairman and CEO Jean-Bernard Lévy said today in an online chat with International Energy Agency (IEA) Executive Director Fatih Birol.

https://www.world-nuclear-news.org/Articles/Head-of-EDF-calls-for-Europe-to-include-nuclear-in

**China's first Hualong One unit connects to grid**

Unit 5 of the Fuqing nuclear power plant in China's Fujian province was connected to the grid on 27 November 2020, China National Nuclear Corporation (CNNC) has announced.

https://www.world-nuclear-news.org/Articles/World-first-Hualong-One-unit-connects-to-grid

**Arktika icebreaker completes first mission**

Russia's new nuclear powered ice-breaker, *Arktika*, completed its first operational voyage - piloting the Siyaniye Severa dry cargo ship to the entrance of the Gulf of Ob in the Russian Arctic.

https://www.world-nuclear-news.org/Articles/Arktika-icebreaker-completes-first-mission

**India, USA extend nuclear cooperation partnership**

India and the USA have extended their Memorandum of Understanding for cooperation on the Global Centre for Nuclear Energy Partnership (GCNEP) by 10 years. The centre - officially opened in 2017 - supports international cooperation in nuclear energy applications.

https://www.world-nuclear-news.org/Articles/India-USA-extend-nuclear-cooperation-partnership

**Key Radiation Safety Areas for the Next Decade Identified**

After two weeks of online discussions at the International Conference of Radiation Safety which concluded on November 20, 2020, more than 2000 participants including experts from 140 Member States and 13 International Organizations, agreed on key areas in radiation protection. Addressing concrete areas such as applying the core radiation protection principles more consistently, a more integrated public communication, and having a strong safety culture, are essential to sustain and improve the protection of workers, patients, the public and the environment from the harmful effects of ionizing radia-

tion.

https://www.iaea.org/newscenter/news/key-radiation-safety-areas-for-the-next-decade-identified-at-the-international-conference-on-radiation-safety

**Nuclear Power Plant life extensions enable clean energy transition**

A new IAEA data animation shows that extending the life of existing nuclear power plants significantly increases the availability of reliable low carbon power, helping to meet climate goals and the transition to clean energy by 2050.

https://www.iaea.org/newscenter/news/iaea-data-animation-nuclear-power-plant-life-extensions-enable-clean-energy-transition

**Nuclear power can speed progress in the developing world**

If the world is to win the fight against climate change, it is vital that developing countries, including those on the African continent, adopt low-carbon electricity systems that can also keep pace with increased demand created by population growth. This was the message of Philippe Costes, senior advisor to the director general of World Nuclear Association, to participants in the *Power & Electricity World Africa 2020* conference held on 6 November.

https://www.world-nuclear-news.org/Articles/Nuclear-power-can-speed-progress-in-the-developing

**New IAEA Publication highlights status of SMR development**

The 2020 edition of the biennial IAEA booklet "Advances in Small Modular Reactor Technology Developments", published in October 2020, provides the latest data and information on SMRs around the world, including detailed descriptions of 72 reactors under development or construction in 18 countries.

https://www.iaea.org/newscenter/news/nuclear-power-for-the-future-new-iaea-publication-highlights-status-of-smr-development

**MAST Upgrade achieves first plasma**

The UK Atomic Energy Authority (UKAEA)'s fusion energy experiment - the Mega Amp Spherical Tokamak (MAST) Upgrade tokamak at Culham Science Centre, achieved first plasma in October 2020.

https://www.world-nuclear-news.org/Articles/MAST-Upgrade-achieves-first-plasma

**UN nuclear weapons ban treaty to enter into force**

The United Nations announced that 50 countries have ratified a UN treaty to ban nuclear weapons triggering its entry into force in 90 days, a move hailed by anti-nuclear activists but strongly opposed by the United states and the other major nuclear powers. This moment has been 75 years coming since the horrific attacks on Hiroshima and Nagasaki, and the founding of the UN which made nuclear disarmament a cornerstone, said Beatrice Fihn, executive director of the International Campaign to Abolish Nuclear Weapons, the 2017 Nobel Peace Prize-winning coalition whose work helped spearhead the nuclear ban treaty

https://www.thehindu.com/news/international/un-nuclear-weapons-ban-treaty-to-enter-into-force/article32939701.ece/amp /

## Conferences

**International Conference on Radioactive Waste Management : Solutions for a Sustainable Future,** to be held in Vienna, during 1-5 November 2021. Interested contributors have until 5 March 2021 to submit abstracts.

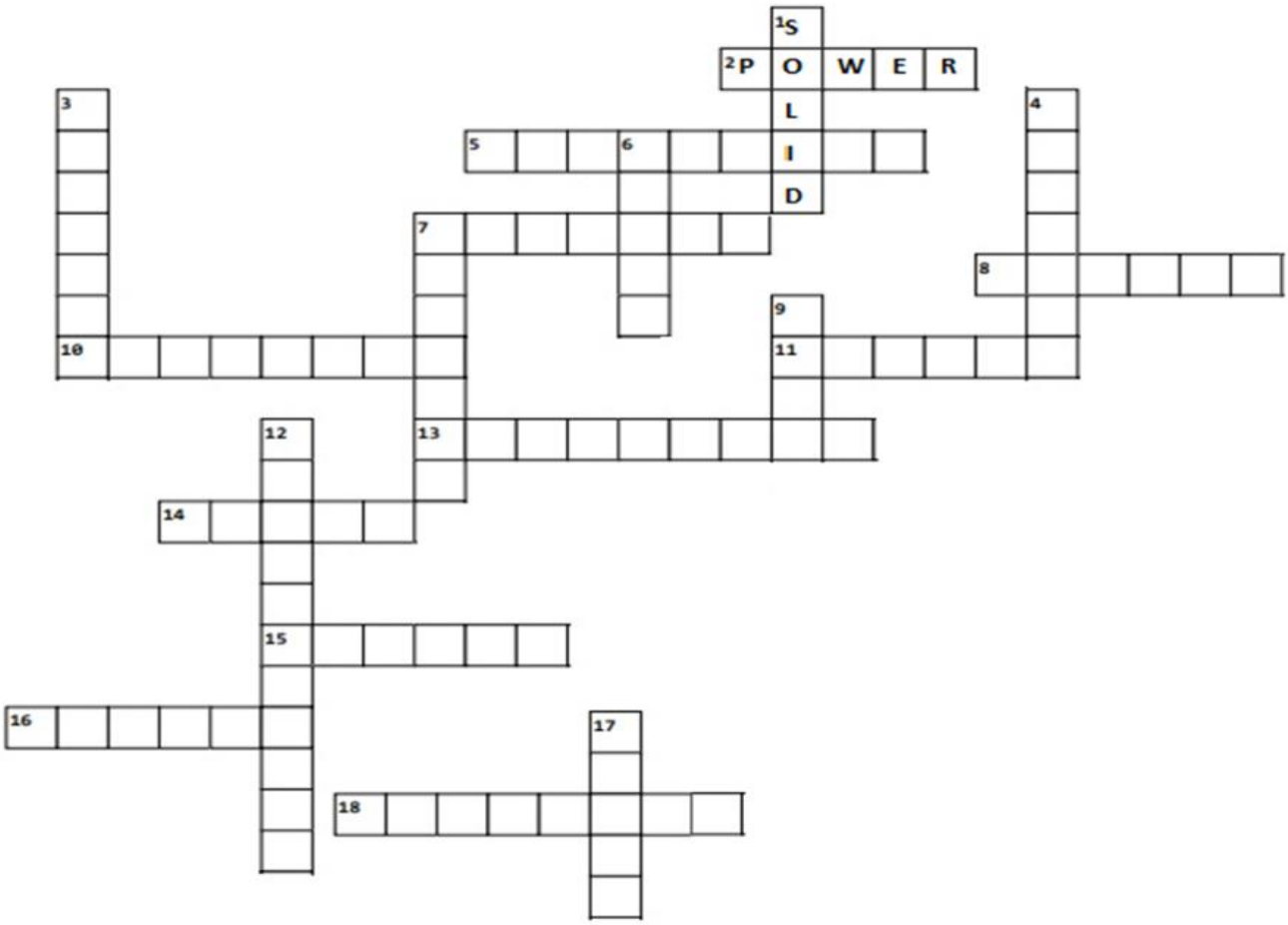
https://www.iaea.org/newscenter/news/call-for-papers-international-conference-on-radioactive-waste-management

**International Conference on Strengthening Nuclear Safety** to be organised at IAEA, Vienna during November 8 – 12, 2021

https://www.iaea.org/newscenter/news/save-the-date-8-12-nov-2021-international-conference-on-strengthening-nuclear-safety

**Compiled by S.K.Malhotra**

# CROSSWORD PUZZLE




**Across**

**2.** Rate of doing work

**5.** Solid matter on heating

**7.** Product of force and time interval of acting

**8.** SI unit of Thermodynamic temperature

**10.** Solid matter on cooling

**11.** Ability to carry out work

**13.** The work per unit charge necessary to move a charged body in an electrical field

**14.** Push or pull of an object

**15.** One_ _ _equals one Kilogram-m/s

**16.** Unit of stress

**18.** Force per unit area

**Down**

**1.** The state that has definite shape & volume

**3.** Energy of moving object

**4.** Medieval fore runner of chemistry

**6.** A mixture of one or more metals

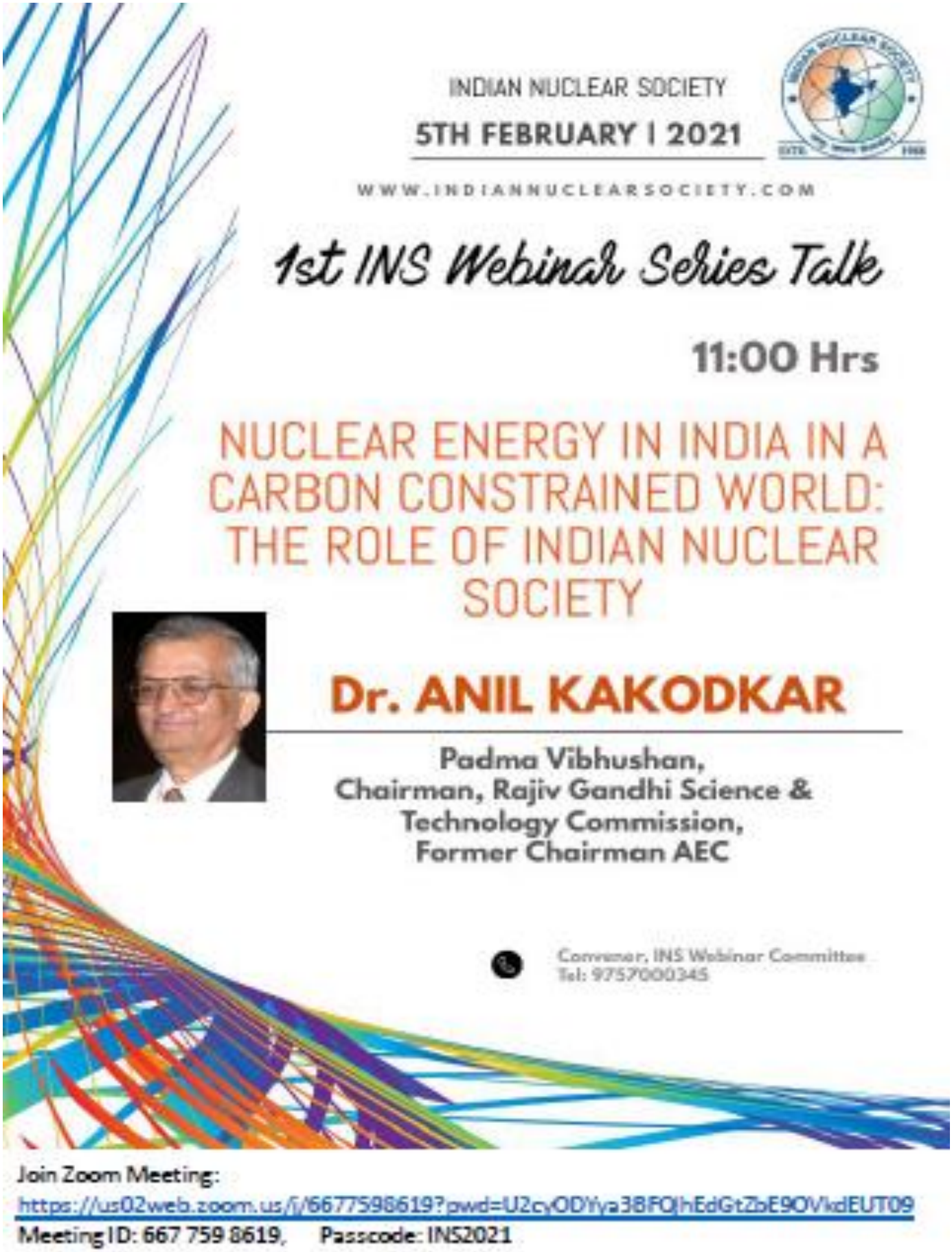
**7.** Chemically nearly similar atoms with different masses

**9.** An electron emitted from a nucleus

**12.** The vocabulary of technical terms in science

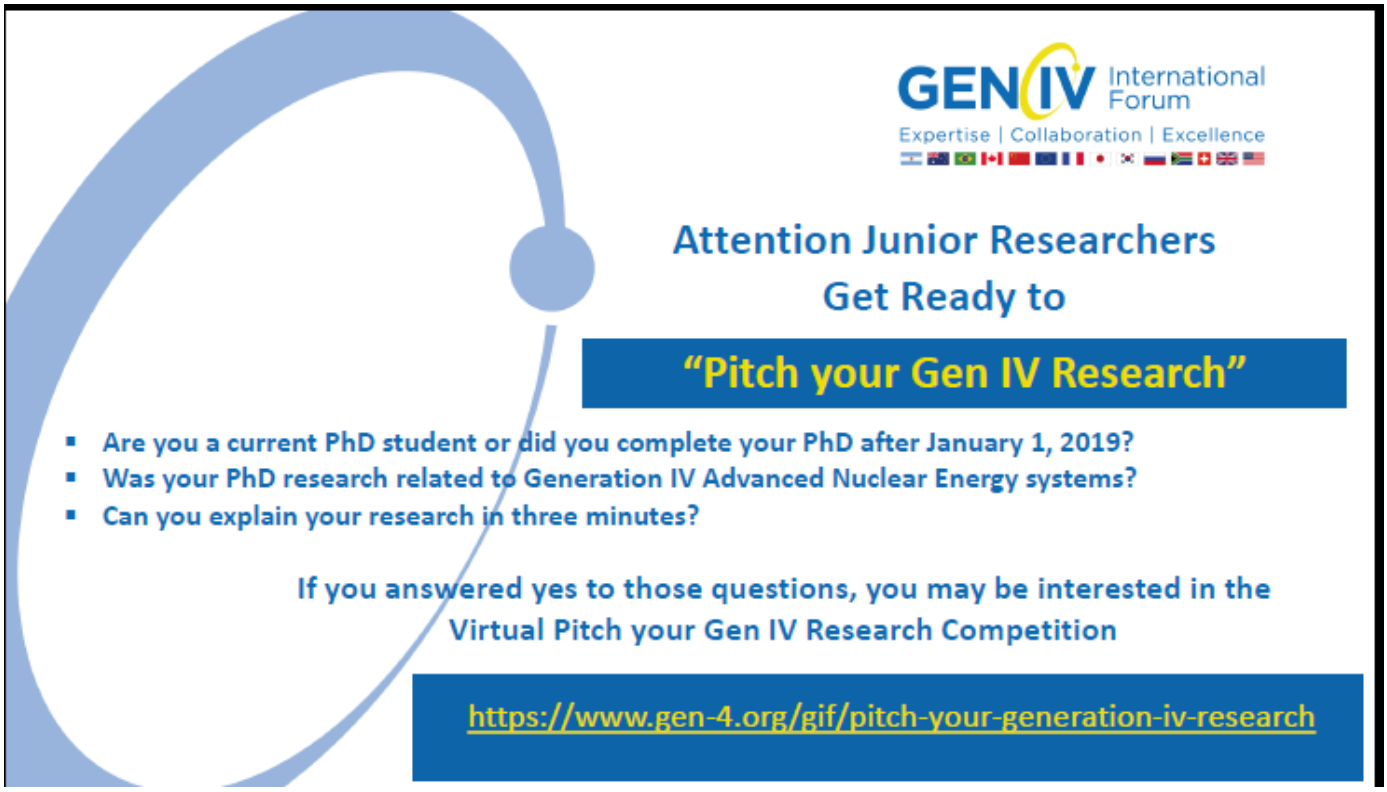
**17.** SI unit of of work

**Contributed by Dr. A.RamaRao**




**Link for the Webinar:**

https://us02web.zoom.us/j/6677598619?pwd=U2cyODYya3BFQlhEdGtZbE9OVkdEUT09




**Location:** Virtual; **Cost:** Free!

**Website** :https://www.gen-4.org/gif/jcms/c_173183/pitch-your-generation-iv-research-competition

**Important dates**
February 1, 2021 - Executive summary submission opens
February 28, 2021 - Executive summary submission closes (no extension)
Mid March, 2021 - Finalists' selection is completed
March 28, 2021 - Video submission are due (no extension)
April 1, 2021 - Popular voting begins
April 30, 2021 - Popular voting ends
May, 2021 - Winners are announced

**Format:** In order to enter the competition, participants are required to submit a one-page executive summary of their research. A panel of experts (GIF Jury) will review the submittals and select up to 25 outstanding research projects based on their relevance to the GIF mission, originality, and significance. Selected participants (finalists) will then be required to record a 3-minute video pitch in March 2021. The recorded videos will be publicly posted (e.g., YouTube) for 30 days to allow world-wide viewing and voting. The public viewing of the pitches will begin in April 2021. The GIF Jury will also judge the video pitches based on their creativity, communication effectiveness, and technical quality. The best pitches will be selected based on (1) the GIF Jury and (2) the popular voting.

**Prizes:** Winners will be selected in both the popular vote category and the GIF Jury category.

**• GIF Jury Category**
**The first-place winner will be:**

(1) invited to present a webinar in 2021 as part of the GIF Education and Training Working Group webinar series, and

(2) invited to attend the next GIF Symposium planned in 2022 (travel expenses will be reimbursed on the OECD NEA basis).

**The second-place winner will be:**
(1) invited to present a GIF webinar in 2022, and

(2) invited to attend a future GIF meeting in their region.

**• The Popular Vote Category**
**The winner - Audience Favorite - will be invited to present a GIF webinar in 2022.**

**The views and opinions expressed by the authors may not necessarily be that of INS**

**INS News Letter is Published by S. P. Dharne on behalf of Indian Nuclear Society, Project Square, Anushakti Nagar, Mumbai – 400094, E- mail: indiannuclearsociety@gmail.com. Tel: 91-22- 2559 8327,**

**Website: www.indiannuclearsociety.com**