ISASINDIA Newsletter

Vol 21, No. 3 *September 2021*

From Editor's desk

Happy Dussehra

The period of this issue has been period of enormous activities. Glad to observe that ISAS is on expanding trend. It is matter of immense pride for ISAS that new chapters are coming into existence. Pune chapter has been formed under the chairpersonship of Dr. Nilima Rajurkar. Pune chapter has enrolled 50 life members. Chief Guest, Prof. S. F. Patil (Former vice Chancellor of NMU and BVDU) inaugurated ISAS, Pune chapter. One unique

event happened for first time is releasing of ISAS geet (song) composed by Dr. Rajukar. Song has made ISAS melodious, indicator of growing popularity and quality. Belagavi Chapter, Department of Chemistry, Rani Channamma University, Karnataka is on active mode. Chapter has conducted its 1st General Body meeting online through google meet on July 15, 2021. Belgavi chapter have enrolled 54 life members. Heartiest congratulations to pune and belgavi chapters. The Nine chapters complete the "Nava Ratnas" of the elegant ISAS Locket. The Ratnas have to keep sparkling, It is satisfying to note that most of the Ratnas are indeed Sparkling. The Ratnas such as Nagpur, Kerala, Belagavi, Tamil Nadu, Baroda, are very much Self Sparkling. Hyderabad is on an occassional sparkling Induced by Nagpur. Jaipur has a high potential and promise of sparkling, subdued by Covid19. Pune has started with a good sparkle and has a high potential to continue. Thus, the overall picture is bright and poised to make a big take off. Such expansion during covid period is really appreciablet. Unfortunately DAE has suffer great loss, two ex chairmans of AEC have expired. Padam Shree Shekhar Basu and Padam Shree S.K Banerjee. ISAS pays tribute to these great personalities. David MacMillan and Benjamin List have won Chemistry Nobel prize for 2021. They created new tools for building molecules, these tools helped make new drugs and are more green. In physics three scientists Syukuro Manabe (USA), Klaus Hasselmann of Germany (Germany) Giorgio Parisi (Italy) won Nobel Prize for work that found order in seeming disorder, helping to explain and predict complex forces of nature, including expanding our understanding of climate change. Two articles gives over view of Nobel laureates work. Article based on webinar on " MATERIALS FOR ANALYTICAL SEPARATION " by Dr. Jayshree Ramkumar, Scientific Officer Bhabha Atomic Research Centre, Mumbai on June 10, 2021 at 7.00 pm Conducted by ISAS, Tamil Nadu Chapter. Another article also based on webinar on " Climate Change and Global Warming: What lies Ahead? " by Dr. V. Balaram Former Emeritus Scientist, Chief Scientist & Head, Geochemistry Division CSIR - National Geophysical Research Institute (NGRI), Hyderabad. We thank both for their contribution. We expect such nice trend to continue in future.

Dr. Pradeep Kumar
Chief Editor ISAS,
Vice President ISAS
Senior Scientist BARC

Message from ISAS President

****

I am happy that the September 2021 Issue of ISAS News Letter is ready and being released. On this occasion, I convey my Best Wishes to the ISAS Fraternity and convey happy reading.

This News Letter will be posted in ISAS Website (isasbharat.in). All ISAS Members are requested to kindly give comments/feed back to enable improvements in the ISAS News Letter.

All ISAS Members are requested to regularly visit ISAS Website and also actively participate in all ISAS Programme that include the all Saturday Evening Webinars.

Best regards to all ISAS Members.

(Dr. P. P. **Chandrachoodan)**

President,ISAS.

Indian Society of Analytical Scientists (ISAS)

Belagavi Chapter

Office address: C/o Department of CHEMISTRY
Rani Channamma University, PB NH-4, Belagavi-591156, Karnataka

Proceedings of the 1st General Body meeting heldonline on **July 15, 2021 @ 7 PM** using the link https://meet.google.com/pza-cgno-rzt

Prof. J. Manjanna, Chairman (Ad-hoc), ISAS Belagavi Chapter has invited and extended a warm welcome to all the Life Members enrolled so far & requested **Dr Rahaw Sharan**, Vice President of ISAS & In-Charge of Chapter Affairs, to be the***Observer*** during the election of Office bearers and Executive committee (**EC**) members.

The Chairman has allowed the LMs to take up the following agenda, one by one.

- Briefing the LMs about the ISAS and its functions, planned activities etc.
- The statement of Account and enrolling activities
- Distribution of e-Certificates & e-Receipts
- Election of Working committee Chairman&Vice-Chairman, Secretary& Joint Secretary and Treasurer& Joint Treasurer &Chapter Executive Committee (***CEC***) Members -**11.**
- Any other appropriate issues.

Resolutions

Based on the thorough discussion on each of these items, and election of Working committee [Office bearers &Chapter Executive Committee (CEC) members] as per ISAS norms, the following resolution are made in the **1st GB meeting**(online) held on **July 15 2021**.

It is proposed to conduct Annual Conference and other scientific events, institute awards and extend a supporting hand to different academic and scientific events after discussion in the working committee (Office bearers and CEC Members).

Working committee consisting the Office bearers viz., Chairman&Vice-Chairman, Secretary& Joint Secretary and Treasurer& Joint Treasurer as well as *Chapter Executive Committee* (***CEC***) Members -**13** have been elected as per ISAS norms. The list of Elected Members is given below.

Office Bearers

- Chairman Prof. J. Manjanna
- Vice-Chairman Prof. N.D. Satyanarayan
- Secretary Dr. Prasanna D. S
- Jt. Secretary Prof. Basavaraj Hungund
- Treasurer Dr. Rajappa S. K
- Jt. Treasurer Dr. Vidyasagar. C. C

Chapter Executive Committee (***CEC***) Members

- Prof. G. J. Sathisha
- Prof. Dinesh Rangappa
- Prof. B.E. Kumara Swamy
- Dr. M.P. Somashekarappa
- Dr. B.P. Nandeshwarappa
- Dr. Basappa
- Dr. Nirmala B
- Dr. Shoba N
- Dr. Prabhakara M. C.
- Dr. Ramesh K. B
- Dr. Suresh D
- Dr. P.M. Gurubasavaraj
- Dr. Laxmi N. Jattinagoudar

****

Indian Society of Analytical Scientists (**ISAS**)

Belagavi Chapter

[**HQ**: REDS, South Site, BARC, Trombay, Mumbai 400 085]

(Reg. No. Bom/213/83 with GB BSD under Societies Regn. Act 1860 Bom/F/8521/83 under Bombay Public Trust Act 1950)

Office address: C/o Department of CHEMISTRY

Rani Channamma University, PB NH-4, Belagavi-591156, Karnataka

Working Committee

Chairman:
Prof. J. Manjanna
Dept. of Chemistry
Rani Channamma University
PB NH-4, Belagavi-591156
Ph. No. +91 9916584954
Email: jmanjanna@gmail.com

Secretary:
Dr. Prasanna D. S
Asst. Prof., Dept. of Appl. Sci.
Visvesvaraya Technological University (VTU), Muddenahlli, Chikkaballapur-562101

Treasurer:
Dr. S. K. Rajappa
Asst. Prof., Dept. of Chemistry
Karnataka Sci. College (KCD)
Dharwad 580001

Vice-Chairman
Prof. N.D. Satyanarayan
Kuvempu Univ.

Jt. Secretary
Prof. Basavaraj Hungund
KLE Technological Univ.

Jt. Treasurer
Dr. Vidyasagar. C. C
Rani Channamma Univ.

Executive Committee (*EC*) Members
Prof. G. J. Sathisha
Prof. Dinesh Rangappa
Prof. B.E. Kumara Swamy
Dr. M.P. Somashekarappa
Dr. B.P. Nandeshwarappa
Dr. Basappa
Dr. Nirmala B
Dr. Shoba N
Dr. Prabhakara M. C.
Dr. Ramesh K. B
Dr. Suresh D
Dr. P.M. Gurubasavaraj
Dr. Laxmi N. Jattinagoudar

Date: **July 16, 2021**

CIRCULAR cum Invitation

The National Webinar on '*Electroanalytical Techniques for the Determination of Biomolecules*' is organized in association with Dept. of Chemistry, Rani Channamma University, Belagavi on **17-07-2021** (Sat) from 6:50 PM.
All those interested Research Scholars, Faculty members & Scientists can join using the link:

https://meet.google.com/pza-cgno-rzt

Chief Guest: **Prof. B.S. Sherigara**
Former Vice-Chancellor, Kuvempu University.
Resource person: **Prof. S.T. Nandibewoor**
Diamond Jubilee Professor for Lifetime, Karnatak University, Dharwad.
Presided by:**Dr P.P. Chandrachoodan**, President, ISAS ;**Dr Rahaw Sharan**, Vice President of ISAS & In-Charge of Chapter Affairs&**Dr. Rajeev Raghavan**, Vice President & Chairman ISAS Webinar Committe
Special Invitees: **Prof. Basavaraj Padmashali**, Registrar, RCU; *EC Members & Office bearers of ISAS;* Chairmen & LMs of *ISAS Chapters*

Looking forward to meet you online on **July 17, 2021 @ 6:50 PM**.

Thanks &Regards

Sd/-
Members of working committee, ISAS Belagavi Chapter

Bank details:
[Life Member Fee, Rs. 2,100/-]

CHAIRMAN CHEMISTRY
A/c no. 05522200027782, **Canara Bank**, IFSC: CNRB0010552
Bhutaramanahatti branch, Belgaum 591156

Dr Rahaw Sharan has congratulated all the Elected Members and the members for their active participation and cooperation in the smooth conduct of GB meeting and the Election of new working committee.

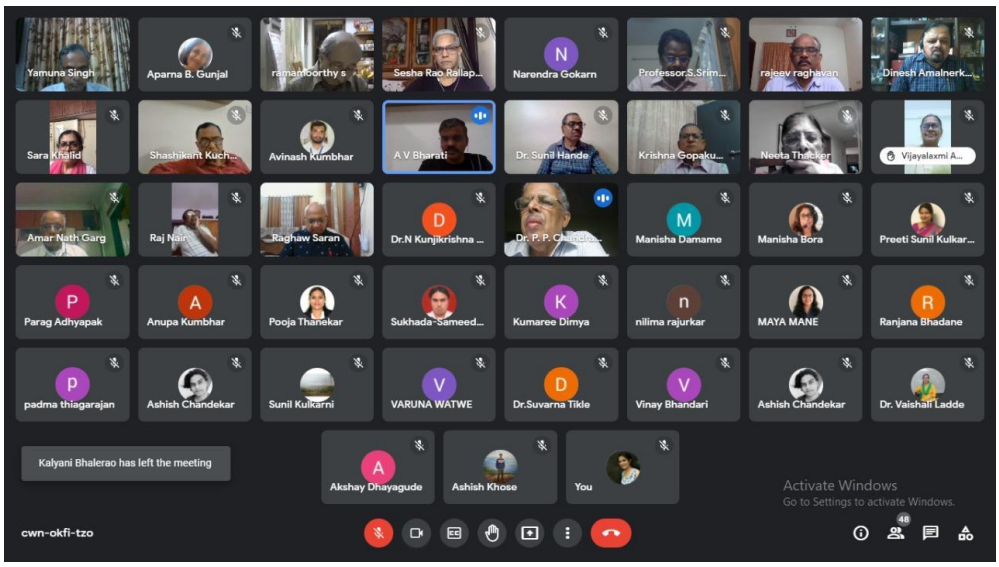
Prof. J. Manjanna, Chairman (Elected), ISAS Belagavi Chapter has thanked all the LMs and the newly elected team. The meeting was concluded with a positive note by all the participants.

Inauguration of ISAS, Pune chapter and A talk in association with ISAS, Nagpur chapter : A brief report

By Dr. Nilima Rajurkar

The program started with a welcome by Dr. Avinash Bharati, chairman, Nagpur chapter on behalf of ISAS followed by virtual Deep prajwalan at the hands of dignitaries. After introduction by Dr Parag Adhyapak, Dr. Nilima Rajurkar (Chairperson, Pune chapter) briefed about the Pune chapter and assured to achieve the goals set by ISAS in promoting excellence and innovation in scientific work by reaching to all sectors of the society through workshops, seminars, invited talks, science popularization and awareness program. Chief Guest, Prof. S. F. Patil (Former vice Chancellor of NMU and BVDU) inaugurated ISAS, Pune chapter and released ISAS geet composed by Dr. Rajukar. In his address he gave an overview of analytical chemistry right from ancient times till today and described how modern analytical techniques play an important role in characterization of different samples and solving problems in various branches of science. President :Dr. chandrachoodan, Vice president: Dr. Saran and chairman, webinar committee: Dr. Raghavan, in their address, congratulated Pune chapter and wished them success in organizing the various activities, After introduction by Dr. Avinash Kumbhar (secretary, ISAS Pune chapter), Dr. D. P. Amalnerkar delivered an insightful talk on "Bridging the gap between Vedic and modern sciences: Nano-centric characterization of typical ayurvedic bhasmas by using ultramodern analytical techniques". He discussed the results obtained by physico-chemical investigations of Swarnabhasma, Roupyabhasma and Jasadbhasma (prepared in accordance with traditional ayurvedic protocol *in toto)* using ultramodern analytical tools such as XRD, FESEM, XPS, FETEM, HRTEM technques along with the elemental mapping. These studies helped to judge structure, texture, morphology and elemental/chemical composition and distribution in prepared bhasmas. He concluded his talk with a hope that such investigations will bridge the gap between Vedic and modern science. Several questions raised by participants were satisfactorily answered by him, the question answer session was handled by Dr. Sunil Hande(treasurer, ISAS Pune chapter). The certificate of excellence was handed over to Dr. Amalnerkar by the chief

guest, Prof. Patil and letter of appreciation was given to Prof. Patil by the president, Dr. Chandrachoodan. Dr. Sameer onkar proposed a vote of thanks . The program was compared by Dr. Suvarna Tikle.



Release of ‘My Stamps’ and ‘Special Covers’ by Department of Posts on commemoration of 50 Years of Commercial operation of TAPS-1&2 on December 28, 2019

Department of Posts released ‘My Stamps’ and ‘Special Covers’ on setting a World Record of 962 days of continuous operation of KGS-1 on November 28, 2019

Dr Srikumar Banerjee

(25 April 1946-23 May 2021)

ISAS pays tribute to

Dr Srikumar Banerjee

Ex. Chairman Atomic Energy Commission

and Director, Bhabha Atomic Research Centre

Dr Srikumar Banerjee was the former Chairperson of the Atomic Energy Commission of India and the former Secretary of the Department of Atomic Energy, Government of India. He was well-known as a metallurgical engineer by training. Banerjee obtained his B.Tech. with honours in Metallurgical Engineering from the Indian Institute of Technology, Kharagpur in 1967. He then went to attend the Training School at BhabhaAtomic Research Centre (BARC). Soon after, in 1968 he formally started his career there with the Metallurgy Division at BARC and went on to become its Director during 2004-2010.

Earlier in 1974, for the work he carried out at BARC, he was awarded the PhD in Metallurgical Engineering from IIT Kharagpur. In the latter part of his career, he also served as DAE Homi Bhabha Chair Professor at BARC. Banerjee held various visiting positions abroad at the University of Sussex, Brighton, England, Max- Planck-Institut für Metallforschung, the University of Cincinnati, and the Ohio State University, USA.

He also served as the Chairman, the Board of Governors of IIT Kharagpur during 2014-2017. He was elected as a fellow of the Indian Academy of Sciences, National Academy of Sciences, India, and the Indian National Academy of Engineering. He received numerous recognitions for his work and contribution to services. Dr Banerjee was awarded the Shanti Swarup Bhatnagar Prize for Science and Technology in Engineering Science (1989) and Padma Shri in 2005. Banerjee passed away during the early hours of 23 May 2021 due to a heart attack.

Source: **Science Reporter, August 2021, 75 Years of S& T in India**
Azadi ka Amrit Mahotsav,
SOME LEADERS WHO HELPED SHAPE SCIENCE IN INDIA

Nuclear scientist Sekhar Basu dies of COVID-19

ISAS pays tribute to

Shekhar Basu

Ex Chairman Atomic Energy Commission

and Director, Bhabha Atomic Research Centre

Veteran atomic scientist and former chairman of Atomic Energy Commission Dr. Sekhar Basu succumbed to COVID-19 early on Thursday at a private hospital here, a health department official said. He was 68.“Dr. Basu was suffering from COVID-19 and other kidney ailments. He died at 4.50 a.m.,” the official told PTI. A mechanical engineer, Dr. Basu is revered for his contributions to the country’s atomic energy programme. He was awarded Padma Shri in 2014. He had also pioneered the highly complex reactor for India’s first nuclear-powered submarine INS Arihant. Nobel chemistry prize goes to duo who developed a tool for molecule building.

Source: https://www.thehindu.com/news/cities/kolkata/nuclear-scientist-sekhar-basu-dies-of-covid-19/article32683891.ece

INDIAN SOCIETY OF ANALYTICAL SCIENTISTS

ISAS Webinar 2021

Talk on :

Challenges and Solutions in Pest Management Strategies in Agriculture

09 October 2021 | Saturday 7.00pm

"Eminent Speaker
Dr. C. A. Jayaprakas
Principal Scientist (Entomology)
ICAR-Central Tuber Crops
Research Institute"

Chief Guest
Dr. Sriman Narayan
Vice Chancellor,
Vels Institute of STAS, Chennai

Dr. P.P. Chandrachoodan
President, ISAS

Dr. Rajeev Raghavan
Chairman, Webinar Committee

zoom Zoom Id : 948 124 3955 | Password : isas2021

ISAS Baroda Chapter & ISAS Head Quarter WEBINAR - 2021

September 18th
7.00 pm
Saturday

Dr. P.P. Chandrachoodan
National President, ISAS

Dr Raghav Saran
National Vice President, ISAS

Dr. Rajeev Raghavan
Chairman
National Webinar Committee

Prof Prakash Samnani,
Secretary
ISAS Baroda Chapter

Dr. Suneet Yadav
Convener
Webinar Committee
ISAS Baroda Chapter

INDIAN SOCIETY OF ANALYTICAL SCIENTISTS

Talk of the day:

Peaceful Applications of Radiation Techniques in Crop Improvement & Food Processing

Speaker: Prof. S.K. Patil
Vice Chancellor
Indira Gandhi Krishi Vishwavidyalaya,
Raipur-492012 (Chhattisgarh)

Chief Guest: Prof. Dr. V. K. Manchanda
Vice President of Indian Nuclear Society.

zoom
Meeting ID: 948 124 3955
Passcode: isas2021

INDIAN SOCIETY OF
ANALYTICAL SCIENTISTS

ISAS Webinar 2021

Talk on :

Crafting a Sustainable Future for Plastics through Circular Economy Approach

28 August 2021 | Saturday 7.00pm

"Eminent Speaker
Dr. G S Kapur
Executive Director (CT & TPF)
R & D Centre
Indian Oil Corporation Ltd."

Chief Guest
Dr. KKA Rashid
Chairman, ISAS Kerala Chapter

Dr. P.P. Chandrachoodan
President, ISAS

Dr. Rajeev Raghavan
Chairman, Webinar Committee

zoom Zoom Id : 948 124 3955 | Password : isas2021

Webinar 2021

Indian Society of Analytical Scientists

Inauguration of ISAS, Pune Chapter

Invited Talk:

In Association with ISAS, Nagpur Chapter

Invited Speaker
Dr. D. P. Amalnerkar
Prof Emeritus,
Technology Dept, SPPU

Chief Guest
Dr. S.F. Patil
Former VC
NMU and BVDU

President, ISAS
Dr P.P.Chandrachoodan

Title: Bridging the Gap between Vedic and Modern Sciences: Nano-centric Characterization of Typical Ayurvedic Bhasmas by using Ultramodern Analytical Techniques

While exploring healthcare applications of nanomaterials, it is intuitively sensed that therapeutic properties of metal based ayurvedic compositions might be associated with the nano-scale features. To bridge the gap between vedic and modern sciences, extensive physico-chemical investigations were performed on Swarnabhasma, Roupyabhasma and Jasadbhasma (prepared in accordance with traditional ayurvedic protocol *in toto)* using ultramodern analytical tools. X-ray Diffractometry (XRD), Field-Emission Scanning Electron Microscopy (FESEM), X-ray Photoelectron Spectroscopy (XPS), Field-Emission Transmission Electron Microscopy (FETEM), High-Resolution TEM (HRTEM), Scanning Transmission Electron Microscopy (STEM) with High Angle Annular Dark-Field (HAADF) and Elemental Mapping were predominantly employed to judge structure, texture, morphology and elemental/chemical composition & distribution in such metal based formulations.

Brief PROGRAMME Schedule

- Welcome & Deep Prajwalan
- Inauguration & ISAS Geet
- Address by Chief Guest
- Remarks by President and Vice president
- Invited talk followed by Discussion
- Vote of Thanks

Saturday, 2 October 2021 at 7 p.m.
Link: https://meet.google.com/cwn-okfi-tzo

Vice President, ISAS
Dr Raghaw Saran

Chairman, Nagpur Chapter
Dr A. V. Bharti

Chairman, Pune Chapter
Dr Nilima Rajurkar

Secretary, Pune Chapter
Dr Avinash Kumbhar

Treasurer, Pune Chapter
Dr Sunil Hande

Indian Society of Analytical Scientists

ISAS Headquarters & ISAS Nagpur Chapter (isasnagpur.in)
in association with
Chemistry Department, RCOEM, Nagpur
organizes a National Webinar

SPEAKER **Agam Khare**
Founder, CEO at Absolute Foods

talks on

Future of Food - Feeding 10bn people by 2050

CHIEF GUEST **Prof. Y C Sharma**
Director, Innovation, Research and Development, Dr CBS Cyber Security Services, Jaipur

Click here for joining → **https://meet.google.com/ixp-cfkg-pmg**

Date: 21.08.2021 (Saturday), Time: 7:00 pm to 9:00 pm

Dr P.P Chandrachoodan
National President, ISAS

Dr. Raghaw Saran
National Vice President, ISAS

Dr Rajeev Raghavan
Chairman, Webinar Committee, ISAS

Dr Avinash Bharati
Chairman, Nagpur Chapter, ISAS

Indian Society of Analytical Scientists

ISAS Headquarters & ISAS Nagpur Chapter (isasnagpur.in)
in association with
Chemistry Department, RCOEM, Nagpur
organizes a National Webinar

SPEAKER **Dr. Virendra Kumar**

Head Advanced Material Section (AMS)
& Associate. Prof. HBNI, Mumbai

talks on

Radiation Technology: A versatile tool for multifaceted applications"

CHIEF GUEST **Dr Alok Kumar Basu**

Ex. Deputy Director cum Co-ordinator, Central Forensic Science Laboratory, Pune

Click here for joining → https://meet.google.com/fsk-exib-xku

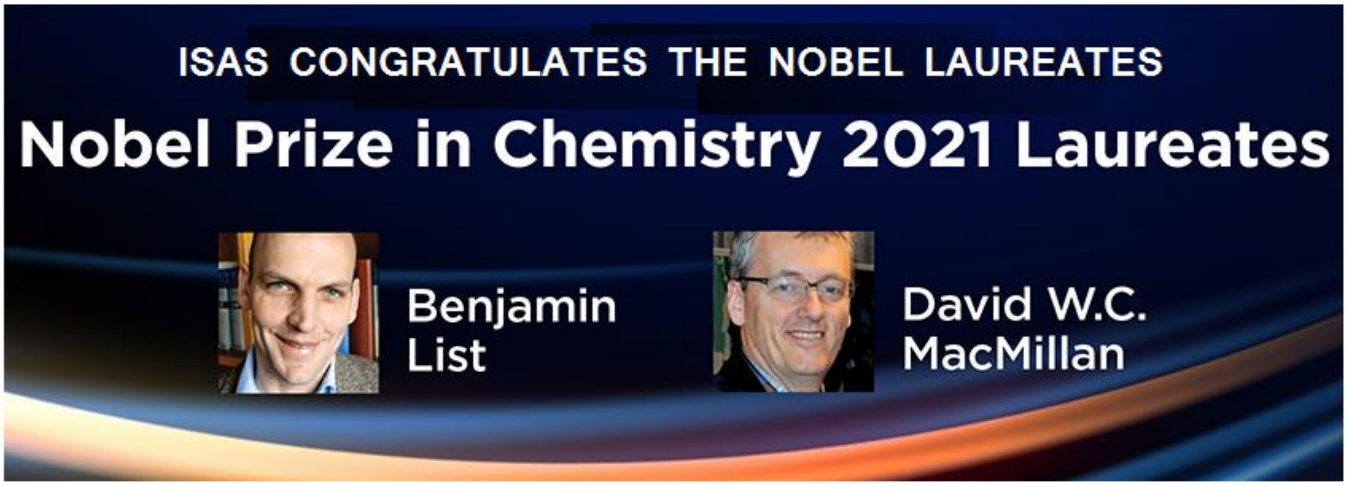
Date: 04/09/2021 (Saturday) , Time: 7:00 pm to 9:00 pm

Dr P.P Chandrachoodan
National President, ISAS

Dr. Raghaw Saran
National Vice President, ISAS

Dr Rajeev Raghavan
Chairman, Webinar Committee, ISAS

Dr Avinash Bharati
Chairman, Nagpur Chapter, ISAS



David MacMillan and Benjamin List win Chemistry Nobel

They created new tools for building molecules

These tools helped make new drugs and are more green

Source: https://axial.acs.org/2021/10/06/the-nobel-prize-in-chemistry-2021-goes-to-benjamin-list-and-david-w-c-macmillan/

STOCKHOLM, Oct 6 (Reuters) - German Benjamin List and Scottish-born David MacMillan won the 2021 Nobel Prize in Chemistry on Wednesday for developing new tools for building molecules that have helped make new drugs and are more environmentally friendly. Their work on asymmetric organocatalysis, which the award-giving body described as "a new and ingenious tool for molecule building", has also helped in the development of plastics, perfumes and flavours. "Organic catalysts can be used to drive multitudes of chemical reactions," the Royal Swedish Academy of Sciences said. "Using these reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells."

Catalysts are molecules that remain stable while enabling or speeding up chemical reactions performed in labs or large industrial reactors. Before the laureates' breakthrough findings at the turn of the millennium, only certain metals and complex enzymes were known to do the trick. The academy said the new generation of small-molecule catalysts were more friendly for the environment and cheaper to produce, and praised the precision of the new tools. Before asymmetric catalysis, man-made catalysed substances would often contain not only the desired molecule but also its unwanted mirror image. The sedative thalidomide, which caused deformities in human embryos around six decades ago, was a

catastrophic example, it said."The fact is, it is estimated that 35 per cent of the world's total GDP in some way involves chemical catalysis," it added.

List, 53, said the academy caught up with him while on vacation in Amsterdam with his wife, who in the past had liked to joke that somebody might be calling him from Sweden. "But today we didn't even make the joke and certainly didn't anticipate this - and then Sweden appears on my phone... it was a very special moment that I will never forget," he said, dialling into the media briefing announcing the winners.

Physics Nobel Rewards Work on Complex Systems, like Climate

5 October, 2021 | by phys.org

Three scientists won the Nobel Prize in physics Tuesday for work that found order in seeming disorder, helping to explain and predict complex forces of nature, including expanding our understanding of climate change

Secretary General of the Royal Swedish Academy of Sciences Goran Hansson, center, flanked at left by member of the Nobel Committee for Physics Thors Hans Hansson, left, and member of the Nobel Committee for Physics John Wettlaufer, right, announces the winners of the 2021 Nobel Prize in Physics at the Royal Swedish Academy of Sciences, in Stockholm, Sweden, Tuesday, Oct. 5, 2021. Credit: Pontus Lundahl/TT via AP

Syukuro Manabe, originally from Japan, and Klaus Hasselmann of Germany were cited for their work in developing forecast models of Earth's climate and "reliably predicting global

warming." The second half of the prize went to Giorgio Parisi of Italy for explaining disorder in physical systems, ranging from those as small as the insides of atoms to the planet-sized. Hasselmann told The Associated Press that he "would rather have no global warming and no Nobel Prize." Manabe said that figuring out the physics behind climate change was "1,000 times" easier than getting the world to do something about it. He said the intricacies of policy and society are far harder to fathom than the complexities of carbon dioxide interacting with the atmosphere, which then changes conditions in the ocean and on the land, which then alters the air again in a constant cycle. He called climate change "a major crisis." The prize comes less than four weeks before the start of high-level climate negotiations in Glasgow, Scotland, where world leaders will be asked to ramp up their commitments to curb global warming.

[Watch video on youtube at https://youtu.be/LJJoPCtgpQI]

The Nobel-winning scientists used their moment in the limelight to urge action. "It's very urgent that we take very strong decisions and move at a very strong pace" in tackling global warming, Parisi said.

He made the appeal even though his share of the prize was for work in a different area of physics. All three scientists work on what are known as "complex systems," of which climate is just one example. But the prize went to two fields of study that are opposite in many ways, though they share the goal of making sense of what seems random and chaotic so that it can be predicted. Parisi's research largely centers around subatomic particles, predicting how they move in seemingly chaotic ways and why, and is somewhat esoteric, while the work by Manabe and Hasselmann is about large-scale global forces that shape our daily lives. The judges said Manabe, 90, and Hasselmann, 89, "laid the foundation of our knowledge of the Earth's climate and how human actions influence it."

Starting in the 1960s, Manabe, now based at Princeton University, created the first climate models that forecast what would happen as carbon dioxide built up in the atmosphere. Scientists for decades had shown that carbon dioxide traps heat, but Manabe's work offered specifics. It allowed scientists to eventually show how climate change will worsen and how fast, depending on how much carbon pollution is spewed. Manabe is such a pioneer that other climate scientists called his 1967 paper with the late Richard Wetherald "the most influential climate paper ever," said NASA chief climate modeler Gavin Schmidt. Manabe's Princeton colleague Tom Delworth called Manabe "the Michael Jordan of climate." Suki set the stage for today's climate science, not just the tool but also how to use

it," said fellow Princeton climate scientist Gabriel Vecchi. "I can't count the times that I thought I came up with something new, and it's in one of his papers." Manabe's models from 50 years ago "accurately predicted the warming that actually occurred in the following decades," said climate scientist Zeke Hausfather of the Breakthrough Institute. Manabe's work serves "as a warning to us all that we should take their projections of a much warmer future if we keep emitting carbon dioxide quite seriously." "I never imagined that this thing I would begin to study has such a huge consequence," Manabe said at a Princeton news conference. "I was doing it just because of my curiosity." About a decade after Manabe's initial work, Hasselmann, of the Max Planck Institute for Meteorology in Hamburg, Germany, helped explain why climate models can be reliable despite the seemingly chaotic nature of the weather. He also developed ways to look for specific signs of human influence on the climate. Meanwhile, Parisi, of Sapienza University of Rome, "built a deep physical and mathematical model" that made it possible to understand complex systems in fields as different as mathematics, biology, neuroscience and machine learning. His work originally focused on so-called spin glass, a type of metal alloy whose behavior long baffled scientists.

Parisi, 73, discovered hidden patterns that explained the way it acted, creating theories that could be applied to other fields of research, too All three physicists used complex mathematics to explain and predict what seemed like chaotic forces of nature. That is known as modeling. "Physics-based climate models made it possible to predict the amount and pace of global warming, including some of the consequences like rising seas, increased extreme rainfall events and stronger hurricanes, decades before they could be observed," said German climate scientist and modeler Stefan Rahmstorf. He called Hasselmann and Manabe pioneers in this field. When climate scientists with the United Nations' Intergovernmental Panel on Climate Change and former U.S. Vice President Al Gore won the 2007 Nobel Peace Prize, some who deny global warming dismissed it as a political move. Perhaps anticipating controversy, members of the Swedish Academy of Sciences, which awards the Nobel, emphasized that Tuesday's was a science prize. "What we are saying is that the modeling of climate is solidly based on physical theory and well-known physics," Swedish physicist Thors Hans Hansson said at the announcement. For a scientist who trades in predictions, Hasselmann said the prize caught him off guard. "I was quite surprised when they called," he said. "I mean, this is something I did many years ago." But Parisi said: "I knew there was a non-negligible possibility" of winning.

Climate researcher Klaus Hasselmann stands on the balcony of his apartment in Hamburg, Germany, Tuesday, Oct.5, 2021. Credit: Georg Wendt/dp

The award comes with a gold medal and 10 million Swedish kronor (over $1.14 million). The money comes from a bequest left by the prize's creator, Swedish inventor Alfred Nobel, who died in 1895. On Monday, the Nobel in medicine was awarded to Americans David Julius and Ardem Patapoutian for their discoveries into how the human body perceives temperature and touch. Over the coming days prizes will be awarded in the fields of chemistry, literature, peace and economics.

****

Shanti Swarup Bhatnagar Prize for science and technology 2021,

Source : https://currentaffairs.adda247.com/2021-shanti-swarup-bhatnagar-winners-announced/

About the Shanti Swarup Bhatnagar Prize: The Prize is bestowed on a person who, in the opinion of CSIR, has made conspicuously important and outstanding contributions to human knowledge and progress fundamental and applied, in the particular field of endeavour, which is his/her specialization.

Shanti Swarup Bhatnagar Prize for science and technology 2021, were announced during the 80th foundation day of the Council for Scientific and Industrial Research (CSIR). Every year, CSIR presents this award to scientists below 45 years of age for their contributions in biology, chemistry, mathematics, physics, medicine, engineering and earth, atmosphere, ocean and planetary sciences. The award comprises a cash prize of Rs 5 lakh. During the ceremony, vice president M Venkaiah Naidu advised CSIR to reinvent itself and turn futuristic while pursuing the science of the highest order.

Here is the list of 11 scientists awardees:

Biological Sciences category:

Dr Amit Singh, department of microbiology and cell biology,

Indian Institute of Science, Bengaluru.

Dr Arun Kumar Shukla, department of biological sciences and bioengineering,

Indian Institute of Technology Kanpur.

Chemical sciences category:

Two researchers from the Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, Dr Kanishka Biswas from the International Centre of Materials

Science and Dr T Govindaraju, from the Bio-organic Chemistry Laboratory, announced as recipients.

Earth, Atmosphere, Ocean and Planetary Sciences category:

Dr Binoy Kumar Saikia from Coal and Energy Research Group,
CSIR North East Institute of Science and Technology, Jorhat, was named recipient.

Engineering sciences category:

Dr Debdeep Mukhopadhyay, Department of Computer Science and Engineering, Indian Institute of Technology Kharagpur, received the award under the engineering sciences category.

Mathematical sciences category:

Dr Anish Ghosh, school of mathematics,
Tata Institute of Fundamental Research, Mumbai.
Dr Saket Saurabh, The Institute of Mathematical Sciences, Chennai,
were announced winners.

Medical sciences:

Dr Jeemon Panniyammakal, Achutha Menon Centre for Health Science Studies, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram.
Dr Rohit Srivastava, department of biosciences and bioengineering,
Indian Institute of Technology Bombay.

Physical sciences:

Dr Kanak Saha, from Pune's Inter-University Centre for Astronomy and Astrophysics, received the award for physical sciences.

MATERIALS FOR ANALYTICAL SEPARATION
A webinar

June 10, 2021 at 7.00 pm

Conducted by

ISAS, Tamil Nadu Chapter in collaboration with the Department of Analytical Chemistry, University of Madras.

Speaker

Dr. Jayshree Ramkumar

Scientific Officer

Analytical Chemistry Division,

Bhabha Atomic Research Centre, Mumbai

Dr. Jayshree Ramkumar joined BARC through the 1 year orientation program (37th Batch of Training School) after the completion of MSc from University of Madras, Chennai. Subsequently she joined the Analytical Chemistry Division in 1994. Since then, she is involved in the development of new separation procedures for toxic species using a wide range of materials from bulk matrices to nanomaterials. She has also developed analytical sensors / methodologies for determination of metal ions like Uranium, Lead and cobalt in aqueous solutions. Her PhD was on the work on ion exchange and related studies using Nafion membrane. She was awarded the MANA Research Fellowship to carry out postdoctoral research at National Institute of Materials Science (NIMS), Ibaraki, Japan in 2009. She is Associate Professor of HBNI, Mumbai. She has more than 65 publications and three book chapters to her credit. She has given talks in various International and national conferences and also served as chairpersons in different conferences.

Analytical chemistry has always been carried out from ancient times for the identification and isolation of different species and it can be qualitative or quantitative in nature. The various concepts of analytical chemistry, including its definition and interpretation is important [1]. Separation is an integral part of Analytical chemistry. Separation is controlled by the property of the solute. The difference in physical properties of the solute is exploited in techniques like distillation, centrifugation, which are less selective. Hence the difference in chemical property of the species is taken advantage of in

more selective techniques, like precipitation, solvent extraction, ion exchange, membrane separation etc.

The basic concepts of separation using membranes and sorbents were discussed in the talk. Membranes can be broadly classified into solid an liquid membranes. Ion exchange membranes [2] especially ionomers could be used for separation of metal ions [3]. Fig 1 gives the chemical formula of Nafion ionomer. Nafion is a brand name for a sulfonated tetrafluoroethylene based fluoropolymer-copolymer discovered in the late 1960s by Walther Grot of DuPont. Nafion is a brand of the Chemours company. It is the first of a class of synthetic polymers with ionic properties that are called ionomers. Nafion's unique ionic properties are a result of incorporating perfluorovinyl ether groups terminated with sulfonate groups onto a tetrafluoroethylene (PTFE) backbone. Nafion has received a considerable amount of attention as a proton conductor for proton exchange membrane (PEM) fuel cells because of its excellent thermal and mechanical stability.

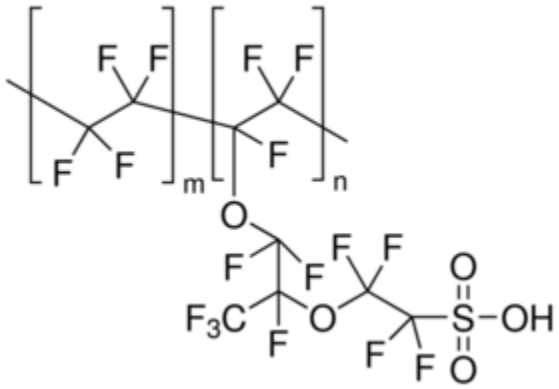


Fig.1: Chemical formula of Nafion ionomer membrane

Though solid membranes are stable, the low selectivity makes it crucial to look for alternatives and liquid membranes seem to be an attractive option. Liquid membrane can be considered to be a combination of both solvent extraction and stripping processes [4]. Liquid membranes can be used in bulk, supported and emulsion type configurations. Fig 2 gives the schematic representation of different liquid membrane systems.

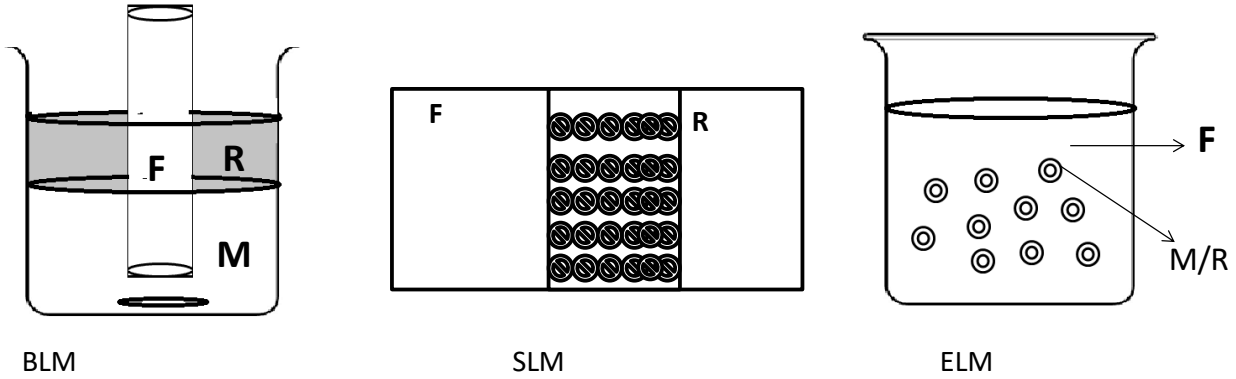


Fig 2: *Schematic representation of different liquid membranes configurations*

Sorption is a separation process which is affected by different parameters like pH, temperature, nature of sorbent etc [5]. It can occur via different mechanisms like ion exchange complexation or physical interactions. During sorption, an equilibrium is established between the amount of sorbate sorbed and that left behind in solution and this is described by various isotherms. The most commonly used isotherms are the Langmuir and Freundlich models which indicate whether sorption is mono or multi-layer and also evaluate the efficacy of different sorbents. The sorption studies carried out in batch mode is represented in Fig.3

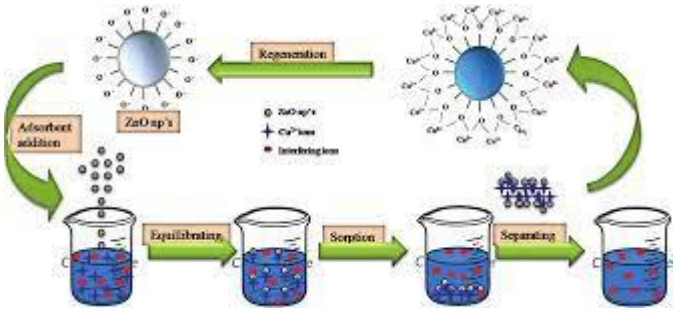


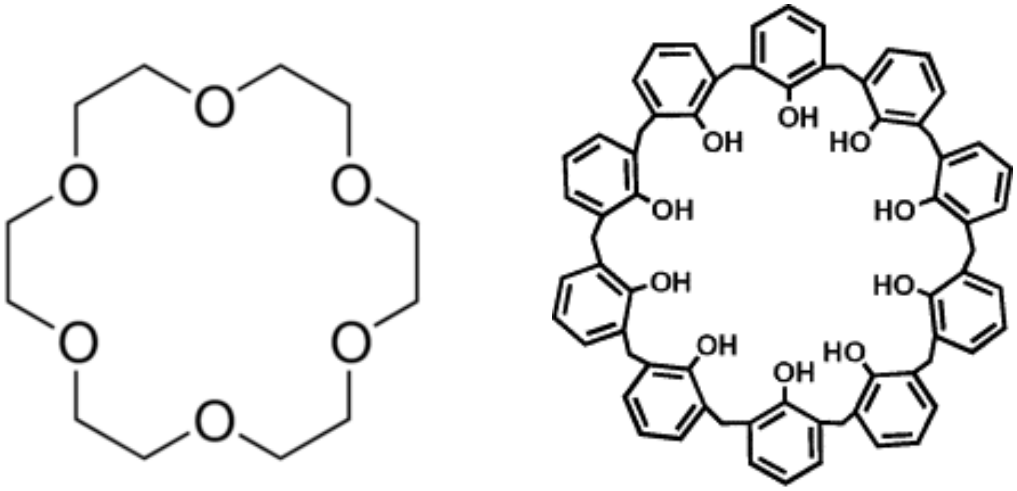
Fig.3: Schematic representation of the sorption desorption process

In order to carry out these studies, various kinds of materials need to be used. Materials have been important to mankind from early ages that the different periods of civilization have been named after the materials used. Nanomaterials were found in use from ancient times and showed unique properties. Different materials can be used as sorbents or membranes to achieve separation of species of interest.

The need for separation is very important with respect to environmental remediation. Due to continuous technological development, environment is not static and pollution results. The removal of toxic species present in environment is known as environmental remediation [6].

The separation of different species was carried out using membranes and sorbents. The selective permeation of cations through cation exchange membranes was achieved using suitable masking agents [7]. The permeation of organic molecules could be achieved using metal ion incorporated Nafion membranes [8]. These cations form a complex with the organic molecules and leads to selective permeation. It was seen that stronger the metal complex, faster is the permeation rate of the particular organic molecule.

Bulk liquid membranes were used for separation of different species using complexing ligands as carriers. The selective transport of copper could be achieved using a mixture of oxine and aminopyridine as carriers and was applied to its recovery from electroplating waste water samples [9]. The use of n-benzoyl-n phenylhydroxylamine as a carrier for selective separation of thorium from its mixture containing different ions including uranium could be accomplished [10]. The separation of uranyl ion from its mixture using potassium selective crown ethers [11] amd caliixarenes [12] as carriers in the liquid membrane phase. The structure of crown ether and calix[6]arene are given in Fig 4.It was seen that the use of calixarene enhanced the transport selectivity and could be used for the recovery of uranyl ion from seawater samples [12].



18C6 **Calix[6]arene**

Fig.4: Structural formulae of the carriers used for uranyl ion transport

Sorption studies in batch mode were used for the removal of metal ions and cationic dyes using bulk and nano materials as sorbents. Boroaluminosilicate glass was evaluated for its sorption efficiency with respect to thorium and it was seen that selectivity was achieved by changing the composition of glass and pH of sample solution [13]. The use of glass for uptake of cationic dyes showed that the sorption did not lead to changes in the structure of the glass or the species taken up [14]. Impregnation and surface

functionalization were found to enhance the selectivity of sorption. Impregnation of organic ligands within bulk supports were used for the removal of thorium [15] and uranium [16] from their mixture containing different transition metal ions. Nanomaterials were also used for their sorption efficiency. It was seen that synthesis protocol had a great role in deciding the surface properties of nano zinc oxide and its sorption property was greatly varying [17-19]. Fig.5 gives a schematic representation of the surface charge dependence on the protocol of synthesis of zinc oxide nanoparticles. It was seen that the nanooxide obtained by all the three methods had the same crystalline structure but the surface charge was different. The use of pyrolysis and gel combustion methods rendered a positive surface charge making them suitable for removal of toxic anions like chromate. But the zinc oxide nanostructures synthesized using co-precipitation method had a negative surface charge making it suitable for separation of cations.

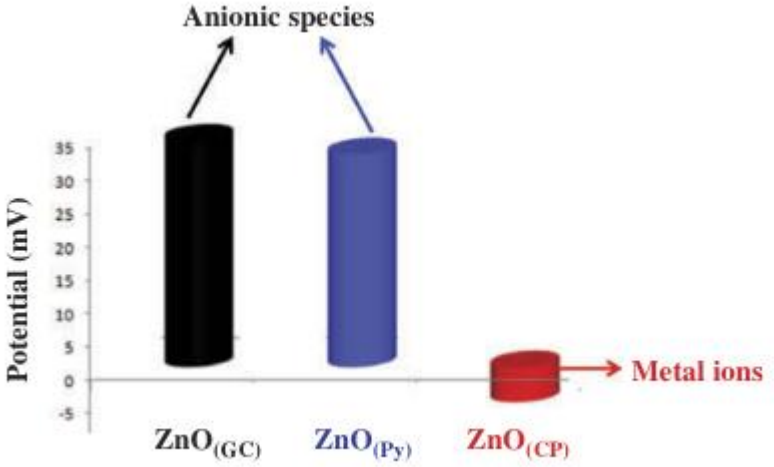


Fig.5: Value of zeta potential of the different ZnO Nps at pH ~ 6 (and the application)

Further surface functionalization was carried out to render great selectivity to heavy toxic metal ions like lead and mercury [20]. The structures of the functionalized NPs is given in Fig 6.

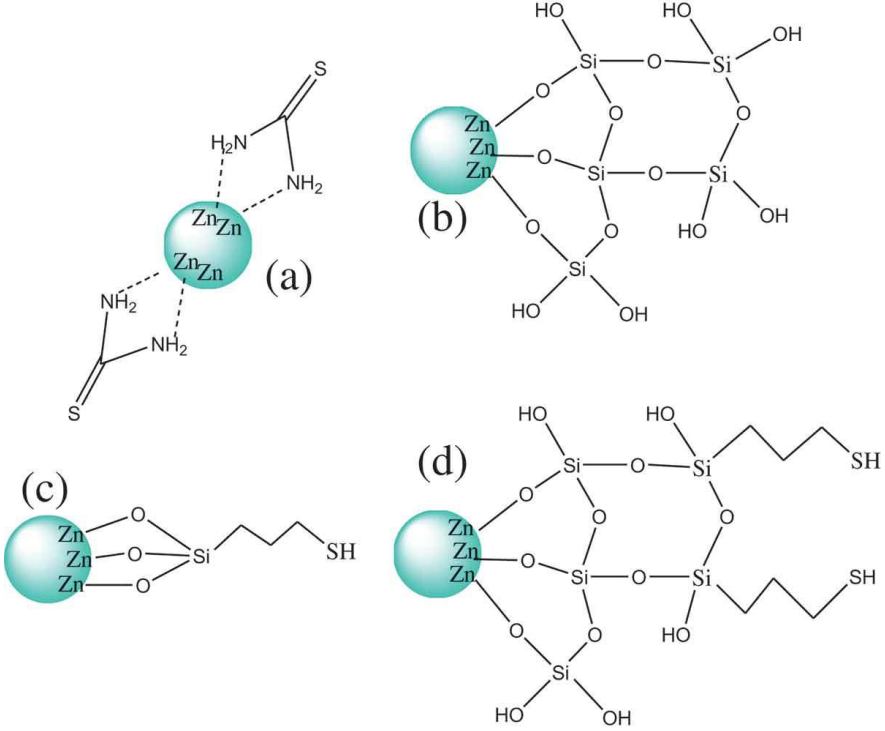


Fig.6: Structural models of (a)TU-ZNP, (b)S-ZNP and (c&d) TFS-ZNP.

The presence of the functional groups made the nanosorbent selective as can be seen from the experimental results shown in Fig 7.

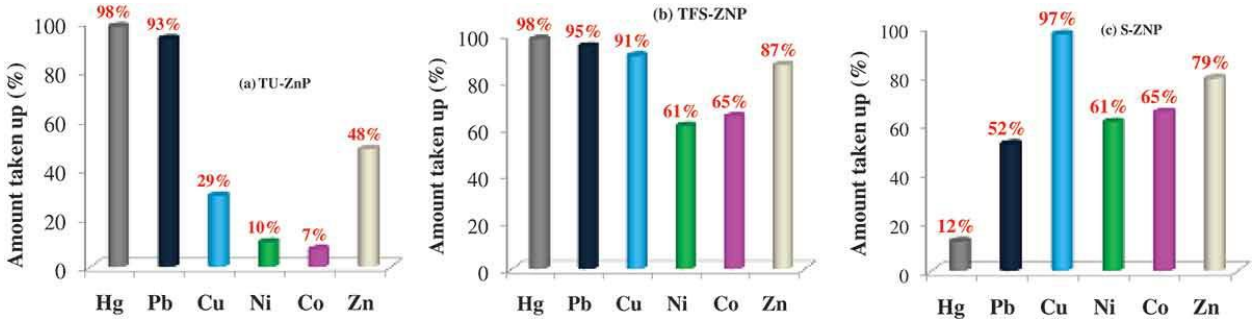


Fig.7: Sorption of different toxic metal ions by (a)TU-ZnNP, (b) TFS-ZNP and (c) S-ZNP.

The sorption of different cationic species on iron oxide @ silica magnetic composite was investigated in detail to understand the reason for the observed selectivity in sorption [21]. The schematic representation given in Fig 8 gives an idea of the sorption process studied.

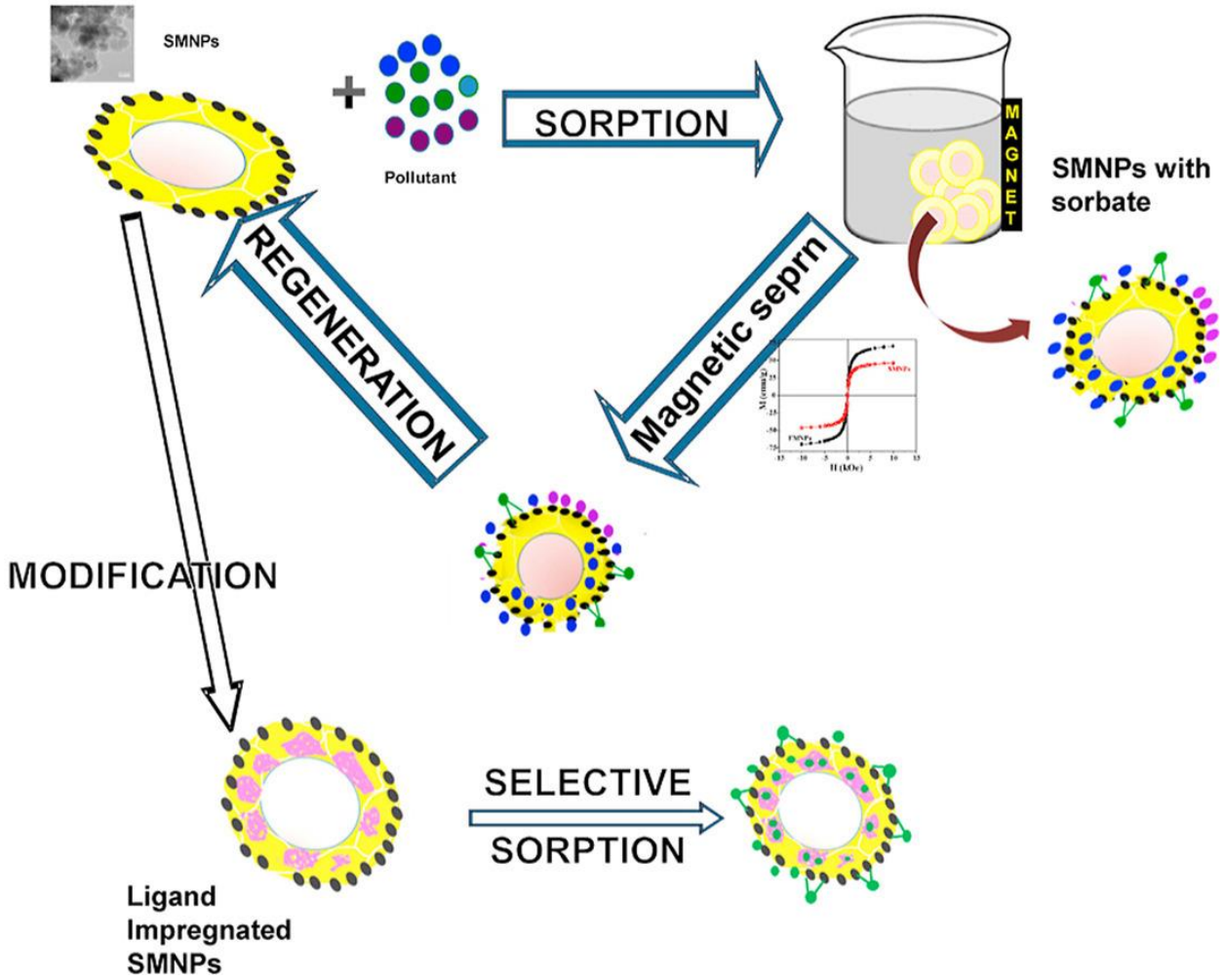


Fig8: Schematic representation of the sorption and selectivity enhancement of Iron oxide@ silica nanocomposites

It was seen that nanocomposite with crystalline iron oxide and amorphous mesoporous silica shell behave as sorbents. The mechanism of sorption was evaluated in detail. The removal of nanocomposite from solution after equilibration could be achieved with the aid of a external magnet. The selectivity of SMNPs with respect to uranyl ions is enhanced by ligand impregnation.

References

1. K. Cammann, K. Analytical Chemistry — today's definition and interpretation. Fresenius J Anal Chem 343 (1993) 812–813

2. Jayshree Ramkumar, Tulsi Mukherjee Principles of Ion Exchange Equilibria, in Eds , Inamuddin & Luqman, Mohammad. Ion Exchange Technology I (2012) 41-49

3. Jayshree Ramkumar Book chapter, Nafion Perfluorosulphonate Membrane: Unique Properties and Various Applications, Functional Materials, 2012, Pages 549-577

4. Jayshree Ramkumar, S. Chandramouleeswaran , Ind. J. Adv. Chem. Sci 3 (2015) 293-298

5. P.S., Syed. (2014). Some basic concepts on Adsorption techniques are discussed. 10.13140/2.1.3032.8966.

6. Jayshree Ramkumar Chapter 9 - Cost Effective Sorbents for Environmental Remediation in Advanced Functional Polymers and Composites: Materials, Devices and Allied Applications. Volume 2 pp. 277-312

7. Jayshree Ramkumar, K.S. Shrimal, B. Maiti, T.S. Krishnamoorthy, J.Memb. Sci 116, (1996), 31-37

8. Jayshree Ramkumar, B. Maiti, T.S. Krishnamoorthy, J.Memb. Sci 125 (1997) 269-274

9. T. R.Reddy, Jayshree Ramkumar, S. Chandramouleeswaran, A.V.R. Reddy, J.Memb. Sci 351, (2010) 11-15

10. S. Chandramouleeswaran, Jayshree Ramkumar, Open J. Chem. Eng. Sciences 1 (2014) 67-77

11. Jayshree Ramkumar, B. Maiti, P.K. Mathur, Kajal Dhole. Sep.Sci.Technol.35 (2000) 2535-2541

12. Jayshree Ramkumar, S.K Nayak, B Maiti, J.Memb. Sci 196 (2002) 203-210

13. S. Chandramouleeswaran, Jayshree Ramkumar, V. Sudarsan, A.V.R. Reddy, J. Haz. Mat. 198 (2011) 159-164

14. Jayshree Ramkumar, S. Chandramouleeswaran, V. Sudarsan, R.K. Vatsa, S. Shobha, V.K. Shrikhande, G.P. Kothiyal, T. Mukherjee, J. Non-Cryst. Sol 356 (2010) 2813-2819

15. S.Chandramouleeswaran, Jayshree Ramkumar, J. Haz. Mat. 280 (2014) 514-523

16. Jayshree Ramkumar, S. Chandramouleeswaran, V. Sudarsan, R.K. Mishra, ... A.K. Tyagi, J. Haz. Mat. 154 (2008) 513-518

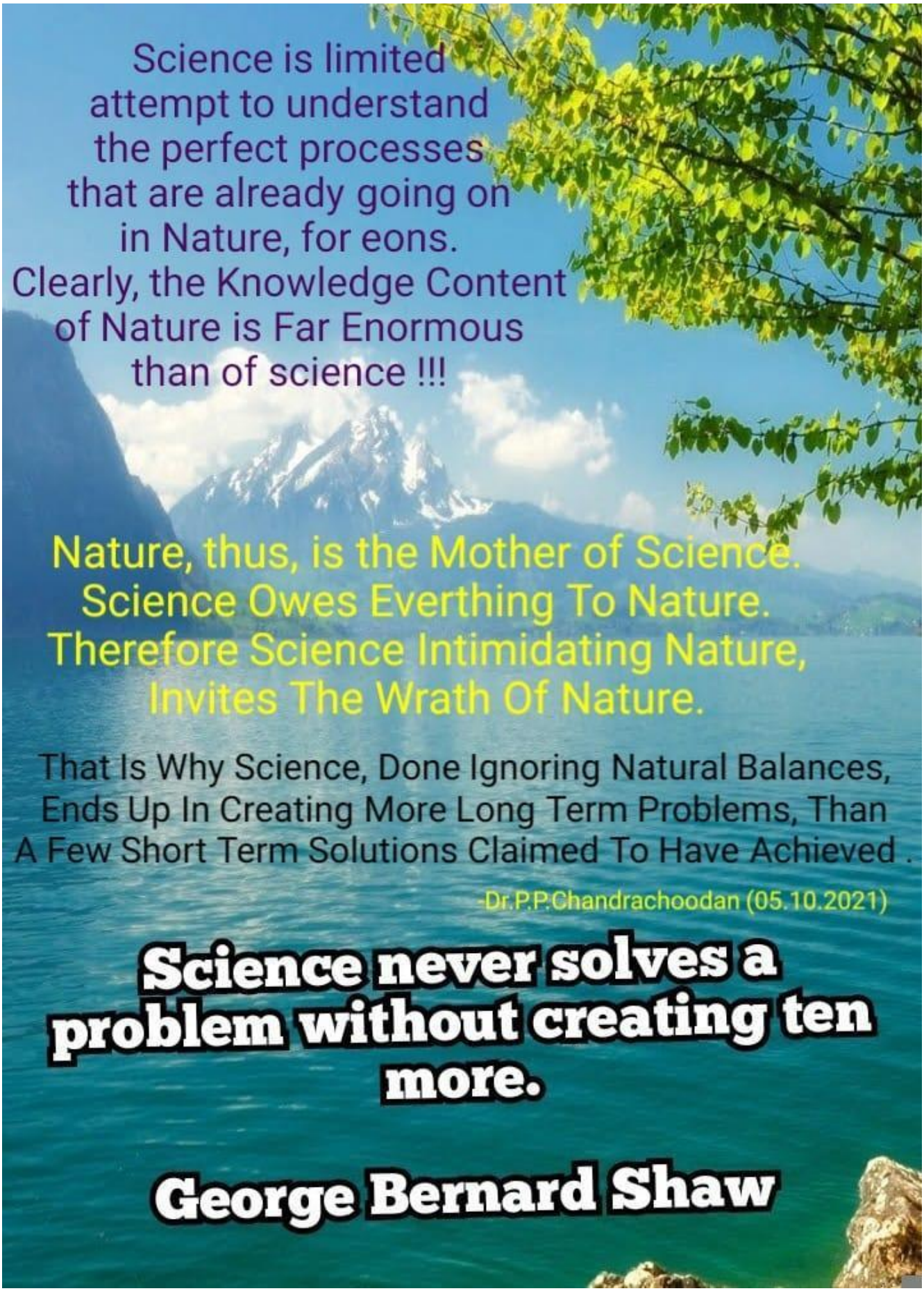
17. Jerina Majeed, Jayshree Ramkumar, S. Chandramouleeswaran and A. K. Tyagi, Sep. Sci. Technol 50 {2015} 404–410,

18. Jerina Majeed, Jayshree Ramkumar, S. Chandramouleeswaran, and A.K.Tyagi, Adv. Por. Mat. 2 (2014) 1–10

19. Jerina Majeed, Jayshree Ramkumar, S. Chandramouleeswaran, O. D. Jayakumar and A. K. Tyagi, RSC Adv., 3 (2013) 3365-3373

20. Jerina Majeed, Jayshree Ramkumar, S. Chandramouleeswaran and A. K. Tyagi, Sep. Sci. Technol. 55 (2020) 1922-1931

21. Jayshree Ramkumar, Jerina Majeed and S.Chandramouleeswaran, Micropor. Mesopor. Mater. 314 (2021) 110858


Science is limited
attempt to understand
the perfect processes
that are already going on
in Nature, for eons.
Clearly, the Knowledge Content
of Nature is Far Enormous
than of science !!!
Nature, thus, is the Mother of Science.
Science Owes Everthing To Nature.
Therefore Science Intimidating Nature,
Invites The Wrath Of Nature.
That Is Why Science, Done Ignoring Natural Balances,
Ends Up In Creating More Long Term Problems, Than
A Few Short Term Solutions Claimed To Have Achieved .
-Dr.P.P.Chandrachoodan (05.10.2021)
Science never solves a
problem without creating ten
more.
George Bernard Shaw

125th Year of the Discovery of X-rays

featuRe ARticle

125th Year of the Discovery of X-rays

Nand Lal Mishra

A photograph of WC Roentgen

X-RAYS not only aid in medical diagnosis, they also provide useful information in several other areas. X-rays were invented 125 years ago on 8 November 1895 by Wilhelm Conrad Röntgen for which he was awarded the first Nobel Prize in Physics in the year 1901. Later, several Nobel prizes were awarded for outstanding research in scientific areas related to X-rays.

The discovery of X-rays came about as an accident. Roentgen was studying the passage of electricity through a partially evacuated glass cathode tube covered with cardboard in a dark room. On that Friday (8 November 1895), when all the assistants in his lab left for home leaving Roentgen alone, he applied a few thousand volt potential difference between the cathode and anode separated by a few centimetres in the partially evacuated tube and expected lot of charged particles (electrons or cathode rays) to be produced and attracted towards the anode in the form of cathode rays. However, he saw that a flickering glow of light was coming from a nearby paper screen covered with Barium platinocyanide kept on a nearby bench even when the room was dark and the cathode tube was covered with cardboard. Barium platinocyanide is a fluorescent material and glows when light falls on it.

Roentgen was surprised to see this phenomenon. He repeated the experiment several times with the same result. He concluded that some new kind of invisible rays were coming from inside the cathode tube. He concluded that he was probably dealing with some new unknown phenomenon involving a particular type of rays which can pass through the cardboard. He put his hand several times in between the cathode ray tube and the fluorescent screen and could see the shadow of bones of his own hand.

To document these observations he used a photographic plate to get an image of the bones after developing the film. He was sure he had discovered a new kind of ray. He kept his discovery a secret for the next seven days, virtually locking himself inside his laboratory and repeating his experiments to validate his observations. Once he was sure, one evening he called his wife to the laboratory and asked her to put her hand on a cassette of the X-ray film placed in between the vacuum tube and film. After a short exposure he developed the film and could see the photograph of the bones and their wedding ring on the finger of his wife. This photograph is believed to be first ever radiograph of the world.

Roentgen was now anxious to publish his discovery in a journal fast. He submitted the paper "On a New Kind of Rays" to a German magazine of the Annals of the Würzburg Physical Medical Society "*Sitzungs berichte der Physikalisch –Medizinischen Gesellschaft zu Würzburg"* in the form of a short manuscript. It was published in the 1895 volume of the Journal. However, Roentgen distributed the prints of this article even before it was published to several renowned scientists. The news of the new kind of rays spread in the scientific community like wildfire.

To differentiate the new rays from other rays, Roentgen named these rays X-rays. He said that the X-rays travelled in straight lines, were not reflected or refracted, and that the intensity of X-rays varied inversely with the distance from their source. Later, the Vienna newspaper *Die Presse* published the discovery as a news item on its first page – this was the first public announcement of the discovery of X-rays.

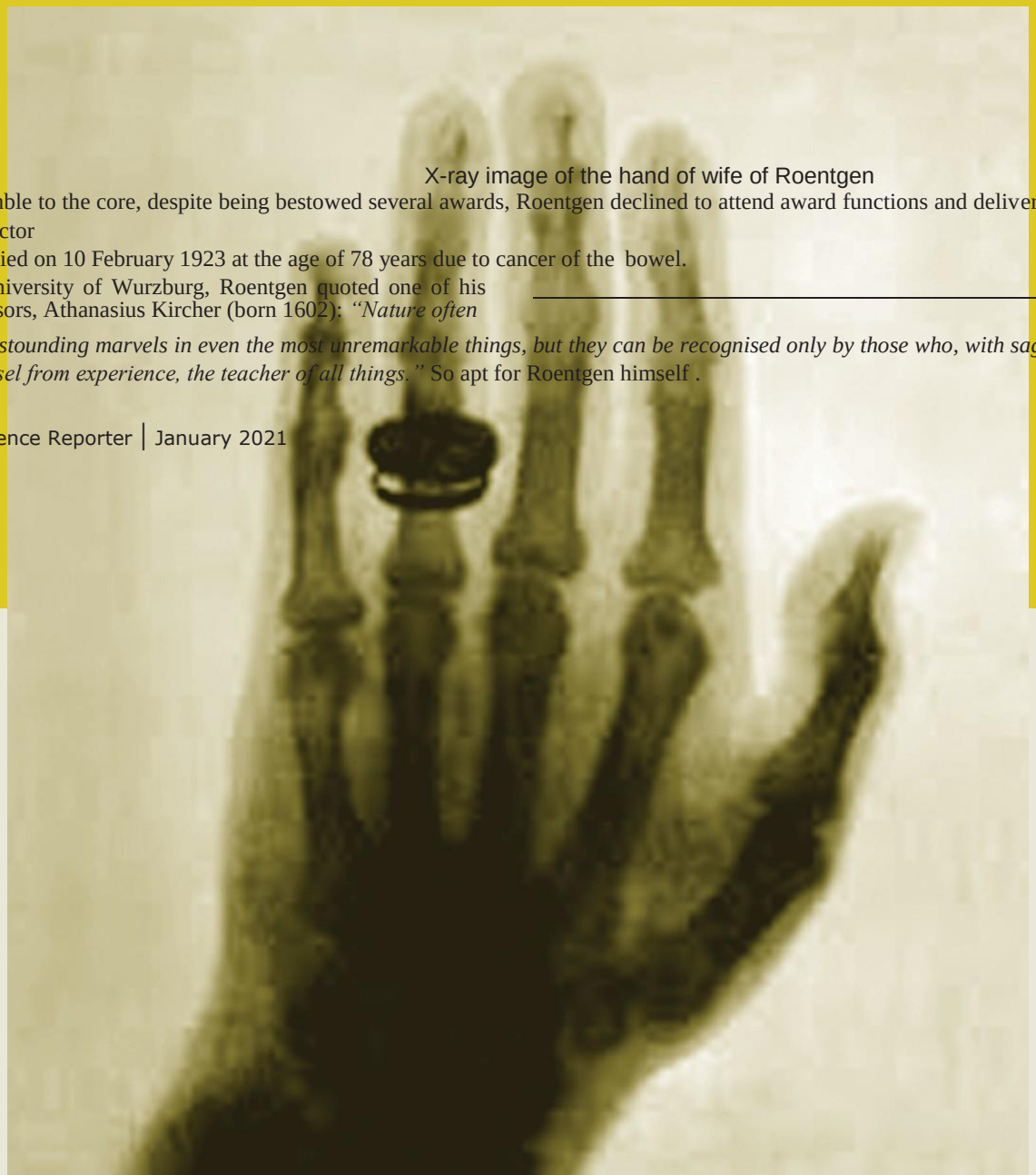
On 7 January 1896, the *Frankfurt Zeitung* and the London morning newspaper *The Standard* published about the possible applications of X-rays (both medical and non-medical) – diagnosis of diseases, fractures in bones, detection of bullets inside the body, etc. The experiments of Roentgen about the discovery and properties of X-rays were repeated by several scientists and were found to be correct.

After these publications, Roentgen was invited by the Würzburg Physical Medical Society to deliver a talk on the "Discovery of X-rays" in front of a small group of scientists. He demonstrated the production and application of the X-rays and recorded a radiograph of the hand of the famous anatomist, Professor Albert von Kölliker, who was present in the meeting. Von Kölliker was very much impressed and proposed Roentgen Rays as the new name of the X-rays. Although this was accepted by all in the meeting, Roentgen humbly declined.

Awards and recognitions followed. The University of Wurzburg which did not give him the position of a lecturer to Roentgen about 18 years back now invited him for the post of Professor of Physics and Director of the new Physical Institute of the University of Würzburg.

Roentgen was awarded the first Nobel Prize in Physics in the year 1901. He donated the prize money to the University of Wurzburg for further support to scientific research. He was also offered the Royal Order of Merit of the Bavarian Crown carrying the status of nobility. However, Roentgen refused it as he believed that scientific discoveries are for the cause of humanity and one should not exploit them for personal gains.

The discovery of X-rays proved a boon for humanity. Today, it is being used in several areas of medical science (e.g. for imaging broken/fractured bones, for finding out the presence infectious diseases and tumours), in environmental science (e.g. finding out the elemental concentration of different pollutants in water, air and soil using different modes of X-ray Fluorescence), in agriculture (e.g. chemical composition of fertilizers, trace elements in agricultural products, variation in elemental concentration of essential elements in fruit and fruit products, etc). Total Reflection X-ray fluorescence finds application in forensic science e.g. analysis of gunshots. X-ray diffraction has proved very useful in protein crystallography to find out the structure of proteins, for developments and quality control of industrial materials and to study the formation of different compounds and development of new materials.



X-ray image of the hand of wife of Roentgen

Humble to the core, despite being bestowed several awards, Roentgen declined to attend award functions and deliver talks. While delivering his first speech as the Rector at the University of Wurzburg, Roentgen quoted one of his predecessors, Athanasius Kircher (born 1602): *"Nature often reveals astounding marvels in even the most unremarkable things, but they can be recognised only by those who, with sagacity and a mind created for research, ask counsel from experience, the teacher of all things."* So apt for Roentgen himself .

He died on 10 February 1923 at the age of 78 years due to cancer of the bowel.

Dr Nand Lal Mishra is Former Head, X-ray Spectroscopy Section, Fuel Chemistry Division, Bhabha Atomic Research Centre and Former Professor, Chemical Sciences, Homi Bhabha National Institute. Address: 402-Krishna Residency, Plot 13 Sector 20, Kharghar, Navi Mumbai, Raigad, Maharashtra-402210; Email: nlmisra@yahoo.com

Climate Change and Global Warming: What lies Ahead?

Dr. V. Balaram

Former Emeritus Scientist, Chief Scientist & Head, Geochemistry Division

CSIR - National Geophysical Research Institute (NGRI), Hyderabad- 500 007, India

At present - Project Consulting Scientist,

Inter-University Accelerator Centre (IUAC), New Delhi

History of Earth's Climate

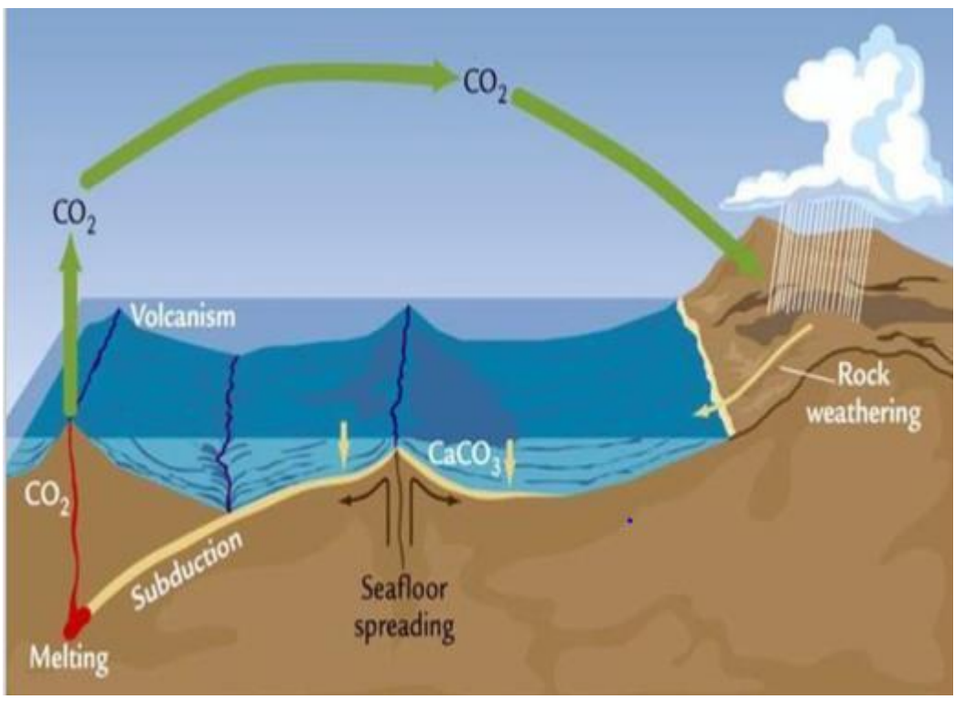
- Earth formed ~4.6 by ago
- Originally very hot
- Liquid water present ~4.3 billion years back
- Microbial life appeared ~4.1 by ago
- Humans ~ 2 my
- Photosynthesis began 3.5-2.5 by ago

- Produced oxygen and removed CO2and CH4 (greenhouse gases)

- Earth went through periods of cooling ("Snowball Earth") and warming
- Earth began cycles of glacial and interglacial periods ~3 my ago
- If it were not for the natural greenhouse gas effect of our atmosphere, our planet would plunge to a chilly 00C

- The average surface temperature (~15°C).
- The hottest temperature ever recorded : 70.7°C (159.3 °F) in the LutDesert of Iran in 2005.
- The coldest temperature recorded on Earth was in Vostok, Antarctica: -89.20C.

CO_2 CYCLE



"Earth knows how to store carbon naturally and does this over geologic time. But we're emitting so much CO2now that Earth can't keep up."

Weathering removes CO_2 from the atmosphere and delivers it to the ocean, where it combines with calcium to form limestone. Limestone is drawn under the Earth's crust by the moment of tectonic plates -a process known as subduction. Heat separates CO2from limestone . CO2 is ejected in to the atmosphere through volcanic eruptions.

What Changes Climate ?

- Changes in:
  - Sun's output
  - Earth's orbit
  - Drifting continents
  - Volcanic eruptions
  - Greenhouse gases

Key Indicators:

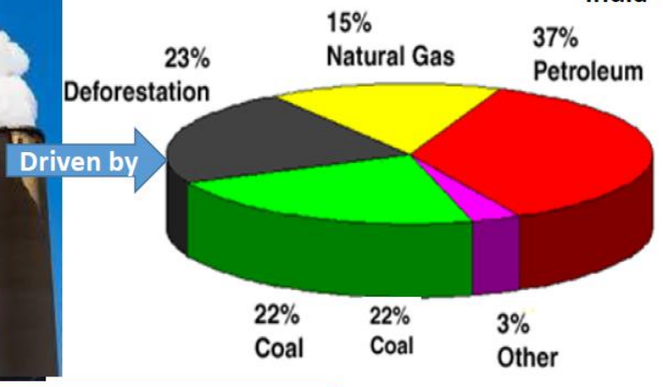
- CO_2 Concentration
- Global Surface Temperatures
- Arctic Ice
- Land Ice
- Sea Level
- Increasing Frequency of Extreme Events
- Sea Surface Temperatures
- Humidity
- Air Temperature Near Surface (Troposphere)
- Glaciers
- Ocean Heat Content

By 2020 temperatures were already 1.2 °C above the historical level.

There will be 3 °C increase by 2050

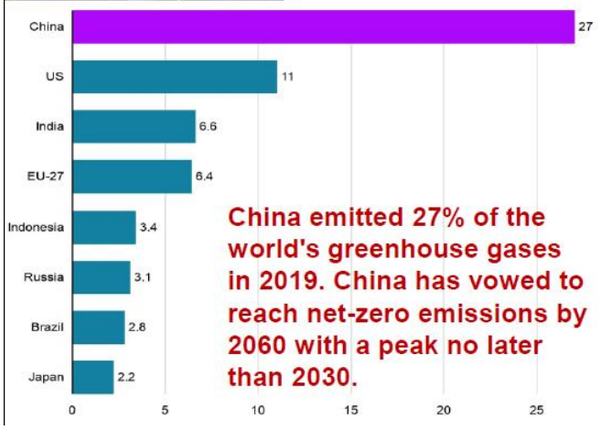
Global GHG Emissions

India - third largest emitter



Cement is the source of ~ 8% of the world's CO_2 emissions

- CH_4 comes from human activities like cattle farming, rice cultivation and fossil fuel extraction.
- N_2O comes from natural and human sources including fertilizer use and industry.



China emitted 27% of the world's greenhouse gases in 2019. China has vowed to reach net-zero emissions by 2060 with a peak no later than 2030.

GHG	Pre-Industrial	May, 2020
CO_2 (ppm)	280 ppm	419.13 ppm
CH_4 (ppb)	0.8 ppm	1.866 ppm
N_2O (ppb)	0.262 ppm	0.331 ppm

Deforestation all over World

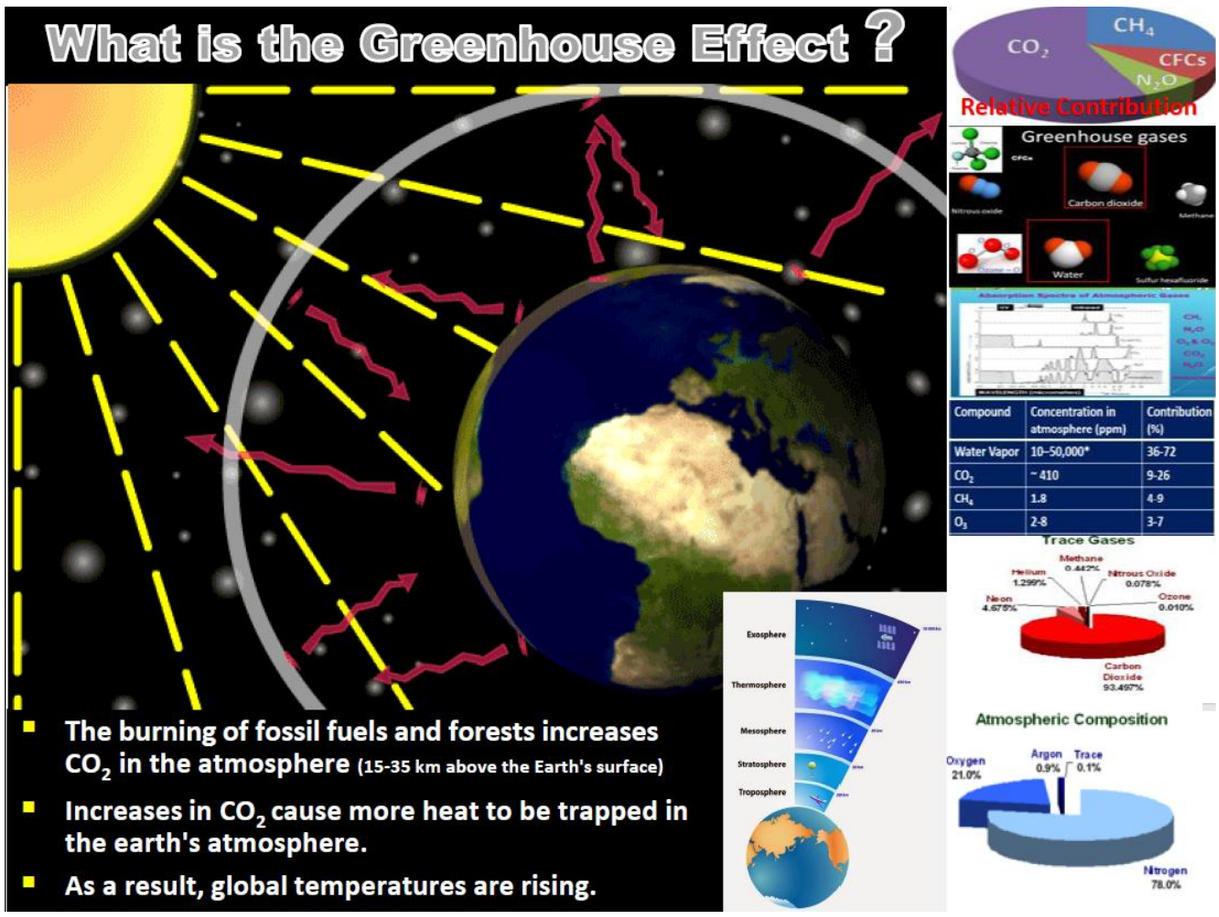
- Only ~ 22% of the earth's original forest coverage remains.
- Western Europe lost 98%
  Asia 94%;
  Africa 92%;
  Oceania 78%;
  N. America 66%,
  & S. America 54%.
- ~ 45% of the world's tropical forests, originally covering 1.4 billion hectares, have disappeared in the last few decades.
- Number of trees halved to 3 trillion in the world

Methane Leak In to Environment

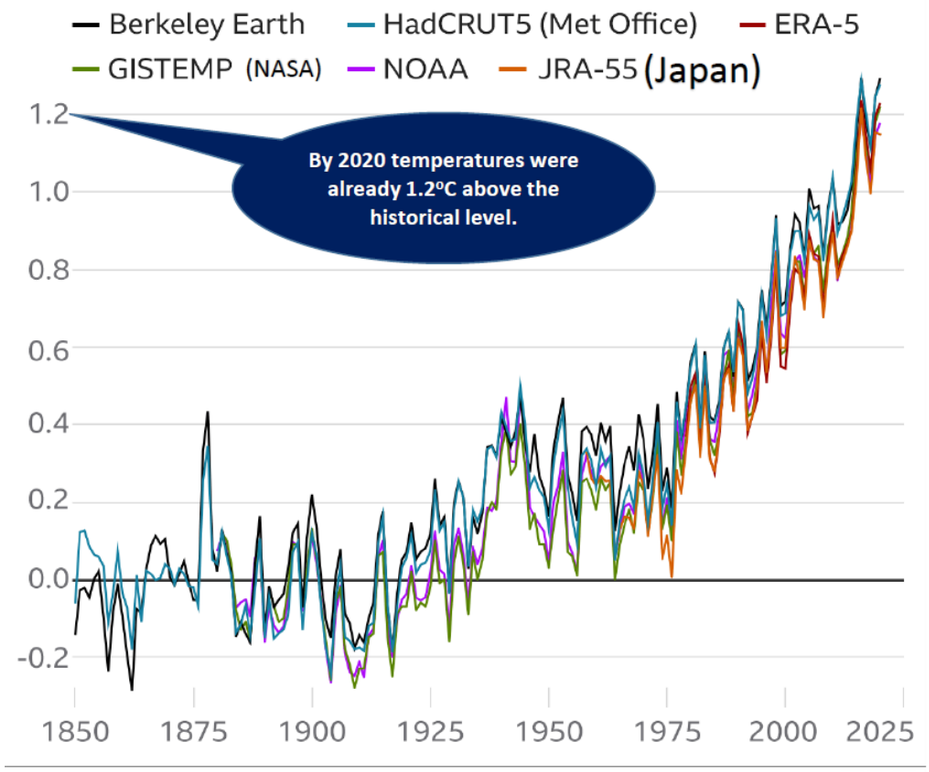
- Scientists have discovered the first active seepage of methane into the atmosphere from the ocean floor and it is a matter of grave concern.
- Methane can leak into the atmosphere from various natural and man-made sources like fossil fuels, wetlands, gas hydrates under the sea bed and rice paddy fields.
- A large amount of the gas remains stored under the oceans and Antarctica which is estimated to contain nearly a quarter of the total marine methane.
- The seepage of the methane was first discovered in 2011 by a team of divers but studies on the site began only in 2016. The seepage of the methane, as well as the cause of it, is a mystery.

Methane gas production is continuing to rise

'*Proceedings of the Royal Society* ,2020.



Temperature Rise Since 1850



Source: Met Office

BBC

- A landmark report by the UN climate panel in 2018 highlighted how the impacts of climate change are far more severe when the increase is greater than 1.5°C.
- At the moment, projections suggest that even with recent pledges to cut emissions of greenhouse gases, the world is on course to heat up by up to 3°C.

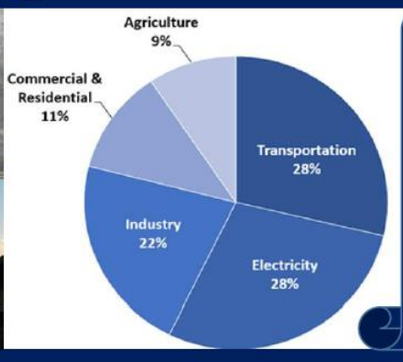
Consequences of Global Warming

Melting of the polar ice caps

- Greater variation in the fluctuation of temperature
- Rising sea levels
- An increase in extreme weather occurrences (heat waves, hurricanes, tornadoes, flash floods, tsunamis, etc.)
- An increase in the occurrence of fires
- An increase in droughts
- The list goes on and on ....

History of Climate Science

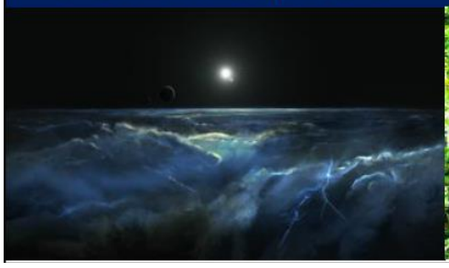
Where CO_2 Comes From?



"Earth knows how to store carbon naturally and does this over geologic time. But we're emitting so much CO_2 now that Earth can't keep up."

Where CO_2 Goes?

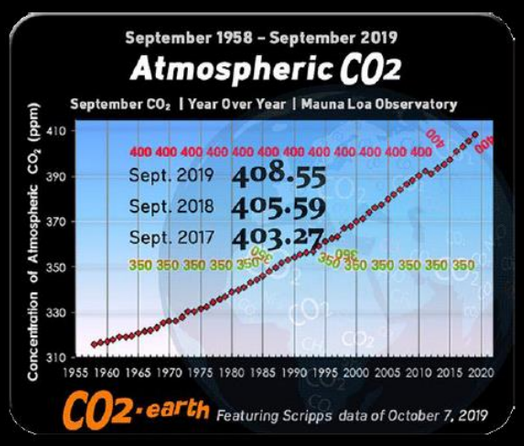
~50% Atmosphere ~26% Forests ~24% Oceans

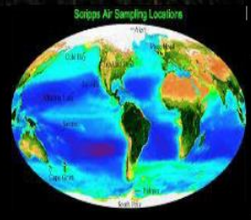


Global Warming Update

Earth's Atmosphere hits Highest Level of CO_2 in Human History

Mauna Loa Observatory on Hawaii's Big Island



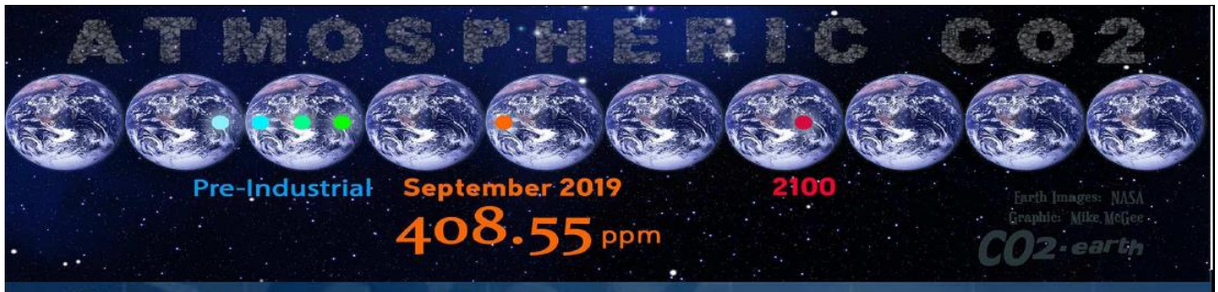


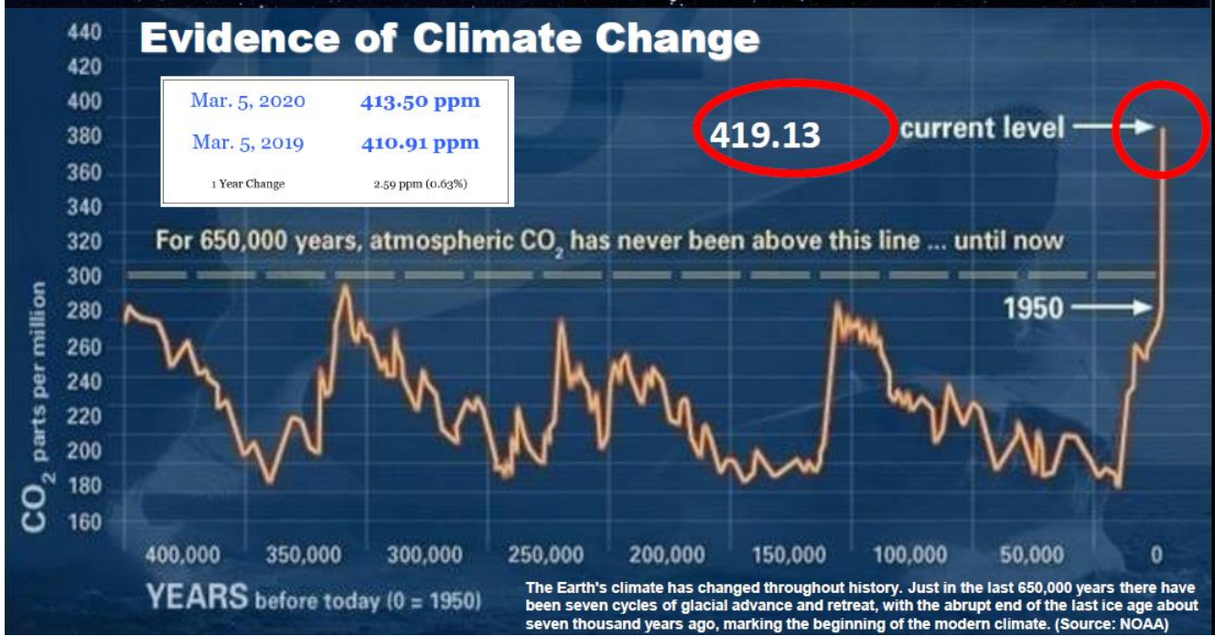
What is the safe limit ? ~ 350 *ppm*

What is current concentration ' 419.13 *ppm*

If the concentration crosses 450 *ppm*, ice is gone !

~ 6,300 Meteorological Stations Around the World





The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about seven thousand years ago, marking the beginning of the modern climate. (Source: NOAA)

How Scientists acquire Knowledge about Earth's Past Climate History ?

❖**The ice cores providing some of the most important clues, airgets trapped by snow as it falls.**

❖**Then more snow falls on top. Pressure builds up and snow is eventually converted into ice --with air bubbles trapped inside.**

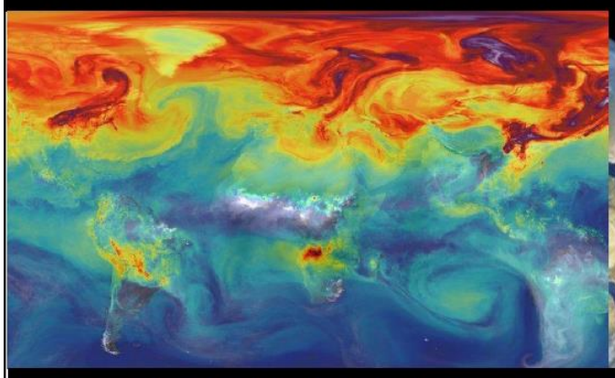
❖**The deeper you drill, the older the ice--and air bubbles "If you drill several kilometres down you find samples that are almost a million years old.**

❖**The oxygen isotopes in a core sample's air bubbles reveal the global temperature for the time**

❖**Similarly, salt and dust contamination provides information about sea levels and the spread of deserts across the globe at any given time over the last 800,000 years.**

- Mass Spectrometry
- Infra-Red Spectroscopy
- GC-MS
- Raman Spectroscopy, etc.

Satellite Network to find Carbon Super-Emitters

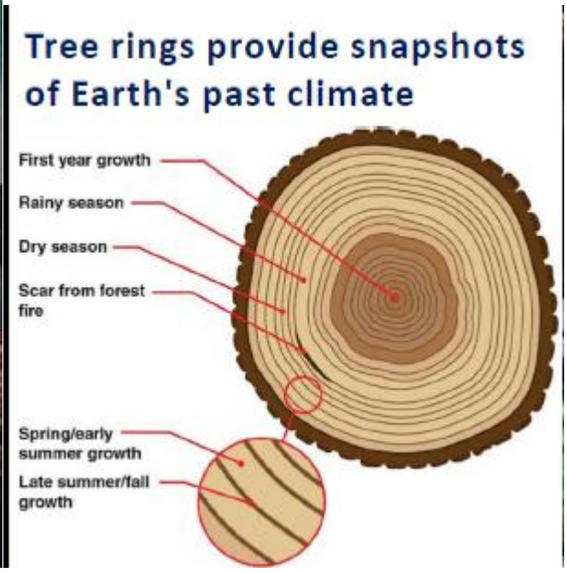


CO_2 is tracked today - but not everywhere, in fine detail and at high frequency

- The whole world is committed to reduce the greenhouse gas emissions by 40% below 1990 levels by 2030, and to eventually get to carbon neutrality.
- CH_4, CO_2 and HFCs gases can be sensed by the on-board hyperspectral instrument called imaging spectrometer developed by NASA.
- The near-500 channels on the sensor can detect and classify all manner of targets and phenomena on the ground, but these bands are also very good at detecting carbon dioxide and methane in the atmosphere.
- Providing the most accurate atmospheric CO_2 and CH_4 satellite data to help meet the challenges associated with reducing greenhouse gas emissions

How do We Study Climate?

Air bubbles in ice cores retain atmospheric gases present when the ice was formed.



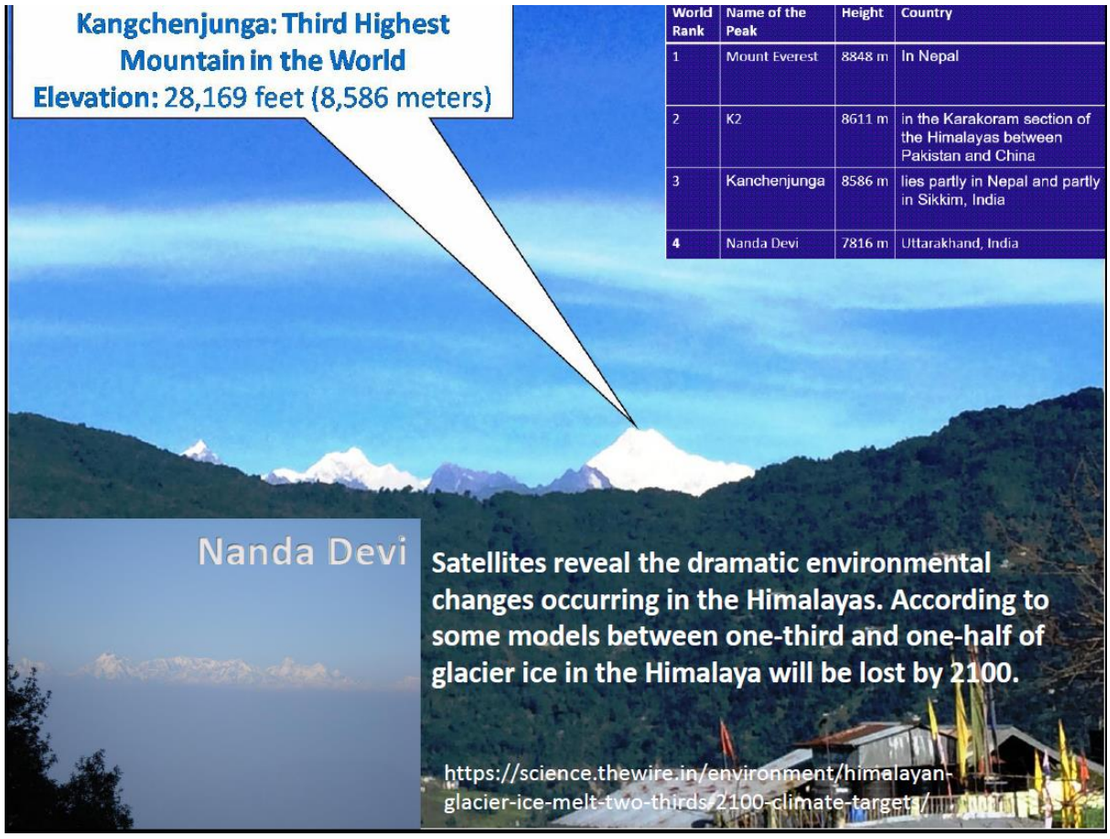
3600 m (2 mi) of Ice Core Drilled at Vostok

The deepest and oldest ice is found at high elevation in Antarctica. Back in the late 1990s the Russians completed drilling and extraction of a core of ice about two miles long from the great dome of ice in Antarctica. A remarkable technical achievement. This provided information on the past 400,000 years of earth history, including the atmospheric CO_2 .

Melting of Ice Caps and Glaciers

Global warming leads to the melting of ice caps over polar land areas and the glaciers on high mountains.

The melted ice-water flows into the sea and contributes to the sea level rise.
1997

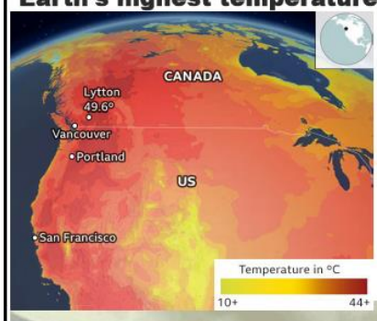


World Rank	Name of the Peak	Height	Country
1	Mount Everest	8848 m	In Nepal
2	K2	8611 m	in the Karakoram section of the Himalayas between Pakistan and China
3	Kanchenjunga	8586 m	lies partly in Nepal and partly in Sikkim, India
4	Nanda Devi	7816 m	Uttarakhand, India

Environmental Disasters Across World in 2020 & 2021

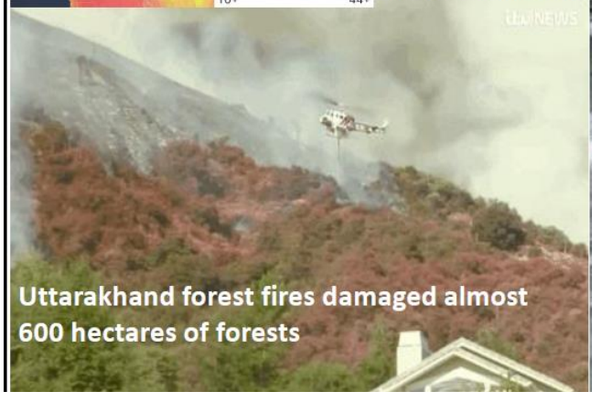
54.4°C (130F) in Aug 2020

Death Valley (Located in both California and Nevada, US)soars to 54.4°C degrees, Earth's highest temperature since 1931



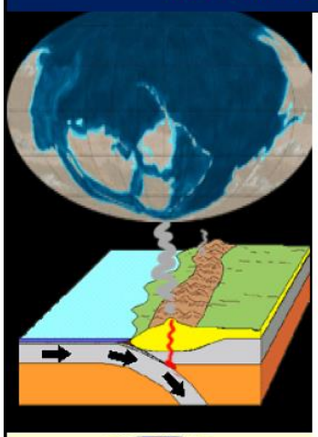
In Lytton a small British Columbia town recorded 49.6°C on 29 June 2021 breaking the country's highest recorded temperature.

Meghalaya received the highest rainfall at 1291.7 mm.

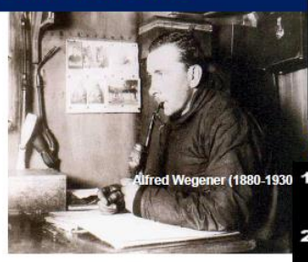


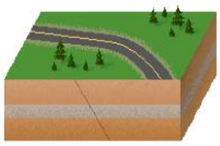
Earthquakes and Plate Tectonic Theory

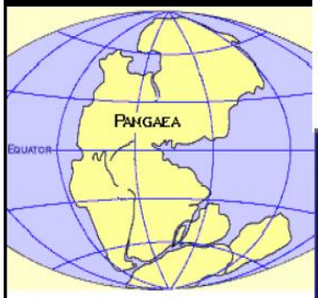
Earth is Becoming More Violent



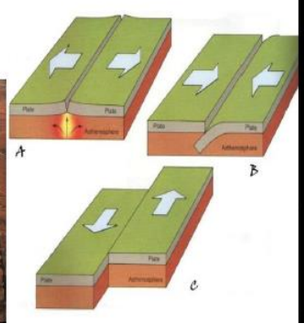
- Some truly revolutionary scientific theories may take years or decades to win general acceptance among scientists.
- This is certainly true of plate tectonics, one of the most important and far-ranging geological theories of all time; when first proposed, it was ridiculed, but steadily accumulating evidence finally prompted its acceptance, with immense consequences for geology, geophysics, oceanography, and paleontology.
- And the man who first proposed this theory was a brilliant interdisciplinary scientist, Alfred Wegener. He died before people accepted his idea







Plates moving in any direction causes earthquakes. The worst are caused by plates rubbing past each other as in C. For example , this happens along the Californian coast



10 Biggest Earthquakes

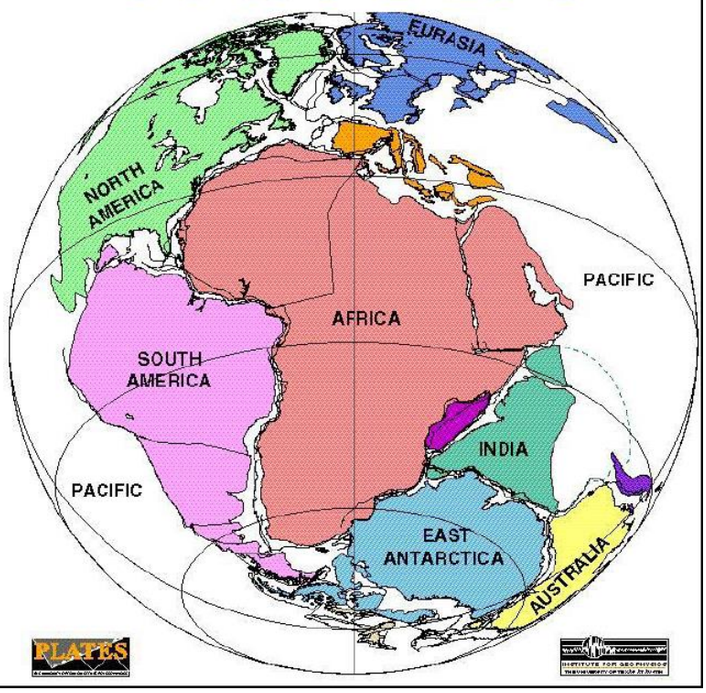
1. Valdivia, Chile 22 May 1960 (9.5)
2. Prince William Sound, Alaska 28 Mar 1964 (9.2)
3. Sumatra, Indonesia 26 Dec 2004 (9.1)
4. Sendai, Japan 11 Mar 2011 (9.0)
5. Kamchatka, Russia 4 Nov 1952 (9.0)
6. Bio-bio, Chile 27 Feb 2010 (8.8)
7. Off the coast of Ecuador 31 Jan 1906 (8.8)
8. Rat Islands, Alaska 2 April 1965 (8.7)
9. Sumatra, Indonesia 28 Mar 2005 (8.6)
10. Assam - Tibet 15 Aug 1950 (8.6)

Data source: USGS, Japan Meteorological Agency.

300 to 200 Million Years Ago

PANGEA

- The hypothetical landmass that existed when all continents were joined, from about 300 to 200 million years ago.
- Pangaea was the most recent supercontinent to have existed and the first to be reconstructed by geologists.
- The concept that the continents once formed a continuous land mass was first proposed by Alfred Wegener, the originator of the scientific theory of continental drift, in his 1912 publication



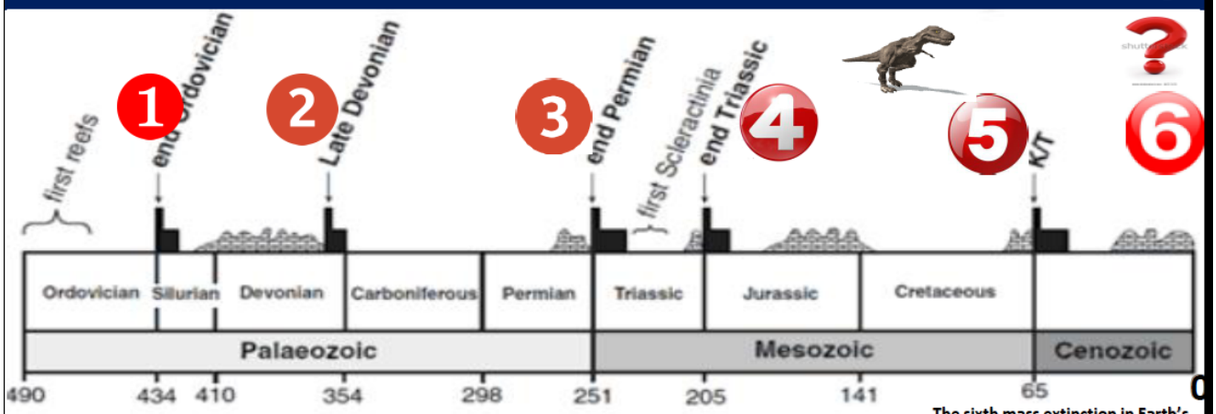
Sea Level Rise due to Global Warming

More Than 260 Airports Worldwide at Risk of Getting Submerged Due to Sea Level Rise and Coastal Flooding including New York's La Guardia Airport

- Global warming is causing global mean sea level to rise in two ways. **First**, glaciers and ice sheets worldwide are melting and adding water to the ocean. **Second**, the volume of the ocean is expanding as the water warms.
- 14,000 airports worldwide were studied. Depending on the amount of global warming in the coming decades, as many as 572 airports could be at risk by 2100.
- **Top 4 countries which are most at risk from rising sea levels - China, Vietnam, Japan & India**
- Globally, NOAA's (National Oceanic and Atmospheric Administration) worst-case scenario predicts sea levels could be as much as 8.2 feet higher in 2100 than they were in 2000. A rise of at least 1 foot by 2100 is considered very likely, even on a low-emissions path.

Climate Risk Management, 2021

Mass Extinctions in the Planet's History

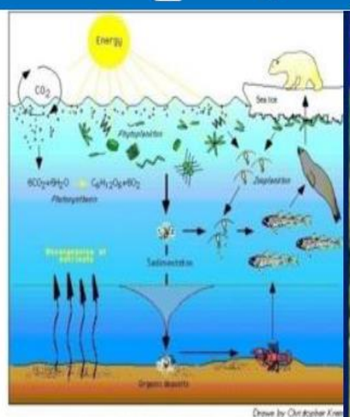


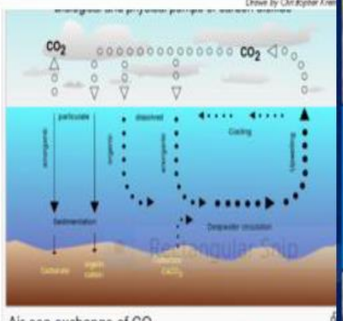
The sixth mass extinction in Earth's history is accelerating as humans rapidly and relentlessly destroy the natural world

1. **Ordovician-Silurian era (440-450Ma): Prolonged Ice Age??**
2. **Late Devonian (375-360Ma): Sea-level changes??**
3. **Permian-Triassic (251 Ma): Earth's largest extinction.** killed off more than 96% of the planet's marine species and 70% of its terrestrial life - triggered by voluminous volcanic eruptions in a region of what is now Siberia (**Nickel isotopes link Siberian Traps aerosol particles to the end-Permian mass extinction**. *Nature Communications*, 2021; 12 (1) DOI: 10.1038/s41467-021-22066-7
4. **Triassic-Jurassic (205 Ma): Sea-level changes??**
5. **Cretaceous-Tertiary (65Ma): Asteroid impact, Dinosaurs Deccan Traps vs Multiple causes**
6. **Sixth Mass Extinction is referred to as the Holocene extinction. This is named after what geologists call the period we as humans have been in. The extinctions include birds, mammals, reptiles, and amphibians. Climate Change**

Absorption of CO_2 by Oceans

- **Tiny free-floating algae called phytoplankton dominate biological production in the world's oceans and sit at the base of the marine food web. Their population dynamics are controlled by sunlight, nutrient availability, grazing by tiny planktonic animals (zooplankton) and mortality caused by viral infection. The models predict that decreased nutrient levels correspond to high viral infection rates among phytoplankton.**
- **On the other hand, increased nutrient levels are predicted to decrease viral infection rates. This means that more of the carbon contained in phytoplankton would be available to zooplankton and other creatures higher up the food chain.**
- **When these organisms die, a proportion of the associated carbon would sink down to the deep ocean, where it could be locked up for centuries, rather than being released back to the atmosphere as CO_2. This mechanism for exporting carbon to the deep ocean is called the biological carbon pump**
- **The findings can have implications for ocean geo-engineering schemes proposed for tackling global warming.**





Air-sea exchange of CO_2

Rhodes et al. *Journal of Theoretical Biology*, 2010; 265 (3): 225

Climate Change is already affecting global food production

The world's top 10 crops --supply a combined 83% of all calories produced on cropland.

❑Yields have long been projected to decrease in future climate conditions.

❑Now, new research shows climate change has already affected production of these key energy sources --and some regions and countries are faring far worse than others.

Deepak K. Ray, Paul C. West, Michael Clark, James S. Gerber, Alexander V. Prishchepov, SnigdhansuChatterjee. **Climate change has likely already affected global food production**. *PLOS ONE*, 2019; 14 (5): e0217148 DOI: 10.1371/journal.pone.0217148

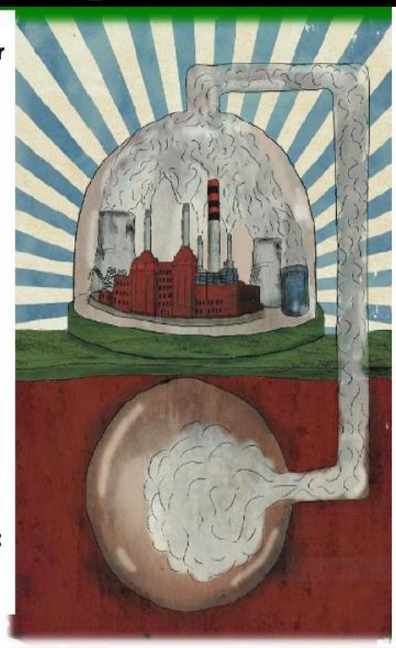
But experts say we have the solutions we need.

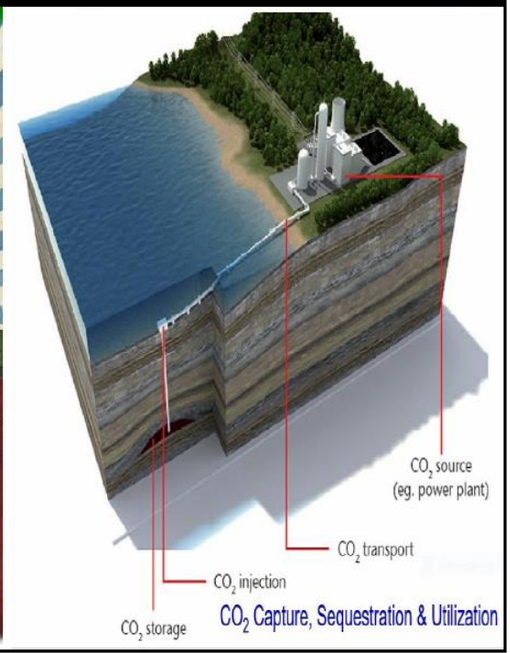
We have the tools and we need to fix this crisis

Scientists Turn CO_2 into Rock to Combat Climate Change

- An alternative to renouncing fossil fuels is not to release their CO_2 into the atmosphere.
- Carbon capture and storage (CCS) technology strips CO_2 out of exhaust gases and stores it underground.
- The technology could reduce carbon emissions from power stations by 80–90%
- Although early implementations will probably concentrate on pumping CO_2 into depleted oil fields
- The technology is likely ultimately to be targeted at saline aquifers, which represent by far the largest CO_2 storage capacity.

Quirin Schiermeier , et al (2008) Nature, 454: 816-823





Let Nature do the Work

Real Geological Storage of CO_2 !

- On average, the Earth emits between 1.5 and 2.5 billion tons of CO_2 each year, by volcanoes and as recycled CO_2 from deeply subducted carbonate rocks. Yet, the Earth's atmosphere has kept its CO_2 concentration within relatively tight bounds during its long geological history.
- If we want to balance the anthropogenic input of CO_2 exclusively by olivine, we need to mine and mill 7 km3 of olivine rock annually (for comparison, the volume of the world's largest open pit mine in Bingham/Utah is 25 km^3). Olivine rocks are abundantly available and occur on every continent, in a number of countries

R.D. Schuiling, Utrecht University, Holland

The figure represents the reaction of CO_2-rich water with olivine rock. CO_2 captured as bicarbonate in a magnesium bicarbonate solution

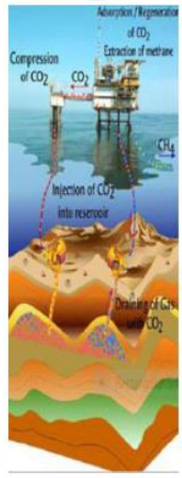
92% Mg_2SiO_4, 8% Fe_2SiO_4

$$Mg_2SiO_4 + 4\,CO_2 + 4\,H_2O \rightarrow 2\,Mg^{2+} + 4\,HCO_3^- + H_4SiO_4$$

This can be achieved by: Mining and grinding large volumes of olivine-rich rocks Spreading the grains in the wet tropics

CURRENT SCIENCE, VOL. 95, NO. 8, 25 OCTOBER 2008, p99

CO_2 Sequestration in Ocean

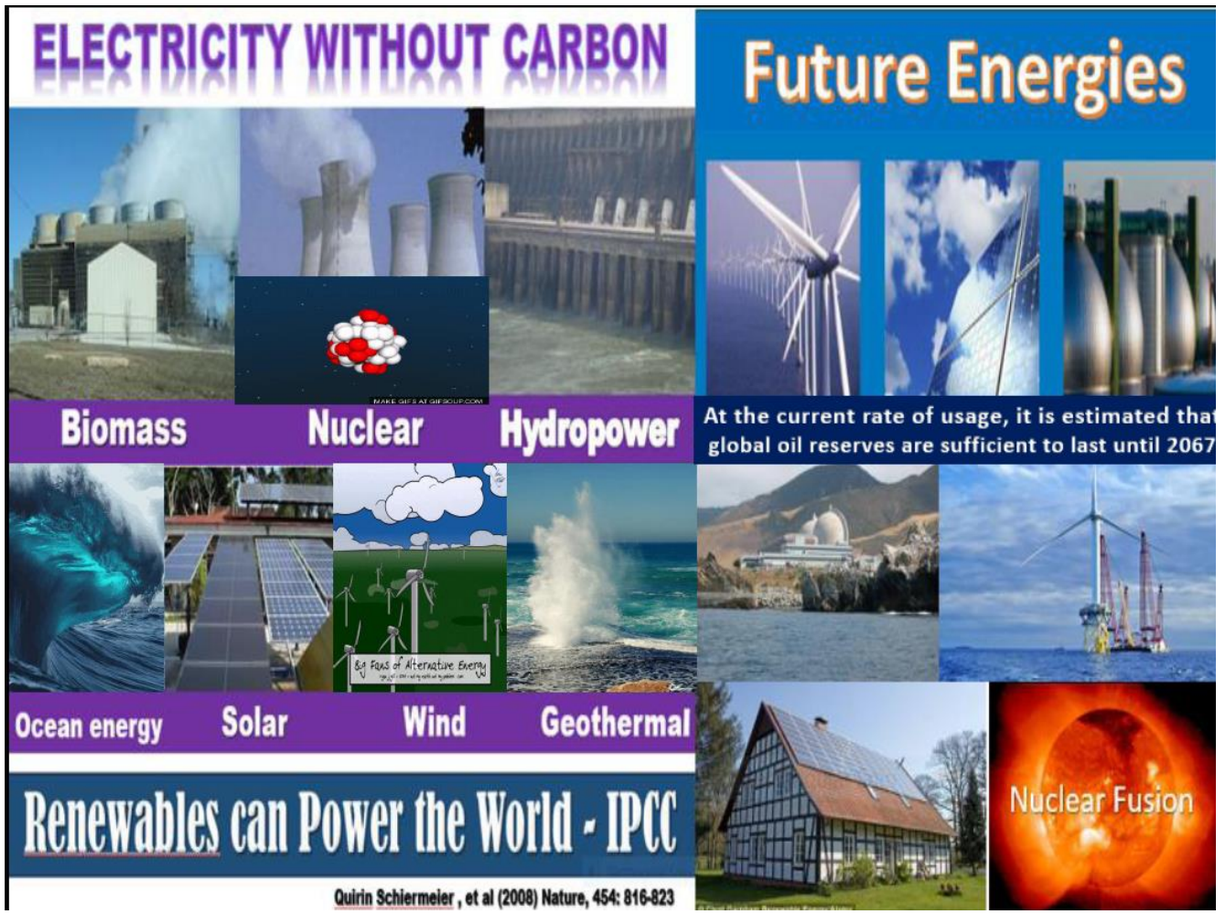


- Conventional proposals for geologic sequestration, including injection into deep saline aquifers, oil and gas fields, and deep coal seams, are prospective, but the stored supercritical CO_2 is buoyant and consequently may escape via permeable pathways into the atmosphere.
- In contrast, liquid CO_2 can be denser than seawater and become gravitationally stable at high pressure and low temperature, which is typical in deep-sea settings.
- However, it suffers from disturbance of ocean currents and negative impacts on the marine environment

New Minerals for Carbon Capture

Hydrotalcites and hydrated Mg-carbonates as carbon sinks in serpentinite mineral wastes

Connor et al (2018) International Journal of Greenhouse Gas Control, 2018; 79: 38



NUCLEAR POWER

Nuclear power produceda total of 43 TWhin 2020-21, contributing 3.11% of totalpowergeneration inIndia(1,382 TWh)

France derives about75% ofits electricity from nuclear energy

Nuclear power is the fifth-largest source of electricity in India after coal & gas (61.3%), hydroelectricity (12.3%) and wind power (10%) and solar power (9.8%). As of November 2020, India has 23 nuclear reactors in operation in 7 nuclear power plants, with a total installed capacity of 7,480 MW.

WIND ENERGY

Global installed wind-generation capacity onshore and offshore has increased by a factor of almost 75 in the past two decades, jumping from 7.5 GW in 1997 to some 564 GW by 2018.

Wind Power in India 3.9 GW (2020) –(10%)

Almost Half (47%) of Denmark's Electricity in 2019 came from Wind Power. Denmark’s wind power vision to make its electricity sector fossil-free by 2030

SOLAR ENERGY

India plans to produce 175 GW of renewable energy by 2022 (9.8%)

- The RewaUltra Mega Solar Limited (RUMSL) project is Asia's largest single-site solar power plant with a total solar installed capacity of 750 megawatts.
- The Rewasolar plant exemplifies India's commitment to attain the target of 175 gigawatt (GW) of installed renewable energy capacity by 2022.
- Andhra Pradesh, Rajasthan, and Gujarat were the top three states for large-scale solar capacity additions, representing around 51 per cent of 2020 installations.
- India added 3,239 MW solar capacity in 2020, down 56% from the previous year. MercomIndia Research is forecasting over

India plans to produce 175 GW of renewable energy by 2022 (9.8%)

- The RewaUltra Mega Solar Limited (RUMSL) project is Asia's largest single-site solar power plant with a total solar installed capacity of 750 megawatts.
- The Rewasolar plant exemplifies India's commitment to attain the target of 175 gigawatt (GW) of installed renewable energy capacity by 2022.
- Andhra Pradesh, Rajasthan, and Gujarat were the top three states for large-scale solar capacity additions, representing around 51 per cent of 2020 installations.
- India added 3,239 MW solar capacity in 2020, down 56% from the previous year. MercomIndia Research is forecasting over

10 GW of solar installations in 2021.

SOLAR ENERGY

Total installed capacity: 1.6 GW by the end of 2020.

India's potential geothermal provinces can produce 10 GW.

- **The most promising of these is in Puga Valley of Ladhak.**

They will replace the heavy pollution-causing deasil engines. Germany and UK are ahead.

❑Britain's first public fueling station for hydrogen-powered vehicles has opened in Swindon, with developers saying that it is a significant step in the creation of a 'Hydrogen Highway' along the M4. There are more in the pipe-line

❑Hydrogen-powered cars could be the future of Formula 1

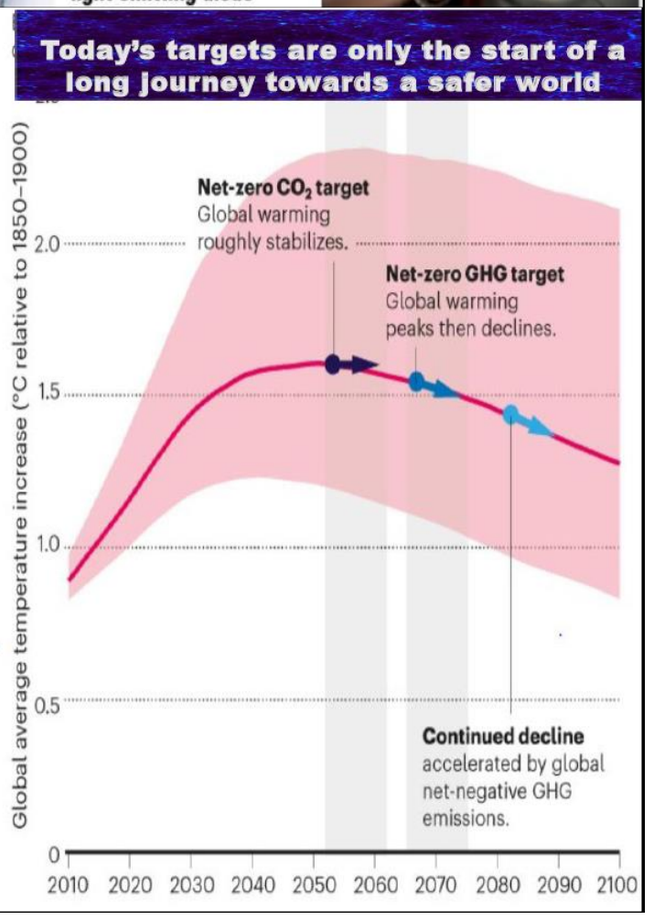
Net-zero emissions targets are vague: three ways to fix

To limit warming, action plans from countries and companies must be fair, rigorous and transparent.

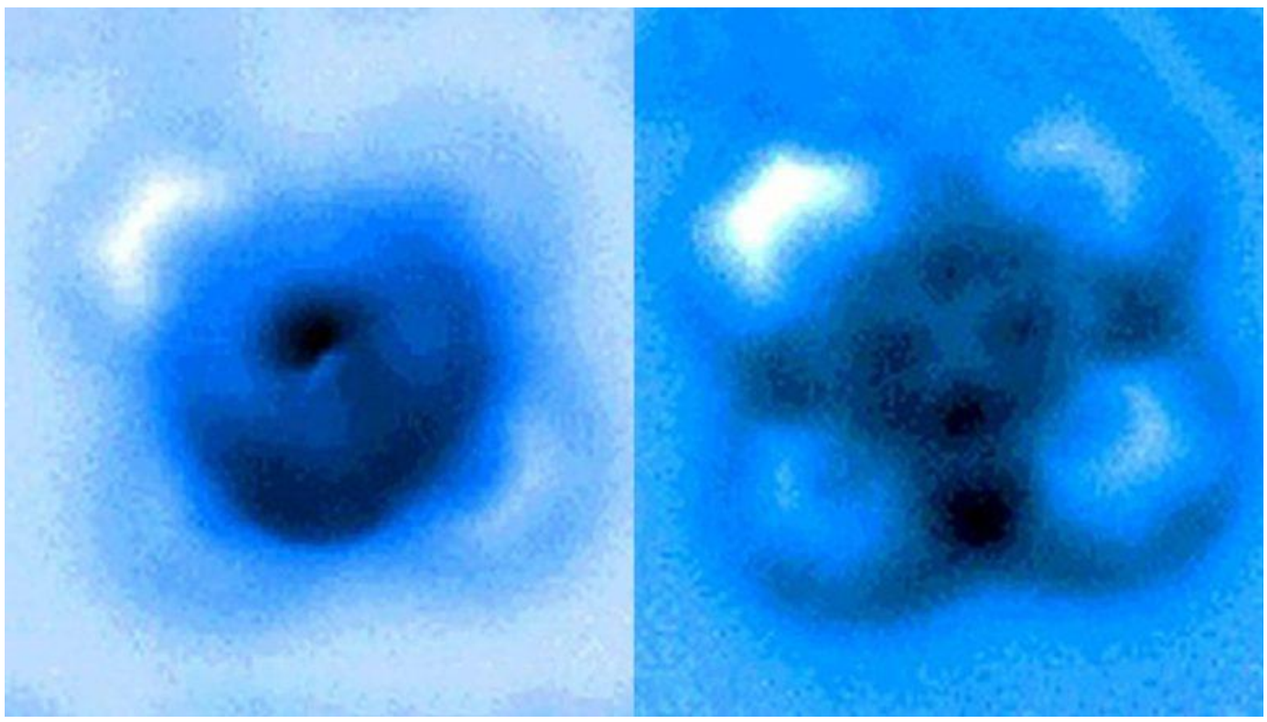
Nature **591**, 365-368 (2021)

doi: https://doi.org/10.1038/d41586-021-00662-3

- **Five years ago, the UN Paris Climate Agreement set a ceiling for global warming at well below 2 °C, ideally 1.5 °C relative to pre-industrial levels.**
- **Each country or organization takes a different tack. The EU targets all greenhouse gases by 2050. China's net-zero plan focuses on balancing only CO_2 emissions, by 2060. the UK announced in 2019 that it would reach net-zero greenhouse-gas emissions by 2050, India is unlikely to bind itself to a net-zero greenhouse gas emissions goal by 2050,**



Researchers Record the Breaking of a Single Chemical Bond –Amazing



Researchers measured the mechanical forces applied to break a bond between carbon monoxide and iron phthalocyanine, which appears as a symmetrical cross in scanning probe microscope images taken before and after the bond rupture. Credit: Pengcheng Chen et al.

Source website links: https://scitechdaily.com/researchers-record-the-breaking-of-a-single-chemical-bond-amazing/

Using advanced microscopy techniques at Princeton University, researchers have recorded the breaking of a single chemical bond between a carbon atom and an iron atom on different molecules.The team used a high-resolution atomic force microscope (AFM) operating in a controlled environment at Princeton's Imaging and Analysis Center. The AFM probe, whose tip ends in a single copper atom, was moved gradually closer to the iron-carbon bond until it was ruptured. The researchers measured the mechanical forces applied at the moment of breakage, which was visible in an image captured by the microscope. A team from Princeton University, the University of Texas-Austin and ExxonMobil reported the results in a paper published on September 24, 2021, in Nature Communications.

"It's an incredible image — being able to actually see a single small molecule on a surface with another one bonded to it is amazing," said coauthor Craig Arnold, the Susan Dod Brown Professor of Mechanical and Aerospace Engineering and director of the Princeton Institute for the Science and Technology of Materials (PRISM)."The fact that we could characterize that particular bond, both by pulling on it and pushing on it,

allows us to understand a lot more about the nature of these kinds of bonds — their strength, how they interact — and this has all sorts of implications, particularly for catalysis, where you have a molecule on a surface and then something interacts with it and causes it to break apart," said Arnold. Nan Yao, a principal investigator of the study and the director of Princeton's Imaging and Analysis Center, noted that the experiments also revealed insights into how bond breaking affects a catalyst's interactions with the surface on which it's adsorbed. Improving the design of chemical catalysts has relevance for biochemistry, materials science and energy technologies, added Yao, who is also a professor of the practice and senior research scholar in PRISM. In the experiments, the carbon atom was part of a carbon monoxide molecule and the iron atom was from iron phthalocyanine, a common pigment and chemical catalyst. Iron phthalocyanine is structured like a symmetrical cross, with a single iron atom at the center of a complex of nitrogen- and carbon-based connected rings. The iron atom interacts with the carbon of carbon monoxide, and the iron and carbon share a pair of electrons in a type of covalent bond known as a dative bond.

Yao and his colleagues used the atomic-scale probe tip of the AFM instrument to break the iron-carbon bond by precisely controlling the distance between the tip and the bonded molecules, down to increments of 5 picometers (5 billionths of a millimeter). The breakage occurred when the tip was 30 picometers above the molecules — a distance that corresponds to about one-sixth the width of a carbon atom. At this height, half of the iron phthalocyanine molecule became blurrier in the AFM image, indicating the rupture point of the chemical bond. The researchers used a type of AFM known as non-contact, in which the microscope's tip does not directly contact the molecules being studied, but instead uses changes in the frequency of fine-scale vibrations to construct an image of the molecules' surface.By measuring these frequency shifts, the researchers were also able to calculate the force needed to break the bond. A standard copper probe tip broke the iron-carbon bond with an attractive force of 150 piconewtons. With another carbon monoxide molecule attached to the tip, the bond was broken by a repulsive force of 220 piconewtons. To delve into the basis for these differences, the team used quantum simulation methods to model changes in the densities of electrons during chemical reactions.

The work takes advantage of AFM technology first advanced in 2009 to visualize single chemical bonds. The controlled breaking of a chemical bond using an AFM system has been more challenging than similar studies on bond formation. "It is a great challenge to improve our understanding of how chemical reactions can be carried out by atom manipulation, that is, with a tip of a scanning probe microscope," said Leo Gross, who leads the Atom and Molecule Manipulation research group at IBM Research in Zurich, and was the lead author of the 2009 study that first resolved the chemical

structure of a molecule by AFM. By breaking a particular bond with different tips that use two different mechanisms, the new study contributes to “improving our understanding and control of bond cleavage by atom manipulation. It adds to our toolbox for chemistry by atom manipulation and represents a step forward toward fabricating designed molecules of increasing complexity,” added Gross, who was not involved in the study. The experiments are acutely sensitive to external vibrations and other confounding factors. The Imaging and Analysis Center’s specialized AFM instrument is housed in a high-vacuum environment, and the materials are cooled to a temperature of 4 Kelvin, just a few degrees above absolute zero, using liquid helium. These controlled conditions yield precise measurements by ensuring that the molecules’ energy states and interactions are affected only by the experimental manipulations.“You need a very good, clean system because this reaction could be very complicated — with so many atoms involved, you might not know which bond you break at such a small scale,” said Yao. “The design of this system simplified the whole process and clarified the unknown” in breaking a chemical bond, he said. Reference: “Breaking a dative bond with mechanical forces” by Pengcheng Chen, Dingxin Fan, Yunlong Zhang, Annabella Selloni, Emily A. Carter, Craig B. Arnold, David C. Dankworth, Steven P. Rucker, James R. Chelikowsky and Nan Yao, 24 September 2021, Nature Communications.DOI: 10.1038/s41467-021-25932-6

The study’s lead authors were Pengcheng Chen, an associate research scholar at PRISM, and Dingxin Fan, a Ph.D. student at the University of Texas-Austin. In addition to Yao, other corresponding authors were Yunlong Zhang of ExxonMobil Research and Engineering Company in Annandale, New Jersey, and James R. Chelikowsky, a professor at UT Austin. Besides Arnold, other Princeton coauthors were Annabella Selloni, the David B. Jones Professor of Chemistry, and Emily Carter, the Gerhard R. Andlinger ’52 Professor in Energy and the Environment. Other coauthors from ExxonMobil were David Dankworth and Steven Rucker. This work was supported in part by ExxonMobil through its membership in the Princeton E-ffiliates Partnership of the Andlinger Center for Energy and the Environment. Princeton University’s Imaging and Analysis Center is supported in part by the Princeton Center for Complex Materials, a National Science Foundation Materials Research Science and Engineering Center. Additional support was provided by the Welch Foundation and the U.S. Department of Energy.