ISASBHARAT Newsletter

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From Editor's Desk

Dear all ISAS Members

It gives me immense pleasure in bringing out second issue of the year 2024. 50 years have been elapsed, India became self reliant in nuclear field by way of carrying out first Peaceful Nuclear Explosion test on 18 may 1974 at Pokharan.

Historical operation "Smiling Budha" brought smile on the faces of all Indians. India ranked sixth nation in the world to enter the elite nuclear club. A function was held on May 20, 2024 at BARC Trombay to celebrate the golden jublee of the event. Lectures were delivered by renowned personalities like Dr. R. Chidambaram and Dr. Anil Kakodkar (Ex Chairman AEC). In order to synchronize with energy transition towards "Net-Zero" target Dr. A. K. Mohanty, Chairman of Atomic Energy Commission (AEC) envisaged that India should focus at 100 Gigawatt (GW) of nuclear power production by 2047. Nobel prize-winning physicist Peter Higgs died at age 94, at the University of Edinburgh

Tuesday. He proposed the existence of the "Boson", "God particle" which was confirmed at CERN at Geneva. Boson was helpful in explaining the matter formation after the Big Bang. Dear, some time you feel angry, no problem my dear, simple method to get rid down of anger is simply write down your feelings and shred the paper to calm down. This is the conclusion of study conducted at Nagoya University Japan. ISRO (may 11, 2024) successfully conducted a long-duration test of PS4 engine using 3D printing. The single piece saves 97% raw material and production time by 60%. In ancient India, metallurgy was very much advanced. Europeans have wrongly propagated that ancient India lacks scientific development and all scientific development took place in west. Harappan Civilization, older than Vedic Civilization was much developed than the contemporary European Civilization. During excavation figures made from bronze were found. Bronze mirrors were produced by lost wax technique. The w*ootz* steel (700 BCE to 1000 CE) was exported to the west and shaped into 'Damascus swords'. Delhi iron pillar in New Delhi is globally acclaimed as rust less wonder owing to its corrosion resistant feature. zinc having a low boiling point (907°C), tends to vaporize while its ore is smelted. India was first to produce pure zinc by 'downward' distillation technique. Do you want to live longer ,cheer up my friends, share a drink with your partner. A University of Michigan study suggests this after analysing data from over 9,000 couples. Beware, be cautious friends, science is performing amazing research.

Scientists have made "significant" strides in the field of reading people's minds. researchers from California decoded thoughts with 79 % accuracy. The "speech decoders" are the brain-machine interface which capture brain activity during inner speech translating it into language. Your heart might be beating fast on reading such news. The heart plays a hidden role in our mental health. Each heartbeat serves as a little signal to the brain. The brain senses these internal

signals. Brain senses each heartbeat signal and prompts a reliable and measurable neural reaction that scientists call a heartbeat-evoked response. Researchers have devised a new liquid metal alloy system for producing diamonds at moderate pressure conditions in just 150 minutes. A study confirms that physical touch, including hugs, can significantly improve both your mental and physical health.

Jai Vigyan

Jai Bharat

Dr. Pradeep Kumar

Chief Editor, ISAS Newsletter

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50 Years of India being a Self-Reliant Nuclear Power. What The Next Govt. Should Focus On?

17 May, 2024 | by Seshadri Chari

Sooner than later, India will have to fast-track the use of thorium as fuel, the third cycle of nuclear progression, reduce the use of fossil fuels, and minimise carbon emissions.

Source website link: https://theprint.in/opinion/50-years-of-india-being-a-self-reliant-nuclear-power-what-the-next-govt-should-focuson/2089126/

Fifty years ago on ***18 May 1974,*** India became the ***sixth nation in the world*** to enter the nuclear club — literally with a bang. Among the many geopolitical reasons that could have influenced then-PM Indira Gandhi to give a go-ahead to the nuclear scientists at the Bhabha Atomic Research Centre (BARC) to prepare for a test, the1971 India-Pakistan war seems to be the most important one. Highly agitated over India's capabilities to liberate Bangladesh and inflict a crushing defeat on Pakistan, the United States stationed a carrier battle group led by USS

Enterprise (CVN-65) in the Bay of Bengal to intimidate New Delhi into forcing a withdrawal and cease-fire. The Soviet Union reacted sharply by sending a nuclear-armed submarine to keep a watch on US Navy movements. Indira Gandhi was quick to realise the salience of nuclear deterrence and authorised a team of about *75 scientists under the leadership of Raja Ramanna* to work on a nuclear fission device.

The first test

On the morning of 18 May, the nuclear device was detonated in the Rajasthan desert near Pokhran. Codenamed "***Operation Smiling Buddha"***, the test was received with shock, awe, consternation, and knee-jerk reaction from Canada, which ended the nuclear cooperation agreement.

Twenty years after the establishment of the Atomic Energy Establishment, Trombay (AEET) under the leadership of Homi Jehangir Bhabha, father of India's nuclear programme, the nation was ready to conduct a nuclear test — a peaceful nuclear explosion (PNE).

The bombing of Dresden by the British (when they dropped some 2,700 tons of bombs on the German city), the incendiary firebombing of Tokyo codenamed 'Operation Meetinghouse', and the Hiroshima- Nagasaki atomic bombings all in the same year, 1945 exemplified the massive devastation that nuclear weapons can cause.

In 1957, PM Jawaharlal Nehru, deeply disturbed by the nuclear destruction, said, during a Lok Sabha address: "We have declared quite clearly that we are not interested in and we will not make these bombs, even if we have the capacity to do so."

But later, he indicated India's determination to use nuclear energy for non-civil purposes if "**compelled**" to do so. "We must develop this atomic energy quite apart from war, indeed I think we must develop it for the purpose of using it for

peaceful purposes…Of course, if we are compelled as a nation to use it for other purposes, possibly no pious sentiments of any of us will stop the nation from using it that way."

Yet, the progress of India's nuclear programme was anything but smooth. The 1962 Chinese aggression, the sudden death of Nehru in 1964, the 1965 India-Pakistan conflict, and the death of India's second PM Lal Bahadur Shastri in Tashkent under mysterious circumstances in January 1966 were major roadblocks in the nuclear research process. In *October 1965, Bhabha announced on All India Radio* that if he was exempted, he could make a nuclear bomb for the country at the cost of just $10 million, and that too within 18 months. Three months after he made this public statement, on 24 January 1966, at about 7:02 am, Air India 101 'Kanchenjunga', a Boeing 707 aircraft, crashed on Mont Blanc near the Franco-Italian border, killing all 117 passengers and crew on board, including the 56-year-old Bhabha. This came as a severe blow to a nation that had signed a peace treaty with Pakistan only 13 days earlier. India's nuclear journey received a jolt but did not stop there; rather it surged ahead with greater force as if with a vengeance at the perceived conspiracy against its growth trajectory.

India has always been self-reliant

In 1954, the United Nations General Assembly resolved to establish the United Nations Scientific Advisory Committee to advise the Secretary-General on arrangements for the First International Conference on the Peaceful Uses of Atomic Energy. The UN convened its first Geneva Conference on peaceful uses of atomic energy from 8 to 20 August 1955. *Bhabha was elected as the president* at the conference. In his presidential address, he said, "*Nuclear energy would provide a shortcut to the prosperity of the developing countries that the industrialised countries were now beginning to enjoy."*

Bhabha was also a member of the Scientific Advisory Committee (SAC) established by the International Atomic Energy Agency (IAEA) in 1958 under the leadership of WB Lewis of Canada. India's commitment to the use of nuclear energy for peaceful purposes and Bhabha's proximity to Canadian experts in the field brought the two countries together to work on developing India's nuclear technology. As part of the Indo-Canadian nuclear cooperation project, a 40 Megawatt CIRUS reactor was built and commissioned on 10 July 1960. CIRUS reactor proved to be an excellent platform for training engineers and scientists and understanding the intricacies of managing natural uranium, heavy water, and reactor systems, which eventually evolved into the Indian pressurised heavy water reactor programme. After 50 years of successful operation, it was decided to permanently shut down the reactor in December 2010. CIRUS was used for the production of isotopes, R&D in reactor technology, training, neutron beam research, neutron activation analysis, development and testing of fuel assemblies and testing of neutron detectors.

Thus, India's nuclear programme was rooted in self-reliance and learning by experiments, which greatly reduced foreign collaborations and meddling. It also maintained necessary secrecy about tests and the collection and publication of data without releasing proliferation-sensitive information.

The second test

Fourteen years later, for the second time, India conducted five nuclear tests of advanced weapon designs on 11 and 13 May 1998 at the Pokhran range. These included a 45 kt thermonuclear device, a 15 kt fission device, and a 0.2 kt sub-kiloton (i.e. less than 1 kiloton) device.

The two nuclear devices detonated simultaneously on 13 May were also in the sub-kiloton range – 0.5 and 0.3 kt. These tests conclusively proved that India possesses

sufficient expertise in all the fields of nuclear weapons development like explosive ballistics, shock wave, radiation–matter interaction and condensed matter physics, radiation hydrodynamics and other areas such as complex computer simulation software development to enable accurate prediction of weapon yields. Besides, India maintains a very high standard of nuclear safety, which has ensured an accident-free nuclear programme for over five decades.

India is committed to total nuclear disarmament and a world free from nuclear weapons. But such an ideal scenario will forever remain a utopic idea unless nuclear powers commit themselves to a nuclear free world and return to the use of nuclear technology for energy, medical, and other peaceful purposes. As one of the most populous countries in the world, India is the third-largest energy consumer after China and the US, indicating an upward growth trajectory as energy is one of the prime indicators of economic growth. Sooner than later, India will have to fast-track the use of thorium as fuel, the third cycle of nuclear progression, reduce the use of fossil fuels, and minimise carbon emissions.

It is estimated that India has a substantial deposit of thorium (518,000 tonnes) in the form of monazite in beach sands, which increases the affordability of long-term projects. The long-term sustainability of the indigenous nuclear power programme in India depends, to a great extent, on the large-scale utilisation of the vast thorium resources to breed ^{233}U and recycle the same in self-sustaining ^{232}Th–^{233}U 'closed' fuel cycle in thermal breeder reactors. With this, India declared itself a full-fledged nuclear state.The next government should work on two priorities — civil and military. In the nuclear weapons field, we should improve competencies to ensure sufficient credible deterrence capabilities, and regarding nuclear energy, speed up the thorium fuel cycle to meet energy demands and mitigate climate change issues.

India Sets the Target to Produce 100GW by 2047: AEC Chairman

08 April, 2024 | by affairscloud.com team

Source website link: https://affairscloud.com/india-sets-the-target-to-produce-100gw-by-2047-aec-chairman/

On the side-lines of launch of the report titled "Synchronizing energy transitions towards possible Net-Zero for India: Affordable and Clean Energy for All", AK Mohanty, Chairman of Atomic Energy Commission (AEC) mentioned that India aims to produce 100 Gigawatt (GW) of nuclear power by 2047.

Key People: The report was launched in the presence of important dignitaries such as: Dr V.K. Saraswat, member, NITI (National Institution for Transforming India) Aayog, Dr. Anil Kakodkar, Chancellor, Homi Bhabha National Institute (HBNI)

Key Findings of Report:

i.) The Department of Atomic Energy (DAE) is preparing a vision document for Amrit Kaal" which aims to achieve a nuclear capacity of about 1 lakh Megawatt

(MW) by 2047.

ii.) The breed reactors would help to generate 3GW of nuclear power.

- Light reactors built with international cooperation would generate 17.6 GW of nuclear power
- While, pressurised heavy water reactors would generate about 40 to 45 GW of nuclear power.

iii.) The report suggested that if India aimed to phase down coal usage in next 30 years then it requires building suitable infrastructure for alternative sources such as: nuclear power. Also, it requires setting up flexible grid infrastructure and storage to support the integration of renewable energy.

iv.) Electricity consumption of end-users will increase from 18% (at present) to 47-52% electricity share in Total Final Electricity Consumption (TFEC).

v.) India's emissions would range between 0.56 billion-tonne of carbon dioxide (bt CO_2) and 1.0 bt CO_2 in 2070.

vi.) During 2020-2070, Government needs financial funding of about Rs 150 -200 lakh crore i.e. USD 40 to 50 billion per year About "Synchronizing energy transitions towards possible Net-Zero for India: Affordable and Clean Energy for All" report:

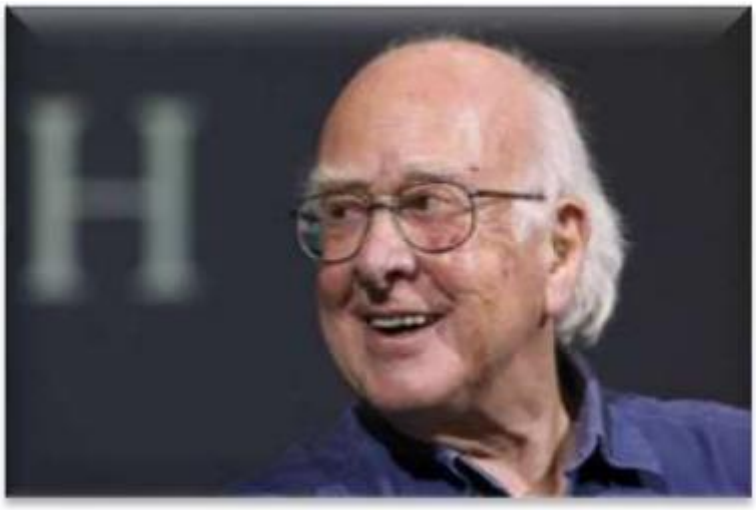
Professor Ajay Kumar Sood, Principal Scientific Advisor (PSA) to the Government of India (GoI) released the report on 3rd April, 2024 at Vigyan Bhawan, New Delhi. The report was prepared by Indian Institute of Management (IIM) Ahmedabad, Gujarat.

The report is largely funded by Office of Principal Security Advisor (PSA) to GoI and received partly-funding from Nuclear Power Corporation of India Limited (NPCIL).

Peter Higgs: Who Proposed the Existence of The 'God Particle,' has Died at 94

09 April, 2024 | by Danica Kirka, Jill Lawless and Jamey Keaten

Source website link: https://phys.org/news/2024-04-peter-higgs-god-particle-died.html



Britain's Professor Peter Higgs smiles during a press conference in Edinburgh, Scotland, on Oct. 11, 2013. The University of Edinburgh says Nobel prizewinning physicist Peter Higgs, who proposed the existence of the Higgs boson particle, has died at 94. Higgs predicted the existence of a new particle — the so-called Higgs boson — in 1964. But it would be almost 50 years before the particle's existence could be confirmed at the Large Hadron Collider. Higgs won the 2013 Nobel Prize in Physics for his work, alongside Francois Englert of Belgium. Credit: AP Photo/Scott Heppell, File

Nobel prize-winning physicist Peter Higgs, who proposed the existence of the so-called "God particle" that helped explain how matter formed after the Big Bang, has died at age 94, the University of Edinburgh said Tuesday. The university, where Higgs was emeritus professor, said he died Monday following a short illness.

Higgs predicted the existence of a new particle, which came to be known as the Higgs boson, in 1964. He theorized that there must be a sub-atomic particle of certain dimension that would explain how other particles—and therefore all the

stars and planets in the universe—acquired mass. Without something like this particle, the set of equations physicists use to describe the world, known as the standard model, would not hold together.

Higgs' work helps scientists understand one of the most fundamental riddles of the universe: how the Big Bang created something out of nothing 13.8 billion years ago. Without mass from the Higgs, particles could not clump together into the matter we interact with every day. But it would be almost 50 years before the particle's existence could be confirmed. In 2012, in one of the biggest breakthroughs in physics in decades, scientists at CERN, the European Organization for Nuclear Research, announced that they had finally found a Higgs boson using the Large Hardron Collider, the $10 billion atom smasher in a 17-mile (27-kilometer) tunnel under the Swiss-French border.

The collider was designed in large part to find Higgs' particle. It produces collisions with extraordinarily high energies in order to mimic some of the conditions that were present in the trillionths of seconds after the Big Bang. Higgs won the 2013 Nobel Prize in Physics for his work, alongside Francois Englert of Belgium, who independently came up with the same theory.

Edinburgh University Vice Chancellor Peter Mathieson said Higgs, who was born in Newcastle, was "a remarkable individual—a truly gifted scientist whose vision and imagination have enriched our knowledge of the world that surrounds us." "His pioneering work has motivated thousands of scientists, and his legacy will continue to inspire many more for generations to come."

Born in Newcastle, northeast England on May 29, 1929, Higgs studied at King's College, University of London, and was awarded a Ph.D. in 1954. He spent much of his career at Edinburgh, becoming the Personal Chair of Theoretical Physics at the Scottish university in 1980. He retired in 1996. One highlight of Higgs' career came in the 2013 presentation at CERN in Geneva where scientists presented in

complex terms—based on statistical analysis unfathomable to most laypeople—that the boson had been confirmed. He broke into tears, wiping down his glasses in the stands of a CERN lecture hall.

"There was an emotion—a kind of vibration—going around in the auditorium," Fabiola Gianotti, the CERN director-general told The Associated Press. "That was just a unique moment, a unique experience in a professional life." "Peter was a very touching person.

He was so sweet, so warm at the same time. And so always interested in what other people had to say," she said. "Able to listen to other people … open, and interesting, and interested." Joel Goldstein, of the School of Physics at the University of Bristol, said, "Peter Higgs was a quiet and modest man, who never seemed comfortable with the fame he achieved even though this work underpins the entire modern theoretical framework of particle physics." Gianotti recalled how Higgs often bristled at the term "God particle" for his discovery: "I don't think he liked this kind of definition," she said. "It was not in his style."

Feeling Angry? Write Down Your Feelings And Shred The Paper To Calm Down,

Source : Science Edited by Bhavya SukhejaUpdated: April 12, 2024

While the anger of the group which placed the paper in a clear folder or a box remained high, "the subjective anger for the disposal group decreased" to the point of being neutralised.

On days when you feel like snapping at someone or screaming into a pillow, try writing your feelings on paper and then shredding or throwing them away to calm down. A study in Japan has found that this is an effective way to get rid of anger. The study, conducted at **Nagoya University** and published in Scientific Reports on Nature, builds on research on the association between the written word and anger reduction as well as studies showing how interactions with physical objects can control a person's mood. "We expected that our method would suppress anger to some extent," said *Nobuyuki Kawai*, lead researcher of the study at Nagoya University. "However, we were amazed that anger was eliminated almost entirely," Mr Kawai added, as per the Guardian. For the research, around 100 students took part in an experiment where they were asked to write brief opinions on social issues, such as whether smoking in public should be outlawed. The researchers told them that a doctoral student would evaluate their writing. However, regardless of what the participants wrote, the evaluators scored them on low intelligence, interest, friendliness, logic and rationality. They also received insulting feedback. The participants then wrote down their feelings, and half of them shredded the paper or threw it away, while the other half put it in a clear folder or a transparent box.


Angry (Sad) Mood After writing down

The study found that all students "showed an increased subjective rating of anger" after being insulted. But while the anger of the group which placed the paper in a clear folder or a box remained high, "the subjective anger for the disposal group decreased" to the point of being neutralised.

Researchers concluded that "the meaning of disposal plays a critical role" in reducing anger. "This technique could be applied in the moment by writing down the source of anger as if taking a memo and then throwing it away," said Mr Kawai. The researchers also said that their findings could be used as a form of *ad-hoc anger management.* "Controlling anger at home and in the workplace can reduce negative consequences in out jobs and personal lives," they said. Moreover, researchers also believe that the shredder results may be related to the phenomenon of "backward magical contagion", which is a belief that actions taken on an object associated with a person can affect the individual themselves. In this case, getting rid of the paper with negative thoughts causes the original emotion to disappear.

Counting System in Ancient India

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All of you must be remembering counting system taught us in schools. It is during primary school, mostly first page of math book. We come across crore and arab. In counting table the numbers were named across maha shankh. Surprisingly we in math we generally come across figure greater than crore and arab. In old Hindu system figures were named upto 10^{27}. One wonders where these figures might have been used. In this table Hindi name of numbers are mentioned.

इकाई	1	पदम	10^{15}
दहाई	10	महा पदम	10^{16}
सैंकड़ा	100	शंख	10^{17}
हजार	1000	महा शंख	10^{18}
दस हजार	10000	अत्या महा अत्या	10^{19}
लाख	100000	मध्या	10^{20}
दस लाख	1000000 (10^6)	महा मध्या	10^{21}
करोड़	10^7	पारध	10^{22}
दस करोड़	10^8	महा पारध	10^{23}

अरब	10^9	धून	10^{24}
दस अरब	10^{10}	महा धून	10^{25}
खरब	10^{11}	अक्षोहिणी	10^{26}
दस खरब	10^{12}	महा अक्षोहिणी	10^{27}
नील	10^{13}		
दस नील	10^{14}		

ISRO Successfully Tests 3D-Printed Rocket Engine - A Major Breakthrough

ISRO achieved the major milestone with the successful hot testing of a liquid rocket engine manufactured through AM technology for a duration of 665 seconds on May 9, a release from the space agency said.

Source :India News Press Trust of IndiaUpdated: May 11, 2024

ISRO has successfully conducted a long-duration test of its PS4 engine, re-designed for production using cutting-edge additive manufacturing (AM) techniques -- also known in common parlance as 3D printing -- and crafted in Indian industry, the space agency said on Friday.The new engine, now a single piece, saves 97 per cent of raw materials and reduces production time by 60 per cent, ISRO said. ISRO achieved the major milestone with the successful hot testing of a liquid rocket engine manufactured through AM technology for a duration of 665 seconds on May 9, a release from the space agency said. The engine used is the PS4 engine of PSLV (Polar Satellite Launch Vehicle) upper stage.

ISRO successfully conducts a long-duration test of the PS4 engine, re-designed for production using cutting-edge additive manufacturing techniques and crafted in the Indian industry. The new engine, now a single piece, saves 97% of raw.

The PS4 engine manufactured in the conventional machining and welding route has been in use for the fourth stage of PSLV which has a thrust of 7.33 kN in vacuum condition. The same engine is also used in the Reaction Control System (RCS) of the first stage (PS1) of PSLV, the release said. The engine uses the earth-storable bipropellant combinations of Nitrogen Tetroxide as oxidiser and Mono Methyl Hydrazine as fuel in pressure-fed mode. It was developed by ISRO's Liquid Propulsion Systems Centre (LPSC). LPSC redesigned the engine making it

amenable to the Design for Additive Manufacturing (DfAM) concept thereby gaining considerable advantages.

The Laser Powder Bed Fusion technique employed has brought down the number of parts from 14 to a single-piece, and eliminated 19 weld joints, saving significantly on the raw material usage per engine (13.7 kg of metal powder compared to the 565 kg of forgings and sheets for conventional manufacturing process) and reduced 60 per cent in the overall production time, the ISRO release said. The manufacturing of the engine was done in Indian industry (M/s WIPRO 3D), and the engine was hot tested at ISRO Propulsion Complex, Mahendragiri, Tamil Nadu. As part of the development programme, the injector head of the engine was realised and successfully hot tested earlier. Detailed flow and thermal modelling, structural simulation, and cold flow characterisation of the proto hardware were carried out to gain confidence for the hot test, ISRO said.

Consequently, four successful developmental hot tests of integrated engine were conducted for a cumulative duration of 74 seconds which validated the engine performance parameters. Furthermore, the engine was successfully tested for the full qualification duration of 665 seconds and observed that all the performance parameters were as expected. It is planned to induct this AM PS4 engine into the regular PSLV programme, ISRO added.

Metallurgy in Ancient India

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Introduction

Material stages that can be chronologically visualized through three broad stages - Stone Age, Bronze Age and Iron Age. The Stone Age, the first period of our prehistoric past to express the timeline of human progress, is divided into three distinct periods - Paleolithic era, Mesolithic era and Neolithic era. The term 'neolith' comprises word 'neo' meaning 'new' and 'lith' referring to 'stone'. As far back as the Neolithic period or the new stone age (c. 7500 BCE -5000 BCE) people had begun to use tools like axe, hammer, chisel, knife, etc. made of stones and bones.

This phase was followed by the Chalcolithic period or the Copper-stone age (2000 BCE -700 BCE) which belong to the Saraswati-Sindhu civilization. As the name suggests, (Chalco = copper, Lithic = stone) both copper and stone were used for preparing implements during the Chalcolithic period. Copper and its alloy bronze were used for making tools, beads, bangles, rings, The excavations at sites like Mohenjo-Daro in Sindh and Harappa in Punjab reveals that the mature phase of this civilization (also called the Bronze-age Harappan Civilization) that flourished between c. 2500 BCE - 1800 BCE was spread over a large part of the Indian subcontinent.

The Neolithic Revolution or first Agriculture Revolution a was the critical transition that resulted in the birth of agriculture, taking Homo sapiens from scattered groups of hunter-gatherers to farming villages and from there to

technologically sophisticated societies with great temples and towers and kings and priests. This all happened around 10,000 years ago . In India the development in agriculture in parts of the Indus and the Ganges valleys . In Neolithic period weapons, tools and implements were made of stone , coarser as well as heavier. Man any how learned the use of Metal for weapons, tools , ornaments , and other craft items . The items made from metal were strong, light, sharp weapon. The use of metal for ornaments enriched cultural life bringing cultural change in society.

In Europe, the Neolithic Age was succeeded by the Bronze Age, but in India, there was no specific Bronze Age. In the northern parts of India, people changed to copper from stones for manufacturing axes, spears, heads and other objects. In India, the use of bronze began in the Copper Age. The Copper Age was the first metal age in India.

Metallurgy may be defined as the extraction, purification, alloying and application of metals. Today, out of 118 elements , 92 metals metals. It is worth mentioning that , but most of metals are discovered in the last two centuries. The 'seven metals of antiquity', as they are sometimes called, were, more or less in order of discovery: gold, copper, silver, lead, tin, iron and mercury. For over 7,000 years, India has had a high tradition of metallurgical skills; let us see some of its landmarks.

Metallurgy before and during the Harappan Civilization

Harappan Civilization is older than vedic civilization. There is no written record of Indus and Harappan Civilization. What ever we know is through excavation.

The outcome of excavation has surprized the whole word. The civilization was much developed the contemporary europian civilisation. The renowned scholars consider the oldest developed civilization. Though written records do not exit, yet historian have interpreted the facts of excavation.

Surprisingly metallurgy was very much advanced in Harappan in those days. A small copper bead was dated to about 6000 BCE; Mehrgarh in Baluchistan , which is first evidence of Metal in the Indian subcontinent. However , the growth of copper metallurgy had to wait for another 1,500 years.

Various tools, vessels ,weapons, craft items obtained during excavation are spearheads, arrowheads, axes, chisels, sickles, blades (for knives as well as razors), needles, hooks, jars, pots and pans etc. Bronze mirrors were obtained. The mirrors are slightly oval, with faces raised, and one side was highly polished. This shows that Harappan people used to like well dressed. True saw was invented by Harappan craftsmen with teeth and the adjoining part of the blade set alternatively from side to side. This type of saw was unknown until Roman times.

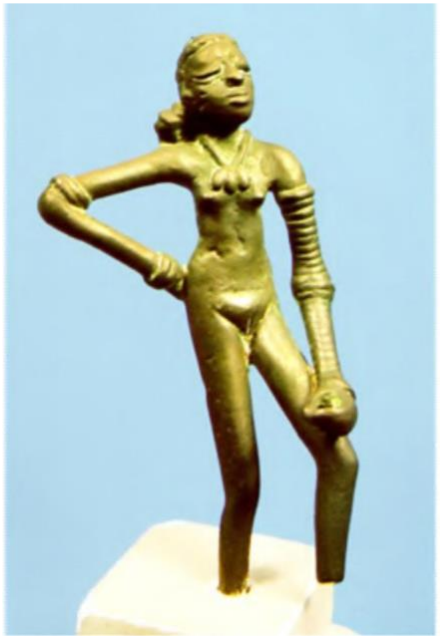
Harappan metal smiths used to acquire copper ore from the Aravalli hills, Baluchistan or beyond. Then soon they might have mastered the knowledge that addition tin to copper in appropriate ratio produce bronze which was much harder than copper having easier casting properties. This alloy was more resistant to corrosion. They further successfully prepared harden bronze to the extent that bronze chisels were able to dress stones. The alloying ranges have been found to be (1–12)% in tin, (1–7)% in arsenic, (1–9)% in nickel and (1–32)% in lead.

How they arrived to such complicated composition. Chemical composition indicates that they Harapanin were very excellent scientist. This composition cannot be matter of chance. Moreover shaping copper or bronze involves sophisticated techniques of fabrication such as forging, sinking, raising, cold work, annealing, riveting, lapping and joining. Means , they have developed all these fabrication techniques . Wonderful in fact.

Artistic activity provide insights into the minds, lives, and religious beliefs. There is notable repertoire of cast-bronze figures, including several fragments and complete examples of dancing girls, small chariots, carts, and animals. The

technical excellence of the bronzes suggests a highly developed art . Those figurines were casted by the lost-wax process. The figure of pure bronze would be very heavy. The reduction in metal weight was used by lost-wax process. The model was made of wax thickly coated with clay. On firing caused the wax to melt away (or 'lost') meanwhile the clay hardened into a mould . Over the mould molten bronze was poured. Thus the figures are hollow from inside, weighing less, easy to carry, saving huge bronze metal.

Other metals used were gold, silver, and lead. The latter was employed occasionally for making small vases and such objects as plumb bobs. Silver is relatively more common than gold, and more than a few vessels are known, generally in forms similar to copper and bronze examples. Gold is by no means common and was generally reserved for such small objects as beads, pendants, and brooches.



The 'Dancing Girl' (Mohenjo-daro), made by the lost-wax process; a bronze foot and anklet from Mohenjo-daro; and a bronze figurine of a bull (Kalibangan).

Harappans also used gold and silver (as well as their joint alloy, electrum) to produce a wide variety of ornaments such as pendants, bangles, beads, rings or necklace parts, which were usually found hidden away in hoards such as ceramic or bronze pots. While gold was probably panned from the Indus waters, silver was perhaps extracted from galena, or native lead sulphide.

After the Harappans

During and after the Harappan civilization massive quantities of copper item continued to produce tools in central and northern India. Those skilled copper-bronze smiths provided myriad sequel of incredible art. The Sultanganj Buddha is a Gupta–Pala transitional period sculpture, the largest substantially complete copper Buddha figure known from the time. The statue is dated to between 500 and 700 AD. It is 2.3 m high and 1 m wide, with a weight over 500 kg. It was found in the East Indian town of Sultanganj, Bhagalpur district, Bihar in 1861 during the construction of the East Indian Railway. It is now in the Birmingham Museum and Art Gallery, Birmingham, England. Surprisingly , Sultanganj Buddha was fabricated by the same "lost-wax" technique that Harappans used three millenniums earlier.

Thousands of statues were fabricated in Tamil Nadu , even upto this date. Beautiful Nataraja statues during the Chola period. The Chola dynasty produced thousands of beautifully detailed statues of Hindu gods from the ninth through the thirteenth century. These bronze sculptures — mainly featuring Shiva — were adorned with jewels and paraded through towns during Chola festivals

A colossal bronze statue of the Buddha, Sultanganj:
(Courtesy: Wiokipedia)

Magnificent Chola bronze statues: Mahālakṣmī and Naṭarāja. (Courtesy: Michel Danino)

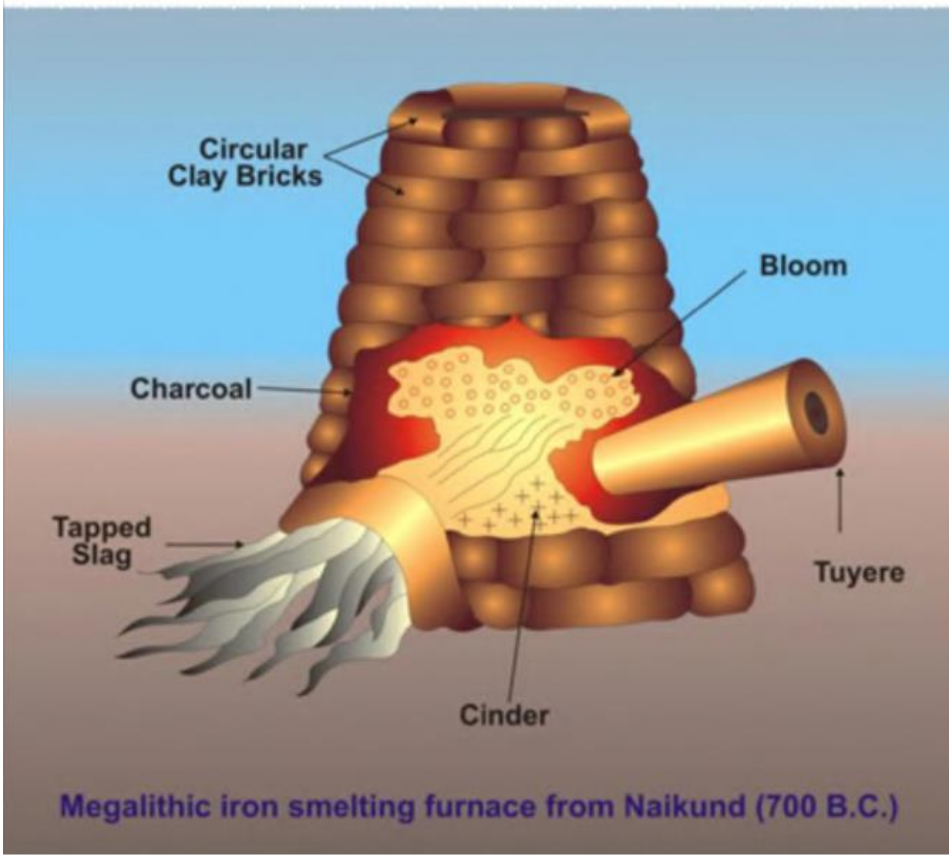
Shiv Parvati While the stone sculptures and the inner sanctum image empowering the temple remained immovable, changing religious concepts during the 10th century demanded that the deities take part in a variety of public roles similar to those of a human monarch. As a result, large bronze images were created to be carried outside the temple to participate in daily rituals, processions, and temple festivals. The round lugs and holes found on the bases of many of these sculptures are for the poles that were used to carry the heavy images. Admired for the sensuous depiction of the figure and the detailed treatment of their clothing and jewelry, Chola-period bronzes were created using the lost wax technique. Even today daily use have continued to be produced , for instance, highly polished bronze mirrors are still made in Kerala today, just as they were in Harappan times.

Bronz Kerala Mirror.

Iron Metallurgy

While the Indus civilization belonged to the Bronze Age, its successor, the Ganges civilization, which emerged in the first millennium BCE, belonged to the Iron Age. According to some experts iron was even produced as early as in 1800 BCE, appears to have become widespread from about 1000 BCE . In late Vedic texts mentions of a ‘dark metal’ (krṣṇāyas), while earliest texts (such as the Rig-Veda) only mentioned of "ayas", now referred as copper or bronze.

Whether other parts of India learned iron technology from the Gangetic region or came up with it independently is not easy task.



A typical iron-smelting furnace in the first millennium BCE.

(Courtesy: National Science Centre, New Delhi)

Further, with the introduction of iron technology, human life got a fresh impetus, when people learned the use of iron and marked the beginning of the Iron Age (c. 1200 – 600 BCE) in India . The use of iron in southern part of India is datable to the period pre-1000 BCE and in the upper Gangetic valley and eastern part of India the use of iron began around 1000 BCE . Iron ores were more readily available than copper ores and cheaper in production than copper and bronze. The process of iron and steel making technology in India has been mentioned in the texts of Vedic period (1500 BCE - 500 BCE). The method of fabrication (c. 700 BCE) of more than a hundred surgical tools made of Fe-C alloys and the process of heat treatment to obtain sharp edges has been mentioned in the *Susruta Samhita* . The process for extraction of iron and alloying of iron-carbon is also mentioned in *Rasa Ratna Samuccaya* (c. 1200CE -800 CE). Varahamihira (c. 550 CE) has mentioned the process of carburization and hardening of iron swords in *Khargalaksnam.* A comparison of ancient irons from India and Japan has revealed superior corrosion resistance quality of the Indian iron.

On earth iron is not found as a usable metal in solid form but is generally found as iron ore. The common ores of iron are haematite (Fe_2O_3), magnetite (Fe_3O_4), goethite (Fe(OH)O) and limonite (FeO(OH)n.H2O). In ancient times, since extraction of iron was done by heating the iron ore with charcoal, the temperature raised in the furnace was not high enough to melt the iron (pure iron melts at 1536 ◦C). So, the iron ore was heated to obtain a soft spongy mass which was hammered to be shaped into the desired objects. The iron produced in ancient India can be classified into three categories; (i) wrought iron with little or no carbon, (ii) cast iron with up to 7% carbon, (iii) steel with up to 1.7% carbon .

Wootz Steel

The w*ootz* steel produced (700 BCE to 1000 CE) in India by ironsmiths was globally acclaimed for its excellent mechanical properties and it was exported to

the West. Instead, India was a major innovator in the field, producing two highly advanced types of iron. The first, wootz steel, produced in south India from about 300 BCE, was iron carburized under controlled conditions. Exported from the Deccan all the way to Syria, it was shaped there into 'Damascus swords'. The Damascus steel swords, renowned for edge sharpness, typical surface structure/pattern, possessed extreme mechanical strength, inherent brittleness, and exclusive banding .

But it is likely that the term 'Damascus' derived not from Syria's capital city, but from the 'damask' or wavy pattern characteristic of the surface of those swords. In any case, this Indian steel was called 'the wonder material of the Orient'. A Roman historian, Quintius Curtius, recorded that among the gifts which Alexander the Great received from Porus of Taxila (in 326 BCE), there was some two-and-a-half tons of wootz steel — it was evidently more highly prized than gold or jewels. Later, the Arabs fashioned it into swords and other weapons, and during the Crusades, Europeans were overawed by the superior Damascus swords. It remained a favoured metal for weapons through the Moghul era, when wootz swords, knives and armours were artistically embellished with carvings and inlays of brass, silver and gold. In the armouries of Golconda and Hyderabad's Nizams, Tipu Sultan, Ranjit Singh, the Rajputs and the Marathas, wootz weapons had pride of place.

A typical sword made of wootz steel (about 18th century); the hilt is of iron *and coated with a thick layer of gold. (Courtesy: R. Balasubramaniam)*

Wootz steel is primarily iron containing a high proportion of carbon (1.0 – 1.9%). Thus the term wootz (an English rendering of 'ukku', a Kannada word for steel) applies to a high carbon alloy produced by crucible process. The basic process consisted in first preparing sponge (or porous) iron; it was then hammered while hot to expel slag, broken up, then sealed with wood chips or charcoal in closed crucibles (clay containers) that were heated, causing the iron to absorb appreciable amounts of carbon; the crucibles were then cooled, with solidified ingot of wootz steel remaining. The surface pattern is developed by the watering treatment. The typical surface pattern and the exceptional strength are attributed to the presence of cementite particles and carbon nanotubes in the *wootz* steel

Right from the 17th century, several European travellers documented India's iron- and steel-making furnaces (Francis Buchanan's accounts of south India are an important source of information as regards wootz). From the 18th century, savants in England (Pearson, Stodart and Faraday), France and Italy tried to master the secrets of wootz; the French Jean-Robert Bréant, conducting over 300 experiments by adding various metals to steel, understood the role of the high carbon proportion in wootz, and was the first European who successfully produced steel blades comparable to the Indian ones. Together, such researches contributed to the understanding of the role of carbon in steel and to new techniques in steel-making.

The Delhi Iron Pillar

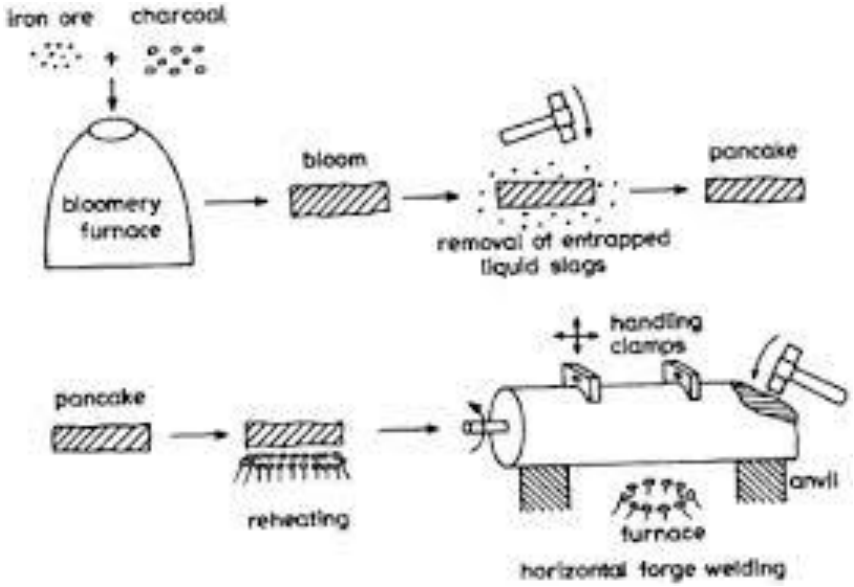
Delhi iron pillar Iron pillar presently located in Mehrauli village in New Delhi is globally acclaimed as rust less wonder owing to its corrosion resistant feature . This is a prominent monument demonstrating an indisputable record of the ancient Indian metallurgical and engineering marvel. The s econd advanced iron is the one used in the famous 1,600-year-old Delhi Iron Pillar, which, at a height of 7.67 m, consists of about six tons of wrought iron. It was initially erected 'by Chandra as a standard of Vishnu at Vishnupadagiri', according to a six-line Sanskrit inscription on its surface. 'Vishnupadagiri' has been identified with modern Udayagiri near Sanchi in Madhya Pradesh, and 'Chandra' with the Gupta emperor, Chandragupta II Vikramaditya (375–414 CE). In 1233, the pillar was brought to its current location in the courtyard of

The Delhi Iron Pillar, with a close-up of the inscription. (Courtesy: R. Balasubramaniam)

the Quwwat-ul Islam mosque in New Delhi's Qutub complex, where millions continue to come and see this 'rustless wonder'. But why is it rustless, or, more precisely, rust-resistant? Here again, numerous experts, both Indian and Western, tried to grasp the secret of the pillar's manufacture. Only recently have its rust-resistant properties been fully explained (notably by R. Balasubramaniam). They are chiefly due to the presence of phosphorus in the iron: this element, together with iron and oxygen from the air, contributes to the formation of a thin protective passive coating on the surface, which gets reconstituted if damaged by scratching. It goes to the credit of Indian blacksmiths that through patient trial and error they were able to select the right type of iron ore and process it in the right way for such monumental pillars.

Preparation of the iron pillar

The pillar was made of wrought iron by solid state reduction of iron ore with charcoal using horizontal forge-welding process . The wrought iron means, the iron which has not been molten and directly made from iron ore. The forge welding is a process in which iron lumps obtained from metal extraction are joined together by forging them in the hot state.



Schematic illustration of the manufacturing methodology of the iron pillar in Delhi

The iron blooms from the bloomer furnace were heated to a relatively high temperature in a bed of charcoal to make them soft. The iron blooms were then hammered to remove the slags. Slag is a glassy substance that results from mineral impurities in the iron ore. Hammering breaks up the slags and also consolidates the internal pores. This produces the wrought iron. The individual iron pancakes obtained by this process, served as the building blocks in the construction of the pillar. The heated iron pancakes were then placed one over another and both were joined by hammering using hand-held hammers. The presence of forged structure is also corroborated by the microstructural analysis of the iron pillar polished and un-polished regions is less for the main body but more at the decorative top region.

Passive film formation on the iron pillar

The characterization techniques confirmed the presence of crystalline iron hydrogen phosphate hydrate (FePO4.H3PO4.4H2O) with some traces of amorphous iron oxides and oxyhydroxides (α-, δ-,γ-FeOOH and magnetite) in the rust sample. The rust on the iron pillar contains iron hydrogen phosphate hydrate phase. It was found that the compositional and microstructural homogeneities of the pillar had no effect on the protective film formation, but the phosphorus content was the main deciding factor. Enrichment of P content in the rust is the main reason for corrosion resistance of the iron pillar.

The formation of protective layer of rust can be understood in the following steps. In the first step, the enrichment of P on the surface on exposure to atmospheric moisture produces phosphoric acid at the metal rust interface. Phosphoric acid causes dissolution of Fe into iron dihydrogen phosphate. In the second step precipitation of monohydrogen phosphate $FeHPO_4$ and tribasic iron phosphate $Fe_3(PO4)_2$ takes place. By alternate wetting and drying cycles of atmosphere, the Fe^{2+} gets oxidized to Fe^{3+} and thus ferric phosphate is formed. Finally, in third step, $Fe_3(PO_4)^2$ is oxidized by atmospheric oxygen and H_3PO_4 to form iron hydrogen phosphate hydrate .

$2H_3PO_4+Fe \rightarrow Fe(H_2PO_4)_2 + H_2$

$Fe(H_2PO_4)_2 \rightarrow Fe_3(PO_4)_2+4H_3PO_4$

$Fe(H_2PO_4)_2 \rightarrow FeHPO_4 + H_3PO_4$

$2Fe_3(PO_4)_2+8H_3PO_4+3 / 2(O_2)+21H_2O \rightarrow 6Fe(PO_4.H_3PO_4.4H_2O)$ I

It has been estimated that, the thickness of the rust on a steel sample kept at the pillar site were found to be 0.2 mils per year . The thickness of the scale formed has been reported to be 50-500 μm in 1600 years.The rust layers formed on iron initially contain γ-FeOOH, which gets transformed into α-FeOOH in natural

alternate wet and dry conditions, providing corrosion resistance to the passive scale formed on the surface of the Iron Pillar.

Other Iron Pillars and Beams

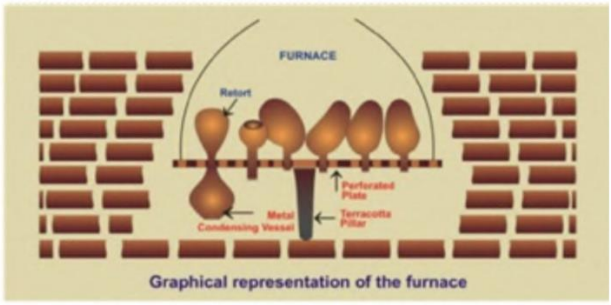
There are a few more such pillars in India, for instance at Dhar (Madhya Pradesh) and Kodachadri Hill (coastal Karnataka). Besides, the same technology was used to manufacture huge iron beams used in some temples of Odisha, such as Jagannath of Puri (12th century). The iron beams at Konarak's famous sun temple are of even larger dimensions.

Chemical analysis of one of the beams confirmed that it was wrought iron of a phosphoric nature (99.64% Fe, 0.15% P, traces of C, traces of S and no manganese).

Zinc

Indian metallurgists were familiar several other metals, of which zinc deserves a special mention because, having a low boiling point (907°C), it tends to vaporize while its ore is smelted. Zinc, a silvery-white metal, is precious in combination with copper, resulting in brass of superior quality. Sometimes part of copper ore, pure zinc could be produced only after a sophisticated 'downward' distillation technique in which the vapour was captured and condensed in a lower container. This technique, which was also applied to mercury, is described in Sanskrit texts such as the 14th -century Rasaratnasamuccaya.

Remains of furnace with retorts at Zawar



Graphical representation of the furnace

Arched pillars & smooth ore faces in ancient underground mine

View along the zinc smelting furnaces at Zawar Mala site 30

Zinc metallurgy at Zawar mines.
(Courtesy: National Science Centre, New Delhi)

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Earliest Building Blocks Of Milky Way Galaxy Named Shakti, Shiva By Scientists

Naming these groups of stars 'Shakti' and 'Shiva', astronomers said the findings are the equivalent of "finding traces of an initial settlement that grew into a large present-day city".

SciencePress Trust of IndiaUpdated: March 22, 2024 6:59 pm IS

New Delhi:

Earliest "building blocks" of our Milky Way galaxy have been identified from 12-13 billion years ago, which is very close in time to when the universe's first galaxies started to form, according to a new research.

Naming these groups of stars 'Shakti' and 'Shiva', astronomers said the findings are the equivalent of "finding traces of an initial settlement that grew into a large present-day city". Milky Way is said to have formed by the merging of smaller galaxies, making way for "fairly large building blocks", according to the

researchers. When galaxies collide and their stellar populations mingle, most of the stars retain very basic properties, directly linked to the speed and direction of their origin galaxy, they explained. In this study published in The Astrophysical Journal, the research team from Max Planck Institute for Astronomy, Germany, analysed stellar datasets and found that stars from the merging galaxies were crowded around two specific signatures of energy and angular momentum, or the rate at which a spinning object's rotating speed changes. Two different star groups were thus formed -- 'Shakti' and 'Shiva'. The study's co-author Khyati Malhan named these two structures Shakti and Shiva, the latter one of the principal deities of Hinduism and the former a female cosmic force often portrayed as Shiva's consort. The researchers found that the "like-minded" stars forming Shakti and Shiva, and coming from two different galaxies, had a higher angular momentum compared to the stars at the heart of the Milky Way. The higher angular momentum observed was consistent with the stellar groups that had belonged to separate galaxies merging with the Milky Way, the team said.

Also, all these stars were low in metal content, signalling that they were formed a long time ago. Stars formed recently contain more of heavier metallic elements, they explained. Therefore, their energy and angular momentum, along with low metallic content, comparable with that of the stars at the heart of Milky Way, makes 'Shakti' and 'Shiva' good candidates for some of the earliest ancestors of our Milky Way, the researchers said. "Shakti and Shiva represent two of those early, massive progenitors that coalesced at high redshift - perhaps 12 gigayears ago - perhaps the last event from the protogalaxy before disk formation commenced," they wrote in their study. A gigayear has a billion years.

Shakti and Shiva might be the first two additions to the heart of the Milky Way, initiating its growth towards a large galaxy, said study co-author Hans-Walter Rix from Max Planck Institute for Astronomy. For their analysis, the researchers used

the data provided by the European Space Agency's Gaia satellite and combined it with the stellar datasets from the US Sloan Digital Sky Survey, having detailed information about the stars' chemical composition.

Launched in 2013, Gaia's dataset now includes positions, changes in the positions and distances for almost 1.5 billion stars within our galaxy, providing an ideal dataset for this kind of "big data galactic archeology", the team said. (Except for the headline, this story has not been edited by NDTV staff and is published from a syndicated feed.

Sharing A Drink With Your Partner? You Might Live Longer, Says Study

According to a researcher at the University of Michigan, couples who drink together could also potentially enjoy longer lives together.

Science Edited by Nikhil Pandey Updated: April 05, 2024 12:19 pm IST

A University of Michigan study suggests couples who share similar drinking habits tend to live longer than those who don't. Researchers analysed data from over 9,000 heterosexual, married, or cohabiting couples. They found couples who both drank moderately lived longer than couples where one partner drank heavily or neither drank. In a recent study published in The Gerontologist, researchers caution against interpreting this as encouragement to drink more. The exact reason for the link between shared drinking habits and longevity remains unclear. However, the study highlights how couples' lifestyles can influence each other's health. Couples with similar drinking habits may reflect a more synchronised lifestyle and better relationship satisfaction. Kira Birditt, research professor at the U-M Institute for Social Research's Survey Research Centre, found that couples who are concordant in their drinking behaviour (that is, both members drink alcohol) tend to live longer.

She says in a statement that a theory in alcohol literature called "the drinking partnership," where couples who have similar patterns of alcohol use tend to have better marital outcomes (such as less conflict and longer marriages), was the inspiration behind the study. Although a great deal of research has examined the implications of couples' drinking patterns for marital outcomes, the implications for health are less clear. Behaviours that are good for marriage are not necessarily good for health, Birditt says. "The purpose of this study was to look at alcohol use

in couples in the Health and Retirement Study and the implications for mortality," she said. "And we found, interestingly, that couples in which both indicated drinking alcohol in the last three months lived longer than the other couples that either both indicated not drinking or had discordant drinking patterns in which one drank and the other did not." The study is limited to heterosexual couples and doesn't account for the type of alcohol consumed. Further research is needed to explore how these factors influence couples in same-sex relationships and how the type of alcohol plays a role.

Scientists Create New Tech That Can Read People's Mind With Shocking Accuracy

The region of the brain that Caltech team used was supramarginal gyrus - a crucial component for the understanding and processing of language.

Scientists have made "significant" strides in the field of reading people's minds. According to New York Post, researchers from California were able to decode the thoughts of participants into words with 79 per cent accuracy. The device has been developed by Caltech's T&C Chen Brain-Machine Interface Centre and will help patients with speech and non-verbal disorders. These 'speech decoders' act as brain-machine interface and capture brain activity during inner speech and translate it into language. The technology is making news because of its high accuracy. The study has been published in Nature Human Behaviour.

For the study, the team of researchers implanted tiny devices in specific areas of the brains of two participants. The devices then read signals from the brain, translated and converted "into text in real time", said the study. The participants were asked to think of words like 'spoon', 'python' or 'battlefield'. These thoughts were then translated in real time. "We captured neural activity associated with

internal speech - words said within the mind with no associated movement or audio output," the team wrote.

The device was able to decode different internal speech strategies including reading the word silently and visualising the object the word depicts.

The region of the brain that Caltech team used was supramarginal gyrus - a crucial component for the understanding and processing of language. The technology works according to the same principle as other brain-machine-interface devices such as Elon Musk's Neuralink. In 2023, the University of Texas in Austin successfully used artificial intelligence-powered decoders to accurately analyse a person's brain activity. The non-invasive procedure was done through functional magnetic resonance imaging (fMRI) readings

The Heart Plays a Hidden Role in our Mental Health

The organ sends messages to the brain. How those signals influence it is still unclear
By Laura Sanders :May 16, 2024 at 1:00 pm
Everyone knows that the brain influences the heart.

Stressful thoughts can set the heart pounding, sometimes with such deep force that we worry people can hear it. Anxiety can trigger the irregular skittering of a trial fibrillation. In more extreme and rarer cases, emotional turmoil from a shock — the death of a loved one, a cancer diagnosis, an intense argument — can trigger a syndrome that mimics a heart attack.

But not everyone knows that the *heart talks back*. Powerful signals travel from the heart to the brain, affecting our perceptions, decisions and mental health. And the heart is not alone in talking back. Other organs also send mysterious signals to the brain in ways that scientists are just beginning to tease apart. A body wide perspective that seeks to understand our biology and behavior is relatively new, leaving lots of big, basic questions. The complexities of brain-body interactions are "only matched by our ignorance of their organization," says Peter Strick, a neuroscientist at the University of Pittsburgh. Exploring the relationships between the heart, other organs and the brain isn't just fascinating anatomy. A deeper understanding of how we sense and use signals from inside our bodies — a growing field called interoception — may point to new treatments for disorders such as anxiety.

"We have forgotten that interactions with the internal world are probably as important as interactions with the external world," says cognitive neuroscientist Catherine Tallon-Baudry of École Normale Supérieure in Paris. These internal signals, most of which we are wholly unaware of, may even hold clues to one of the grandest scientific puzzles of all — what drives human consciousness.

The heart pulls the brain's strings

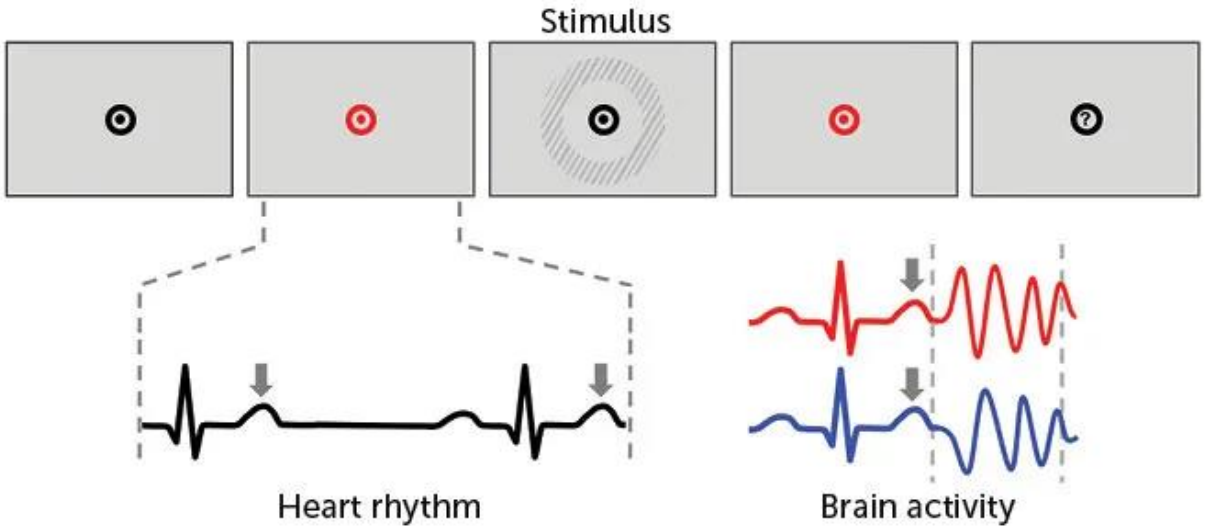
Coalitions of cells in the brain exert exquisite control over the heart. In some parts of the brain, more than 1 in 3 nerve cells influence the heart's rhythm, Tallon-Baudry and her colleagues reported in 2019 in the Journal of Neuroscience. One of these brain regions, the *entorhinal cortex*, is famous for its role in memory and navigation. It makes sense that these two jobs — physically moving through the world and influencing heart rate — would fall to the same neurons; the tasks of seeing a jogging path and priming the heart for running are linked. The brain bosses the heart around. But that's not the whole story — not even close. Scientists are finding that information from *the heart can boss around our brains* and our behavior, too.

Each heartbeat serves as a little signal to the brain. It's an event, much like seeing an apple or hearing the first note of a song. But unlike those external events, the heartbeat signals come from inside the body. The brain senses these internal signals. Each heartbeat prompts a reliable and measurable neural reaction that scientists call a *heartbeat-evoked response, or HER*. And though this heart-initiated, neural thrumming is only on the inside, it can influence what we see in the outside world, Tallon-Baudry and colleagues have found. In one study of 17 people, messages from the heart sharpened eyesight. When certain areas of the brain responded strongly to heartbeat, creating a large HER, people were more likely to see faint gray lines around a red dot. When the HER was weaker, people were less likely to see the lines, the researchers reported in 2014 in Nature Neuroscience.

Seeing with heartbeats

Study participants were asked to look out for a hard-to-see gray circle (stimulus), while scientists measured their heartbeats (left, bottom) and brain activity (right,

bottom) in the same moment (gray arrows). When the brain responded strongly to the heart rhythm, people were more likely to report seeing the gray circle.



Signals from the heart also appear to play a role in memory. In lab experiments, people were shown brief blips of words on a screen. When a word showed up as the heart was contracting, a squeezing phase called systole, people were more likely to forget the word on later memory tests, neuroscientist Sarah Garfinkel and colleagues reported in 2013 in Psychophysiology.

There are hints that the *heart can influence intuitions, decision making and emotions.* People who were better able to feel their hearts' rhythms reacted more intensely to *emotional images* than people who were worse at sensing their heartbeat, for instance. These results and others suggest the tantalizing possibility that our brains are taking in and using information from the heart — and perhaps other interoceptive awareness — to help us make sense of the world. But findings from people are often correlational. It's been hard to know whether beating hearts caused the effects or whether they just happened at the same time.

A recent study in mice got around this problem in an unexpected way (SN: 3/14/23). The experiment relied on a powerful technique that can control neuron behavior with light, developed in part by neuroscientist Karl Deisseroth at Stanford

University. Called optogenetics, the method uses specific wavelengths of light to force cells to fire an electrical impulse (SN: 6/18/21). Along with Deisseroth, bioengineer Ritchie Chen used the technique to control mice's heartbeats with exquisitely precise timing. "We can target a specific cell without ever touching it," says Chen, of the University of California, San Francisco.

With each flash of a light, delivered through a fabric vest worn by the mice, muscles in the heart ventricles contracted, slamming blood out of the heart and into the body. "It was incredibly exciting to see these really precise heart contractions being evoked with light just delivered through the skin," Chen says. The researchers then studied the brains and behaviors of mice whose hearts were set racing. An artificially fast heartbeat didn't always affect mouse behavior, the team was surprised to learn. In some situations, the mice didn't seem to notice. But when they encountered danger — an exposed area, where in the wild the mice would be vulnerable to predators, or a sip of water that could come with a shock — the mice behaved more anxiously when their hearts were forced to race than when their hearts beat normally.

A pounding heart "wasn't this primal circuit to induce panic," Chen says. *The mice were integrating signals from their heart and signals from their environment to arrive at a course of action. "*And that was exciting to us because it meant that the brain was involved." Further experiments turned up a key player in the brain: the insula. The human insula, one on each side of the brain, has been shown to have a role in emotions, internal sensations and pain. Shutting down neuron activity in the mice's insula silenced the racing heart's influence on behavior, the team found.

"Being able to manipulate the heart in this way," Tallon-Baudry says, "opens all sorts of ways to look at things that are much more subtle and might not be related to anxiety at all." The precise control of optogenetics could help researchers investigate the heart's influence on perceptions, decisions and memory — some of

the key attributes that shape how a thinking, remembering, feeling person experiences the world.

Wiring diagrams are missing. In Chen's study, how signals moved from the heart to the insula and beyond isn't clear. "*We are very much at the beginning of circuit dissection between the brain and the body,"* he says. Still, scientists know some of the routes signals can take as they move from the heart to the brain. The textbook version goes something like this: *Muscles in the heart ventricles contract, squeezing blood out. Cells in nearby blood vessels, including the aorta and carotid artery, sense the change and relay it to nerves. One of those nerves is the vagus nerve, a rambling superhighway to the brain that sends missives about heart rates, digestion and breathing (SN: 11/13/15). Once the information arrives at the brain, it bounces from spot to spot in unknown ways. Our knowledge of these biological daisy chains is woefully incomplete, Tallon-Baudry says. "The full story is not so easy to get."*

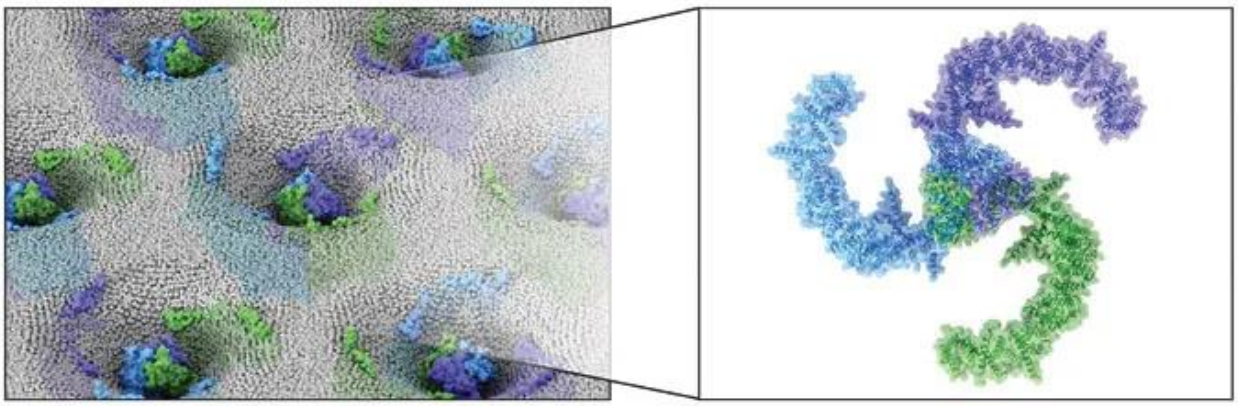
Strick, the neuroscientist at the University of Pittsburgh, shares the same lament: *"There are nerves that speak to the organs, and the organs speak to the brain, but we don't know anything about the wiring diagram,"* how and where these bits of crucial information actually get exchanged. And that's an important thing to be missing. "You can say, "Who is driving whom?' But we're even more primitive than that. We don't have a wiring diagram," he says. One way of scoping out the wiring involves, of all things, rabies virus. Years ago, Strick realized that he could use the virus to trace cell connections in the brain and body thanks to the virus' very unusual trick: Rabies virus can hop backward from neuron to neuron, from message receiver to message sender. When designed to carry a fluorescent molecule, the virus can illuminate entire neural circuits in an animal.

That's what Strick and colleagues have done with various organs — stomach and kidney, for instance — and the brain. Some of the most tantalizing connections he has found are between the *adrenal glands*, which pump out *fight-or-flight hormones in an emergency*, and specific brain regions, especially neural locales that control muscles and that's what Strick would like to do with the heart as well. So far, he has a single glimpse of that data from a monkey. "We have one successful heart injection, and the data's amazing," Strick says. "The regions of the cerebral cortex that control the heart are mind-blowing. But it's an n of 1." This preliminary result needs to be confirmed in more animals, Strick emphasizes.

Tracing these paths would illuminate anatomical connections that undoubtedly exist. Strick and his colleagues are keen to explore more of the body, including the *immune system's spleen and the pancreas.* But another project has raised the possibility of a shortcut that jumps from heart to brain, and it was discovered by accident. *Neuroscientist Veronica Egger of the University of Regensburg in Germany* and colleagues were curious about the connections between nerve cells that process odors. To get a good look at the behavior of these cells, the team co-opted an ultrasimple system: a rat's olfactory bulb, which is a part of the brain that handles smells, and the single blood vessel that supplies it with nutrients. In the experiment, an artificial pump sent fluid through the vessel.

But the experiment yielded a worrisome signal: *rhythmic, collective activity in the nerve cells that seemed to be created by the pump*. "Every neuroscientist knows pump artifacts and hates them," Egger says. But this signal, it turned out, was no artifact. It was the real deal. On a hike, Egger had a flash of insight that led to the discovery. Perhaps, she thought, the neurons were sensing the pressure caused by the pump directly. This direct sensing is a cellular possibility. In 2021, neuroscientist Ardem Patapoutian, a Howard Hughes Medical Institute Investigator at Scripps Research in La Jolla, Calif., had received a Nobel Prize for the discovery

of mechanical sensors called PIEZO1 and PIEZO2, present in many animals including humans. These sensors, which sit in cell membranes and look like three-bladed propellers, can detect pressure changes, including the inflating of lungs that comes after a deep breath, the stretch of a full bladder and the pressure of blood moving through a vessel.



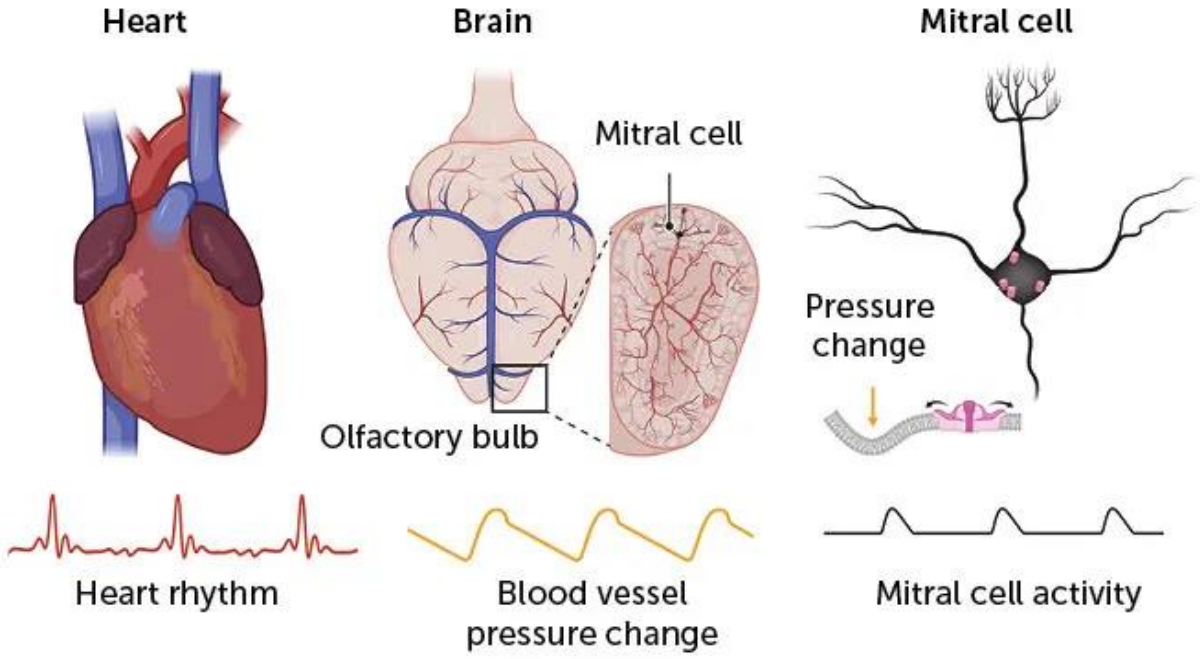
Propeller-shaped proteins called PIEZO channels sit in cell membranes and serve as mechanical sensors. Forces, such as the pressure changes created by pulsing blood vessels, can alter the channels' shape, alerting the cell to the change. M. Poised on neurons in the olfactory bulb, these sensors might be detecting when the pump had pushed fluid. When Egger and her colleagues analyzed the system, they found that the neurons were in fact responding to the pressure changes from the pump. Blood pushing through vessels in mice's brains also influenced the firing activity of nerve cells elsewhere, further experiments revealed. That included the hippocampus, which is involved in memory, and the prefrontal cortex. These effects, aren't large; they're quite subtle, Egger says. "We haven't seen this before because it's a very weak effect." Still, the effect seems to indicate that neurons throughout these rodents' brains have their fingers on the body's literal pulse — an immediate signal that doesn't need to travel through nerves from the heart.

"It is extremely likely that human brains do this," Egger says, though that remains to be shown. Also unclear is what the brain might do with this pulse information or

how it might be used to take measure of the body's internal state. "What the brain needs this fast pathway for is completely unknown," she says. "We just know that it happens."

Message delivered

Brain cells can take the heart's pulse directly. When heart muscles squeeze (left), blood is pumped out into vessels, including those in the brain (rat brain shown, middle). In the olfactory bulb, specialized nerve cells called mitral cells (right) sense and respond to the pressure change, connecting the three rhythms (bottom lines).



Why should we listen to the heart?

With all these lines of research, the field of interoception is energized in a way it hasn't been before, says Garfinkel, of University College London. "It's blown my mind how much the field has changed, and how much people are embracing the idea." One of the reasons for the momentum is that *body-brain communications* might point to ways to treat disorders such as anxiety. "I do think it opens a window in understanding more about the fundamental etiology of these

conditions," Garfinkel says. "Looking at the brain, you're looking at part of the story."

Though Garfinkel was focused on study participants' brain activity initially, she saw that their bodies were also responding, with racing hearts and other signs of panic. "Interoceptive numbing," in which a person is less able to accurately sense their bodily signals, has been linked to suicide attempts. And a lessened awareness of heart activity has been tied to a poorly understood kind of seizure. These days, Garfinkel is listening in on people's heart-brain conversations and testing whether training people to better detect their own heartbeat could alleviate anxiety. Anyone can experience anxiety, but autistic people have higher than average rates of anxiety. In 2021 in e Clinical Medicine, Garfinkel and colleagues reported that after undergoing rounds of training to better sense the rhythm of their hearts, people with autism reported being less anxious. The training procedure asked people to say whether a steady beat they listened to was the same or different from their own internal heartbeat. Over six training sessions, each lasting about half an hour, people's accuracy improved. And their anxiety scores went down.

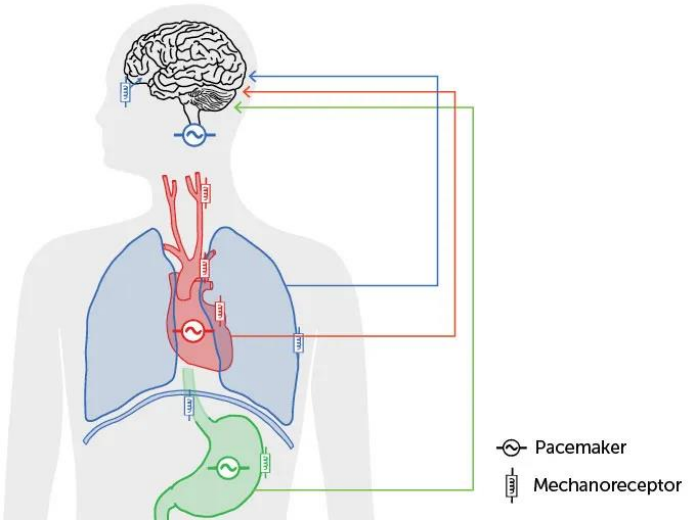
Garfinkel and her colleagues have since found similar results in people without autism, though those results have not yet been published. It's not at all clear why this training procedure might alleviate anxiety, Garfinkel says. But still, the link may point to ways to treat anxiety. In many ways, the body is easier to change than the brain, Garfinkel says. "Rather than hit people with heavy medications that change their brain, it's intriguing and exciting to think there's an easier route — to change the body." Understanding interoception may yield insights that go beyond alleviating anxiety. Some scientists, including Tallon-Baudry, suspect that signals from inside our bodies collectively help give rise to consciousness. The concept that consciousness requires a body that can be sensed and an organism striving to

stay alive isn't new, but recent interoception results have added evidence to support the idea that the body's drive to monitor itself may be more important than previously thought.

Tallon-Baudry and her colleagues studied 68 people who had been fully unconscious. Their goal was to split these people into two groups: Those who still have no signs of consciousness, and those who had signs of consciousness in their brains. The team used HER signals, when a heartbeat prompts a neural thrum, to predict which people may have fleeting moments of consciousness but are unable to show it. "This is the moment when we do find the brain is responding to the heartbeat," she says. These results, published in 2021 in the Journal of Neuroscience, highlight just how rich and powerful signals from the heart to the brain can be, she says.

All together now

Pacemaker cells in the heart, stomach and brain stem (controlling the lungs) and cells that can sense mechanical changes (mechanoreceptors) generate signals that can be used by the brain. These various body rhythms may contribute to a range of tasks, from perceptions to consciousness itself.



And remember that study she did that linked the HER thrum to whether a person saw a faint grid? She says that the people's perception of the grid had a lot to do with the eyes, the visual system, but it also depended on having a perspective — a point of view. But the perception also requires a person to experience the vision, interpret it and have that point of view — the "I" in the simple sentence, "I see it."

Interoceptive signals, and not just those from the heart, but also from the lungs, stomach, muscles, skin and more, may help create a person's sense of self — their "I," their identity as a conscious, aware entity with a point of view. Tallon-Baudry and colleagues described last year in Nature Neuroscience how rhythmic signals from the heart, the lungs and the stomach all converge in the brain. That review also advanced the idea that a sense of self relies on internal body signals.

Without a body and a beating heart, a stomach that can rumble and lungs that fill, the brain would be adrift. We navigate the world by seeing, hearing and touching too. We make choices to stay alive. Perhaps the real magic of consciousness comes from the combinations — of heart and brain, of the outside world and inside world, as mysterious as it may yet be.

Development of organic semiconductors featuring ultrafast electrons

Date: April 19, 2024
Source: Pohang University of Science & Technology (POSTECH)

Summary:

Collaboration has led to the successful observation of these ultrafast electrons within conducting two-dimensional polymers.

Professors Kimoon Kim and Ji Hoon Shim along with Dr. Yeonsang Lee from the Department of Chemistry at Pohang University of Science and Technology (POSTECH) and Professor Jun Sung Kim from POSTECH's Department of Physics and the Center for Artificial Low Dimensional Electronic Systems at the Institute for Basic Science created conducting two-dimensional polymers exhibiting electron mobility comparable to graphene. Their research has been featured in the online edition of Chem, an international chemistry journal.

Graphene, called a "dream material," exhibits electron mobility 140 times faster than silicon and a strength 200 times that of steel. However, its lack of a band gap, which is essential for regulating electrical current, prevents its use as a semiconductor. Researchers have been actively exploring various approaches to develop a semiconductor that shows graphene's exceptional properties. One promising approach is the development of conducting polymers. Researchers are exploring conducting polymers with a fused aromatic backbone, mimicking the chemical structure of graphene, aiming to attain exceptional properties. Yet, challenges arise during synthesis due to the interlayer stacking between growth intermediates, hindering proper polymer growth.

In this research, the team utilized triazacoronene, possessing a chemical structure similar to graphene, and introduced bulky pendant functional groups to its periphery. By introducing steric hindrance from these pendant groups, the team

successfully suppressed the stacking of two-dimensional polymer intermediates during the polymerization of triazacoronene monomers. This led to increased solubility of the intermediates and facilitated the synthesis of two-dimensional polymers with higher degree of polymerization and fewer defects, resulting in outstanding electrical conductivity after p-type doping.

Remarkably, magnetotransport measurements revealed that coherent multi-carrier transport with finite n-type carriers show exceptionally high mobility over 3,200 cm2 V−1 s−1 and long phase coherence length surpassing 100 nm, in stark contrast to hole-carrier transport with 25,000 times lower mobility at low temperatures. This dramatic disparity between electron and hole-carrier transport is attributed to spatially separated electronic states near the Fermi level, which consists of dispersive and flat bands. Professor Kimoon Kim from POSTECH expressed the significance of the research by saying, "We've achieved a breakthrough in addressing the low electron mobility, a major challenge in organic semiconductors, and in controlling the conduction pathways for electrons and holes at the molecular level." He added, "This research shed light on enhancing material performance across various industrial applications including batteries and catalysts.

Scientists Grow Diamonds In Minutes Using Liquid Metal

Researchers have devised a new liquid metal alloy system for producing diamonds at moderate pressure conditions. Diamonds typically take billions of years to form naturally and weeks to be produced synthetically. But researchers have developed a new method using a special liquid metal mix that can grow diamonds in just 150 minutes, all at normal atmospheric pressure. This new technique eliminates the need for the immense pressure traditionally required for diamond production. The researchers, led by a team from South Korea's Institute for Basic Science, believe this method can be scaled up for significant industrial applications.

While dissolving carbon in liquid metal isn't a new idea, previous methods still involved high pressure and diamond seeds. This new approach utilizes a specific blend of liquid metals - gallium, iron, nickel, and silicon - heated rapidly in a vacuum chamber with methane and hydrogen gases. ge limitations, such as the current diamond film's depth, but they believe improvements can be made through a larger growth area and optimized carbon distribution methods.

This new technique has the potential to revolutionize diamond production across various fields, from industrial applications and electronics to quantum computers. The study's authors believe this liquid metal approach can be further developed to grow diamonds on diverse surfaces and even on existing diamond particles.

This research, published in the journal Nature, holds promise for a faster, easier, and more efficient way to produce diamonds.

Science Says Hugs Help Fight Pain, Anxiety, And Depression

A research team analyzed over 130 international studies involving around 10,000 participants to understand the impact of touch on humans.

Science :

A new study confirms that physical touch, including hugs, can significantly improve both your mental and physical health. Researchers from Germany and the Netherlands reviewed over 200 studies on touch and found it can reduce pain, anxiety, and depression in people of all ages. Interestingly, even short, gentle touches seem to have a positive effect. A research team from Bochum, Duisburg-Essen, and Amsterdam analysed over 130 international studies with around 10,000 participants to answer these questions. The researchers proved that what touch really does is alleviate pain, depression, and anxiety. The team published their findings in the journal Nature Human Behaviour on April 8, 2024.

The study also found that, while humans and animals provide the most well-rounded benefits, even inanimate objects like weighted blankets can offer some physical comfort. However, human or animal touch appears to be key for mental well-being. This positive impact of touch is especially strong for newborns when it comes from a parent. As we get older, the familiarity of the touch giver seems to matter less.

"We were aware of the importance of touch as a health intervention," says Dr Julian Packheiser from the Institute of Cognitive Neuroscience at Ruhr University Bochum. "But despite many studies, it remained unclear how to use it optimally, what effects can be expected specifically, and what the influencing factors are." Following the comprehensive meta-analysis, the team was able to answer many of these questions. Both adults and infants benefit from touch. "In the case of infants, it's important that it is the parents who administer the touch; their touch is more

effective than that of a care professional," points out Dr. Helena Hartmann from the University of Duisburg-Essen. "In adults, however, we found there was no difference between people our volunteers were familiar with and a nursing professional." The researchers caution that touch should always be consensual, and individual responses can vary. However, this large-scale analysis suggests that incorporating more physical contact into our lives could be a simple yet powerful way to boost our overall health. So next time you see someone you care about, don't hesitate to reach out for a hug.