TARGET PRELIMS 2024
BOOKLET-40; S&T-14
CA UPDATES ON S&T-2

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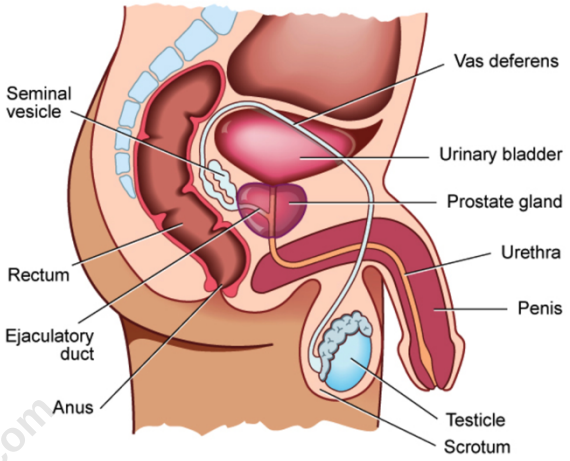
1. HEALTH

1) PROSTATE CANCER

- **What is Prostate?**
  - » Prostate is a gland which is part of **male reproductive system**.
  - » **What is the function of Prostate?**
    - ▫ Prostate contributes additional fluid to your semen (ejaculate). Ejaculate is a whitish grey fluid that release from your penis when you get orgasm. It contains enzymes, zinc and citric acid, which help nourish sperm cells and lubricate your urethra.
    - ▫ Prostate muscle also helps push semen into and through your urethra when you orgasm.
  - » **Location**: Prostate gland is located below the bladder and in front of your rectum. The urethra runs through the centre of the prostate.
  - » **Note**: **Women doesn't have prostate gland**. Women and people Assigned Female at Birth (AFAB) have Skene's gland. However, some people refer to Skene's gland as the female prostate gland.
  - » **Note**: Sperm is produced by Testes and not in Prostate.
  - » **Urethra**: It is the tube through which ejaculate and pee flow out of your body.



- **Prostate Cancer**: It is the one of the most common type of cancer that affects men and people assigned male at birth (AMAB).

- **Lancet Report (April 2024)**
  - » **Situation in India**:
    - » **Prostate cancer** accounts for 3% of all cancers in India, with an estimated 32K to 42K new cases diagnosed annually.
    - » Large proportion of cases are diagnosed in advanced stage which means that the **cancer has spread at the time of diagnosis**. Therefore, 65% of the patients die of the disease.
    - » **Prostate Cancer cases** in India will double to 71,000 new cases per year by 2040.
      - **Why?**
        - Ageing population and increasing life expectancy means there will be higher number of older men in the coming years.
        - The **main risk factors** are age and genetics, which, according to him, are **aggravated** by additional factors like smoking, obesity, a poor diet and lifestyle.
  - » **Global Scenario**:
    - » Globally cases are expected to double from 1.4 million per year in 2020 to 2.9 million per year by 2040 **with low and middle income countries predicted to see the highest increase**.
  - » **Recommendations**:

» Early testing in men over 60 as prostate cancer account for 3% of high risk cancers in India. This will pickup cancer at treatable stage.

2) H5N1 (BIRD FLU)

- **Since 2020**, a highly pathogenic version of bird flu, H5N1, has been spreading across the globe. It is becoming an existential threat birds and wildlife.

- The **virus** has infected birds in more than 80 countries (as of Dec 2023) and resulted in culling of millions of chickens and turkeys at commercial poultry farm. It also stuck numerous species of wild birds, such as gulls and terns, killing them by thousands.

- The **flu is also spreading to mammals**. Tens of thousands of seals and sea lions in different parts of the world have died due to the disease.

- The infection has also infiltrated mainland Antarctica for the time in history.

- **Factor behind large scale spread**: Largely unknown. Climate change could be one of the reasons. Soaring global temperature impact the behavior of birds in such a way that it exacerbates the spread of flu. These birds are forced to move to new territories and mix with species that they usually don't interact with, which possibly boosts the chances for the virus to spread even further.

3) INDIA TB REPORT, 2024: RELEASED BY MOH&FW IN MARCH 2024

- **Decline in 16% in TB incidence** (new cases emerging each year) since 2015.
  - » The incidence rate has fallen from 23.7 lakh population in 2015 to 19.9 million per lakh in 2022.

- **Decline in mortality due to TB** by 18% since 2015.
  - » Mortality rate has declined from 28 per lakh population in 2015 to 23 per lakh population in 2022, according to the India TB report 2024.

- **The gap between estimated number and actual cases of TB** is closing.
  - » There were only 2.3 lakh missing cases in 2023, as compared to 3.2 lakh the year before.
  - » This gap has been reducing over the years, specially with the government's Ni-Kshay portal tracking all TB patients.

- **Notification from Private sector**: Of all the TB cases notified in 2023, nearly 32% of notification came from the private health care sector which is an increase of 17% from the previous year.

- **Key Initiatives:**

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» After the COVID-19 pandemic, the National TB Elimination Program (NTEP) embarked on a journey towards accelerating TB elimination, guided by the National Strategic Plan (NSP) 2017-25.

» **NTEP**: It continued providing free diagnostic services, conducting approx. 1.89 crore sputum smear test and 68.3 lakh nucleic acid amplification tests (NAAT) in 2023.

» **DBT under the Nishay Poshan Yojana** continued to provide financial support to TB patients, with approx. Rs 2,781 crore disbursed to approximately one crore beneficiaries. It added that more than 1.5 lakh **Nikshay Mitras** have come forward and committed support persons affected with TB.

2. DEFENCE

1) AGNI-P (OR AGNI-PRIME)

- **Why in news?**
  - » New Generation Ballistic Missile Agni-Prime successfully flight tested by Strategic Force Command & DRDO (April 2024: Source - PIB)

- **Details**
  - » Agni P is **a new generation advanced variant of Agni class of missiles**. It is **a two stage, surface to surface, solid fueled, canisterized missile** with range capability between 1,000 and 2,000 kms. It is being developed by DRDO and will be successor of Agni-1 and Agni-2 missiles.
  - » It is the sixth missile in the Agni Series of **ballistic missile**. Since it is canisterized, it can be transported on train or stored in canister.
  - » It is also **lighter than earlier Agni Missiles**.

- **April 2024 Test**: Strategic Force Command (SFC), along with DRDO, conducted the successful flight-test of the New Generation Ballistic Missile Agni-Prime from Dr APJ Abdul Kalam Off the coast of Odisha. The **test met all the trial objectives** validating its reliable performance.
  - » Note: The missile was first tested in June 2021. Then in June 2023, the first pre-induction night launch was conducted by the users after three successful development trials of the missile, validating the accuracy and reliability of the system.

- **Background:**
  - » **Agni class of missiles** are the mainstay of India's nuclear launch capability which also includes the Prithvi short range ballistic missiles, submarine launched ballistic missiles and fighter aircraft. The longest of the Agni series, Agni-V, an Inter-Continental Ballistic Missile (ICBM) with a range of over 5,000 km, has already been tested several times and validated for induction.

2) AKASHTEER SYSTEM

- **Why in news?**
  - » Army inducts indigenous Akashteer system (April 2024)

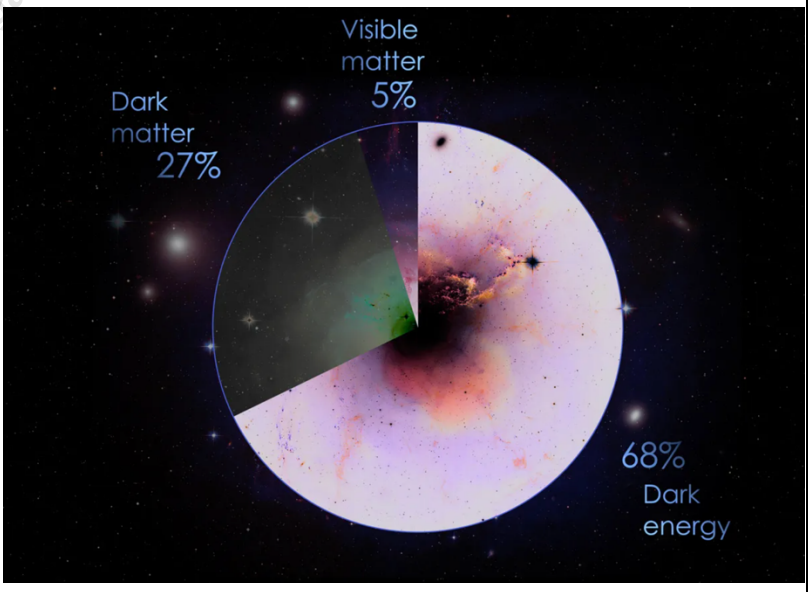
- **About Akashteer**:
  - » The Automated Air Defence Control & Reporting System 'Project Akashteer' is an initiative to **automated air defence control** and **reporting processes by digitizing the entire process**.
  - » It will empower the Air Defence Unit of Indian Army with an indigenous, state of art capability, **to effectively operate in an integrate manner**. It will enhance the operational efficiency and integration of the Army's air defence mechanisms.
  - » It will **enable monitoring of low-level airspace** over the battle areas of Indian army and effectively control the Ground Based Air Defence Weapon Systems.
- **In April 2024**, Army started induction of control and reporting systems under 'Project Akashteer' to bolster its air defence capabilities.
- **Earlier in May 2023**, Ministry of Defence had signed a contract with **Bharat Electronics Limited (BEL)** for procurement of Automated Air Defence Control and Reporting System 'Project Akashteer' worth Rs 1,982 crore for the Indian Army.

3. SPACE

1) BUILDING BLOCK OF THE UNIVERSE: NORMAL MATTER, DARK MATTER AND DARK ENERGY

- **Introduction**: Everything that we can observe in the universe is made of matter. **Matter** is defined as any substance that has mass and occupies space. But there is more to the universe than the matter we can see. **Dark Matter** and **Dark Energy** are mysterious substances that affect and shape the cosmos, and scientists are still trying to figure them out.

- **Normal Matter**: It makes up everything that we can observe. This matter can be seen by us in visible light with our own eyes or through a telescope that can detect light we can't see, like ultraviolet or infrared. It can exist as a gas, liquid, or plasma of charged particles. While normal matter is everywhere in our daily lives, it composes less than 5% of the total universe.



- **Dark Matter**: Like ordinary matter, dark matter takes up space and holds mass. But it doesn't reflect, absorb, or radiate light – at least not enough for us to detect yet. While scientists have measured that dark matter makes up about 27% of the cosmos, they're not sure what it is. **Theories** include several kinds of as-yet unidentified types of particles that rarely interact with normal matter.

» **How was Dark matter first understood**: In the 1930s, Swiss astronomer Fritz Zwicky coined the term while studying the Coma galaxy cluster. It contains more than 1,000 galaxies. The speed at which galaxies within a galaxy cluster move depends on the cluster's total mass and size. Zwicky noticed that **galaxies in the Coma Cluster were moving faster than could be explained by the amount of matter astronomers could see**.

- **Dark Energy**: It may be comprising roughly 68% of the universe, but **scientists know even less** about it than they do about dark matter. But **something like dark energy must exist to explain the universe's accelerating expansion**.

- Since the late 1920s, astronomers have known that the **universe is expanding**. In the 1990s, observations of distant star explosions, called supernova, showed that the **universe expanded more slowly in the past than it does now**. The reason for this remains unclear, but the leading explanation is that the universe contains something that has a **repulsive gravitational effect** – it pushes the universe apart instead of pulling it back together. This phenomenon is called dark energy.

1) DARK ENERGY SPECTROSCOPIC INSTRUMENT (DESI)

- An international team of scientists has released the **most comprehensive "three dimensional" map of the Universe**, which, scientists hope, **could reveal some clues about dark energy**, the mysterious force that is believed to be causing the universe to expand uncontrollably.
- The researchers, including a team from India's TIFR, has published its findings from the first year of observation by the **Dark Energy Spectroscopic instrument, or DESI.**
  - » DESI is a unique piece of equipment that, once fitted over a telescope, can capture light from 5,000 galaxies at the same time.
  - » **DESI** is measuring the effect of dark energy on the expansion of the Universe. It is obtaining optical spectra for 10s of millions of galaxies and quasars, constructing a 3D map spanning the nearby universe to **11 billion light years**.
  - » **The survey** is being conducted on the **Mayall 4-mter telescope** at Kitt peak national observatory, Arizona, USA.

- **The key thing** is that scientists have been able to **measure the distance between these galaxies** with a very high degree of accuracy. This is why **scientists are calling it a 3-D Map**. Knowing the precise distances of the galaxies is crucial because that allows us to **calculate the expansion rate of the Universe**. This can offer first clues into the mystery of dark energy.

- **Some important information provided by DESI**:
- The DESI collaboration has measured that the expansion rate of the Universe was increasing by 68.5 km/s after every 3.26 million light year of distance, a unit astronomers define as **megaparsec**. This expansion rate can give first clue into the behavior of dark energy.

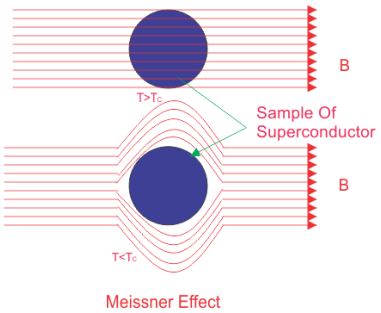
- **Future**: So far scientists have analyzed only 1 year of observational data from DESI. On 31st March 2024, DESI has been collected data for 3 years and it is scheduled to run for five years.

4. PHYSICS: MISCELLANEOUS TOPICS

1) SUPERCONDUCTIVITY

- **Why in news?**
  - » In Aug 2023, two South Korean researchers posted two related papers on the internet, not yet peer-reviewed, claiming that a lead based compound they had developed had shown superconducting properties at room temperature, under normal pressure conditions. (Aug 2023)

- **Definition**
  - » Some materials when they are cooled below certain temperatures ($T_{critical}$), they lose all electrical resistivity. This is called superconductivity.
    - ▫ It is one of the nature's most intriguing quantum phenomenon and was first discovered more than 100 years ago in mercury cooled to temperature of liquid helium (-270 degree C) by **Heike Kamerlingh-Onne**s in 1911. He received 1913 physics Nobel Prize.
    - ▫ **How many elements show superconductivity.**
      - Almost half of the elements in the periodic table display low temperature superconductivity, but applications of superconductivity often employ easier to use or less expensive alloys. For e.g., MRI machines use an alloy of niobium and titanium.
  - » **At what temperature superconductivity is achieved**: The first material to have been discovered to show superconductivity was mercury. Most of the other materials commonly used as superconductors - Lead, Aluminium, Tin, Niobium, and several others also become superconducting at comparable temperatures, called **Critical temperature.**
  - » **In some cases**, superconductivity is achieved at slightly higher temperature but that is under increased pressure conditions.
  - » Even the materials that are classified as '**high temperature superconductors**', as of now, show superconductivity properties only **well below -150 degree C**.
  - » The temperature at which the metals change from normal conducting state to superconducting state is called **Critical/Transition** temperature.
    - ▪ For e.g. below 4-degree Kelvin the metal mercury becomes a superconductor, therefore critical temperature for mercury is 4 K.
- ▪ The transition from normal conducting stage to superconducting stage is **reversible**.
- The super conducting material shows **some extra ordinary properties** which make them very important for modern technology. The research is still going on to understand and utilize these extraordinary properties of superconductors in various fields of technology.
  - ▫ **Infinite conductivity** (zero electric resistance)
    - » **Persistent current**
  - ▫ **Meissner Effect**: a superconductor, expel the magnetic field and doesn't allow the magnetic field to penetrate inside it. This phenomenon in superconductors is called Meissner effect.
  - ▫ **Critical temperature**
  - ▫ **Critical magnetic field**



Meissner Effect

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- **Critical Current**

- **Applications of Superconductivity**
  - **Medical Sector:** Used in magnetic resonance imaging, Magnetic Source imaging etc.
  - **Electric Engineering:** For generation of high performing generators, motors, transformers, relays, superconducting magnets etc.
  - **Electronics: Quantum Computing**, high quality sensors, filters, circuitry radar etc.
  - **Transportation:** Magnetically levitated trains, Marine propulsion motors etc.
  - **Fundamental Physics:** Particle accelerators, Magnets, Plasma / fusion research etc.

- **Superconductivity at Room Temperature???**
  - The **holy grail of superconductivity** today is to **find or create materials that can transfer energy between each other in a non-pressurized container**.
    - If an efficient superconductor becomes possible at room temperature, it would revolutionize power transmission system for industry, commerce, and transportation.
  - **Several Wrong Claims and Skepticism**: In recent years several claims of achieving superconductivity at room temperature has been found to be wrong. This has made scientific community a bit skeptic about any such new claim.
    - For e.g. in July 2023 only a research paper published in Physical Review Letters in 2021, by a US-based researcher making a similar claim had to be retracted.
    - Scientists at IISc Bengaluru had made similar claims in 2018, only to be sent for more reviews. The case is still unresolved.
  - **In July 2023**, the South Korean researchers have posted two related papers on internet, not yet peer reviewed, claiming that a lead-based compound that they had developed had shown superconducting properties at room temperature, under normal pressure conditions. They are calling this material to be **LK-99**.

2) QUANTUM MECHANICS

- **Introduction**
  - Quantum mechanics is the science of very small. Quantum mechanics explains the behaviour of matter and its interaction with energy on the scale of atoms and subatomic particles.
  - **Three revolutionary principles**
    - **Quantized Property**
      - Some properties, such as position, speed and color, can sometimes only occur in specific set amounts.
    - **Particles of Light**
      - Light can sometimes behave as particles.
    - **Waves of Matter**
      - Matter can also behave like wave.

  - **Differences between Classical Mechanics and Quantum Mechanics**

Concept	Classical Mechanics	Quantum Mechanics
	Continuous, everything is allowed	**Discrete**, discontinuous, not all allowed

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	All wavelength available in light	Each element is unique, not every wavelength is possible
	Something is wave or particle	Both - everything is wave and particle
Heisenberg's uncertainty principle	Know position and velocity precisely	Know either position of velocity precisely. We can't know both accurately

» **Uses**
  - Since the breakthrough of renormalization, QFT has served as the foundation for developing quantum theories about four fundamental forces of nature
    - » Electromagnetism
    - » The weak nuclear force
    - » The strong nuclear force
    - » Gravity

» **Uses for real life.**
  - **Ultra-Precise Clocks**
    - » Atomic clocks, are able to use principle of quantum theory to measure time
  - **Uncrackable codes**: **Quantum Cryptography**
  - **Superpower Computers**
    - » Quantum computers supercharge processing power because they use quantum bits, or qubits, which exist in a superposition of states - until they are measured, qubits can be both 1 or 0 at the same time.
  - **Improved Microscopes**
    - » This type of microns **fires two beams of photons at a substance** and measures the interference pattern created by the reflected beam - pattern change based on whether they hit flat or uneven surface.
  - **Biological Compass**
    - » A light sensitive protein called cryptochrome, which may contain entangled electrons.

3) ATOMIC CLOCK

- An atomic clock is a clock device that uses an **electronic transition frequency** in the microwave, optical, or ultraviolet regions of the electromagnetic spectrum of atoms as a frequency standard for its timekeeping element.
- They are the most accurate time and frequency standards known and are used as primary standards for international time distribution services, to control the wave frequency of television broadcasts, and in global navigation satellite systems such as GPS.
- **Principle**
  - » Based on atomic physics. It uses the microwave signal that **electrons in atoms emit when they change energy levels**.
  - » When exposed to certain frequencies of radiation, such as radio waves, the subatomic particles called electrons that orbit an atom's nucleus will "jump" back and forth between energy states.

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Clocks based on this jumping within atoms can therefore provide an extremely precise way to count seconds.

» Currently the most accurate atomic clocks first cool the atoms to near absolute zero temperature by slowing them with lasers and probing them in atomic fountains in a micro-wave filled cavity.

» Since 1967, the official definition of a second is **9,192,631,770** cycles of the radiation that gets an atom of the **element called cesium to vibrate between two energy states**.

▪ Inside a cesium atomic clock, cesium atoms are funneled down a tube where they pass through radio waves. If this frequency is just right 9,192,631,770 cycles per second, then the cesium atoms "resonate" and change their energy state.

» **Accuracy**

▪ The NIST-F1 cesium clock can produce a frequency so precise that its time error per day is about 0.03 nanoseconds, which means that the clock would **lose one second in 100 million years**.

- **Where is atomic clock used -> Wherever accurate timings are required:**
  - » Satellite navigation services
    - ▪ E.g. GPS
  - » CERN lab for precisely timing the collision.
  - » Standard organization (to provide accurate time)

4) NOBEL PRIZE IN CHEMISTRY: QUANTUM DOTS

- **Quick Summary**:
  - » The **Royal Swedish Academy of Sciences** has decided to award the Nobel Prize in Chemistry, 2023 to:
    a. **Moungi G. Bawendi** (MIT, USA)
    b. **Louis E. Brus** (Columbia University, USA)
    c. **Alexei I. Ekimov** (Nanocrystals Technology Inc., New York, NY, USA)

  "**For the discovery and synthesis of "Quantum Dots**".

- **Details**:
  - » **Quantum Dots** are nanoparticles so tiny that their size determines their properties.
    - ▪ **Understanding Size of Quantum Dots**:

A quantum dot is a crystal that often consists of just a few thousand atoms. In terms of size, it has the same relationship to a football as a football has to the size of the Earth.

- **Understanding Properties:** They have many fascinating and unusual properties. Importantly, they have different colors depending on their size.

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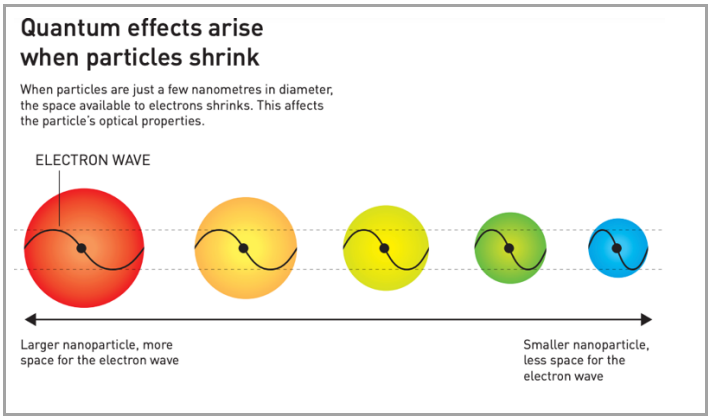

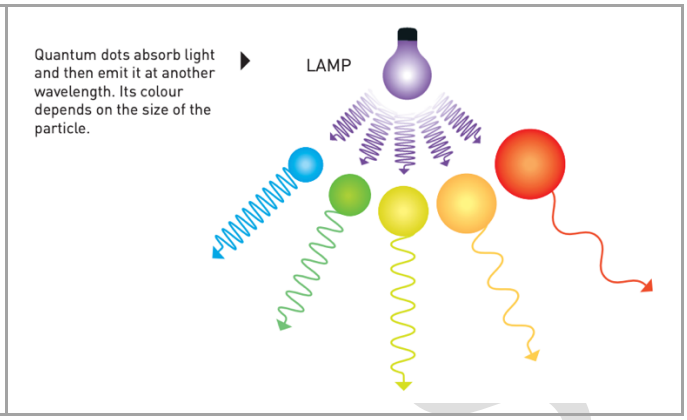

- **For decades**, Quantum phenomena in the nanoworld were just a prediction.
- **Contributions:**
  - » **In the early 1980s,** Alexie Ekimov and Louis Brus succeeded in creating - independently of each other - quantum dots, which are nano-particles so tiny that quantum effects determine their characteristics.
    - ▫ **Alexie Ekimov**, in early 1980s, succeeded in creating size-dependent quantum effects in colored glasses.
      - ▪ The color came from nanoparticles of copper chloride and Ekimov demonstrated that the particle size affected the color of the glass via quantum effects.
      - ▪ This was the first time someone had succeeded in deliberately producing quantum dots - nanoparticles that cause size-dependent quantum effects.
    - ▫ **Louis Brus**, a few years later, was the first scientist in the world to prove **size-dependent quantum effects** in particles floating freely in a fluid.
  - » **Moungi Bawendi**, in 1993, revolutionized the chemical production of quantum dots, resulting in almost perfect particles. This high quality was necessary for them to be utilized in applications.

- **Applications:**
  - » Researchers have primarily utilized quantum dots to create colored light.
    - ▪ The luminous property of quantum dots are utilized in **computer and television screens** based on QLED technology, where the Q stands for quantum dot.
    - ▪ In these screens blue light is produced using the energy-efficient diodes that were recognized with the Nobel Prize in Physics 2014. **Quantum dots are used to change the color of some of the blue light, transforming it into red or green**. This makes it possible to produce three primary colors of light needed in a television screen.
  - » **LED Lamps**: Quantum dots are used in LED lamps to adjust the cold light of the diodes. The light can then become as energizing as daylight or as calming as the warm glow from a dimmed bulb.
  - » **Biochemistry and Biomedicine**: Biochemists attach quantum dots to biomolecules to map cell and organs. Doctors are also investigating the potential use of quantum dots to track tumour tissue in the body. Chemists instead use the catalytic properties of quantum dots to drive chemical reactions.
  - » **Health Sector**: These can guide surgeons when they remove tumour tissues, among many other things.
  - » **Future Applications**: Researchers believe that in the future they could contribute to flexible electronics, tiny sensors, thinner solar cells, and quantum cryptography.

5) THE NOBEL PRIZE IN PHYSICS 2023: ATTOSECOND PHYSICS

- **Quick Summary:**
  - » **Anne L'Huillier**, **Pierre Agostini** and **Ferenc Krausz** have been awarded Nobel Prize in Physics, 2023.
  - » **What did they do?**
    - ▫ Through their experiments, they have created **flashes of light that are short enough to take snapshots of electrons**' extremely rapid movements.
    - ▫ **Anne L'Huillier** discovered a new effect from laser light's interaction with atoms in a gas.
    - ▫ **Pierre Agostini** and **Ferenc Krausz** demonstrated that this effect can be used to create shorter pulses of light than were previously possible.

- **Background: Understanding the Problem**:
  - » Human eyes cannot clearly see hummingbird's beating its wings which can be around 80 times per second. We are only able to perceive this as a whirring sound and blurred movement. It is because extremely short events are impossible to observe by human eyes.
  - » **High Speed photography** can capture detailed images of fleeting (short) phenomena. **A highly focused photograph of a hummingbird in flight requires an exposure time that is much shorter than a single wingbeat**.
  - » **The faster the event, the faster the picture needs to be taken if it is to capture the instant**.
  - » **Atom's** natural timescale is that of femtoseconds (10^{-15} sec). These movements can be studied with the very shortest pulses that can be produced with a laser.
    - ▪ A **femtosecond** was, in the 1980s, regarded as the limit for the flashes of light it was possible to produce.

Explanation:	Light consists of waves – vibrations in electrical and magnetic fields – that move through a vacuum faster than anything else. These have different wavelengths, equivalent to different colours. For example, red light has a wavelength of about 700 nanometres (4.29 * 10^{14} Hz), one hundredth the width of a hair, and it cycles at about four hundred and thirty thousand billion times per second. We can think of the **shortest possible pulse of light as the length of a single period in the light wave**, the cycle where it swings up to a peak, down to a trough, and back to its starting point. In this case, the wavelengths used in ordinary laser systems are never able to get below a femtosecond, so in the **1980s this was regarded as a hard limit for the shortest possible bursts of light**

- But, electrons natural timescale is further lower in **attoseconds (10^{-18} sec)** i.e. in the world of electrons, positions and energies change at speeds of between one and a few hundred attoseconds. Therefore, flashes of light produced at femtosecond was not enough to see processes occurring on the timescale of electrons.

- **Development of Attosecond Pulses**:
  - » The mathematics that describes waves demonstrate that any wave form can be built if enough waves of the right sizes, wavelengths, and amplitudes (distance between peaks and troughs) are

used. The **trick to attosecond pulses** is that it is possible to make shorter pulses by combining more and shorter wavelengths.

» **In 1987**, **Anne L' Huillier and her colleague**s at a French laboratory passed an infrared laser beam through a noble gas. The beam's interaction with atoms in the gas produced **overtones** (overtones are waves of light whose wavelength was an integer fraction of the beam. For e.g, if the beam had a wavelength of 100, the overtones would have wavelength of 10, 25, 50 etc.)
  - By finetuning the setup used to produce the overtones, scientists realized that it should be possible to create intense pulses of light each a few attosecond long.

» **In 2001**, **Pierre Agostini** and his research group in France successfully produced and investigated a series of 250-attosecond light pulses, or a pulse train.

» **At the same time**, **Ferenc Krausz** and his team in Australia developed a technique to separate an **individual 650 second pulse from a pulse train**.
  - Using this researcher were able to measure the energy of some electrons released by some krypton atoms.

- **Applications of attosecond physics**:
  » It allows scientists to capture images of activities that happen in incredible short spans. This can be used for exploring short-lived atomic and molecular processes implicated in fields like material, science, electronics, and catalysis.
  » In **medical diagnostics,** attosecond pulses can be used to check for the presence of certain molecules based on their fleeting signatures.
  » These pulses could also be used to develop faster electronic devices, and better telecommunication, imaging and spectroscopy.

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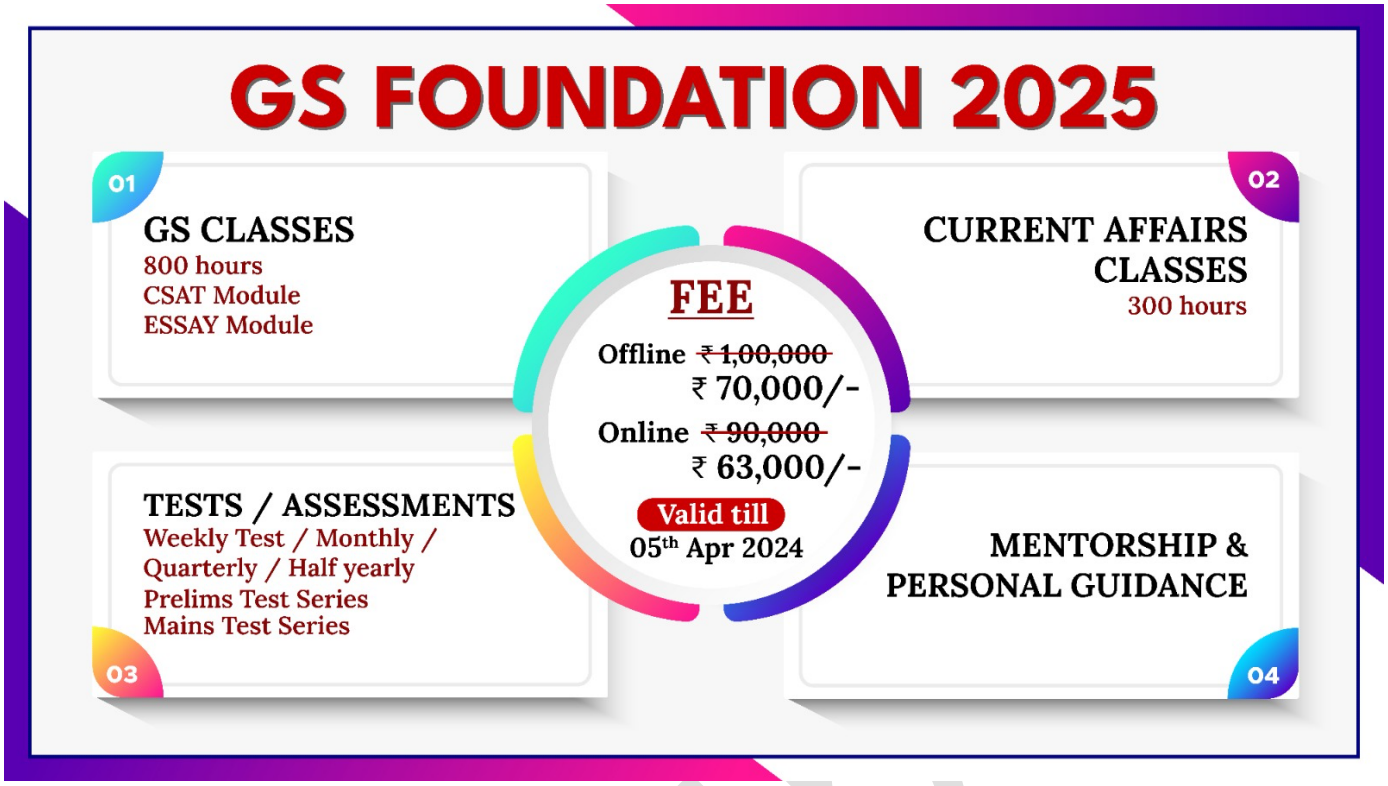

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