Topics

- MOND (for MOdified Newtonian Dynamics),
- Dark Matter
- Particulate Matter
- World wealth report
- Person in news
- Gene Therapy
- Mains

By saurabh Pandey

THE HINDU

Target Mains -2024/25 -

Q ''Economic inequality is an outcome of many inaccessibilities'' Explain

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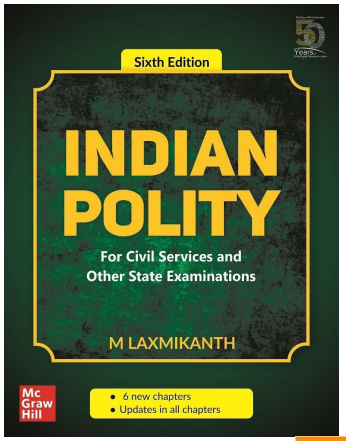

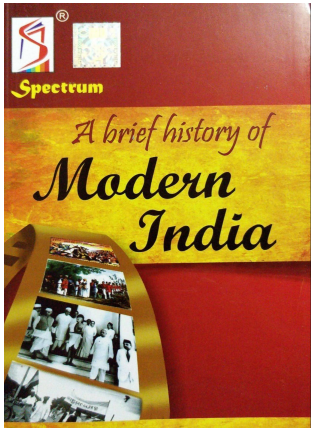

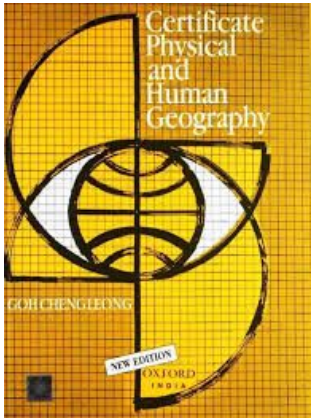

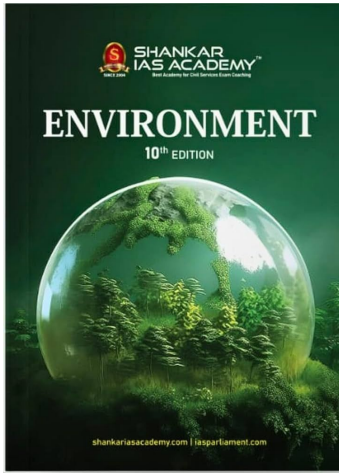

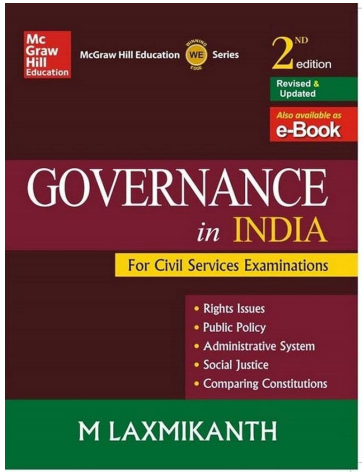

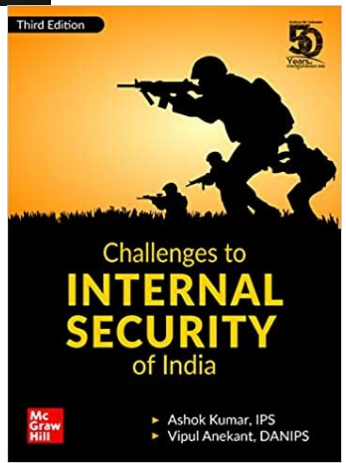

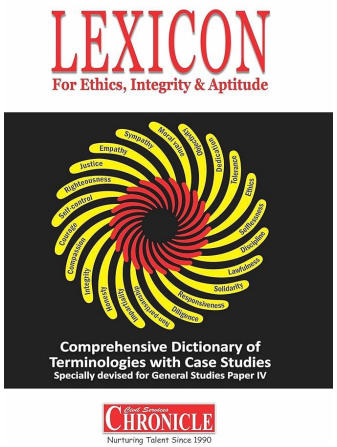

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With bad news from Cassini, is dark matter's main rival theory dead?

To prevent galaxies from flying apart, additional gravity is needed. So the idea of an invisible substance called dark matter was proposed. But nobody has ever seen the stuff, leading to a rival idea, called MOND, that the galactic discrepancies are caused instead by a breakdown of Newton's laws

Indranil Banik
Harry Desmond

One of the biggest mysteries in astrophysics today is that the forces in galaxies do not seem to add up. Galaxies rotate much faster than predicted by applying Newton's law of gravity to their visible matter, despite those laws working well everywhere in the Solar System.

To prevent galaxies from flying apart, some additional gravity is needed. This is why the idea of an invisible substance called dark matter was first proposed. But nobody has ever seen the stuff. And there are no particles in the hugely successful Standard Model of particle physics that could be the dark matter – it must be something quite exotic.

This has led to the rival idea that the galactic discrepancies are caused instead by a breakdown of Newton's laws. The most successful such idea is known as Milgromian dynamics or MOND, proposed by Israeli physicist Mordehai Milgrom in 1982. But our recent research shows this theory is in trouble.

The main postulate of MOND is that gravity starts behaving differently to what Newton expected when it becomes very weak, as at the edges of galaxies. MOND is quite successful at predicting galaxy rotation without any dark matter, and it has a few other successes. But many of these can also be explained with dark matter, preserving Newton's laws.

So how do we put MOND to a definitive test? We have been pursuing this for many years. The key is that MOND only changes the behaviour of gravity at low accelerations, not at a specific distance from an object. You'll feel lower acceleration on the outskirts of any celestial object – a planet, star or galaxy – than when you are close to it. But it is the amount of acceleration, rather than the distance, that predicts where gravity should be stronger.

This means that, although MOND effects would typically kick in several thousand light years away from a galaxy, if we look at an individual star, the effects would become highly significant at a tenth of a light year. That is only a few thousand times larger than an astronomical unit (AU) – the distance between the Earth and the Sun. But weaker MOND effects should also be detectable at even smaller scales, such as in the outer Solar System.

This brings us to the Cassini mission, which orbited Saturn between 2004 and its final fiery crash into the planet in 2017. Saturn orbits the Sun at 10 AU. Due to a quirk of MOND, the gravity from the rest of our galaxy should cause Saturn's orbit to deviate from the Newtonian expectation in a subtle way.

This can be tested by timing radio pulses between Earth and Cassini. Since Cassini was orbiting Saturn, this helped to measure the Earth-Saturn distance and allowed us to precisely track Saturn's orbit. But Cassini did not find any anomaly of the kind expected in MOND. Newton still works well for Saturn.

One of us, Harry Desmond, recently published a study investigating the results in greater depth. Perhaps MOND would fit the Cassini data if we tweaked how we calculate galaxy masses from their brightness? That would affect how much

A multi-spectral view of Messier 74, a.k.a. the Phantom Galaxy, captured by the Hubble and the James Webb Space Telescopes. Galaxy rotation has long perplexed scientists. ESA/WEBB, NASA & CSA, J. LEE

of a boost to gravity MOND has to provide to fit models of galaxy rotation, and thus what we should expect for Saturn's orbit.

Another uncertainty is the gravity from surrounding galaxies, which has a minor effect. But the study showed that, given how MOND would have to work to fit with models for galaxy rotation, it cannot also fit the Cassini radio tracking results – no matter how we tweak the calculations.

With the standard assumptions considered most likely by astronomers and allowing for a wide range of uncertainties, the chance of MOND matching the Cassini results is the same as a flipped coin landing heads up 59 times in a row. This is more than twice the "5 sigma" gold standard for a discovery in science, which corresponds to about 21 coin flips in a row.

More bad news for MOND

That's not the only bad news for MOND. Another test is provided by wide binary stars – two stars that orbit a shared centre several thousand AU apart. MOND predicted that such stars should orbit around each other 20% faster than expected with Newton's laws. But one of us, Indranil Banik, recently led a very detailed study that rules out this prediction. The chance of MOND being right given these results is the same as a fair coin landing heads up 190 times in a row.

> The main postulate of MOND is that gravity starts behaving differently to what Newton expected when it becomes very weak, as at the edges of galaxies

Results from yet another team show that MOND also fails to explain small bodies in the distant outer Solar System. Comets coming in from out there have a much narrower distribution in energy than MOND predicts. These bodies also have orbits that are usually only slightly inclined to the plane that all the planets orbit close to. MOND would cause the inclinations to be much larger.

Newtonian gravity is strongly preferred over MOND on length scales below about a light year. But MOND also fails on scales larger than galaxies: it cannot explain the motions within galaxy clusters. Dark matter was first proposed by Fritz Zwicky in the 1930s to account for the random motions of galaxies within the Coma Cluster, which requires more gravity to hold it together than the visible mass can provide.

MOND cannot provide enough gravity either, at least in the central regions of galaxy clusters. But in their outskirts, MOND provides too much gravity. Assuming instead Newtonian gravity, with five times as much dark matter as normal matter, seems to provide a good fit to the data.

The standard dark matter model of cosmology isn't perfect, however. There are things it struggles to explain, from the universe's expansion rate to giant cosmic structures. So we may not yet have the perfect model. It seems dark matter is here to stay, but its nature may be different to what the Standard Model suggests. Or gravity may indeed be stronger than we think – but on very large scales only.

Ultimately though, MOND, as presently formulated, cannot be considered a viable alternative to dark matter any more. We may not like it, but the dark side still holds sway.

(Indranil Banik is a postdoctoral research fellow in astrophysics, University of St. Andrews. Harry Desmond is senior research fellow of cosmology, University of Portsmouth. This article is republished from The Conversation.)

MOND (for MOdified Newtonian Dynamics),

- In 1983, the physicist Mordehai Milgrom initiated a new research program in cosmology, called MOND (for MOdified Newtonian Dynamics), or Milgromian dynamics.
- In three papers, Milgrom proposed a set of postulates describing how Newton's laws of gravity and motion should be changed in regimes of very low acceleration.
- Milgrom's postulates were designed to explain the asymptotic flatness of galaxy rotation curves, without the necessity of postulating the existence of "dark matter".
- Milgrom showed that a number of other, novel predictions follow from his three postulates, and proposed these predictions as tests of the theory.

What is Dark Matter?

Dark matter is a mysterious, invisible substance that makes up about 27% of the universe's mass and energy. Unlike ordinary matter, it neither emits, absorbs, nor reflects light, making it undetectable through electromagnetic observations.

Its presence is inferred from gravitational effects on visible matter and cosmic structures. The exact nature of dark matter remains unknown, but it is believed to consist of non-baryonic particles.

While it does not interact with electromagnetic forces, its gravitational influence plays a crucial role in shaping the large-scale structure of the cosmos. Research continues to unravel the enigma of dark matter and its impact on the universe.

Goodbye, Cassini

On September 15, the only spacecraft ever to orbit Saturn will dive into the gas giant, ending its 20-year-long mission.

Sources: NASA, ESA

QUICK FACTS

Launched:
Oct 15, 1997

Time in space:
7,276 days

Launch mass:
5,712 kg

Cost:
$3.9bn

Distance travelled:
7.9 billion km

Fuel source:
33kg of plutonium

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Particulate matter, or PM, is the air pollutant most responsible for human morbidity and mortality. FILE PHOTO

Global project 'paints' evidence of air pollution in India

Press Trust of India

Researchers and artists have joined forces for an international project to make invisible air pollution in India visible, demonstrating the health risks posed to the population.

Combining digital light painting and low-cost air pollution sensors, the scientific team produced photographic evidence of pollution levels in cities across three countries — India, Ethiopia, and the U.K. — to spark debate among local communities.

Their findings, published in *Nature Communications Earth & Environment* on Wednesday, record how photographs taken as part of the 'Air of the Anthropocene' initiative stimulated discussion around the impact of air pollution.

The illustrations covered two children's playgrounds in India, 500 km apart — one in urban Delhi, the other in rural Palampur — with PM2.5 values at the Palampur playground at least 12.5 times less than those measured in Delhi.

"Air pollution is the leading global environmental risk factor. By painting with light to create impactful images, we provide people with an easy-to-understand way of comparing air pollution in different contexts — making something that was largely invisible visible," said Francis Pope, an environmental scientist from Birmingham University and co-creator of the project with artist Robin Price.

"Air of the Anthropocene creates spaces and places for discussions about air pollution, using art as a proxy to communicate and create dialogues about the issues associated with air pollution," he said.

Combining digital light painting and low-cost air pollution sensors, the scientific team produced photographic evidence of pollution levels in cities across three countries

Air pollution also varied dramatically between locations in Ethiopia — a kitchen using biomass stoves for food preparation had PM2.5 concentrations up to 20 times greater than an outdoor site nearby.

In Wales, large variations in air pollution around the Tata Steel Port Talbot steelworks were noted. Air quality monitoring and light painting at dusk in summer measured PM2.5 concentrations higher than the hourly average value.

Particulate matter, or PM, is the air pollutant most responsible for human morbidity and mortality. It has multiple impacts on physical health and is responsible for diseases, including heart disease, stroke, and cancers.

The "painting with light" team used low-cost air pollution sensors to measure PM mass concentrations. The sensors' real-time signal was used to control a moving LED array programmed to flash more rapidly as PM concentration increased.

"By providing a visual understanding of air pollution that is accessible to people who don't necessarily have a scientific background, the light painting approach can demonstrate that managing air pollution levels can have a significant impact on people's day-to-day lives," said Mr. Price.

Co-author Carlo Luiu, from the University of Birmingham, commented: "Thanks to the power of images, we can provoke people's emotions — fostering awareness and prompting people to share their perspectives and take action to

Particulate Matter

PM stands for particulate matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.

- **PM10 : inhalable particles, with diameters that are generally 10 micrometers and smaller; and**
- **PM2.5 : fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.**

Sources of PM

These particles come in many sizes and shapes and can be made up of hundreds of different chemicals.

Some are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires.

Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries and automobiles.

What are the Harmful Effects of PM?

- Particulate matter contains microscopic solids or liquid droplets that are so small that they can be inhaled and cause serious health problems.
- Some particles less than 10 micrometers in diameter can get deep into your lungs and some may even get into your bloodstream.
- Of these, particles less than 2.5 micrometers in diameter, also known as fine particles or PM2.5, pose the greatest risk to health.
- Fine particles are also the main cause of reduced visibility (haze) in parts of the United States, including many of our treasured national parks and wilderness areas

World's richest have never been so wealthy, says Capgemini in study

Agence France-Presse
PARIS

The world has never had so many rich people and their investments in soaring stock markets have made them wealthier than ever recorded, according to a study published on Wednesday.

The number of "high net worth individuals" (HNWI) – defined as people with liquid assets of at least $1 million – rose by 5.1% last year to 22.8 million, according to consulting firm Capgemini.

Their total wealth reached $86.8 trillion in 2023, a 4.7% increase from the previous year, according to the annual World Wealth Report.

For equality: Rising global wealth and inequality fuelled debates on making rich pay their fair share of taxes. GETTY IMAGES VIA AFP

The number of HNWIs and their total wealth are the highest since Capgemini began the annual study in 1997.

Their fortunes have risen as stock markets have surged: New York's tech-heavy Nasdaq surged 43% in 2023 while S&P 500 gained 24%. The Paris CAC 40 grew 16% while the Frankfurt DAX advanced by 20 percent.

The number of HNWI and their wealth had each fallen by more than 3% in 2022, a year of macroeconomic uncertainty and geopolitical tensions, the report said. The decline in the wealth was the steepest in a decade as equities fell. "However, 2023 brought economic growth and improved fortunes for major investment sectors to reverse the falloff," the report said.

"Despite ongoing interest rate uncertainty and rising bond yields, equities surged along with the tech market, fueled by enthusiasm for generative AI and its potential impact on the economy." Rising wealth and inequality in the world have fuelled debates on making the rich pay their fair share of taxes.

World wealth report (Capgemini)

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MOSCOW

Russian cosmonaut becomes the first to spend 1,000 days in space

AP

A 59-year-old Russian cosmonaut has become the first person to spend 1,000 days in space, Russian space agency Roscosmos said on Wednesday. Oleg Kononenko achieved the milestone on Tuesday, having made five journeys to the International Space Station dating back to 2008. AP

- Russian cosmonaut has become the first person to spend 1,000 days in space, Russian space agency Roscosmos
- Oleg Kononenko achieved the milestone on Tuesday, having made five journeys to the International Space Station dating back to 2008.

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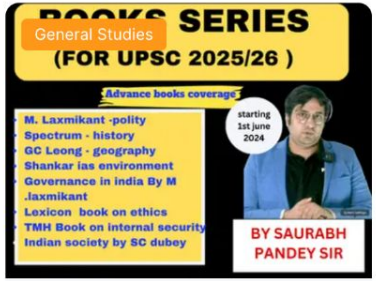

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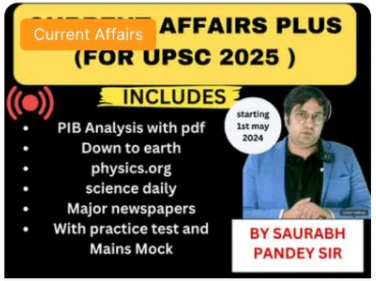

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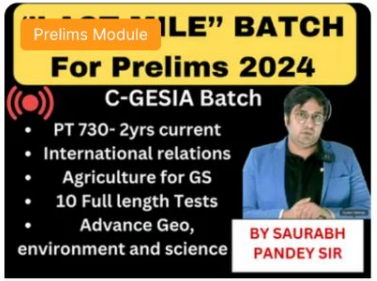

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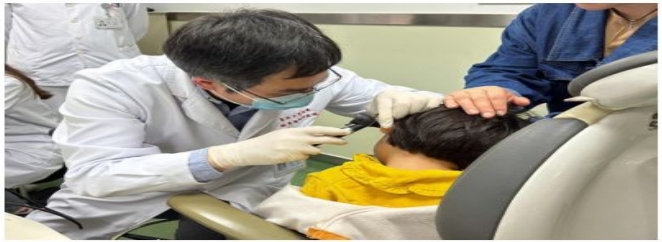

The treatment involves injecting a modified virus into the ear that smuggles in a working version of OTOF gene. AFP

Gene therapy offers hope for children with hearing disability

Agence France-Presse
WASHINGTON

Zhu Yangyang babbles away like a typical happy three-year-old, calling out for "mama" and "papa" and accurately naming colours — a remarkable achievement considering he was completely without hearing just months ago.

He is one of five children whose hearing was restored through a revolutionary new gene therapy in a clinical trial led by Chinese and American researchers, offering hope for those born with a rare genetic mutation of the OTOF gene. This means they are unable to produce the protein otoferlin, which is needed for hair cells in the inner ear vital for hearing.

The treatment involves injecting a modified virus into the inner ear that smuggles in a working version of the OTOF gene.

Yangyang's mother Chang Yiyi says she was moved to tears when she realised, around three weeks after the treatment last September, that he could hear her.

The results of the study was published in *Nature Medicine* on Wednesday. "This is absolutely a turning point," Zheng-Yi Chen, the study's senior author at the Eaton-Peabody Laboratories at Mass Eye and Ear, said, adding that companies were now conducting clinical trials with the goal of moving towards regulatory approval.

"If the results hold, without any complications, I think in three to five years, it may be a medically approved product," he added.

Gene Therapy

Gene therapy is a technique that modifies a person's genes to treat or cure disease. Gene therapies can work by several mechanisms:

- **Replacing a disease-causing gene with a healthy copy of the gene**
- **Inactivating a disease-causing gene that is not functioning properly**
- **Introducing a new or modified gene into the body to help treat a disease**

Gene therapy products are being studied to treat diseases including cancer, genetic diseases, and infectious diseases.

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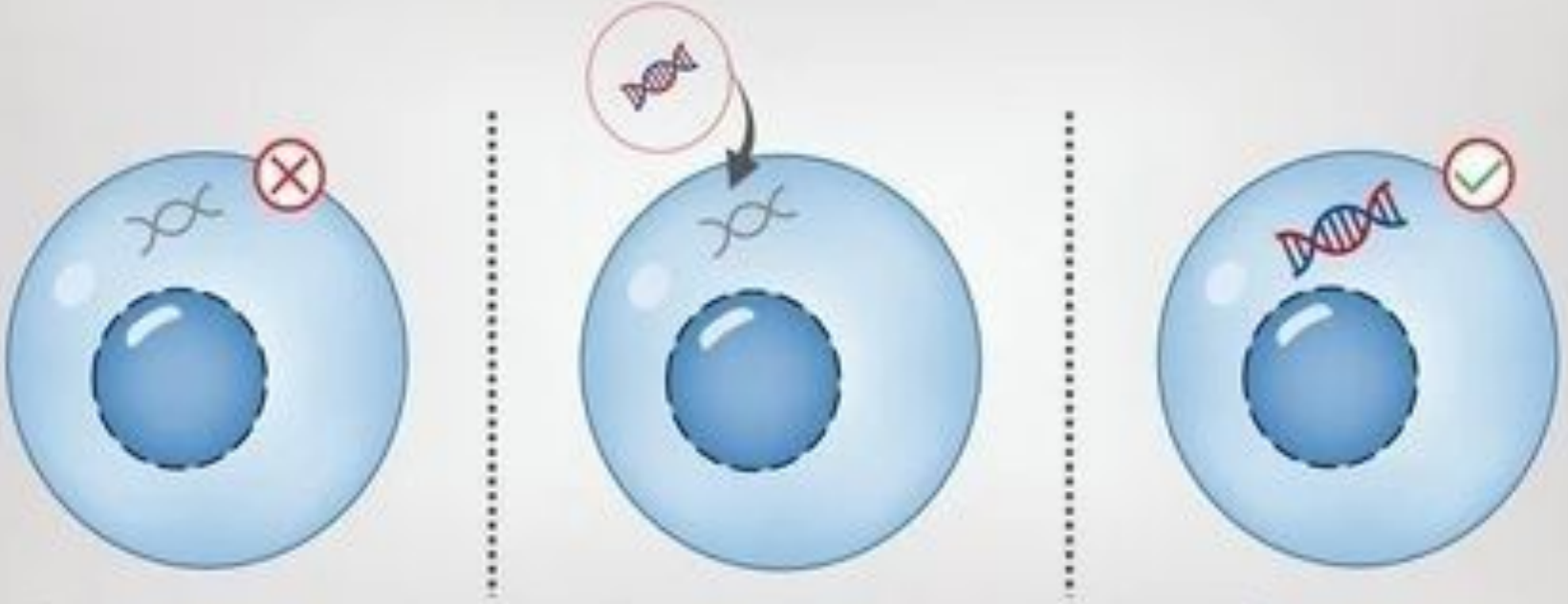
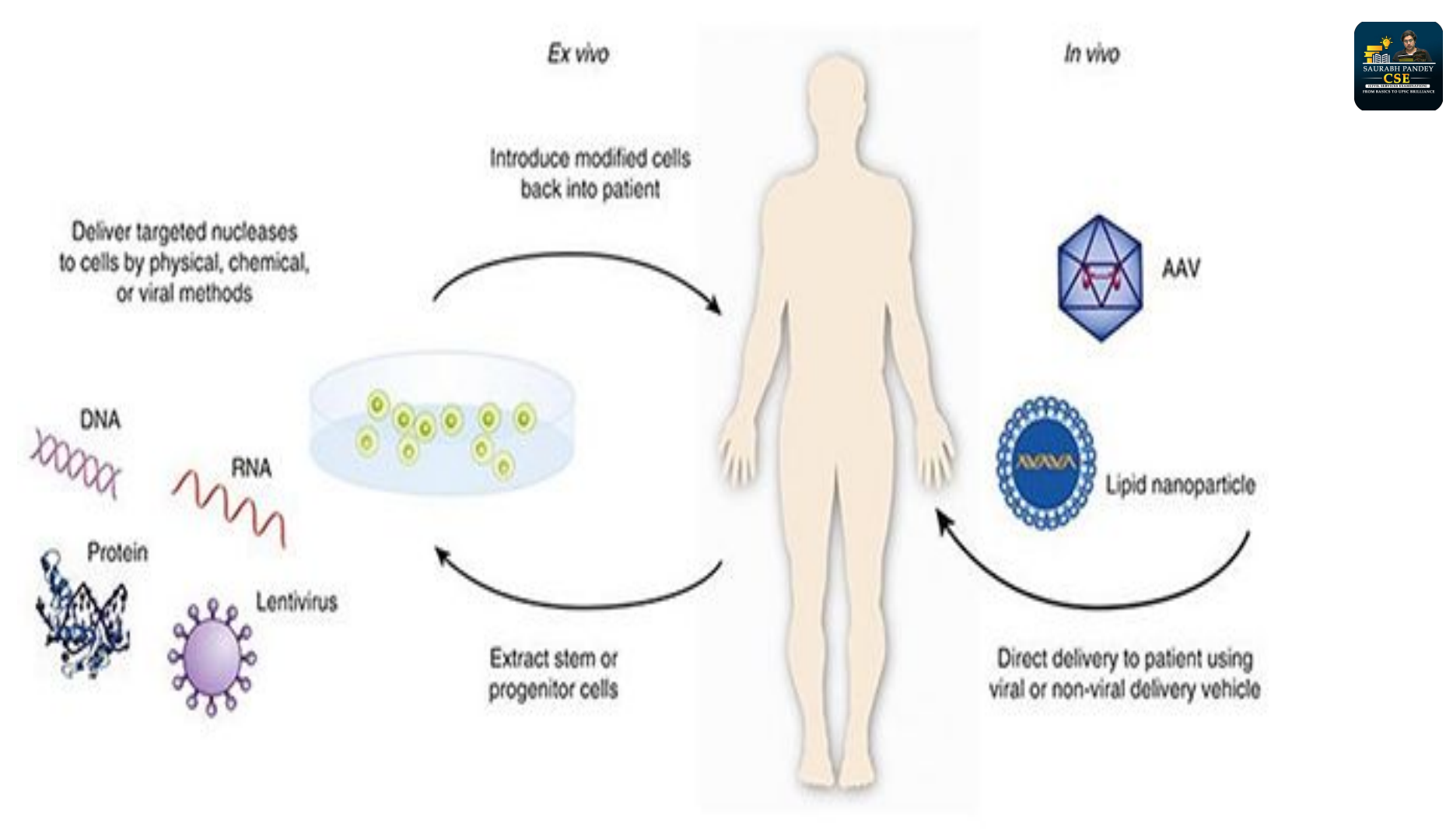
Gene Therapy



There are a variety of types of gene therapy products, including:

- Plasmid DNA: Circular DNA molecules can be genetically engineered to carry therapeutic genes into human cells.
- Viral vectors: Viruses have a natural ability to deliver genetic material into cells, and therefore some gene therapy products are derived from viruses. Once viruses have been modified to remove their ability to cause infectious disease, these modified viruses can be used as vectors (vehicles) to carry therapeutic genes into human cells.

- **Bacterial vectors: Bacteria can be modified to prevent them from causing infectious disease and then used as vectors (vehicles) to carry therapeutic genes into human tissues.**
- **Human gene editing technology: The goals of gene editing are to disrupt harmful genes or to repair mutated genes.**
- **Patient-derived cellular gene therapy products: Cells are removed from the patient, genetically modified (often using a viral vector) and then returned to the patient.**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In vivo
Introduce modified cells back into patient
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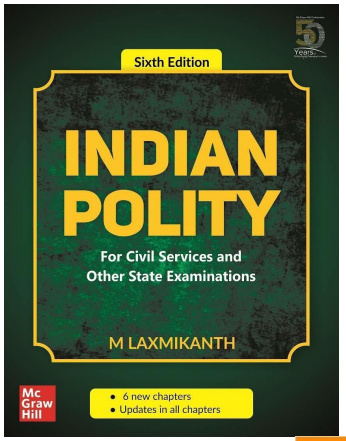

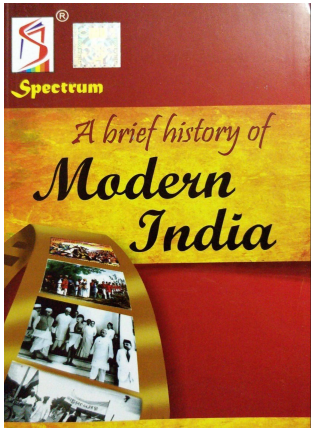

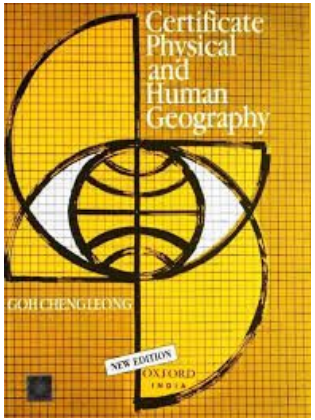

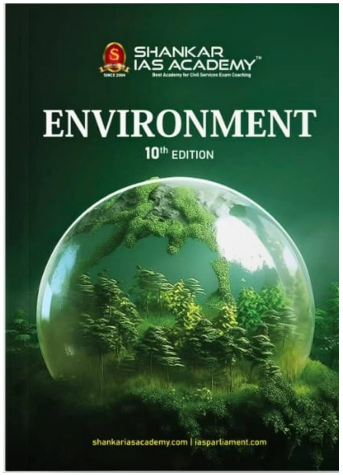

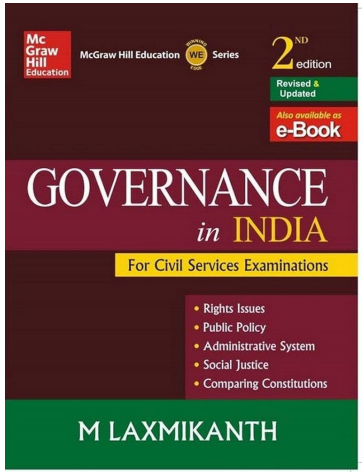

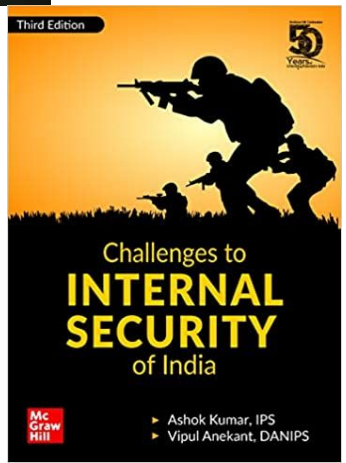

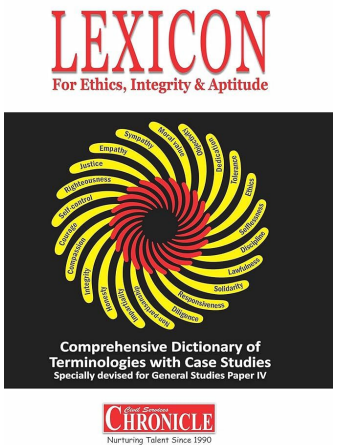

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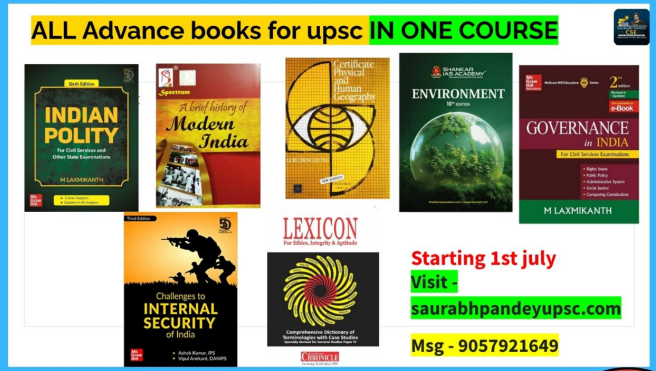

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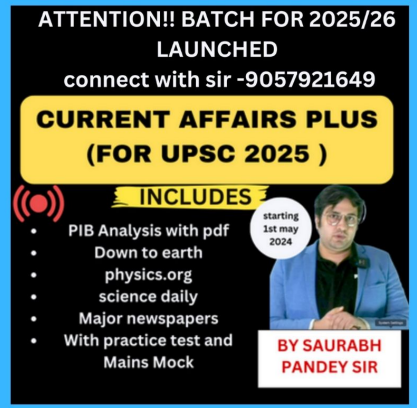

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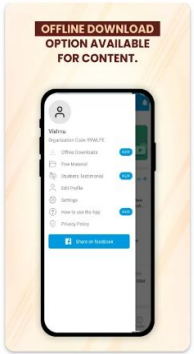

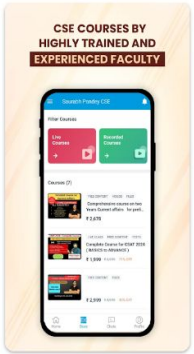

App support