VAJIRAM & RAVI

Institute for IAS Examination

Current Affairs

for **IFS(Indian Forest Service), 2023**

Mauryan Period (321 BCE-185 BCE)

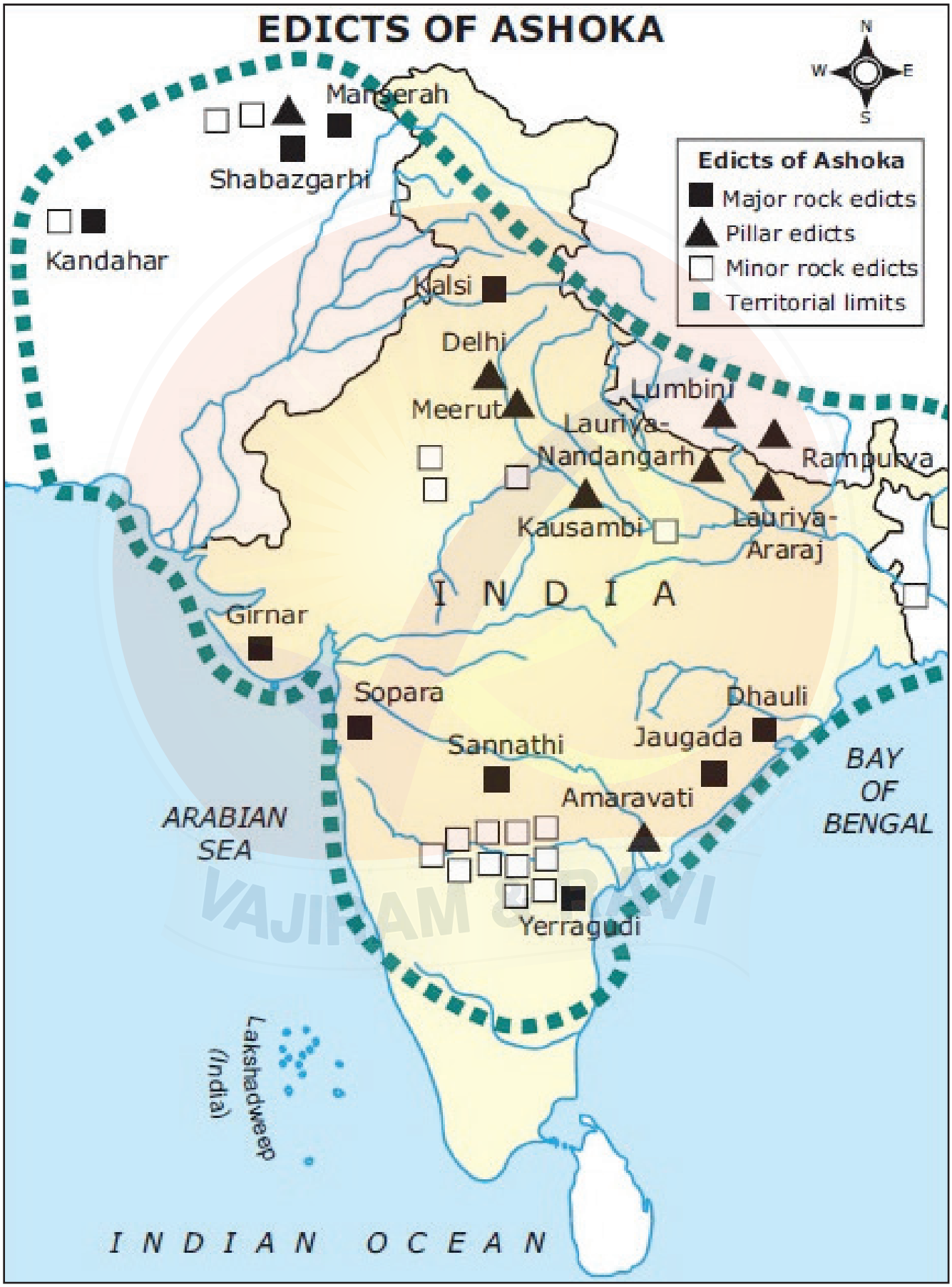
Introduction

- First pan-Indian empire, started by Chandragupta Maurya in 321 BC with capital **Pataliputra**
- Spanned across central and northern India and parts of modern-day Iran

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• **Centralised** administration as compared to other major kingdoms. • **King:** Supreme and sovereign authority of the Mauryan administration. • **Mantri Parishad (Council of Ministers):** aided and advised king • **Provincial administration:** divided into four provinces • **District administration:** under the charge of **Rajukas**, assisted by Yuktas or subordinate officials. • **Village administration:** under **'Gramani'**, and his superior **Gopa** (ten to fifteen villages). • **Revenue administration: Samharta** (officers for revenue collection). • **Judicial administration:** » **King**: head of Judiciary, highest court of appeal. » **Dharmathikarin:** The chief justice at the capital. » **Amatyas:** Judicial officers of subordinate courts. • **Military administration:** under the control of Senapati	• The empire → provinces → districts → village units. • **Four Provinces:** Taxila, Suvarnagiri, Tosali and Ujjain. • Kautilya mentions "**Saptanga theory of State**", which describes the nature of the State. • **Arthasastra** mentions the role of Nagarika (city superintendent). • **Sannidhata**: (in-charge of the treasury and store) • **Kautilya and Asokan Edicts** mention jails and jail officials. • Greek author Pliny mentions information about the Mauryan army.
Economy	• **Agrarian economy:** Janapadanivesa as a process of settlement • **Coins:** Use of punch-marked coins for transaction • **Land Revenue:** the primary source of revenue (as one-sixth of the produce) • **Famines:** Occurrences of famines reported in kautilya's Arthashastra • **Taxes:** Bali, Hiranya, pindakara • **Trade routes:** along the Ganges River and the Himalayan foothills	• **Sohgaura** copper plate inscription deals with famine relief measures. • Pana, pada and asta-bhaga as silver coins • **Megasthenes** mentions a land route connecting the North West with Pataliputra.
Society	• Four-fold **Varna system** • Existence of inter-caste marriages: Anulom and Pratilom • Presence of slavery as per Arthashastra • Women's position in society deteriorated	• Ashokan Major Rock Edict V relates about the policy towards slaves • Widow remarriage stopped and institution of 'ganikas' expanded.
Art and architecture	• **Two types of art:** Court art by court and popular art by individuals • Northern Black Polished Ware Pottery • Shift from the use of wood in early Mauryan period to **stones** during Ashoka. • Achaemenid connection to the art and architecture • **Pillars:** free-standing, tall, well proportionate, with tapering shafts and monolithic • Construction of Stupas • Large statues of Yakshas and Yakshinis	• Ex: Pillars and Stupa (Court Art), Pottery and sculpture (Pupular) • Sarnath pillar is a stone erected pillar of Ashoka. • Mauryan Palace inspired by Achaemenid palace art • Sanchi and Barhut Stupa • Didarganj Yakshini

Decline

- Fragmentation of empire followed by quick succession of rulers
- Antagonism of Brahmins
- Centralised administration became difficult to manage
- Pushyamitra Sunga killed the last Mauryan king Brihadratha.
- Division of Mauryan into two parts: eastern and western.



Ashoka

Introduction

- Third emperor of the Mauryan dynasty, ascending the throne in 268 BC
- Change in policy of war and religion after the Kalinga war in 261

DIMENSION	DESCRIPTION	SUBSTANTIATION
Ashoka's Dhamma	**The main features of Asoka's Dhamma:** • Service to father and mother, practice of ahimsa, love of truth, reverence to teachers and good treatment of relatives. • Prohibition of animal sacrifices and festive gatherings and avoiding expensive and meaningless ceremonies and rituals. • Efficient organisation of administration in the direction of social welfare and maintenance of constant contact with people through the system of Dhammayatras. • Humane treatment of servants by masters and prisoners by government officials. • Consideration and non-violence to animals and courtesy to relations and liberality to Brahmins. • Tolerance among all the religious sects. • Conquest through Dhamma instead of through war.	• **Rock Edict I:** prohibition of animal sacrifice and holidays of festive gatherings. • **Rock Edict V:** appointment of Dhammayatras. • **Rock Edict VII:** mentions a plea for toleration amongst all the sects. • **Rock Edict XII:** appeal towards toleration among sects.
Propagation of Dhamma	• **Missionaries** sent to foreign countries such as Greece and Sri Lanka. • Issued **rock edicts** and inscriptions to disseminate the idea of Dhamma. • **Dhamma yatras** by Ashoka for direct contact with his subjects. • Convened **Third Buddhist** Council at Pataliputra in 240. • Appointment of **Dhamma Mahamatras**.	• Ashoka sent his son Mahindra and daughter Sanghamitra to Sri Lanka • 14 major rock edicts • Ashoka's visit to Lumbini • 3rd Buddhist Council was presided by Moggaliputta Tissa • Mentioned in rock edict
Impact of Ashoka's Dhamma	• Prominent sway of cultural influence under Ashoka • Promotion of value of moral values • Reduction in crimes and promotion of welfare • Pause to the conquest policy of Ashoka	• Influence of Buddhism • Change in policy after Kalinga war
Ashokan inscriptions	• **Sarnath Pillar** located in Varanasi built during 250 BC • **Kanaganahalli Inscriptions:** mentions Ashoka as "Ranyo Ashoka" (Raja Ashoka). • **Bhabru inscription** located in Calcutta • **Maski inscription** located on Maski river in Karnataka. • **Allahabad inscription** • **Rummindei Pillar Edicts** located in Nepal	• The national emblem of India. • first-ever sculpture of Ashoka with his name inscribed. • only inscription in the Boustrophedon script. • Ashoka is referred to by his name instead of Devanampiyadasi • Mentions Ashoka's wife Kaurwaki. • Ashoka's visit to Lumbini, which exempted Lumbini from paying tax.

Buddhism & Jainism

Introduction

- **Buddhism:** founded by Gautam Buddha (Siddhartha) around the 5th-6th century BC
- **Jainism:** One of the oldest religions, 24 Tirthankaras, Mahavir Jain as 24th Tirthankaras
- Both Buddhism and Jainism rose in prominence to the Vedic religion, **rejecting the Vedas**. (Both believed in the idea of Karma)

DIMENSION	DESCRIPTION	SUBSTANTIATION
Causes for rise	• **Religious unrest** in the later Vedic period due to complex rituals. • Social and economic factors due to **rigid caste structure** • Support by Kshatriyas and Vaishyas • Use of **simple language** understood by masses, instead of complex Sanskrit • New simple doctrines and promotion of morality	• Expensive sacrificial ceremonies • Domination of Brahmins • Khsatriyas resented priestly class and rise in conditions of Vaishyas • **Pali** by Buddhism and **Prakrit** by Jainism • Non-violence of Jainism and Middle Path of Buddhism
Principle tenets	**Buddhism:** • **Four Noble Truths** (Chatwari Arya Satyani): Sabbam Dukkam, Dwadash Nidan, Nirvana and Ashtangika Marga	• **Sabbam Dukkam:** World full of suffering • **Dwadash Nidan:** Desire as cause of suffering • **Nirvana:** Removal of suffering • **Ashtangika Marga:** Eightfold Path
	Jainism: • **Triratnas:** Right Faith, Right Knowledge and Right Conduct. • **Panchamahavratas:** Ahimsa, Satya, Asteya, Aparigraha and Brahmacharya	• **Right faith:** Belief in teachings and wisdom of Mahavira. • **Right knowledge:** Existence of a world without a creator. • **Right conduct:** observance of Panchamahavratas
Difference and similarities between Jainism and Buddhism	**Jainism** • Believes in existence of soul for even non-living things • Kaivalya (complete understanding) for attaining spiritual liberation • Existence of world without any creator • Reject Vedas and Believed in karma • Extreme emphasis on non-violence	**Buddhism** • Does not believe in the idea of soul • Nirvana as the ultimate goal of life • neither accepted nor rejected the existence of God • Reject Vedas and Believed in karma • Moderate emphasis on non-violence
Impact on Indian society	• Opposed the caste system dominated by Brahminsm • Rise in pali and Prakrit literature • Contributed to architecture by building stone pillars, caves, temples, and statues • Concept of non-violence and truth • Spread of education and scriptural traditions • Promotion of moral and ethical values	• Inculcation of all into new religion without discrimination • Angas and Purvas of Jainism, and Tripatakas of Buddhism • Example: Stupa at Sanchi and Jaina temples at Mount Abu • Mainstream in the national movement • Nalanda and Taxila university • Eightfold Path in Buddhism and Five Great Vows in Jainism
Causes for decline of Buddhism	• Revival of Brahmanism and rise of Bhagavatism • Loss of royal patronage after Harshavardhana • Division in Hinayana and Mahayana • Foreign invasions and decay of monasteries	• Role of Bhakti movement in mediaeval period • Patronage of Vedic religion by Pushyamitra Sunga and Guptas • Mahayana promoted idol worship and rituals • Attack of Huns in 5th and 6th century AD and Turkish in 11th century AD

Sangam Age

Introduction

- Period in ancient Tamil Nadu around the 3rd century BC to the 3rd century AD.
- Named after the Sangam assemblies of poets Madura under patronage of Pandyas
- Recent excavations at Keeladi have pushed the Sangam age back about 300 years earlier than the previously believed third century BCE.

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• Followed hereditary monarchy • **Decentralised** administration • **Five councils:** Assisted king • **Efficient military administration** • **Revenue administration:** Income through land revenue and customs duty	• King: Supreme authority • Kingdom → Mandalam (Territory) → Nadu (province) → Ur (town) • Ministers (**amaichar**), priests (anthanar), military commanders (senathipathi), envoys (thuthar) and spies (otrar) • Each ruler had a regular army and **Kodimaram** (tutelary tree). • **Pattinappalai** refers to customs officials.
Economy	• **Agriculture:** chief occupation of the populace. • **Trade:** Both domestic and foreign (Greece, Rome). • Flourished handicrafts industry and craft production centres	• Paddy: chief crop mentioned in Sangam Literature texts. • Ports: Puhar, Tondi and Musiri • Greater demand from the Western world for cotton clothes woven at Uraiyur.
Society	• **Caste system prevalent:** Arasar (ruling class), Anthanar (religion), Vanigar (trade) and Vellalar (agriculturists) • Better position of women: involved in literary work, dance and music. • Miserable life of widows • Religion: Worship of indigenous gods	• Four castes mentioned in **Tolkappiyam**. • Women poets of Sangam: Avvaiyar, Nachchellaiyar, and Kakkaipadiniyar. • Prevalence of practice of Sati • **Example:** Seyon (Murugan), Mayon (Vishnu) and Vendan (Indra)

Sangam Literature

Introduction

- Earliest Tamil literature written during the Sangam age

DIMENSION	DESCRIPTION	SUBSTANTIATION
Three Sangams	• First Sangam in Madurai: no recorded accounts. • Second Sangam in Kapadapuram in Tamilnadu. • Third Sangam in Madurai.	• Attended by gods and sages • Tholkappiyam: Only surviving literary work. • Literary works: Ettuthogai, Pathupattu, etc.
Early Sangam literature	• Agam and Puram concept: Mutually related but opposite • Agathiyam: earliest book on Tamil grammar • Tholkappiyam: First extant Tamil literary work • Ettuthogai: eight anthologies, part of Pathinen Melkanakku • Pattuppattu: anthology of ten longer poems	• Aham: interior, feminine, and related to love. • Puram: exterior, masculine, related to war and heroism. • No copies exist today. • Information on political and socio-economic conditions. • Ainkurunuru, Narrinai, Aganaooru, Purananooru, Kuruntogai, Kalittogai, Paripadal and Padirruppattu
Later Sangam literature	• Patinen Kilkanakku (The Eighteen Lesser Texts) • Silappadikaram by Ilango Adigal • Manimekhalai by Seetalaisattanar • Jivaka Chintamani by Tiruttakrdeva • Valayapathi • Kundalakesi by Nathakuthanaar	• Deals with morals and ethics. • Story of Kovalan and Kannagi • Sequel to Silappadikaram, information on the Sangam polity and society. • associated with life of Jiva and Jainism • Supported the ideologies found in early Jainism • Related to Buddhism

Gupta Empire

Introduction

- Founded by Sri Gupta in 3rd Century AD around northern, central, and parts of southern India.

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• **King:** Supreme authority, considered as divine • **Council of ministers:** assisted king in administration • Decentralised administration (Feudal system) • Revenue administration: land revenue primary source • Efficient military administration, forces supplied by feudatories • More liberal administration as per Fahien	• Kings compared to god, coins depicting kings • Mahanandanayaka: Chief Justice • Mahapratihar: Maintenance of royal palace • Empire → Bhukti (province) → Vishyas (districts) → Nagaras • Fahien mentions Gupta administration • Taxes: Uparikara, Sulka, Visthi and Bali • Mahasandhivigrahika: minister for war and peace • No restriction on movement, safe roads, fewer crimes
Socio-economic conditions	• Issued extensive gold coins • Decline in long-distance trade • Landowning priestly class became influential • Practice of untouchability prevalent • Miserable position of women • Rise in Brahmanism	• Gold coins: Dinars • Romans learned silk cultivation from Chinese • Land grants to Brahmins and chiefs • Fahien mentions that Chandalas were segregated from the society. • Prohibited from studying religious texts and Early marriages • Vaishnavism and Shaivism
Causes for decline	• Foreign invasions • Establishment of independent kingdoms by feudatories such as Maitrakas • Decline in economic sphere	• Huna gained control of many northwestern parts • Incompetent rulers and weak central authority • Loss of trading opportunities, debasement of gold, crop failures

Contribution of Guptas ("Golden Age" of Culture)

DIMENSION	DESCRIPTION	SUBSTANTIATION
Art	• **Sculpture:** highly skilled, aimed at depicting ideas • **Paintings:** Mural paintings, related to Buddhism • **Performing arts:** Concepts of rasa and bhava gained more importance • **Sarnath school of art:** Standing Buddha, padmasana mudra and abhanga pose	• Depiction of Bodhisattvas, Vishnu and Tirthankaras • Mural paintings found at Ajanta, Bagh, and Badami • Bharata Muni's **Natyashastra**: Theory and practice of performing arts • • Example: Standing Buddha in Sarnath
Architecture	• Development of stupa, vihara and chaitya architecture • New elements in cave architecture: presence of Mahayana features, influence of all three religions • Emergence of free-standing temples (Nagara style) • Temples built on platforms, Flat roof replaced by towers (pyramidal or curvilinear)	• Example: Dhamekh stupa at Sarnath and Buddha temple at Nalanda • Ellora Caves in Maharashtra: influence of Buddhism, Jainism and Hinduism • Example: Deogarh temples at Jhansi, Dashavatara temple (UP)
Literature	**Secular literature:** • Historical plays depicting political and royal events • Insight into socio-cultural conditions of the time • Depiction of contemporary way of life and cultural norms	• Mudra Rakshas and Devichandraguptam by Vishakhadatta • Mrichchhakatikam by Shudraka • Amarkosha by Amarasimha (Sanskrit dictionary)
	Religious literature: • Finalisation and composition of Puranas • Compilation of the Mahabharatha and Ramayana in its present form • Composition of smritis: moral and social code of conduct	• Puranas: Vishnu Purana, Matsya Purana etc. • Smritis: Vishnu Smriti, Narada Smriti, Katyayana Smriti
	Scientific literature: • **Aryabhatta:** First to evolve "sine" functions and apply place theory, Pioneered trigonometry. • **Varahamihira:** Multidisciplinary work covering astronomy, and astrology • **Vagbhatta:** Made comprehensive treatise on Ayurvedic medicine, surgery, and hygiene	• Aryabhattika: text on trigonometry, algebra, and arithmetic • Surya Sidhanta by Aryabhatta: related to solar and lunar eclipses • Brihat Samhita and Panchasiddhantika by Varahamira • Ashtanga Sangraha by Vagabhatta

Vijayanagara Empire

Introduction

- Mediaeval Indian empire founded by Harihara I and Bukka Raya in southern India in1336 to 1646.
- Famous for its own style of architecture (Vijayanagara style)

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• **King:** absolute authority in all matters, hereditary succession, assisted by a council of ministers • Division of empire into administrative sub-units • **Amaranyaka system** like iqta system of Delhi sultanate • **Revenue:** income from land revenue, gifts and tributes from vassals • **Army:** Well organised and efficient • Ayagar system of village organisation	• King was the highest court of appeal • Mandalams → Nadus → Sthalas → Gramas • Nayakas: Feudal military chiefs, Governors of Mandalam • Land revenue: 1/6th of produce • Nayakas/Poligars: Top-grade army officers • Ayagars:12 functionaries for village affairs.
Socio-economic conditions	• **Society:** Existence of four castes and presence of slavery • **Religion:** Shaivites and Vaishnavites but religious freedom enjoyed by people • **Women:** Popularity of the devadasi system, practice of sati strengthened, presence of women poets • **Agriculture:** the chief occupation of the people • **Trade:** Flourished inland, coastal and overseas trade. • **Exports:** cotton, spices etc • **Imports:** horses, pearls etc.	• Castes mentioned in Manucharitam by Allasani Peddanna • Employment of Muslims in administration and allowed to build mosques. • Nuniz refers to Sati • Gangadevi wrote Maduravijayam • Irrigation canals on Tungabhadra river • **Cannanore:** chief port • Commercial contacts with west and east countries.
Cultural contribution	• **Vijayanagara style:** New elements in Dravidian temple architecture • **Metal Casting:** Creation of metal images • **Art:** Patronage of music, and dance • **Sculptures:** Intricate sculptures on pillars with distinctive features. • **Literature:** Flourished Sanskrit, Kannada and Telugu literature, • **Ashtadiggajas:** eight great poets of Telugu literature	• Construction of Raya Gopurams, Kalyanamandapam with carved pillars, addition of Amman shrines • Virupaksha Temple at Hampi and Hazara Rama temple of Deva Raya I • Metal images of Krishna Deva Raya and his queens at Tirupati. • System of dancing girls • Carnatic music under Purandaradasa • Horse as common animal found in pillars. • Amukthamalyada by Krishnadevaraya, Raja kalanirnaya by Guru Vidyaranya, Manucharita by Allasani Pedanna

Bhakti Movement

Introduction

- Religious movement emerged in mediaeval India.
- Emphasis on rejection of religious formalism, spiritual devotion, equality etc.

DIMENSION	DESCRIPTION	SUBSTANTIATION
Causes for rise	• **Social inequality,** Varna system, discrimination • **Complex rituals** and religious practices controlled by priests • Use of vernacular languages, easily understood by all • Reaction to foreign invasions in later period • Influence of ideas of sufism	• Bhakti movement as a platform for all people without caste barriers. • Bhakti bypassed intermediaries and rituals. • **Sanskrit:** complex language, not understood by everyone • Bhakti movement developed during these foreign invasions • **Sufism:** belief in one god, rejection of caste system etc.
Features	• Preaching Monotheism (Oneness of God) • Seeking freedom from the cycle of life and death • Against caste system, idol worship and ritualism • Against priestly class's domination and Sanskrit language • Emphasis on singing of hymns with deep devotion	• Rejection of class divisions and promotion of universal brotherhood • Salvation by deep devotion and faith in God • As per them, all living beings are god's children • Priestly class domination →caste discrimination • Devotional songs essential in expressing one's love and devotion to God
Philosophies	• **Advaita philosophy** (non-dualism): Propagated by Adi Shankaracharya • **Dvaita philosophy** (dualism): propagated by Madhavacharya • **Visishtadvaita Philosophy:** propagated by Ramanuja • **Shuddhadvaita philosophy** (pure non-dualism): propagated by Vallabhacharya • **Achintya Bheda Abheda:** propagated by Chaitanya Mahaprabhu	• Philosophy of oneness (ultimate reality is one) • Transient phenomenal world is an illusory appearance • Brahman and Atman are distinct entities • Bhakti as the path to eternal salvation • The creative process and all the objects in creation are real but not illusory • God, soul, matter are real. But God is an inner substance and the rest are his attributes. • Entire universe is real and delicately Brahman • Brahma never exists in dual form • Creator and creation are both different and indifferent
Importance	• Salvation was accessible to everyone • Development and profusion of regional languages • Awakening against false superstitions and rituals • Loosening of caste ridden system • Provided equal importance to women • Promoted a simple religion over complex rituals • Encouraged idea of a life of charity and service to fellow people	• Extended opportunity for salvation regardless of social status. • Abhangas in Marathi, Kabir's Dohe, use of Brij language by Surdas • Influenced socio-religious movement in later period • Sharing of kitchens and meals • Female bhakti saints: Janabai, Akkamahadevi, Mirabai etc. • Spirituality became more accessible • Focus from ritualistic practices to acts of kindness

Pallava Dynasty

Introduction

- Ancient Indian dynasty from 3rd century AD to 9th century AD.
- Ruler over the parts of southern India with capital Kanchipuram.

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• **Monarchy:** hereditary succession • Council of ministers: assisted king • **Division** of empire in sub-units • **Village administration:** by local autonomous local assemblies • Well maintained organised army • **Revenue administration:** land tax as primary source of revenue, no tax from Devadanas, Agraharas and Brahmadeyas	• King: fountain of justice • King title: Dharma-Maharaja • Amatyas: ministers • Empire →Mandalams/ Rashtra →Kottams →Nadus →Gramas • Sabha for Brahmadeya villages and Ur for different castes • Army comprised infantry, cavalry, elephants, and chariots. • **Taxes:** Irai, Kaanam, Poochi, Paatam, Kusakaanam
Socio-economic conditions	• **Rigid caste system:** Brahmins occupied high place • **Religion:** rise of Saivism and Vaishnavism and decline of Buddhism and Jainism. • **Agriculture:** chief occupation, high production • **Trade:** Less development in improving trade and commerce but boost in **maritime** trade	• System of Brahmadeyas (land grants to Brahmin) strengthened • Saiva Nayanmars and Vaishnava Alwars contributed to the growth of Saivism and Vaishnavism. • Hiuen Tsang mentions flourishment of agriculture and fertile land • Frequent conflicts with Chalukyas and Pandyas → less internal trade • Trade port: Mahabalipuram
Art and literature	• **Literature:** Sanskrit and Tamil literature flourished • **Education:** attracted students from all parts of India • Flourishment of music, dance and painting • Development of sculptural paintings on walls: features of open gallery	• **Works:** Mattavilasa Prahasanam by Mahendravarman I, Devaram by Nayanaras, Nalayira Divya Prabandham by Alwars • Ghatika at Kanchi • System of dancing girls • Mamandur and Kudumianmalai inscriptions: related to musical notes • Sittannavasal paintings • Example: The Descent of the Ganges (Penance of Arjuna)
Contribution to architecture	• Introduced the art of excavating temples from the rock • Development of architecture in four stages: Mahendra → Mamalla → Rajasimha → Aparajita • **Mahendra style:** introduced rock-cut temples • **Mamalla Style:** introduction of monolithic rathas • **Rajasimha Style:** introduced structural temples • **Aparajita Style:** Ornamentation in structural temples	• Beginning of Dravidian style of architecture • Example: Lakshitayatana cave temple • Example: Panchrathas of Mammallapuram • Example: Kailasanatha temple at Kanchi and Shore temple at Mamallapuram • Example: Vaikundaperumal temple, Muktheeswara temple

Delhi Sultanate

Introduction

- Foreign muslim invasions → establishment of Delhi Sultanate over north India from A.D. 1206 to 1526
- Five different dynasties: Slave, Khalji, Tughlaq, Sayyids and Lodhis

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• **King:**Ultimate authority, representative of the Caliph, No definite succession • **Central administration:** divided into various departments and officers for assisting king • **Provincial administration:** division of sultanate into subunits, introduction of Iqta system • **Village administration:** basic unit of administration, administered by officers • **Justice administration:** through village panchayats and qazis • **Advanced military administration:** Sultan as supreme authority, Ariz-i-Mumalik (head of military department)	• Name of the Caliph in the khutba or prayer and coins. • Finance (Diwani Wizarat), military (Diwani Ariz), religious affairs (Diwani Rasalat), and judiciary (chief Qazi) • Iqta (headed by muqti) → Shiq (headed by shiqdar) → Paragana (headed by amil) → Gram (headed by muqaddam) • **Officers:** Muqaddam (village headman), Patwari (village accountant) • Muslims governed by Sharia law and Hindus by their own law • Use of cannons and matchlock muskets, armoured cavalry units • Dagh system: branding of horse
Economy	• Reforms in land revenue: one-third of produce • Agricultural reforms • Boost to process of urbanisation • Reforms in currency system • Flourishment of inland and foreign trade	• Type of lands: Iqta, Khalisa and Inam lands • Takkavi and Sondhar loans • **Cities:** Firozabad, Tughlaqabad etc. • Silver tankas by Iltutamish, Token currency of Muhammad Tughlaq • Connection to Persian Gulf and Red Sea
Society	• Prevalence of rituals and ceremonies • Miserable position of women • System of slavery: women slaves, prisoners of war • Prevalence of four varna system	• Example: Upanayana samskara among Hindus and Bismillah Khani among Muslims • Practice of Sati, Purdah system • Malik Kafur: prisoner slave of Alauddin Khilji • No inter caste marriages
Cultural contribution	**Architecture:** • Emergence of Indo-islamic architecture, introduction of arches, domes, minarets, and Arabic script decoration • New methods of decoration • Colours to the buildings • Conversion of existing structures into mosques	• Qutub Minar, Kotla Fort, Palace complex of Tughlaqabad • Calligraphy, arabesque methods • Use of Marbles, yellow and red sandstone • Quwwat-ul-Islam
	Music: • Introduction of new musical instruments like sarangi and rabab • Introduction of new ragas	• Qawali style of music and ghora and sanam ragas by Amir Khusrau
	Literature: • Patronage of Arabic and Persian literature • promotion of history writing.	• Tarikh-i-Firozshahi by Barani, Tabaqat-i-Nasari by Minhaj-us-Siraj • Sabaq i-Hind: New style of Persian poetry by Khusrau
Decline	• **Weak rulers:** No succession law, short reigns of weak rulers → unable to stop the decline of the empire • Arrogance and insulting attitude of some rulers: Nobles were put to the death • External invasions of Mangols, Timurids and Mughals • **Economic decline:** unstable economic position, biased taxation policies • **Religious discrimination**: administration based on Islamic principles, intolerance towards Hindus (destruction of temples) • Babur's invasion against Ibrahim Lodhi, on the invitation by Daulat Khan	• Sayyid rulers ruled only from 1414-1451 • Ibrahim Lodhis's attitude toward Alam Khan and Daulat Khan • Timur's invasion in 1438 and invasion by Babur in 1526 resulting in the establishment of Mughal empire • Exemption of Muslims from taxes • Policies of Muhammad Bin Tuglaq • Privileged position of Ulemas • Imposition of Jaziya tax • Conversion of temples into mosques • Defeat of Lodhis in First Battle of Panipat in 1526

Mughal Empire

Introduction

- Started by Babur in 1526 by defeating Ibrahim Lodhi in the First Battle of Panipat
- Ruled parts of Afghanistan and most of the Indian Subcontinent

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• **Central:** Highly centralised and bureaucratic government • **Provincial:** division of the empire in sub-units • **Local:** through villages and cities, basic unit of administration • **Mansabdari system:** for military administration, not hereditary • **Zabti or Bandobast system:** for land revenue administration	• Four ministries under Mir Bakshi, Sadr, diwan and Mir saman • Empire → Subha → Sarkars → Parganas • Officers: Muqaddam, Patwari, Chowkidar • Ranking (mansab) of officers, divided into Zat and Sawar • Fixed revenue on average yield of land in past ten years
Socio-economic conditions	• **Agriculture:** chief activity in the economy, introduction of new crops • Flourished urban economy • Growth in trade both domestically and foreign • Dominant caste structure, no improvement in women's position • Wealthy people wore silk and cotton clothes, while poor people wore minimum cloths	• Ain-i-Akbari mentions Tobacco, maize, potato etc. • Prevalence of Kharkhanas • Coromandel coast famous for textile production • Limited inheritance rights • Nikitin mentioned people of Deccan as bare-footed
Architecture	• Massive structures with bulbous domes, minarets • Charbagh style of laying gardens with running water • Use of red sandstone and tudor arch during Akbar and marble later • Decoration techniques on structures • Use of foreshortening technique	• Taj Mahal, Agra Fort • Nishat Bagh in Kashmir Shalimar Bagh in Lahore • Moti Masjid made entirely of white marble. • Pietra-dura technique and Jaali work
Painting:	• Shift of focus from god to glorifying kings • Establishment of separate department; Tasvir Khana during Akbar • Emphasis on naturalism in paintings	• Hunting scenes, historical events and court paintings • Daswanth, Basawan and Kesu: Famous court poets • Painting of Zebra by Jehangir
Music	• Flourishment of music, development of new ragas by Tansen	• Akbar patronised Tansen of Gwalior. • New Ragas: Yaman, Sarpada etc.
Language and literature	• Persian language became widespread in the Mughal Empire • Translation of Sanskrit texts in persian • Development of regional languages due to impact of Bhakti movement	• Aini-i-akbari and Akbarnama by Abul Fazl • Translatilation of Mahabharata in Persian • Development of Bengali, Rajasthani etc.
Decline	• Succession issues → weak central authority • Regional rebellions: the rise of Marathas, independent kingdoms • Weak and inefficient rulers after Aurangzeb • Intolerant religious policy of Aurangzeb • Foreign invasions and rise of east India company	• Fratricidal wars after death of Aurangzeb, court factions • Independent kingdoms: Awadh, Hyderabad and Bengal • Example: Farrukhsiyar, Alamgir II • Reimposition of Jaziya, Sikh resistance (Guru Teg Bahadur killed by Aurangzeb) • Nadir Shah imprisoned Muhammad Shah • Defeat in Battle of Buxar against EIC

Sufi movement

Introduction

- Liberal reform movement within Islam.
- Originated in Persia and spread in India in the 11th century.

DIMENSION	DESCRIPTION	SUBSTANTIATION
Features	• Organised in different silsilas (orders) • Emphasis on spiritual development and union with God • Critical of the dogmatic methods of interpreting Quran • Service to poor and downtrodden sections of society • Emphasis on meditation, self-discipline, prayers and pilgrimages, fasting, and ascetic practices.	• Orders: Chishti, Suhrawardi and Naqshbandi • Need of a spiritual guru or Pir • Belief in simple, love and devotion • Nizamuddin Auliya famous for distributing gifts to needy
Spread in India	• Sufi saints arrived and settled in India • • Spread of Chishti silsilah and Suharwardi silsilah in India • Spread of Qadri Silsilah in Punjab region: Supporters of Mughals • 15th and 16th century AD witnessed the development of other sufi orders in other parts of India	• First Sufi saint: Shaikh Ismail of Lahore • **Founders:** Chishti by Khwaja Muinuddin Chishti and Suhrawardi by Bahauddin • Founder: Sheikh Abdul Qadir (Supported Akbar) • Firdausi order in Bihar region by Shaikh Badruddin Samarqandi and Rishi order in Kashmir region by Shaikh Nuruddin Wali
Importance	• Infused a new liberal outlook within Islam • Influence on sufi movement • Helped to build Hindu-Muslim unity and solidarity • Cross-cultural exchange • Growth of rich regional literature • Social welfare and reforms	• Opposition to orthodox rituals and ulemas • One god, love and devotion • Emphasis on universal brotherhood • Exchange of ideas between Sufis and Indian yogis • Translation of hatha-yoga treatise Amrita Kunda into Arabic and Persian. • Baba Farid's use of the Punjabi language and Syed Gesu Daraz's use of Hindi in his writings • Emphasis on charity and opposition to orthodox practices

Mughal Emperor Akbar

Introduction	• Born in 1542, crowned in 1556 under protector Bairam Khan • Defeated Hemu in the second battle of Panipat in 1556
Military Conquests	• Malwa was conquered in 1562 from Baz Bahadur • Annexation of Gondwana from Rani Durgavati in 1564 • Annexation of Chittor followed by the surrender of Ranthambore, Kalinjar, Bikaner, Jodhpur and Jaisalmer • Conquered Gujarat from Muzaffar Shah in 1573 • Annexation of Bihar and Bengal in 1576 by defeating Daud Khan • Occupied Khandesh region in 1591 • Berar in 1596 from Chand Bibi

DIMENSION	DESCRIPTION	SUBSTANTIATION
Rajput Policy	• Marriage alliances with Rajput princesses • High positions in the Mughal court for Rajputs • Religious and social reforms • Integration of Rajput administrators and warriors	• Marriage with Harkha Bai (Daughter of Raja Bhar Mal) • Example: Raja Bhagwan Das and Raja Man Singh • Abolition pilgrimage and Jiziya tax • Abolition of Sati • Example: Raja Todar Mal and Birbal
Religious Policy	• Began as a pious Muslim but later adopted an accommodative approach • Tolerance and inclusivity towards other faiths and religions • Discussion on spiritual matter with different interfaith scholars • Belief in one god and influence of sufism, unified and inclusive religious framework • Translation of other religious texts	• Contact with Sufi saints, teachings of his tutor Abdul Latif, marriage to Rajput women • Abolition pilgrimage and later Jiziya tax • Akbar's philosophy of Sulh-i-Kul • Establishment of Ibadat Khana • Propagation of Din-i-ilahi • Translation of Ramayana, Mahabharata, the Atharva Veda, the Bible and the Quran into Persian.
Mansabdari system	• Rank (Mansab) assignment to the officers: Princes of royal blood received even higher ranks • Non-hereditary system • Promotions and demotions • Determination of soldiers and horses • Salary in cash but paid through assigning Jagirs	• Division of ranks into "zat" and "sawar" • Transfer of Mansabdars • Promotion through getting higher Mansabs or face demotions by having Mansabs reduced • Zat rank: number of soldiers required by each Mansabdar • Sawar: number of horses by required • Jagir: an estate from Mansabdar could collect money in lieu of his salary

Harshavardhana

Introduction

- Pushyabhuti emperor who ruled northern India during 7th century AD.

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• Similar to the administration of the Gupta empire • Council of Ministers to aid and advice king • Maintenance of public records • Well-maintained army • Mahasamantas (independent rulers) helped in military reinforcements • **Revenue administration:** land revenue as 1/6th of produce	• Feudal and decentralised • Empire division: Provinces (Bhuktis) → districts (Visayas) → villages • Avanti: Minister for Foreign Relations and War • Simhananda: Commander-in- Chief • Niolpitu: archive of Harsha period • Four divisions: foot, horse, chariot and elephant • Madhuvana Copper Plate related to King's due of Harsha period • **Taxes:** Bhaga, Hiranya and Bali
Socio - economic conditions	• Four varna system: Brahmins had high status • Unsatisfactory position of women • Decline in trade and commerce • Tolerant religious policy	• Hiuen Tsang mentions that the Sudras practised agriculture • Purdah system, practice of Sati, decline in Swayamvara marriages • Less number of trade centres and less coins • Allahabad conference: gifts to all religions
Cultural contribution	• **Architecture:** Building of monasteries and temples • **Literature:** Harsha himself was an author and patronised Banabhatta, Matanga Divakara etc. • Promotion of Buddhism in later period by Harsha • Education: Grants to Nalanda university	• Example: brick temple of Lakshmana at Sirpur • Monastery at Nalanda • Works of Harsha: Ratnavali, Priyadarsika and Nagananda • **Example:** Kannauj Assembly to honour Hiuen Tsang • Nalanda university at its peak, student from abroad countries

Cholas

Introduction

- Ruled the Tamil country in the early Sangam period, described as the Muvendhar in the Sangam literature
- Became prominent in the ninth century and extended their sway in Sri Lanka and the Malay Peninsula.

DIMENSION	DESCRIPTION	SUBSTANTIATION
Administration	• **Central:** Hereditary monarchical power, assisted by a council of ministers • **Provincial:** Feudatory system, division of the empire into sub-units • **Village:** Village autonomy, village assemblies (Ur, Urar, Agraharams) • **Military:** well-maintained army, consisting of cavalry, bowmen, elephant corps etc.	• Perundanam and sirudanam: administrative machinery of officials • Empire →mandalams (under royal princes) → valanadus (under periyanattar) →nadus (under nattar) • **Uttarmerur inscription:** information about village councils • **Nilaipadai:** Military outposts in the conquered territory
Socio-economic conditions	• Prevalence of Varnashrama system • Hierarchy according to land ownership • No improvement in the position of women • Flourishment of Saivism and Vaishnavism • Expansion of agriculture • Improved irrigation system • Increased trade both domestically and abroad • Development of weaving industry • Practice of free labour in public works	• Valangai and Idangai castes • Brahmadeya-kilavars > landholders of vellanvagai villages > Ulukudi • Practice of 'sati', Devdasi system • Nayannars and Alvars flourished during this period. • Production of food grain surplus • Practice of turn system, Vativaykkal: criss-cross channel • Garveras and Gaudas/ Gavundas: Trading castes • Maritime trade centres: Munai-santai, Nagapattinam etc • Idangai: Artisanal and trading caste groupings • Vetti and Amanji: Forms of free labour
Cultural contribution:	**Architecture:** • Use of stone instead of bricks • Features: Boundary wall, vimana, Gopurama, Antarala, water tank etc	• Examples: Nataraja Temple, Chidambaram, Rajarajeswara temple, Gangaikondacholapuram Temple
	Art: • **Sculptures:** on walls and interiors of temples, use of lost wax technique • **Paintings:** attention to facial expressions and hand gestures • Music and dance: return of tevaram music to temples by Rajaraja I	• Example: bronze statue of Nataraja • Example: painting of Rajaraja Chola I, listening to his preceptor Karuvur Devar • Oduvars and Padikam Paduvars: singers and Theli-cheri-pennugal: dancers
	Literature: • Development of Tamil literature • Saiva Siddhanta: philosophical system founded during this period	• Sivakasintamani by Thiruthakkadevar, Virasoliyam by Buddhamitra

Alauddin Khalji

Introduction

- Ruler of the Khalji dynasty that ruled the Delhi Sultanate
- Became second ruler of Khalji dynasty after murdering his father-in-law Jalaluddin Khalji

DIMENSION	DESCRIPTION	SUBSTANTIATION
Military Campaigns	• Military expedition against Gujarat • Expeditions against Rajput states • Expedition against Deccan and southern state	• Capture of Gujarat in 1299 by Nusrat Khan and Ulugh Khan • Expedition against Ranthambore and Chittor • Submission of Devagiri ruler, defeat of Hoysala ruler VeerBhalla II
Reforms	• **Army:** maintenance of a large permanent army, payment in cash from the royal treasury • **Market reforms:** establishment of four separate markets, fixed price of commodities, registration merchants with market departments • Esatblishment of spy agents on the functioning of market reforms • Hrash punishment for violetion of orders • Reforms in land administration	• Introduction of **Dagh system** (branding of horse) • **Huliya:** descriptive list of soldiers • **Shahna-i- Mandi:** A high officer in control of markets • **Naib-i-Riyasat:** officer in control of Diwani Riyasat • **Munhiyans**: secret agents • Maintenance of same prices even during famine • Ordered measurement of land

Foreign sources in constructing history of India

Introduction

- Foreign sources such writings of greek and roman authors and accounts of chinese and arab travellers supplement the indigenous sources for reconstructring the history of India

DIMENSION	AUTHOR/TRAVELLER	DESCRIPTION
Greco Roman Scholars	**Megasthenese (3rd century BC)**	• **Indica:** mentions geographical features of India, absence of slavery, presence of caste system, mauryan administration
	Strabo (1st century BC)	• **Writing:** Geographia • Mentions marital relationship between Seleucus Nicator and Sandrokuttus (Chandragupta Maurya)
	Pliny (3rd century AD)	• **Naturulis Historica:** gives description about India, trade relations between India and Rome
	Ptolemy (2nd century AD)	• **Geography:** Information about ancient geography and trade between India and Rome
	Kosmos Indicopleustes (6th century AD)	• **Christian Topography of the Universe:** information on trade relations between India and Sri Lanka
	Others	• **Periplus of the Erythrean Sea:** Glves idea about maritime activities of India and Sangam period
Chinese travellers	**Fa-Hien (5th century AD)**	• Came during the reign of Gupta ruler Chandragupta II • **Fu-Kuo-Ki (Records of Buddhist Countries):** description on history, and culture of Gupta period
	Hiuen Tsang (7th century AD)	• Came during the reign of Harshvardhana • **Si-Yu-Ki:** described city life in India, life of Harsha, educational system of the time, mention of Huna ruler Mihirkula
	Itsing (7th century AD)	• **A Record of the Buddhistic Religion:** information about Sanskrit Literature, information on socio-economic conditions of the time, give reference to Sri Gupta
Arab travellers	**Sulaiman (9th century AD)**	• **Silsilah-ut-Tawarikh:** description about Pala, Pratihara and Rashtrakuta
	Al Masudi (10th century AD)	• **Muruz-ul-Jahab:** description of horses and camels of Mahipala I and Paan (beetal leaf)
	Alberuni (11th centruy AD)	• **Kitab-ul-Hind (Tarikh-i-Hind):** topics on different subjects beginning with question
	Ibn Batuta (14th century AD)	• Came to India during the reign of Mohammad Bin Tughlaq • **Rihla:** details about socio-cultural life of India in 14th century, description of Paan and Coconut, description of Delhi and mention of postal system
	Abdur Razzaq (15th century AD)	• Visited the Vijayanagara Kingdom at the time of Dev Raya II • Matla-us-Sadain-wa-Majma-ul-Bahrain: description of maritime trade through Indian Ocean

BIOTECHNOLOGY

Genetic Modified Organism (GMO)

DIMENSIONS	DESCRIPTIONS	SUBSTANTIATION
What is GMO?	Organisms whose genetic material has been altered using genetic engineering techniques, are created to enhance desired traits such as increased resistance to pests or improved nutritional content.	
Why in the News?	Near about 500 tonnes of Golden rice (a GM crop) were found in the consignment of rice exported from India to Europe.	
Types of GMO	• **Transgenic Organisms:** Genes from one species inserted into another. • **Cisgenic Organisms:** Modified with genes from the same or a closely related species. • **RNAi GMOs:** Modified to have reduced expression of certain genes through RNA interference. • **Site-Directed Mutagenesis GMOs:** Specific DNA sequences altered without introducing foreign DNA. • **Plasmid GMOs:** Organisms modified using plasmids, circular DNA structures. • **Viral GMOs:** Organisms with integrated viral DNA to achieve specific traits.	• Bt corn-donor organism is a naturally occurring soil bacterium. • GM Apple varieties to resist browning using apple genes. • Potatoes are engineered to produce less acrylamide when fried. • Crops edited using CRISPR technology to enhance drought resistance. • Bacteria are modified to produce insulin for medical use. • Plants modified with viral genes to develop resistance against that particular virus.
Significance of GMO for India	• **Food Security:** It can potentially increase yield and reduce losses due to pests. • **Reducing Imports:** High-yield oilseeds could decrease India's edible oil imports. • **Farmer Income:** Higher yields and increased income. • **Environmental benefits:** Decrease in the use of pesticides and herbicides. • **Drought Resistance:** Engineered to handle weather variations and extremes. • **Nutritional Enhancement:** Aid in countering hunger and malnutrition	• GMO globally has increased food production by 311.8 million tonnes over 15 years. • Edible oil is the third largest import of India valued at $10 billion annually. • GM mustard has a huge yield potential • Reduced pesticide use with Bt Cotton in India • GM Maize can thrive in India's semi-arid regions. • Golden rice, enriched with Vitamin A, can combat malnutrition issues.
Status of different GMO crops in India	**Bt Cotton:** » Bt cotton is genetically modified using a gene from the bacterium Bacillus thuringiensis (Bt). » Produces insecticide to protect against the bollworms. » This is the only GM crop approved for commercial cultivation in India.	• Indian farmers began growing Bt cotton in 2002-03. • About 96% of India's cotton cultivated area (2014). • India ranks fourth in GM crop cultivation by area.
	GM Mustard » Approved by the GEAC for commercial cultivation. » It employs genes from soil bacteria, improving mustard's hybridization.	• Dhara Mustard Hybrid (DMH-11) is the name of variety. • Has over 25-30% yield increase over non-hybrids
	Bt Brinjal » In 2007, GEAC recommended the commercial release of Bt Brinjal. » The government though banned the cultivation of Bt brinjal in 2010	• The Variety reduces reduces the need for chemical insecticides,

	Other GM Crops » **Golden rice:** Increases beta-carotene production, aiding against vitamin A deficiency. » **Papaya ringspot virus-resistant papaya**: for resistance against the papaya ringspot virus. » **Resistant cassava:** Modified to resist viral diseases. » **Frost-tolerant strawberries:** Genetically modified to endure frost.	
Issues associated with GMO adoption in India	• **Environmental impact:** GMOs could cause irreversible environmental effects, such as creating invasive species. • **Unintended consequences:** Genetic modifications can lead to unfore it seen results, like unexpected allergens. • **Cross-contamination:** Accidental GMO mix with non-GMO crops could impact GMO-free markets. • **Corporate control and monopoly:** Few large corporations dominating GMO patents might control the food supply. • **Market Access:** Concerns about export markets that have restrictions or bans on GM products.	• Invasive species-impating species diversity • Allergens impacting human health • Reduction in locally adapted crop varieties. • IP and patents on GM seeds
Possible Solutions	• **Comprehensive risk assessment:** Rigorously evaluate GMOs for environmental, health, and unintended risks before release. • **Transparency and labelling:** Mandate clear GMO labelling for informed consumer choices. • **Environmental monitoring**: Set up systems to continuously monitor GMOs' environmental and health impacts. • **Biodiversity protection**: Design GMOs to minimize potential harm to biodiversity. • **International collaboration:** Foster global agreements for consistent GMO development, testing, and trade standards.	• Engage diverse stakeholders in GMO development discussions • GMO mark on the lines of Agmark. • Develop synergy between sustainable farming and GMO development.

Three Parent Baby

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is a Three - Parent Baby?	A **"three-parent baby"** is a child conceived through a technique that combines DNA from two women and one man, primarily to prevent certain mitochondrial diseases.	
Why in the News?	A baby in the UK, is born with the DNA of three parents.	
What are Mitochondrial Diseases	Disorders caused by **dysfunctional mitochondria.** It can result from mutations in **mitochondrial DNA (mtDNA**) or in nuclear DNA that codes for mitochondrial components.	• Example- **Leigh Syndrome, Kearns-Sayre syndrome (KSS), Mitochondrial Myopathy.** • Globally, an estimated 1 in 5,000 people have a genetic mitochondrial disease
Science of Mitochondrial Donation Treatment	**Identification of suitable candidates**: Aimed at couples desiring a genetic child without using a donor egg.	

	Selection of Donor and Biological Parents: The biological mother with a mitochondrial disease provides her eggs. » A separate female donor with healthy mitochondria is selected.	Eggs are fertilized with the biological father's sperm
	Mitochondrial Replacement: DNA from the donor's egg is removed and replaced with DNA from the biological parents.	The resulting embryo has the parents' DNA and the donor's mitochondria.
	Implantation and Pregnancy: A modified embryo is implanted in the uterus.	The baby is born, free from the mother's mitochondrial disease.
Potential Side Effects	**Potential risk**: Small chance of transferring faulty maternal mitochondria during the procedure.	More research and data publication are required.

Stem Cell

DIMENSION	DESCRIPTION	SUBSTANTIATION
What are Stem Cells	Stem cells are undifferentiated cells that have the potential to develop into many different types of cells in the body. They serve as a repair system for the body, replenishing adult tissues.	
Why in the News?	The Delhi High Court Thursday permitted two children with autism spectrum disorder (ASD) to undergo stem cell therapy for treatment of their condition.	
Types of Stem Cells	**Embryonic Stem Cells (ESCs):** These are derived from embryos.	Developed from eggs that have been fertilized in vitro
	Adult (or Somatic) Stem Cells: These are found in small quantities in most adult tissues	Derived from bone marrow or fat
	Induced Pluripotent Stem Cells (iPSCs): These are adult cells that have been genetically reprogrammed into an embryonic stem cell	
	Perinatal Stem Cells: These can be isolated from amniotic fluid.	They have characteristics of both embryonic and adult stem cell
What is Stem Cell therapy?	Stem cell therapy is a medical approach that utilizes undifferentiated cells to repair or replace damaged tissues and organs in the body.	
Application	**Regenerative Medicine:** Replacing damaged organs or tissues.	Aid in cure of heart disease, diabetes, etc.
	Neurodegenerative Diseases: Replace damaged neurons	Treat conditions like Parkinson's or Alzheimer's
	Immune system: Treatment of Blood and Immune System-Related Conditions	Bone marrow transplantation for leukaemia
Challenges and concerns	**Ethical Issues:** Controversies surrounding the use of embryonic stem cells.	
	Safety and Efficacy: Need for thorough clinical trials before wide application.	Potential for tumours or unwanted immune responses.
	Regulatory and Approval Hurdles: It can slow down the process of making treatments available.	

CAR T-Cell Therapy

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is CAR T-cell Therapy?	It is a type of immunotherapy where a patient's T cells are genetically modified to produce chimeric antigen receptors (CARs) that target cancer cells.	
Why in the News?	CAR T-Cell has emerged as the new technology goes beyond providing a new lease of life to people with leukaemias and lymphomas.	
What are T-cells?	• T cells are a variety of white blood cells essential to the body's immune defence. • Types of T cells: the helper T cell and the cytotoxic T cell	• They help the body recognize and respond to foreign substances • Helper T-Cell-help' other cells of the immune system, • Cytotoxic T cells kill virally infected cells
The science behind the procedure	• **Introduction:** T cells are extracted from the patient's blood. • **Receptor:** A gene for a receptor that attaches to a specific protein is introduced to the T cells. • **Multiplication** These CAR T cells are multiplied in large quantities in the lab. • **Infusion:** Patients receive the CAR T cells through infusion**.**	
Significance	• **Targeted agents**: CAR T-cell therapies are highly specific, surpassing targeted agents. • **Immune system:** They directly activate the patient's immune system to combat cancer.	• This results in increased clinical effectiveness. • They are termed "living drugs" due to their nature.
Challenges	• **Preparation:** Preparing CAR T-cell therapies is challenging, limiting their widespread adoption. • **Side Effects:** High efficacy (up to 90%) in certain leukaemias but lower in other cancers. • **Affordability**: Implementing CAR T-cell therapy in India presents cost and value challenges.	• India's first indigenous therapy was conducted in 2021. • Serious side effects include cytokine release syndrome and potential harm to normal cells.

Whole Genome Sequencing

DIMENSION	DESCRIPTION		SUBSTANTIATION
What is Whole Genome Sequencing	Whole genome sequencing deciphers an organism's entire DNA sequence, providing comprehensive genetic information. It aids in diagnosing diseases, understanding genetic predispositions, and advancing personalized medicine and evolutionary studies.		
Why in the News?	Recently, the use of rapid whole-genome sequencing (WGS) in newborns, including healthy newborns, has emerged as a revolutionary approach to diagnose and treat genetic diseases.		
Gene vs Genome	**Gene**	**Genome**	
	A gene is a part of a DNA molecule	The genome is the total DNA in a cell	
	Hereditary element of genetic information	All set of nuclear DNA	

	Encodes protein synthesis	Encodes both proteins and regulatory elements for protein synthesis	
	Length is about a few hundreds of bases	Length of the genome of a higher organism is about billion base pairs	
	A higher organism has about thousands of genes	Each organism has only one genome	
	Variations of the gene named alleles can be naturally selected	Horizontal gene transfer & duplication cause large variations in the genome	
Advantages of Whole Genome Sequencing	**Digital Data Conversion:** Turns every gene into digital data for comprehensive analysis.		Early diagnosis of rare genetic disorders
	High-Resolution Insight: Helps pinpoint likely causal variants, aiding further investigation into gene expression and regulation.		
	Comprehensive Scan: Captures both large and small genetic variants that targeted methods might miss.		Tailoring cancer treatments based on the genomic mutations
	Applications in Medicine: Using bioinformatics, next-gen sequencing now informs treatments for conditions like colorectal cancer and melanoma.		Determining how a patient is likely to respond to a drug
	Depth and Precision: Superior determination of genetic variations due to longer reads.		Sequencing crops to develop strains that are more drought-resistant.
Limitations of Whole Genome Sequencing	**Costly and Time-Consuming:** WGS is more expensive and time-intensive than targeted sequencing methods.		Diagnosing a specific mutation using a targeted sequencing panel can be faster and cheaper
	Lack of a Gold Standard: No established standard to evaluate the overall effectiveness of genomic screening on populations.		
	False Negatives: Disease-causing mutations might be mistaken for normal genes.		
	Incomplete Reference Genomes: The reference genomes used to compare and analyze individual genomes are not complete		Sequences unique to certain ethnic groups might not be well-represented in reference genomes**.**
	Phenotypic Expression Variability: The same genetic mutation can manifest differently in different individuals.		Two individuals with the same mutation might have varying onset ages and severity.

NUCLEAR SCIENCE

Applications of Nuclear Energy

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is Nuclear Energy?	Nuclear energy arises from splitting (fission) or merging (fusion) atomic nuclei. This process releases a significant amount of heat energy. This heat is used to produce steam which drives turbines to generate electricity.	
Why in the News?	The third unit of the indigenously developed 700-megawatt electric (MWe) nuclear power reactor at the Kakrapar Atomic Power Project (KAPP3) in Gujarat has commenced operations at full capacity.	
Applications	**Agriculture** • **Improve crop yield:** Through radiation-induced mutation breeding. • **Pest control: Sterile insect technique** using radiation. • **Food preservation**: Through irradiation to kill pathogens. • **Soil moisture analysis-** Gauging soil fertility • **Radiotracers:** Tracing fertilizers and water uptake in plants. • **Radioactive isotopes**: Studying nutrient utilization in animals. • **Neutron moisture gauges**: Optimization of irrigation. • **Development of biofertlising agents**: Aiding in better plant growth.	• BARC develops high-yielding seed varieties by inducing mutations using Gamma radiation. • KRUSHAK was developed by BARC for Radiation processing. • Gamma radiation processing plant under the SAMPADA Scheme
	Medicine • **Radiotherapy:** Targeted radiation to destroy cancerous cells. • **Positron Emission Tomography (PET):** Scans for detailed body imaging. • **Radioactive iodine:** Treat thyroid disorders. • **Radiotracers:** For detection of bone abnormalities and assessment of blood flow in organs and tissues. • **Radiopharmaceuticals**: Radioactive compounds used in diagnosis and treatment. • **Myocardial perfusion:** Imaging to evaluate heart health.	• Bhabhatron delivers radiation therapy for the treatment of cancer patients • Radiopharmaceuticals manufactured in India-99mTc-Technetium-cancer detection, 18F-Fluorine-diagnosis of neuro diseases
	Industry • **Radiography:** To inspect welds and materials for defects. • **Radiation analysis:** To measure thickness, density, and moisture content. • **Ion implantation:** Modification of materials' properties. • Use of radiotracers for tracking flow rates and **detecting leaks in industrial systems.**	
	Environmental Conservation • **Pollution Control:** Using radiotracers to track and manage pollutants in ecosystems. • **Waste Management:** Reducing hazardous waste volumes via radiation treatments. • **Freshwater Conservation:** Isotope techniques for optimizing groundwater use and recharge. • **Carbon Monitoring:** Isotopic methods to track carbon sequestration and storage • **Reforestation:** Radiotracers to study nutrient and water uptake in reforested areas. • **Water Desalination**: Nuclear-powered desalination of seawater.	• BARC has developed several water purification and desalination technologies. • BARC has developed a Nanocomposite Ultrafiltration Membrane for purification with respect to Arsenic, Iron and Microbial Contamination
	Space Exploration • Radioisotope thermoelectric generators (RTGs) provide power to spacecraft. • Radioisotopes act as a heat source in cold environments. • Nuclear instruments help in **deciphering cosmic phenomena.**	

	Archaeology • **Radiocarbon Dating**: Determining the age of ancient organic materials. • **Gamma Spectroscopy:** Studying radiation emitted from samples for dating and analysis. • **Muon Radiography:** Penetrating imaging to study large structures like pyramids.	• Accelerated Mass Spectrometry (AMS) is India's dedicated carbon dating facility • A muon detector, called CORMIS (Cosmic Ray Muon Imaging System), to examine the wall of Xi'an city.

Three-Stage Nuclear Programme

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is the Three-Stage Nuclear Programme?	Dr. Homi Bhabha devised India's three-stage nuclear power programme in the 1950s. Its aim was to ensure India's long-term energy autonomy using uranium and thorium from South India's monazite sands.	
Why in the News?	India has begun commercial operation of its first domestically designed 700-MWe pressurized heavy water reactor (PHWR) at the Kakrapar nuclear power plant in Gujarat	
Stage-I-Pressurized Heavy Water Reactor [PHWR]	• Use of natural uranium to produce electricity and generate plutonium-239 from U-238 • Doesn't require enriched uranium • Heavy water acts as the moderator and coolant.	• Nearly all of India's current nuclear power capacity consists **of first-stage PHWRs.**
Stage-II-Fast Breeder Reactor	• Fast breeder reactors (FBRs) use **plutonium-239 from reprocessed spent (first stage)fuel.** • Plutonium-239 in FBRs undergoes fission for energy production. • Stage II FBRs are engineered to produce more fuel than they utilize.	• A prototype of FBR was developed by the **Indira Gandhi Centre for Atomic Research (IGCAR)** at Kalapakkam
Stage-III-Thorium Based Reactors	• Operate on a self-sustaining thorium-232-uranium-233 fuel cycle. • They are thermal breeder reactors that can be refuelled with natural thorium after the initial charge.	• Deficit in fissile material has hindered the widespread implementation of thorium reactors in India.
Why the emphasis on Thorium technology?	• Produce **much less waste.** • Simplifying **waste management.** • Higher burnup makes thorium reactors more cost-effective.	• Efficiently burn highly radioactive actinides
Challenges to 3 stage nuclear power elements	• Safety and waste management • **Fissile material availability** is limited, necessitating diplomatic efforts. • **Land acquisition** for Nuclear Power Plants. • **Reprocessing and enrichment capacities.**	• **Not being an NPT and NSG** signatory limited India's nuclear supply,

Small Modular Reactors

DIMENSION	DESCRIPTION	SUBSTANTIATION
What are Small modular reactors?	SMRs are compact nuclear power units with a smaller output than traditional reactors. They can be manufactured off-site and easily transported for assembly, offering scalable and potentially more cost-effective nuclear energy solutions.	
Why in the News?	Recently, India has decided to upscale private sector participation in Nuclear energy through SMR	

Advantages of SMR	**Reliable Low-carbon Electricity:** • SMRs provide consistent, low-carbon electricity, complementing intermittent renewables. • Essential for grid reliability and cost reduction in green electricity systems.	• There are two Small Modular Reactor projects that have reached at operational stage globally » **Akademik Lomonosov** floating power unit in Russia » **HTR-PM** demonstration SMR in China • SMR will aid in the decarbonization of the power industry.
	Land Acquisition Benefits: • SMRs produce less nuclear waste and suit brownfield sites, easing land challenges. • Simpler design and serial manufacturing potentially lower costs.	
	Alternative to Critical Minerals: • Clean energy transitions lean on Critical Minerals like lithium, raising geopolitical and environmental issues. • SMRs use low-enriched uranium, more common than critical minerals.	
	Alignment with India's Energy Goals: • India targets net zero by 2070; SMRs can boost energy security and grid stability. • The Central Electricity Authority sees SMRs as key; private investment and partnerships drive expansion.	
Applications	• **Electricity Generation:** Especially in areas where larger reactors might not be feasible. • **Ship Propulsion:** power large naval or commercial vessels. • **Hydrogen Production:** It can be employed in high-temperature steam electrolysis processes to produce hydrogen. • Replacing Aging Reactors: SMRs can serve as replacements, offering newer technology and enhanced safety features. • **Desalination**: It powers desalination plants, providing freshwater from saltwater sources.	• For SMR, deployment in the Inda amendment in the Atomic Energy Act, 1962 is required to permit private sector participation.

Nuclear Fusion

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is the Nuclear Fusion?	Nuclear fusion is a process where atomic nuclei combine, releasing vast energy, powering the sun and offering potential for clean, limitless terrestrial energy sources.	
Why in the News?	Recently a few scientists at the Lawrence Livermore facility, the US have achieved **a net gain in energy from a nuclear fusion reaction,** which is seen as a big breakthrough.	
Applications of the Nuclear Fusion	**Electricity Production:**Generate large-scale electricity by harnessing the energy released from fusion reactions.	The ITER project aims to prove as a large-scale power source.
	Medical Isotope Production: Fusion reactions can produce specific isotopes used in medical treatments and diagnostics.	
	Production of Rare Elements: Fusion reactions can be used to produce scarce and valuable isotopes.	E.g. Tritium, used in various industrial and scientific applications.
	Astrophysical Studies: Fusion processes on Earth can help us understand the internal processes of stars	Aid astronomers understand stellar evolution and phenomena.
	Potential Desalination: Fusion power could be harnessed to drive the energy-intensive process of turning seawater into fresh water.	
	Space Propulsion:Fusion-driven rockets might offer much faster space travel	

Challenges associated with Nuclear Fusion	**Containment of High Temperatures:**Fusion requires temperatures of millions of degrees.	Use of magnetic confinement are being explored.
	Economic Viability: Building fusion reactors requires enormous capital investment.	
	Long Development Timeline: Commercial fusion power remains a long-term goal.	
	Energy Input vs. Output: Fusion experiments have consumed more energy to initiate and maintain the reaction than the energy produced	Net Positive energy is essential for commercial viability
	Material Degradation: The intense neutron bombardment from fusion reactions can damage reactor materials over time	
ITER TOKAMAK and its Significance	A tokamak is a device designed to confine plasma in a toroidal shape using a powerful magnetic field. • **Reduced Radioactive Waste:**Produce minimal and short-lived radioactive waste, • **Fuel Abundance:** Uses deuterium which can be extracted from sea water. • **Safety:**Inherently safer than fission reactions in traditional nuclear reactors • **Advancing Plasma Physics:** Expand understanding of plasma physics	To be used for harnessing nuclear fusion energy. • There's no risk of a meltdown • Aid in space propulsion and medical technologies.
India's contribution to ITER	**Cryostat Manufacturing:** The ITER cryostat is manufactured by an Indian company, Larsen and Toubro.	It provides a high vacuum for superconducting magnets.

CLEAN TECHNOLOGIES

Green Hydrogen

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is Green Hydrogen?	Green hydrogen is produced by splitting water into hydrogen and oxygen through the electrolysis process, powered by renewable energy sources like solar or wind. This hydrogen serves as a clean and renewable fuel.	
Why in the News?	India has launched the National Green Hydrogen Mission. The mission targets the production of 5 million tonnes of green hydrogen for local consumption.	
Applications	**Agriculture Sector** • **Fertilizer Production:** It can produce ammonia, potentially replacing traditional fertilizers.: • **Farm Machinery:** Tractors, harvesters, and irrigation tools can operate using green hydrogen. • **Water Management:** It can energize desalination plants, turning saltwater into freshwater.	• Carbon-free with increased efficiency • Reduces greenhouse gas emissions • Lessens dependence on dwindling freshwater supplies.
	Transportation Sector • **Hydrogen Fuel Cells:** Transform hydrogen and oxygen's chemical energy into electricity, water, and heat.	Longer range than electric vehicles and emit zero pollutants.
	Industrial Sector • **Waste Management:** Supports waste reduction and sustainability. • **Energy Efficiency Enhancement:** On-site production and storage make it a consistent energy source	• Curb energy costs and foster sustainability. • Reduce grid reliance
Challenges	**Cost:** Pricier than traditional fossil fuels	It requires 3-6 USD per kg production
	Infrastructure: Comprehensive adoption of green hydrogen necessitates a strong infrastructure.	Specialized infrastructure for its production, storage, and distribution.
	Energy Storage: It relies on renewable energies like wind, solar, and hydro, which are intermittent.	
	Safety: It is highly flammable and requires special storage and handling precautions.	
	Public Acceptance: Widespread acceptance is key for green hydrogen's success.	
India's Initiative	**National Hydrogen Mission:** Establishing India as a major player in the green hydrogen and its derivatives market.	
	Green Hydrogen Consumption Mandates: Set consumption benchmarks for the fertilizer and petroleum refining sectors,	
	Development of Green Hydrogen Hubs: Developing areas for large-scale green hydrogen production or utilization.	
Way Forward	**Addressing High Production Costs:** Partner green hydrogen production with other renewables	Using advanced materials for electrodes or better catalysts.

	Regulatory Incentives and Government Role: Foster green hydrogen adoption via regulatory boosts like tax breaks and financial aids.	Need for a tax break and financial aid.
	Infrastructure and Supply Chain Development: It demands specific infrastructure for its entire lifecycle, from production to distribution.	
	Inter-sectoral Coordination: Multiple entities, from renewable energy producers to end-users, are involved in the green hydrogen value chain.	Need for coordinated policies, regulations, incentives, and markets
	Promotion and Skill Development: Green hydrogen's nascent status requires heightened awareness and capacity enhancement**.**	Skill and expertise development is crucial

Fuel Cell Technology

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is a Fuel cell?	A fuel cell is an apparatus that produces electricity through a chemical reaction, utilizing a positive ion, hydrogen, and an oxidizing agent, oxygen**.**	
Why in the News?	Germany launched the world's first fleet of fully hydrogen-powered trains, these are emissions-free trains	
Science of a Fuel Cell	**Operation Duration:** They generate electricity and heat as long as fuel is present.	Eliminates the need for recharging.
	Components: ● Anode (Negative Electrode): Receives fuel like hydrogen. ● Cathode (Positive Electrode): Intakes air.	
	Functional Mechanism: ● Electrons: Traverse an external circuit, generating electricity. ● Protons: Move through the electrolyte to the cathode.	
Advantages of Fuel cell	**Low Emission:** Produces no pollutants when powered by pure hydrogen.	Emits pollution is less than one ounce per 1,000 kilowatt-hours.
	Noise Aspects: Minimal noise pollution makes them unobtrusive whether placed indoors or outdoors.	Operates quietly, approximately 60 dB less than conventions
	High Efficiency: Superior efficiency compared to combustion systems due to electrochemical energy generation.	Achieves 40-50% fuel-to-electricity efficiency
	Constant Power Supply: Ensures uninterrupted power, especially critical during weather disruption	
	Durability: Versatile placement options, from rugged terrains to extreme environments.	Military applications are significant
	Scalability: Modular design allows for tailored power solutions based on requirements.	
	Portability and Lifespan: Longer operational lifespan than batteries	Use in laptops and cell phones

Challenges	**Hydrogen Extraction:** Extraction processes are energy-intensive and often rely on fossil fuels.	it must be derived from water or separated from fossil fuels**.**
	Investment Needs: It requires substantial investments to become a feasible energy source.	
	Cost of Raw Materials: It often uses precious metals as catalysts leading to high initial costs.	
	Regulatory Challenges: The absence of clear regulatory frameworks can inhibit commercial ventures.	
	Storage and Transportation: It is more challenging and costlier than fossil fuels.	
	Infrastructure: Existing energy infrastructure is tailored for fossil fuels**.**	
	Safety Concerns: Hydrogen is highly flammable, posing potential safety risks.	It can combust in air at concentrations between 4 to 75 percent.
Applications	**Fuel Cell Electric Vehicle (FCEV):** It has high energy conversion efficiency and near-zero emissions.	Could replace diesel buses in public transport
	Power Generation: Fuel cells are well-suited for decentralized, small-scale power generation.	Useful in commercial buildings, hospitals, airports, and remote military sites
	Aviation and Fuel Cells: The fuel cell is integrated into the aircraft's aerodynamic surfaces.	Power small UAV

SPACE TECHNOLOGY

Chandrayaan-3

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is Chandrayaan-3	Chandrayaan-3 is India's 3rd Lunar mission successfully landed the Vikram Lander and Pragyan Rover on the Lunar South Pole. India is the first country to achieve a soft landing at this location and the fourth globally on the moon.	
Background	In 2019, Chandrayaan-2 did not succeed in its mission due to a failure to achieve a soft landing. The primary cause of the mishap was that the lander's five thrusters generated a velocity greater than anticipated.	
Key reasons behind the success of Chandrayaan-3	• **"Failure-based Design" Over "Success-based Design":** Designed for soft landing even if all systems, including sensors and electronics, failed. • **Increase in Landing Area:** A larger area provides the Lander with more site options for landing. • **Additional Fuel for the Lander:** Allows the Lander to cover longer distances • **Support from Chandrayaan-2 Orbiter**: Utilizes high-resolution images from Chandrayaan-2 orbiter. • **Robust integrated craft enhancements:** Strengthened Lander weight and design	Facilitates travel to alternate landing sites Chandrayaan-3 doesn't have its own orbiter. Solar panels to guarantee power generation post-landing
Components of Chandrayaan-3	The Chandrayaan-3 Mission consists of two modules - **The propulsion module (PM) and the Lander module (LM).**	
	Propulsion Module- carried the lander and rover configuration	Carries till 100km of lunar orbit
	Lander Module: It consists of a **Lander (Vikram) and a Rover (Pragyan).** Lander payloads	Lander Module made the soft landing using the **Automatic Landing Sequence (ALS),**
Scientific Payloads	**Propulsion Module** • **Spectro-polarimetry of Habitable Planet Earth (SHAPE)-** It will conduct novel spectro-polarimetric studies of Earth from lunar orbit.	To look for smaller planets that could be habitable in the reflected light.
	Lander • **Radio Anatomy of Moon Bound Hypersensitive Ionosphere and Atmosphere (RAMBHA):** To measure the plasma density • **Chandra's Surface Thermophysical Experiment (ChaSTE)**-To carry out the thermal traits of the moon's • **Instrument for Lunar Seismic Activity (ILSA)**-To measure seismic activity. • **LASER Retroreflector Array (LRA)**: To understand the dynamics of the Moon system	• Understand Fluctuations near the lunar surface. • Sutdy frigid polar zones. • For unveiling lunar crust-mantle configuration
	Rover • **Alpha Particle X-ray Spectrometer (APXS):** To study soil and rocks • **LASER Induced Breakdown Spectroscope (LIBS):** To analyse elemental constitution	• Determine chemical composition and mineral attributes • Aid in enriching lunar geology insights
Objectives after landing	**Operation:** Operate for one lunar day (14 Earth days) on the moon's surface	

	Pragyan Rover: Explore within a 500-meter radius of the landing site.	Conduct experiments and send data/ images to the Vikram lander.
	Vikram Lander: Relays data and images to the orbiter.	Transmit information to Earth
	Scientific Payloads: Comprehensive lunar investigations	Exploration for water and potential resource reservoirs.
	Propulsion Module: Study spectral and polarimetric measurements of Earth from the lunar orbit.	Carried the lander and rover up to 100 km lunar orbit.
Significance of the mission	• **Human Presence:** Aids in India's goal to establish human presence on the moon. • **International Collaboration:** JAXA for LUPEX benefits from this Mission's success. • **Advance Space education:** Inspires future space enthusiasts. • **Asteroid Impact:** Study potential asteroid impacts. • **Geological insight:** Fresh geological insights of the South Pole and lunar interior dynamics. • **Aerospace boost:** Investment and job growth in the sector. • **Recognition and Space Race:** It will earn India global recognition and reinforce India's strategic position in the space race.	.

Small Satellite Launch Vehicles

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is SSLV?	SSLVs are designed for quick and **cost-effective launches** of small satellites. They carry fewer components compared to other launch vehicles, ensuring a **shorter turnaround time.**	
Why in the News?	Recently, ISRO launched **SSLV-D2,** which deployed ISRO's earth observation satellite **EOS-07, along with two other satellites, Janus-1 and AzaadiSat2.**	
Key features	The SSLV is a three-stage launch vehicle featuring both solid propulsion stages and a liquid propulsion-based **Velocity Trimming Module (VTM),** it can launch satellites **weighing 10 to 500 kg into a 500 km planar orbit.**	
Significance	**Diverse payload:** Shift from prioritizing larger payloads to diverse entities launching satellites.	Covers the majority of stakeholders from governments to universities.
	Data and services: Drive the need for space-based data and services	Space-based commerce
	Cost-effective: Save cost and high launch fees	Starlink and One Web project
	Commercial advantage: Aid in Increasing the frequency of cost-effective rocket launches.	Aid in ISRO commercial activities
Applications	**Earth Observation:** Observe various phenomena on Earth.	Satellite EOS-07 of ISRO
	Communication- to relay television, radio, and phone signals.	Better connectivity in remote areas.
	Scientific Research satellites from universities and colleges	KalamSAT, Parikshit etc.
	Space Exploration- Sending probes or instruments to study other celestial bodies	
	Surveillance and reconnaissance- To monitor regions for various purposes, from border security to environmental monitoring.	

NAVIC

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is NAVIC?	NAVIC (Navigation with Indian Constellation) is India's regional satellite navigation system developed by ISRO. It covers an area extending up to 1,500 km from the country's boundary. The system consists of a constellation of seven satellites	
Why in the News?	The government of India is planning to make all devices to be compatible with the indigenous Navigation System, NavIC (Navigation with Indian Constellation).	
Significance of NAVIC Integration into Smartphones	• **Strategic technological autonomy:** Secure vital navigation infrastructure for defence and national security. • **Enhanced accuracy and reliability:** Provides precise positioning in the Indian subcontinent. • **Tailored solutions for Indian terrain:** Optimized for India's unique geographical conditions. • **Broadening use cases and innovation:** Encourages diverse location-based services and apps.	• Aid in disaster response, agriculture, urban planning, and transport. • Precise location services in remote areas • Aids Startup ecosystem.
Applications	**Agriculture:** Efficient use of water and fertilizers	Precision Farming
	Disaster Management: Predict and monitor real-time development	Early warning system for cyclones
	Urban Planning: Efficient transport routes and infrastructure.	Bhuvan Maps
	Maritime Navigation: To get alerts about international boundary crossing and weather conditions.	Sagar Setu mobile app
	National Security and Defense: Missile guidance and navigation of drones	Aakash Weapon System
	Location-based services and apps: Efficient route optimization and accurate ETA calculations.	Food delivery, E-commerce and taxi services in India

Aditya L-1

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is Aditya L-1 mission?	Aditya-L1 is India's first space-based solar mission to study the Sun.	
Why in the News?	Indian Space Research Organisation (ISRO) has launched Aditya-L1 using the PSLV-C57 rocket into a halo orbit around the Sun-Earth Lagrange point 1 (L1)	
Payloads and Objectives	**Remote Sensing Payload** • **Visible Emission Line Coronagraph (VELC):** Studies the solar corona. • **Solar Ultra-violet Imaging Telescope (SUIT)**: Captures images of the Solar Photosphere and Chromosphere in near Ultraviolet (UV). • **Solar Low Energy X-ray Spectrometer (SoLEXS)**: Functions as a Soft X-ray spectrometer. • **High Energy L1 Orbiting X-ray Spectrometer (HEL1OS)**: Acts as a Hard X-ray spectrometer.	• Observe dynamics of Coronal Mass Ejections. • Measures solar irradiance variations in near UV. • Studies X-ray flares from the Sun • Investigates X-ray flares from the Sun

	In-situ Payloads • **Aditya Solar Wind Particle Experiment (ASPEX):** Studies solar wind and energetic ions. • **Plasma Analyser Package for Aditya (PAPA):** Gather data on plasma characteristics and composition in the interplanetary space. • **Advanced Tri-axial High-Resolution Digital Magnetometers (MAG):** To measure the low-intensity interplanetary magnetic field in space	• Analyze energy distribution of solar wind. • Provides insights into solar wind interactions with the environment.
Lagrange Points	**Meaning**: They represent specific locations in space where the gravitational pulls from two large celestial bodies in orbit.	the Sun and Earth, counteract and neutralize each other.
	L1: Satellites in halo orbit around L1 can continuously view the Sun without interruptions from occultations/eclipses.	Home to the Solar and Heliospheric Observatory Satellite (SOHO).
	L2: Ideal for observing the vast Universe without Earth's shadow interference.	James Webb Space Telescope orbits near L2.
	L3: Located behind the Sun, opposite Earth and just beyond Earth's orbit.	Enables potential observations of the Sun's far side.
	L4 and L5: Objects maintain stable positions, creating an equilateral triangle with the two larger bodies.	Commonly used for space observatories, especially those focused on asteroids.
Significance of the mission	**Understanding our solar system:** Sun characteristics influence all other celestial bodies.	Deepens knowledge of our solar neighbourhood.
	Space Weather Prediction: Solar activities like solar flares and coronal mass ejections affect Earth's space environment.	Predicting disruptions to communication, navigation, and power grids.
	Advancing Solar Physics: develop an understanding of sun magnetic fields, heating mechanisms, and plasma dynamics	
	Enhancing Energy Research: The study of the Sun core can aid in the development of a nuclear fusion reactor.	The Sun acts as a natural fusion reactor.
	Improving Satellite Operations: For improved spacecraft design and operation.	Solar radiation and wind impact satellite and spacecraft functioning.

Gaganyaan

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is Gaganyaan Mission?	The Gaganyaan mission aims to showcase ISRO's ability to send a human crew to a 400 km orbit and safely return them to Earth.	
Why in the News?	ISRO has successfully conducted the TV D1 mission, the inaugural uncrewed test flight for the 'Gaganyaan' human spaceflight program	
Integral Components of the Gaganyaan Spacecraft	Orbital Module (OM): » Central hub of the Gaganyaan Mission. » Consists of Crew Module (CM) and Service Module (SM). Service Module: » Contains propulsion, thermal, power, and avionics systems, plus deployment mechanisms. .Crew Module: » Features crew interfaces, human-centric products, life support, avionics, and deceleration systems.	• Equipped with advanced avionics systems. • Provides essential support to the Crew Module in orbit • Mimics an Earth-like environment for crew in space.

Gaganyaan Mission Stages and Milestones	**Integrated Air Drop Test (IADT):**Part of the Parachute Deceleration System (PDS) test.	A 5-ton dummy was dropped from 2.5 km by the Indian Air Force.
	Pad Abort Test (PAT): Trial to check spacecraft's launch abort system.	Ensures crew and spacecraft can escape a failing rocket.
	Crew Abort Test Mission: Uses an unpressurized crew module version with deceleration and recovery systems.	Autonomous abort sequence with the crew module landing in the Bay of Bengal.
	Vyomitra:Humanoid robot for the second uncrewed Gaganyaan mission.	Simulates human functions and can warn of uncomfortable cabin changes
	Manned Flight: The core of the Gaganyaan mission; sends a human astronaut to space.	The astronaut will return safely, landing in the Arabian Sea near Gujarat.
Benefits of Gaganyaan Mission	**Innovation Environment**:Inspires creativity and innovation among the next generation.	
	Industrial development: It will promote industrial advancement.	It brings diverse range of agencies, labs, sectors, and departments.
	Private Sector Growth: Mission success will drive private investments in space technologies.	Increase private participation in the space sector through IN-SPACe
	International Collaboration: Showcases India's capabilities, opening doors for global space partnerships.	Partnership with NASA, JAXA and ESA on ISS like endeavour
	Industry-Academia Partnership: Strengthens collaboration between educational institutions and industries for national growth.	

ARTIFICIAL INTELLIGENCE

AI and its key technologies

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is Artificial technology?	Artificial Intelligence aims at creating machines that can perform tasks requiring human-like intelligence. It enables machines to learn from experience, adapt to new inputs, and make decisions.	
Key Technologies for AI	The primary technologies of artificial intelligence can be categorised into the foundational infrastructure layer at the bottom and the algorithmic layer at the top.	
Machine Learning	A subset of AI that allows systems to learn and improve from experience without being explicitly programmed	
Applications	**Medical diagnosis:** Assisting doctors in identifying diseases by analyzing medical images.	Identification of diabetic retinopathy with over 90% accuracy
	Predictive analytics: Forecasting stock market trends, sales, and weather patterns.	E-commerce analysis of purchase history to recommend products.
	Image and speech recognition: Use in Airport entry and in mobile phones	Google Photos and Siri
	Autonomous vehicles: Powering self-driving cars.	Aid in real-time driving decisions
	Supply chain optimisation: Forecasting inventory and optimising delivery routes.	Google Could Vertex
Deep Learning	A subset of ML that uses neural networks with many layers. It's particularly useful for complex tasks like image and speech recognition.	
Applications	**Object Detection:** Identifying objects in images and videos, often used in surveillance, autonomous vehicles, and many other areas.	Security cameras can identify and track unauthorised entry in restricted areas
	Drug Discovery: Predicting the the effectiveness of potential new drugs.	ENNAVIA developed by Patrick Timmons identify peptides with low toxicity.
	Chatbots and Personal Assistants: Providing more natural interactions and a better understanding of context.	ASK DISHA ChatBot of IRCTC
	Predictive Maintenance: Analyzing machinery and equipment data to predict and prevent potential failures.	RECAST was developed by the University of California to forecast aftershocks of earthquakes
Robotics Process Automation	Involves automating rule-based tasks in business processes. Not strictly AI in itself but often incorporates AI components.	
Applications	**Data extraction and processing:** Automatically extracting information from documents.	
	Fraud detection: Analyze patterns in transactions to detect and alert about potential fraudulent activities.	Positive Pay System for Cheque Authentication.
	Healthcare patient records: Update and retrieve patient information, schedule appointments, and automate billing.	Development of Electronic Health Records
Natural Language Processing (NLP)	It is a subfield of artificial intelligence (AI) that focuses on the interaction between computers and humans through natural language.	

Applications	**Language modelling:** Predicting the likelihood of a sequence of words, often used in predictive text systems.	Voice assistants such as Siri and Alexa
	Sentiment analysis: Determining the sentiment or emotion behind a piece of text.	Social media monitoring and brand monitoring
	Information extraction: Extracting structured information from unstructured text, such as names, dates, or addresses from documents	Big data analytics of Aadhaar data
Edge AI	Deploying AI algorithms on edge devices, like IoT devices, instead of cloud or centralized servers.	
Applications	**Industrial IoT (IIoT):** Monitor equipment health and predict maintenance needs or detect faults**.**	Vehicular emission tracker
	Agriculture: Sensors and devices in precision farming that monitor soil health, weather conditions, or pest activity.	Precision irrigation system
	Medical Devices: Portable diagnostic devices that can analyze samples on the spot.	Portable ECG and blood sugar monitoring
Stages of Artificial Inteligence	**Stage 1: Artificial Narrow Intelligence:**Systems designed and trained for a specific task. They don't possess consciousness or reasoning.	Siri, Alexa, and other virtual assistants and Image recognition software
	Stage 2: Artificial General Intelligence: Human-like intelligence with consciousness, reasoning and emotional understanding.	No real-world AI has achieved this level of capability.
	Stage 3: Artificial Super Intelligence: It is a speculative stage of AI which will surpasses human intelligence in every field.	

Generative Artificial Intelligence

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is Generative AI?	GAI are AI models designed to create new content resembling input data. These models, produce synthetic images, text, music, or other forms of data. Their creations mimic real-world patterns but are generated anew.	
Why in the News?	JanAI is being mooted as a basic framework for the proposed Generative AI model for India.	
Structure of the Generative Adversarial Network (GAI)	GAIs consist of two neural networks, which are trained together: » Generator: Tries to create data. » Discriminator: Tries to differentiate between genuine data and data produced by the generator.	
Application of Generative AI	**Art and Creativity**: Generative AI fosters unique art creations, enabling artists to expand traditional boundaries	• DALL·E2 is an OpenAI model crafting images based on textual cues. • AIVA employs AI to generate original compositions spanning diverse genres.
	Music: Generative AI aids musicians in exploring varied sounds, enriching music diversity.	
	Computer graphics: Enhances film and gaming through realistic 3D graphics and effects.	
	Healthcare: Advances medical imaging, bolstering diagnostic precision and treatment efficiency.	
	Manufacturing and robotics: Refines and enhances manufacturing efficiency and quality.	

Concerns associated with AI	• **Partisan GAI models:** If trained on biased data, GAI can produce skewed results, perpetuating societal biases. • **Privacy:** GAI training might use sensitive data, posing risks of unethical utilization like targeted ads or political manipulation. • **Responsibility:** GAI-generated content, including potential fake news, poses ethical quandaries about accountability. • **Automation and job loss:** GAI might automate tasks, leading to job losses and ethical concerns about its impact on workers and society.	

Applications of AI

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is Artificial intelligence?	Artificial Intelligence refers to computer systems designed to mimic human intelligence and perform tasks such as recognition, decision-making, and problem-solving.	
Application	**Health** • **Disease identification:** AI algorithms analyze medical images for early detection of diseases like cancer. • **Drug discovery:** AI accelerates the process of drug development by predicting molecule interactions. • **Genomic analysis:** AI aids in analyzing large genomic sequences to identify mutation patterns. • **Surgical robotics:** Robots, guided by AI, assist surgeons in performing precise procedures. • **Radiology:** AI-enhanced image interpretation boosts accuracy in detecting anomalies in X-rays, MRIs, and CT scans. • **Epidemic outbreak prediction:** AI systems analyze global health data to predict and manage disease outbreaks.	• PathAI- tools reduce errors in cancer diagnosis. • AI-enhanced microscopes • Virtual health assistants • AI-based mapping of diseases. • Reduction dosage error
	Agriculture • **Precision agriculture:** AI enables precise application of fertilizers and pesticides, minimizing waste. • **Crop monitoring:** Drones equipped with AI analyze fields for crop health and pest detection. • **Yield prediction:** Algorithms forecast crop yields based on historical and real-time data. • **Soil analysis**: AI assesses soil quality and recommends specific crops or amendments. • **Water quality monitoring:** AI systems ensure water used in irrigation meets quality standards. • **Disease detection:** Image recognition identifies plant diseases and nutrient deficiencies.	• Smart spraying • Vertical farming software • IoT-based agriculture drones. • Greenhouse robots
	Industry • **Quality inspection:** Automated systems detect and classify product defects with high precision. • **Supply chain optimization:** Predicts demand, streamlining inventory and logistics**.** • **Energy consumption:** Optimize energy use, reducing costs and environmental impact. • **Waste management:** Systems identify and manage waste, promoting sustainability. • **Customized production:** AI facilitates mass customization, tailoring products to individual preferences.	• Cobots for quality inspection • Airport operations and traffic reports • Intelligent garbage bins

	Environmental Protection • **Pollution monitoring:** AI analyzes air and water quality in real-time, identifying pollution sources. • **Deforestation detection:** Satellites equipped with AI detect illegal logging and forest degradation. • **Emission control:** Predictive systems optimize industrial processes to minimize harmful emissions. • **Climate modeling:** AI enhances the accuracy of climate prediction models, forecasting environmental changes. • **Wildlife conservation:** Automated systems track and monitor endangered species to protect habitats.	• Use of AI in prediction of cloud development to aid Solar power plant. • Simulation of Climate Hazards • Motion sensors to detect poachers
	Policy Making and Judiciary • **Fraud detection:** Identifies discrepancies in public funding and spending. • **Optimization of resources:** Allocates resources effectively for public services and infrastructure. • **Legal research:** Automates and expedites the process of finding relevant legal precedents. • **Risk assessment:** Evaluates the potential risk of offenders for informed sentencing and bail decisions. • **Evidence analysis**: Uses pattern recognition to identify inconsistencies in evidence.	• SUVAS: It is an AI system that can assist in the translation of judgments into regional languages. • SUPACE: AI assistant launched by the Supreme Court of India.
	Transportation • **Smart signalling:** Traffic lights adapt in real-time based on traffic flow, enhancing road efficiency. • **Railway track inspection:** Automated systems detect anomalies in rail tracks, ensuring safety. • **Vehicle-to-Vehicle communication:** AI allows cars to communicate, avoiding collisions and streamlining traffic. • **Public Transit:** AI optimizes bus and train schedules based on real-time demand and conditions.	• Pedestrian detection • Route optimization in google maps • Collision avoidance by direct loco to loco communication.

INTERNATIONAL YEARS

International Year of Crystallography

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is the International Year of Crystallography	Celebrated in 2014 by UNESCO, the year aimed to promote education and research in crystallography, emphasizing its interdisciplinary relevance in areas like chemistry, biology, physics, and earth sciences.	
What is Crystallography	It is the scientific study of crystals and their structures. It explores the arrangement of atoms in solid materials and uses techniques like X-ray, electron, or neutron diffraction to determine these structures.	
Applications of Crystallography	**Drug Design**: Determination of the 3D structure of proteins for specific drug design	More effective treatments with fewer side effects.
	Material Science: Identifying the atomic structure of new materials	Used in designing of semiconductors and durable alloys.
	Geology and Mineralogy: Identifying the structures of minerals	Glve insight into mineral formation and properties
	Environmental Science:Studying pollutants at the molecular level	Devise method for removal of pollutants.
	Nanotechnology: Designing nanostructures with specific properties	Improve product stability
India and Crystallography	**Research Institutes:**Indian Institute of Science (IISc) and the Tata Institute of Fundamental Research (TIFR).	
	Ramachandra Plot: It is a graphical representation of of amino acid residues in protein structures	Used to evaluate and predict protein conformations.
	Protein Structures: Contribution to the Protein Data Bank- a global repository of protein structures.	
	Novel Techniques: Development of new methods and algorithms in the area of crystallographic computations.	
	Organic Crystallography: Use of X-ray crystallography to determine the structures of organic compounds.	Key contribution of K. Venkatesan

International Year of Astronomy

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is the International Year of Astronomy?	It was celebrated in 2009 by UNESCO to mark the 400th anniversary of the first recorded astronomical observations with a telescope by Galileo Galilei.	
What is Astronomical Science	The study of celestial objects such as stars, planets, comets, galaxies, and the overall structure and nature of the universe. It seeks to understand the origins, evolution, and eventual fate of celestial bodies and phenomena.	

Applications of Astronomy	**Celestial Navigation:** Using stars, the sun, moon, and planets to determine one's location	
	Calendars: Based on the movements of celestial bodies	
	Satellite Technology: Study of Earth's orbit has enabled **satellite placements for global communication**	
	Space Weather Prediction: Monitoring solar flares and other solar activities	Predict geomagnetic storms
	Studying Other Planets: Provides insights into Earth's climate change	
India's contribution to Astronomy	**Ancient Texts and Observatories:** • **Vedas and Puranas:** Early Indian scriptures contained astronomical references. • **Aryabhata:** Aryabhata presented advanced mathematical explanations of astronomical science. • **Brahmagupta:** Contributed to understanding of eclipses and the brightness of the moon and planets. • **Surya Siddhanta:** Discusses the motion of planets, lengths of day and night, and the determination of equinoxes..	• Movements of celestial bodies and eclipses • Rotation of the stars and the motion of planets • Khandakhadyaka astronomical work of Brahmagupta • Part of Varahamihira five astronomical canons,
	Saha Ionization: It relates the ionization state of a gas in thermal equilibriumproviding insights into stellar atmospheres.	Used to determine the temperature of stars
	Chandrashekar Limit: Maximum mass theoretically possible for a stable white dwarf star.	Understanding the life cycles of stars
	Wilson-Bappu effect: Aids in the determination of distances to the stars.	
	Astrosat: First dedicated multi-wavelength space observatory.	

International Year of the Periodic Table of Chemical Element

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is the International Year of the Periodic Table of Chemical Element?	The International Year of the **Periodic Table of Chemical Elements (IYPT)** was celebrated in **2019 by UNESCO** to mark the 150th anniversary of the discovery of the **Periodic System by Dmitri Mendeleev in 1869.**	
What is a Periodic Table?	It is a tabular arrangement of chemical elements, organized based on their atomic number, electron configuration, and recurring chemical properties. It provides a comprehensive reference for element properties and relationships.	
Applications of Perodic Table	**Predicting Chemical Behavior:** Based on group and period placement, the reactivity of elements can be anticipated.	
	Understanding Atomic Structure: Shows the number of valence electrons, aiding in predicting bonding patterns	Identification of reactivity of elements.
	Industrial Applications: Guides the selection of elements for specific industrial processes.	

	Medical Applications: Helps in understanding radioisotopes used in medical treatments.	Use of radioactive elements for cancer treatments.
	Environmental Monitoring: Assists in tracking elemental pollutants.	Track presence of lead and mercury in Water
India's contribution to Perodic Table of Chemical element	• **Ancient Alchemical Practices:**Laid the groundwork for understanding metals and their transformations. • **Ayurveda:**Recognition of various metals and minerals in Ayurveda • **Rasendra Chudamani:**Discusses various metals and their properties. • **Engagement with IUPAC:** Indian chemists and institutions actively engage with the International Union of Pure and Applied Chemistry	

PARTICLE PHYSICS

Subatomic Particles

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What are Sub - Atomic Particles?	**Subatomic particles** are particles smaller than atoms. They include protons and neutrons (found in the atomic nucleus) and electrons (orbiting the nucleus). These particles form the basis of atomic structure and behaviour.	
Why in the News?	The **Large Hadron Collider (LHC)** has detected three previously undiscovered particles: a novel form of "pentaquark" and a unique pair of "tetraquarks", with one being a new variant of tetraquark.	
Key Sub-atomic Particles	• **Quark-**Smallest Elementary particle which makes up protons and neutrons. • **Pentakquark-**a pentaquark is a composite particle made up of five quarks. • **Tetraquark-** a type of exotic meson; composed of four quarks-two quarks and two antiquarks.	• There are six types (or "flavors") of quarks: up, down, charm, strange, top, and bottom. • Their existence was reported by experiments at the Large Hadron Collider in 2015.
Applications	• **Proton therapy:** To treat cancerous tumours.	• Proton beam therapy is launched in Tata Memorial Centre
	• **High-resolution imaging:** Through the use of electron microscopes	
	• **Positron emission tomography (PET):** For medical imaging.	• PET detect early signs of cancer, heart disease and brain conditions.
	• **Neutron scattering:** To study material properties.	
	• **Muon tomography:** For deep earth scanning and structure analysis.	• Recently, Scientists examined the fortress wall of Xi'an using muons.
	• **Neutrino observatories:** To study cosmic phenomena.	• India's neutrino observatory to be set up in Tamil Nadu

Gravitational Waves

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
Why in the News?	A global group of astronomers declared scientific proof validating the existence of gravitational waves through pulsar studies. In this India's Giant Metrewave Radio Telescope (GMRT)	
What are gravitational waves?	Gravitational waves are ripples in spacetime caused by massive celestial events. Predicted by Einstein's general theory of relativity in 1915, they transport energy as gravitational radiation. Their detection provides a new way to observe the universe.	
Key aspects related to gravitational waves	• Originate from- merging black holes, colliding neutron stars, rotating non-axisymmetric neutron stars, and supernovae.	
	• Detection-Gravitational waves were first detected in 2015 using Laser Interferometer Gravitational Observatory (LIGO) detectors.	• Interferometers detect gravitational waves by observing minute alterations in spacetime.
Applications	**Probing the Universe's History:** Aids in observation of very early phase of universe.	Study moments just after the Big Bang.
	Studying Black Holes: The first direct detection of gravitational waves by LIGO was from the merger of two black holes.	Gives data about black hole masses, spins, and populations.

	Testing General Relativity: Provides a testing ground for Einstein's theory of general relativity,	
	Cosmology and Measuring the Universe:provide an independent method to measure the Hubble constant.	Provide rate of expansion of the Universe
	Understanding Fundamental Physics: It can be used to study the equation of state of neutron stars	Understanding of behavior of matter at ultra-high densities.
GMRT and detection of Gravitational Waves	**Pulsars as Celestial Clocks:** It detects gravitational waves using pulsars.	It is the only accessible celestial clocks.
	Radio Wave Emission: Pulsars emit consistent radio wave pulses.	Allows precise measurement of radio waves
	Pulsar Timing Arrays (PTAs): By observing PTAs across the sky it monitors minuscule variations in gravitational waves	It affects the Earth-pulsar sightline.
	GMRT's Unique Contribution: It offers distinct data with its low radio frequencies and heightened sensitivity.	

Standard Model of Particle Physics

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is Standard Model of Particle Physics?	The Standard Model is a foundational theory in particle physics that outlines the basic particles and how they interact. It encompasses three primary forces: **electromagnetism, the weak nuclear force, and the strong nuclear force.** Notably, **gravity is omitted from this model.**	
Why in the News?	Certain physicists are conducting experiments to identify inconsistencies in the Standard Model of particle physics, specifically considering the electron dipole moment.	
Components of Model of Particle Physics	• **Fermions:** Particles constituting matter. » **Quarks**: Fundamental components of protons and neutrons. » **Leptons:** Examples include electrons. • **Bosons:** Mediator particles for fundamental forces. » **Photons:** Mediate electromagnetism. » **W and Z Bosons:** Mediate the weak force. » **Gluons:** Mediate the strong force. » **Higgs Boson:** Gives particles mass.	
Applications of the Model	**Particle Accelerators:** Predicting outcomes in particle colliders like the Large Hadron Collider (LHC).	
	Cosmology: Providing insights into the Big Bang and the early universe's conditions.	
	Nuclear Reactions: Explains the processes in nuclear reactions.	Study of Nuclear reactions in stars
	Technological Innovations: Advancements in particle physics research have led to many technological breakthroughs.	Development of MRI scanners and the WWW
	Dark Matter and Dark Energy Research: Aids in research of Dark matter.	
	Particle Therapy in Medicine: Utilizing particle beams to target tumors.	Aid in Cancer treatment

NANOTECHNOLOGY

Nanofertilizers

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What are Nano-fertilizers?	Nanofertilizers are a type of agricultural input wherein nanoparticles are used to enhance nutrient delivery to plants. They offer a targeted and efficient release of nutrients, which can increase absorption rates and reduce environmental impact.	
Why in the News?	The Department of Fertilisers carried out an audit that showed a decrease in nitrogen use by 25-50% following the use of nano urea.	
Significance of Nanofertilizers	**Enhanced Nutrient Uptake:** Provide a targeted release ensures more efficient nutrient absorption. .	Reduces the frequency of application.
	Reduced Environmental Impact: They minimize nutrient leaching into water sources and soil contamination	Reduces water and soil pollution
	Increased Crop Yield: Ensures optimal nutrient availability	Ensure high yield
	Enhanced Resistance: They can aid in enhancing plant resistance against pests and diseases.	Aid in cost effective farming due to less use of pesticides.
	Modern Agriculture: Suitable for modern agricultural practices allowing for better efficiency.	Aids in adoption of precision agriculture
Challenges in adoption of Nano-fertilizers	**High Initial Costs:** They can be more expensive than traditional fertilizers	Difficult for adoption for small-scale farmers.
	Safety & Environmental Concerns:Potential long-term effects on soil health and ecosystems are not fully understood.	Possibility of bioaccumulation of nanoparticles in the food chain.
	Regulatory Issues: Absence of a clear regulatory framework specific to nanofertilizers.	Could led to poor quality control and inconsistent results.
	Market Acceptance: Skepticism among farmers due to unfamiliarity with nanotechnology.	Limited training on its proper usage and benefits.
	Infrastructure Limitations: Lack of facilities for the production and distribution of nanofertilizers at scale.	

Applications of Nanotechnology

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is Nanotechnology	Nanotechnology involves manipulating and controlling matter at the nanoscale, typically between 1 and 100 nanometers. It enables the creation of new materials and devices with unique properties.	
Applications in Health	**Drug Delivery:**Improving the efficacy of drugs and reducing side effects.	Liposomes and polymeric nanoparticles can target specific cells
	Cancer Treatment: Using infrared light to kill cancer cells without harming surrounding tissues.	Gold nanoparticles used to target cancer molecules

	Biosensors: Nano-based sensors can detect diseases at a molecular level	A glucose nanosensor can detect blood sugar levels without blood samples
	Bone Repair and Implants:Nanomaterial coatings on implants can enhance their integration with bone and tissue.	Nanophase ceramics can stimulate bone growth and repair.
	Regenerative Medicine:Nanofibrous scaffolds can guide the growth and differentiation of stem cells in tissue engineering	Aid in the regeneration of damaged tissues.
	Vaccine Development: Nanoparticle-based vaccines utilize lipid nanoparticles to deliver and protect mRNA molecules in the body.	Covid-19 vaccines developed using same tech
Applications in Environment	**Water Purification:** To remove pollutants, bacteria, and viruses from water, providing cleaner drinking water.	Use of Carbon nanotubes and nanoporous membranes
	Sensors for Environmental Monitoring: Offers early warnings and facilitating timely interventions.	Nanosensors can detect trace amounts of pollutants or toxins in the environment
	Solar Energy Conversion: Improve their efficiency by capturing a broader spectrum of sunlight.	Quantum dots can be incorporated into solar cells
	Eco-friendly Materials: It can produce lightweight, durable, and recyclable materials	Nanocomposites can reduce the environmental footprint.
	Air Quality Improvement: Use to break down organic pollutants in the air when exposed to sunlight.	Photocatalytic nanoparticles can aid in air quality improvement
	Enhanced Crop Protection and Reduced Pesticides: Nano-encapsulation of pesticides allows for controlled release	Reduces the amount needed and minimizing environmental runoff.

QUANTUM TECHNOLOGY

Quantum Technology Principles

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is Quantum Technologies	Quantum Technology is rooted in the principles of **Quantum mechanics**, formulated in the early 20th century to explain the **behavior of atoms and elementary particles.**	
Key Quantum Technologies	**Quantum Computing** • **Quantum Processors:** Devices that manipulate quantum bits (qubits) to perform calculations. • **Quantum Algorithms:** Specific procedures for quantum processors • **Quantum Simulators:** Devices to model complex quantum systems.	• Google's Sycamore processor is a quantum processor • Shor's algorithm used for factoring. • Simulating complex molecules to assist in drug discovery.
	Quantum Communication • **Quantum Key Distribution (QKD):** Secure method to exchange cryptographic keys using quantum principles. • **Quantum Teleportation:** Transfer of quantum information between particles over distance.	• Secure banking transactions using quantum-secure communication. • Transmitting qubit states over long distances for quantum networks.
	Quantum Sensing and Metrology • **Quantum Sensors:** Devices that exploit quantum coherence and entanglement to achieve high sensitivity. • **Quantum Metrology:** The study of measurements using quantum mechanical systems to improve precision.	• Detecting tiny magnetic fields for medical imaging. • More accurate atomic clocks for global positioning systems.
	Quantum Materials and Applications • **High-Temperature Superconductors:** Materials that conduct electricity without resistance at relatively high temperatures. • **Topological Insulators**: Materials with unique electronic properties, potential for quantum computing.	• Aid in building efficient power transmission lines.
	Quantum Software and Algorithms • **Quantum Software Platforms:** Tools and libraries for designing, simulating, and running quantum programs. • **Hybrid Algorithms:** Algorithms combining classical and quantum computing for problem-solving.	• IBM's Qiskit platform for quantum programming. • Aid in optimization of supply chain logistics
Applications of Quantum Technologies	**Drug Discovery:** Simulation complex molecules and reactions at the quantum level to discover new drugs.	
	Cryptography and Secure Communication Using quantum principles to establish secure communication channels.	The Chinese satellite Micius established a quantum key distribution from space
	Medical Imaging: Use of quantum sensors to achieve high-resolution imaging.	Detect diseases earlier and more accurately.
	Traffic Optimization: Using quantum algorithms to reduce congestion and optimize traffic flow.	Japan is using quantum annealing for Traffic optimization
	Improved Sensing and Measurement: Make more accurate measurements in fields like geology and astronomy.	Quantum gravimeters can detect small variations in gravitational fields
	Power and Energy Optimization: Designing new materials and processes for better energy storage and transmission.	Development of superconducting materials at room temperature.

Quantum Key Distributions

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is Quantum Key Distribution?	Quantum Key Distribution (QKD) technology leverages the principles of quantum mechanics to create and share cryptographic keys between parties securely.	
Why in the News?	Indian Institute of Technology (IIT) Delhi has successfully demonstrated Quantum Key Distribution link between Prayagraj and Vindhyachal in Uttar Pradesh.	
Categories of the QKD	• **Prepare-and-Measure Protocols:** Concentrates on measuring unknown quantum states. • **Entanglement-based Protocols:** Centers on entangled quantum states where two objects form a combined state.	• Detects eavesdropping and estimates data intercepted. • A change in one object due to interference affects the other, alerting involved parties**.**
Working of the QKD	**QKD and Qubits:**QKD sends encryption keys as 'qubits' through optical fibers.	Qubits are the quantum counterpart of classical binary bits.
	Optical Fibers: Transmits data over longer distances and faster than other methods.	Operates on the principle of total internal reflections.
	Authentication in QKD: Legitimate user interactions in QKD must be authenticated.	Authentication achieved through various cryptographic methods.
	Key Generation:QKD enables distant users without an initial secret key to generate a shared random secret key.	
	Communication Channel Transformation: QKD converts an authenticated communication channel into a secure one.	
	Security Mechanism: QKD is structured such that any unauthorized attempt to read transmission disrupts the qubits encoded on photons.	This disturbance causes transmission errors, alerting the legitimate users immediately.
Applications of QKD	**Secure Communication:** Governments can use QKD to transmit top-secret information.	All Intercepted data remains unreadable.
	Secure Voting Systems: Ensures that votes are transmitted securely and remain tamper-proof.	Aid is tamper proofing of Electronic Voting Machine
	Banking and Financial Transactions: Safeguard the transfer of sensitive financial data	Prevention of potential breaches of data.
	Critical Infrastructure Protection: Power plants and other critical infrastructures can employ QKD to secure their communication networks.	Reduces risk of cyber attacks on critical infrastructure
Challenges Associated	**QKD System Integration:**Challenging to establish an optimal infrastructure for QKD	
	Photon Travel Distance: Current fiber optic cables have a photon carry limit	
	Speed Limitations:QKD systems can have lower key generation rates compared to classical systems.	
	Lack of Standardization: No universally accepted standard for QKD could cause potential compatibility issues.	
	Reliance on Classical Systems: QKD requires an existing classically authenticated communication channel	

Way-Forward	• **Harnessing Quantum Expertise:** Utilize the capabilities of startups and Big Tech in quantum technology development. • **Long-Term Strategy:** Formulate a comprehensive plan for the next 10-15 years. • **Reduction in Costs:** Focus on manufacturing advancements and economies of scale to make QKD systems more affordable.	

National Quantum Mission

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What is National Quantum Mission?	Initiative of the Department of Science & Technology (DST). Scheduled for 2023-2031, the mission's objective is to foster and expand scientific and industrial R&D, establishing a dynamic and innovative Quantum Technology (QT) ecosystem.	
Key Features of the Mission	**Quantum Computer Development:** Aim to develop quantum computers	50-100 qubits in 5 yr and 50-1000 qubits in 8 yr
	High-Precision Instrumentation: Foster the creation of highly sensitive magnetometers for precise timing	Development of atomic clocks
	Quantum Materials Development: Support the design and synthesis of quantum materials	Development of superconductors, novel semiconductor structures.
	Quantum Communication Goals: Develop satellite-based secure quantum communications between ground stations	Implementation of inter-city quantum key distribution
	Establishment of Thematic Hubs: Set up four Thematic Hubs (T-Hubs) in leading academic and national R&D institutes	Focus on Quantum computation, Quantum communication, Quantum sensing & metrology and Quantum materials & devices.
Significance of National Qauntum Mission	• **QT-Driven Growth:**Speed up economic growth through Quantum Technologies, positioning India as a frontrunner in Quantum Technologies & Applications (QTA). • **Diverse Applications:** Benefit sectors like healthcare, diagnostics, defense, energy, and data security. • **Indigenous Quantum Computing:** Focus on domestically developing quantum computers that offer superior power and security, capable of addressing highly intricate problems.	

MISCELLANEOUS

Internet of Things (IOT)

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is IOT?	Internet of Things (IoT) refers to **interconnected devices across the globe,** collecting and sharing data.It **automates tasks, betters user experiences, and reshapes businesses, and homes** using technology.	
Why in the News?	Recently, the Telecommunication Engineering Centre (TEC) under the Ministry of Communications released a report on securing consumer IoT devices, titled **"Code of Practice for Securing Consumer Internet of Things(IoT)."**	
Working of IOT	**IoT Device:** Hardware with sensors that send data online from one place to another. This need a wireless connection.	Cell phones, household gadgets, medical tools, and cars.
	Data: IoT's main job is to collect large data volumes, process them, and boost the app's performance.	Music apps collect data about personal song and artist choices.
	Analytics: Proper analysis and efficient processing of gathered data are crucial.	Extremely beneficial for daily life and businesses
	Connectivity: Connectivity enables the devices, data, and analytics to work in conjunction.	
Types of IOT	**Internet of Everything (IoE) -** It encompasses processes, data, and people; aims for universal connectivity.	Traffic lights equipped with sensors to detect traffic flow,
	Internet of Nano Things (IoNT) - Connects nanoscale devices online to exchange information.	Nanoscale capsules are introduced into a patient's bloodstream.
	Internet of Mobile Things (IoMT) - It considers changes in connection, context, privacy, and energy.	
	Internet of Mission-Critical Things (IoMT) - Used in vital military tasks such as surveillance, border patrol etc.	Drones equipped with sensors to fly over sensitive border areas,
	Industrial Internet of Things (IIoT) - Automates industrial processes.	Predictive maintenance sensors detect wear and tear in real-time,
	Infrastructure Internet of Things - Emphasizes new infrastructures using IoT	Used for upkeep and cost reduction.
	Commercial Internet of Things - Targets IoT's commercial applications in multiple places.	Used in stores, hospitals, and hotels.
Technologies of IOT	**Sensors and actuators:** They enable **automation without human intervention.**	Detect changes **like temperature, light, and motion.**
	Connectivity Technologies: IoT **devices need internet connections to send data.**	Common technologies **Wi-Fi, Bluetooth, cellular, Zigbee etc.**
	Cloud Computing: IoT d**ata is stored, processed, and analyzed in the cloud.**	Provide necessary **infrastructure and tools for IoT applications.**
	Big Data Analytics: Advanced analytics **tools process vast IoT data.**	Tools include **machine learning, data visualization, and predictive analytics.**
	Security and privacy Technologies: Security and **privacy are vital for widespread IoT use.**	Tools like **encryption, access controls, and intrusion detection systems.**

Applications of IOT	**Healthcare:**They track medical tools, manage stock, and ensure medication compliance.	Fitness trackers, smartwatches, and health monitors.
	Manufacturing: Industrial IoT devices monitor machine efficiency, foresee failures, and refine production.	Industrial automation and production line optimization.
	Retail: IoT tracks customer patterns, oversees stock, and refines store designs.	It can enhance product positioning and shopping experience.
	Agriculture: To monitor soil health, climate changes, and plant growth.	Sensors detect soil moisture to time irrigation perfectly.
	Transportation: IoT tracks vehicle health, fine-tunes routes, and keeps an eye on shipments.	Aids is fuel efficiency of vehicles, promoting cost-saving and sustainability.
Significance of IOT	**Efficiency and Productivity:** By automating processes and enabling real-time monitoring of devices	IoT helps industries and businesses become more efficient.
	Environmental Monitoring: IoT applications help in monitoring and managing environmental factors	Monitor pollution levels, wildlife, and water quality.
	Enhanced Customer Experience: IoT data collection offers tailored customer experiences.	Retailers track in-store customer movements to give tailored offers.
	Safety and Security: From smart surveillance systems to connected fire alarms	Security at homes, workplaces, and public spaces.
	Sustainability: By optimizing resource utilization and improving efficiency,	Plays a role in building sustainable systems and practices.
Challenges of IOT	**Security and Privacy Concerns:** The growth in IoT devices amplifies security and privacy challenges.	IoT devices poses data protection worries.
	Interconnection Challenges Different manufacturers may use varied standards, hindering seamless device communication.	Leads to integration problems and isolated data pockets.
	Overwhelming Data Volume: Huge data quantities which can be hard for new businesses to handle.	Gleaning actionable insights from this data is challenging.
	Expense and Intricacy: Implementing an IoT system can be costly and intricate, requiring notable investment in various components.	Operating and upkeeping an IoT system demands specific expertise.
	Regulatory and Legal Hurdles: The prevalence of IoT devices introduces new legal and regulatory challenges.	
IOT in India	• **Digital India Mission and IoT:** Integration of IoT into the Digital India Mission. • **National Digital Communications Policy 2018:** Launched with an aim to introduce and expand IoT, 5G technology, and M2M communication. • **Foreign Direct Investment (FDI):** The government allowed 100% FDI in the telecom sector to boost IoT growth in India. • **Draft Policy by DeiTY:** Unveiled a draft IoT policy. • **IoT Market Projection:** A goal to reach a USD 15 billion market value for IoT by 2020.	

Web 3.0

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is Web 3.0?	Web 3.0 is the next generation of the internet, **emphasizing decentralized, semantic, and intelligent technology, enhancing user control**, privacy, and interaction, while integrating artificial intelligence and blockchain technologies.	
What are previous versions of Web?	**Web 1.0:** This initial phase featured a predominantly "Read-only" web.	Enable users to view content without much interaction.
	Web 2.0: Introduced enhanced interaction.	Features like 'liking' on social media, 'commenting' on videos
Advantages of Web 3.0	**Open Network Framework:** Utilizes open-source software for application and program development.	Development code is made available to the public.
	Decentralized Data Control: Individuals gain control over their data.	Eliminate third-party reliance
	Direct Seller-Customer Interaction: Fostering direct connections between sellers and consumers.	Non-fungible token is prime example.
	Blended Realities and Personalization: It can merge the physical and digital realms.	It can help sellers tailor their offerings based on buyer behavior.
	Empowered Content Monetization: It offers creators better avenues to monetize their work.	About 2 million professional content creators in India can benefit from this.
Disadvantages of Web 3.0	**Cyber Crime Concerns:**Regulating Web 3 is perceived as challenging.	Cryptocurrency-based crime is rising with increased transaction volumes.
	Redressal Mechanism Issues: Uncertainty arises about whom to contact for grievances due to decentralisation.	Questions arise regarding accountability in the event of data breaches.
	Censorship Complications: Potential increase in the spread of obscene or provocative content.	Difficulty for authorities to remove inappropriate information or media.
	Scalability Challenges: Blockchain's append-only data mechanism limits modifications.	Rising demand versus limited storage capacity poses concerns.
	Regulatory Ambiguity: Web3 industries in India and other countries are still defining regulatory guidelines.	Many nations lack clear protocols for Web 3.0 usage.
Way Forward	**Tech-Driven Socio-Economic Growth:**India has harnessed technology for inclusive societal development.	Successful tech implementations include Aadhaar, Jan Dhan, UPI, and CoWin.
	Potential with Web 3.0: It can boost the value of India's digital economy.	Promoting the startup ecosystem can help position India
	Enhancing E-Governance: It can improve user experience in digital government services.	Offers quality data for evidence-based policymaking.
	Focus on Standards:The evolution of the internet necessitates ethical and interoperable systems.	Urgent actions are needed to establish open and robust standards for Web 3.0.
	Decentralized Science (DeSc): It can revolutionize science and research by removing patent barriers.	Data storage-such as DNA genome sequencing data related to viruses.

Indian Nobel Prize Awardees in Science and Technology

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
Name of the Laureate	**CV Raman- 1930**	Raman Scattering
	Har Gobind Khorana-1968	Genetic code and protein synthesis
	S. Chandrashekhar-1983	Studies on the evolution of stars
	Venkatraman Ramakrishnan-2009	Structure and function of ribosomes
What is the Concept which won the Nobel?	**Raman Scattering**: Scattering of light as it passes through a transparent medium.	Used to gain information about materials.
	Genetic code and protein synthesis: Synthesizes RNA molecules in the laboratory	Understand how genetic information is translated into proteins.
	Chandrashekar Limit: maximum mass theoretically possible for a stable white dwarf star.	understanding the life cycles of stars- less than CL end their lives as white dwarfs
	Structure and function of ribosomes: Determine the atomic structure of the ribosome	essential for developing novel antibiotics-act against AMR
Applications	**Raman Scattering** • **Pharmaceutical Analysis:** Quality control and drug development. • **Medical Diagnostics:** Non-invasive detection of diseases through biofluid analysis. • **Environmental Monitoring:** Detection of pollutants in air, soil, and water. • **Remote Sensing:** Atmospheric gas analysis using satellite or ground-based systems. • **Geological Exploration:** Mineral identification and analysis of geological samples.	
	Genetic code and protein synthesis • **Gene Therapy:** Correcting defective genes responsible for disease development. • **Agricultural Enhancement:** Developing genetically modified crops with desired traits. • **Biotechnology:** Producing specific proteins or enzymes for industrial applications. • **Disease Diagnosis:** Identifying genetic markers associated with certain diseases. • **Evolutionary Biology:** Tracing evolutionary relationships based on genetic sequences. • **Protein Engineering:** Designing new proteins with novel functions or improved properties.	
	Chandrashekar Limit • **Stellar Evolution:** Predicting the fate of medium-sized stars post their main-sequence phase. • **White Dwarf Stability:** Understanding conditions under which white dwarfs remain stable. • **Supernova Precursors:** Identifying stars that might undergo supernova explosion upon exceeding the Chandrasekhar Limit. • **Cosmic Element Production:** Explaining the synthesis of heavy elements during supernova explosions. • **Astrophysical Observations:** Assisting in the interpretation of astronomical data related to star masses and their end states. • **Neutron Star Formation:** Predicting the creation of neutron stars from white dwarfs exceeding the limit.	

	Structure and Function of Ribosomes • **Protein Synthesis Research:** Studying mechanisms of protein translation for therapeutic applications. • **Genetic Engineering:** Modifying ribosome functions to produce specific proteins in modified organisms. • **Disease Treatment:** Understanding ribosomal mutations that can lead to diseases. • **Evolutionary Biology: T**racing the origins and evolution of life through ribosomal RNA analysis. • **Cell Biology:** Investigating cell growth, death, and differentiation through ribosome functions.	

India Semiconductor Mission (ISM)

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What are semiconductors?	A semiconductor is a material that has **electrical conductivity properties between that of conductors, like metals, and insulators**, such as glass. Semiconductors form the foundation of modern electronics	
Why in the News?	Ministry of Electronics & Information Technology has inaugurated the first-ever **Semicon India conference** under the India Semiconductor Mission	
Components of the Mission	**Semiconductor Fabs Setup:** To attract large investments for semiconductor wafer fabrication in India.	Provides fiscal support to qualified applicants.
	Display Fabs Setup: For establishment of TFT LCD/AMOLED-based display fabrication in India.	Offers financial backing to eligible entities.
	Specialised Semiconductor Facilities: For manufacturing of Compound Semiconductors, Silicon Photonics and Sensors	Fiscal aid covering 30% of the Capital Expenditure
	Design Linked Incentive (DLI) Scheme: Development of Integrated Circuits (ICs), Chipsets, System on Chips (SoCs) Systems & IP Cores	Provides for Financial incentives and design infrastructure support.
Significance of the Mission	• **Focused Growth:** Aid in the growth of the semiconductor and display industry. • **Strategy Development:** Strategise display manufacturing, and design ecosystem • **Supply Chain Security:** Ensure flow of key raw materials, chemicals, gases, and equipment. • **Growth Facilitation:** Bolster the Indian semiconductor design industry • **Promotion of IP:** Indigenous Intellectual Property creation and promote technology transfers. • **Collaborative Endeavors:** Foster national and international partnerships for R&D and skill development.	
Challenges for ISM	• **Infrastructure Gaps**: Limited advanced manufacturing facilities. • **Capital Intensity**: High initial investments required. • **Skilled Workforce:** Shortage of trained professionals in semiconductor design and manufacturing. • **Technological Evolution**: Rapid pace of technology changes in the semiconductor industry. • **Supply Chain Reliability:** Dependence on imports for raw materials and equipment. • **Global Competition**: Established semiconductor hubs in other countries. • **Environmental Concerns:** Semiconductor manufacturing's environmental footprint.	• Small Scale fabrication plant requires investment of $300million to $400million. • Requires skillset related to Process and Industrial engineering • Covid-19 pandemic affected on SCM of semiconductors • Semiconductor manufacturing contributes to 31% of global greenhouse gas emissions

Initiatives	**Semi-conductor Laboratory (SCL):** MeitY plans to modernize and commercialize the Semi-conductor Laboratory.	
	Compound Semiconductors:30% fiscal support on capital expenditure for approved Compound Semiconductors units.	
	Production Linked Incentives (PLI): Coverage includes Largest Scale Electronics Manufacturing, PLI for IT Hardware,and EMC 2.0 Scheme.	An incentive of Rs.55,392 crore has been sanctioned.
Way-Forward	• **Utilizing India's PSEs:** Using PSEs to establish a semiconductor fab foundry. • **Shifting Focus:**Prioritize being a significant entity in a trusted, plurilateral semiconductor ecosystem. • **Trade Policies:**Favourable polices for crafting a successful plurilateral semiconductor ecosystem.	• Collaboration with global players by BEL.

Dual use technology

DIMENSIONS	DESCRIPTION	SUBSTANTIATION
What are Dual Use technology?	Dual-use technologies refer to **innovations and products designed for civilian applications but can also be used for military purposes**.Dual-use technologies often come under regulatory scrutiny and may be subject to export controls.	
Why in the News?	United states have raised concerned over illicit technology procurement by Russia for Ukraine war.	
Types of Dual-Use technology	**Aerospace and Propulsion**: Use in space technology development such as GPS	GPS used for civilian navigation as well as missile guidance.
	Biotechnology and Pharmaceuticals: Pathogen research can lead to medical breakthroughs	Pathogen use in biological warfare
	Materials and Manufacturing: Lightweight materials beneficial for civilian transportation	Lightweight materials can also be used for weapon production
	Electronics and Computers: High-performance integrated circuits for consumer devices	IC usage in missile development
	Telecommunications: Encryption technologies protect private communications	Use of encryption tech by terror groups
	Robotics and Artificial Intelligence: Drones use in aerial photography	Drones use as weapons
	Marine Technology: Underwater autonomous vehicles can be used for deep-sea research	Use of such vehicles in naval warfare.
Threats from Dual use of technology	**Nuclear Threat:** Diversion of use of nuclear energy for production of nuclear weapons.	Nuclear black-marketing-Iran Nuclear
	Infrastructure Attack: Civil technologies can be adapted to target essential infrastructures	Attacks on power grid
	Autonomous Systems: AI-driven technologies might be adapted for unregulated warfare.	Autonomous weapons systems-slaughterbots
	Civilian Monitoring: Technologies like facial recognition can be used to monitor citizens.	Misuse of facial recognition-Uygher monitoring in Xinjiang
	Dependency Risks: Over-reliance on foreign dual-use tech might lead to vulnerabilities.	Economic espionage can harm global businesses.

Initiatives to control dual use of technology	**International Treaties and Agreements**: • **Nuclear Non-Proliferation Treaty (NPT)**: Prevents the spread of nuclear weapons and technology. • **Biological Weapons Convention (BWC)**: Bans the production and possession of biological weapons. • **Chemical Weapons Convention (CWC):** Eliminate the production, stockpiling, and use of chemical weapons and their precursors.	
	Export Control Regimes: • **Wassenaar Arrangement:** Controls the export of conventional arms and dual-use technologies. • **Nuclear Suppliers Group:** Regulates the export of nuclear equipment, material, and technology. • **Missile Technology Control Regime (MTCR):** Prevent the proliferation of missile and UAV technology capable of delivering weapons of mass destruction. • **Australia Group (AG):** Control the export of chemicals and technologies that could be used in the production of chemical and biological weapons.	

Samudrayaan

DIMENSION	DESCRIPTION	SUBSTANTIATION
What is Samudrayaan Mission?	Its manned mission to probe the deep ocean aims to research deep-sea resources and **undertake biodiversity evaluations.** The mission is committed to ensuring that the oceanic ecosystem remains **undisturbed by the submersible's activities.**	
Why in the News?	According to the Ministry of Earth Science, **the Samudrayaan Mission is expected to be realised by year 2026.**	
What is Matsya 6000?	• **Development and Origin:** Crafted by the National Institute of Ocean Technology (NIOT) in Chennai. • **Mission Objective:**To enable human exploration of deep-sea mineral resources. • **Operational Capabilities:** Engineered to function in the deep ocean for 12 hours, with emergency operations extending up to 96 hours. • **Launch:** Projected launch in 2024-25 capable of conducting manned under-sea expeditions beyond 5,000 meters.	• It will position India among an elite group of six nations US, Russia, Japan, France, and China.
Significance of the Mission	**Manned Submersible:**Enables scientists to directly explore and comprehend untouched deep-sea zones.	
	Central Government's Vision: Underscores the Blue Economy as a principal growth sector.	Aligns with 'New India' initiative
	Resource Mapping: It can lead to resource mapping of the Ocean.	Aid in discovery and mapping of precious minerals and resources on the ocean floor**.**
	Strategic Importance: Indigenous deep-sea exploration will enhance marine defence capabilities	
Applications of Deep Ocean Research	**Biomedicine:** Many deep-sea organisms have unique biological compounds.	Aid in development of new pharmaceuticals and medical treatments.
	Climate Change Studies: Deep oceans act as carbon sinks.	Helps in understanding global carbon cycles

Geological Insights: Studying deep ocean tectonics	Aids in understanding of eological events like earthquakes, tsunamis, etc.
Mineral & Resource Exploration: Exploration can lead to potential mining, though it raises environmental concerns.	Deep-sea bed is rich in minerals like polymetallic nodules, sulfides, and rare earth elements.
Deep Ocean Currents: Understanding deep water currents can help in predicting climate patterns	Implications for naval and commercial operations.
Technological Advancements: Deep ocean research drives innovations in technological advancements	Development of submersibles, robotics, and sensor technologies.