

1. Short Notes on ANY TWO of the following:

(a) Effects of Colonial Policies on Preservation of Indigenous Scientific Knowledge

Colonial policies significantly undermined the preservation and development of indigenous scientific knowledge systems in colonized regions. This occurred through several mechanisms:

- **Suppression and Devaluation:** Colonial powers often dismissed local knowledge as primitive or unscientific, actively suppressing its practice and transmission. Western scientific paradigms were promoted as superior, leading to the marginalization of traditional systems (e.g., Ayurveda, indigenous agricultural practices).
- **Imposition of Western Education:** Educational systems were restructured to prioritize Western curricula, leading to a decline in the teaching and learning of indigenous sciences. This created a generation alienated from their own intellectual heritage.
- **Resource Exploitation:** Colonial resource extraction often disregarded sustainable indigenous practices, leading to

environmental degradation and the loss of traditional ecological knowledge tied to those resources.

- **Disruption of Knowledge Transmission:** Oral traditions, which were crucial for transmitting much indigenous knowledge, were disrupted by social upheaval and the imposition of new administrative structures. The cumulative effect was the erosion of indigenous scientific knowledge, leading to a loss of valuable insights in fields like medicine, agriculture, metallurgy, and environmental management.

(b) Importance of Vaccination in Human Health

Vaccination is a cornerstone of public health, playing a critical role in preventing infectious diseases and improving global human health. Its importance stems from several key benefits:

- **Disease Prevention:** Vaccines introduce weakened or inactive forms of pathogens (or their components) to the immune system, allowing the body to develop immunity without experiencing the full disease. This prevents millions of illnesses, hospitalizations, and deaths annually from diseases like polio, measles, tetanus, and influenza.
- **Herd Immunity:** When a significant portion of a population is vaccinated, it creates "herd immunity," protecting even those who cannot be vaccinated (e.g., infants,

immunocompromised individuals). This collective protection reduces the spread of disease, making outbreaks less likely.

- **Eradication/Elimination of Diseases:** Vaccination campaigns have led to the global eradication of smallpox and the near-eradication of polio, demonstrating their power to eliminate devastating diseases entirely.
- **Reduced Healthcare Burden:** By preventing illness, vaccines reduce the strain on healthcare systems, freeing up resources for other medical needs.
- **Economic Benefits:** Healthy populations are more productive. Vaccination prevents lost workdays, reduces treatment costs, and allows individuals to lead healthier, more economically active lives.

(c) Climate Resilient Crops

Climate-resilient crops are varieties of plants specifically bred or engineered to withstand the adverse effects of climate change, such as extreme temperatures, droughts, floods, increased salinity, and new pests/diseases. Their importance lies in ensuring global food security amidst a changing climate.

- **Characteristics:** These crops possess traits like enhanced drought tolerance (requiring less water), flood resistance, heat tolerance, salinity tolerance, and increased

pest/disease resistance. Some are also designed to have a shorter growth cycle or higher nutritional value under stress conditions.

- **Importance:** They help stabilize agricultural yields in unpredictable weather, reduce crop failures, and maintain food supply for vulnerable populations. By adapting to new climatic realities, they contribute to the livelihoods of farmers and prevent food crises, making agricultural systems more sustainable and productive in the face of climate variability. Examples include drought-resistant maize, flood-tolerant rice, and heat-tolerant wheat varieties.

How did the Green Revolution contribute to food security in India?

The Green Revolution, a period of significant agricultural advancements starting in the mid-20th century, profoundly transformed India's food landscape and played a crucial role in achieving food security. It primarily involved the introduction of **High-Yielding Varieties (HYVs)** of wheat and rice, coupled with increased use of fertilizers, pesticides, and improved irrigation methods.

Its contributions to food security in India include:

1. **Massive Increase in Food Grain Production:** The most direct impact was an unprecedented surge in the production of staple food grains, particularly wheat and rice. HYVs, with their genetic potential for higher yields, responded dramatically to improved inputs. For instance, wheat production more than tripled between 1960 and 2000.
2. **Achieving Self-Sufficiency:** Before the Green Revolution, India was heavily reliant on food imports, often facing famines and food shortages. The increased domestic production allowed India to become self-sufficient in food grains, ending its dependence on foreign aid and imports. This was a critical step for national sovereignty and stability.
3. **Reduced Hunger and Famine:** The increased availability of food grains at affordable prices significantly reduced the incidence of widespread hunger and famine, which had plagued India for centuries. More food meant more people had access to basic sustenance.
4. **Stabilization of Food Prices:** Higher production helped stabilize food prices, making essential food items more accessible to the poorer sections of society.
5. **Increased Farmer Incomes (initially):** Farmers, especially those with access to irrigation and capital for inputs, saw

their incomes rise due to higher yields, leading to improved livelihoods in some regions.

6. **Buffer Stocks:** The surplus production enabled the government to build substantial buffer stocks of food grains, which could be used to manage price fluctuations and address food shortages during lean periods or natural calamities.

In essence, the Green Revolution transformed India from a food-deficit nation into a food-surplus one, fundamentally altering its trajectory towards greater food security and national resilience.

What were the environmental consequences associated with the Green Revolution?

While the Green Revolution significantly boosted food production, it came with substantial environmental consequences due to its intensive agricultural practices:

1. Water Depletion and Mismanagement:

- The HYVs required significantly more water, leading to an over-reliance on irrigation. This resulted in the rapid depletion of groundwater reserves, particularly in states like Punjab and Haryana, through extensive use of tube wells.

- Inefficient irrigation methods also led to waterlogging and increased soil salinity in some areas.

2. Soil Degradation:

- The intensive use of chemical fertilizers (nitrogen, phosphorus, potassium) without adequate organic matter replenishment led to a decline in soil health, structure, and fertility over time.
- Continuous monocropping (growing the same crop repeatedly) depleted specific nutrients and reduced soil biodiversity.

3. Loss of Biodiversity:

- The widespread adoption of a few HYV strains led to the displacement and loss of numerous traditional, diverse crop varieties (landraces). This genetic erosion made agricultural systems more vulnerable to pests, diseases, and climate shocks.
- Pesticide use also harmed beneficial insects, pollinators, and other non-target organisms, impacting ecosystem health.

4. Pesticide and Chemical Pollution:

- The heavy reliance on synthetic pesticides and herbicides led to widespread chemical pollution of soil, water bodies, and the food chain. This posed risks to

human health (farmers, consumers) and aquatic ecosystems.

- Pesticide resistance in pests also emerged, necessitating even higher doses or new chemicals.

5. Greenhouse Gas Emissions:

- The increased use of fossil fuels for machinery, fertilizer production, and irrigation pumps contributed to greenhouse gas emissions.
- Nitrogen fertilizers, in particular, release nitrous oxide (N_2O), a potent greenhouse gas.
- Waterlogged paddy fields (for rice) are significant sources of methane (CH_4), another powerful greenhouse gas.

These environmental consequences highlight the trade-offs involved in achieving food security through an input-intensive agricultural model, necessitating a shift towards more sustainable and ecologically sound farming practices.

How has India's scientific history contributed to contemporary areas in mathematics and technology?

India has a rich and ancient scientific history that has made foundational contributions, many of which continue to influence contemporary areas in mathematics and technology.

Contributions to Mathematics:

1. **Concept of Zero and Decimal Place Value System:** Ancient Indian mathematicians (like Brahmagupta) developed the concept of zero as a number and a placeholder, along with the decimal place value system. This revolutionary innovation simplified calculations immensely and is the bedrock of virtually all modern mathematics, computing, and technology. Without it, complex algorithms and digital systems would be impossible.
2. **Numerals (Hindu-Arabic Numerals):** The numeral system we use globally today originated in India before being transmitted to the Arab world and then to Europe. This system's efficiency is fundamental to all quantitative sciences and technologies.
3. **Trigonometry:** Indian mathematicians like Aryabhata (5th century CE) developed early concepts of trigonometry, including the sine function (Jya) and cosine. These concepts are crucial for modern engineering, physics, computer graphics, navigation systems (GPS), and signal processing.

4. **Algebra and Algorithms:** Early algebraic concepts, solutions to indeterminate equations, and algorithmic approaches to problem-solving were present in Indian mathematics (e.g., Bhaskara II). This laid groundwork for modern computer science and algorithm design.
5. **Calculus (Precursors):** Some scholars argue that Indian mathematicians like Madhava of Sangamagrama (14th century CE) developed foundational ideas related to infinite series, calculus, and mathematical analysis centuries before their independent discovery in Europe. These concepts are integral to modern physics, engineering, and data science.

Contributions to Technology:

1. **Metallurgy:** Ancient India was renowned for its advanced metallurgical skills. The Delhi Iron Pillar (4th century CE), a rust-resistant iron structure, stands as a testament to sophisticated iron smelting and corrosion-prevention techniques. This historical expertise in materials science indirectly informs modern materials engineering and manufacturing.
2. **Astronomy:** Indian astronomers developed precise calendars, understood planetary movements, and made advancements in observational astronomy. The Siddhantas

contained detailed astronomical calculations. This historical emphasis on celestial mechanics contributes to the foundational understanding required for contemporary space technology and satellite navigation.

3. **Medicine (Ayurveda and Surgery):** Ayurveda, an ancient Indian system of medicine, offers a holistic approach to health. Sushruta (6th century BCE) is considered the "Father of Surgery" for his detailed descriptions of surgical procedures, instruments, and plastic surgery techniques. While not directly "technology" in the modern sense, this historical emphasis on systematic observation, diagnosis, and intervention laid a conceptual groundwork for scientific inquiry in health and biomedical fields.
4. **Textile Technology:** India was a global leader in textile production (e.g., fine cottons, dyes). The sophisticated processes involved in spinning, weaving, and dyeing represent early forms of chemical and mechanical engineering.

In contemporary areas, India's scientific history provides a legacy of intellectual rigor, mathematical innovation, and a spirit of inquiry. The foundational mathematical concepts are directly embedded in all digital technologies and scientific computing. While ancient technologies were distinct, the underlying principles

of systematic observation, experimentation, and logical deduction from India's past continue to inspire and inform scientific and technological advancements today.

What are the leading causes of global warming and climate change?

Global warming and climate change are primarily driven by the **enhanced greenhouse effect**, caused by an increase in the concentration of greenhouse gases (GHGs) in Earth's atmosphere. While natural factors play a role, the overwhelming scientific consensus points to human activities as the leading cause of the rapid warming observed since the Industrial Revolution.

Leading Causes (Human-Induced Factors):

1. **Burning of Fossil Fuels:** This is the largest contributor.
 - **Coal, Oil, and Natural Gas:** Used for electricity generation, transportation (cars, trucks, planes, ships), industrial processes, and heating/cooling. Burning these fuels releases vast amounts of carbon dioxide (CO₂), the most significant long-lived GHG.
2. **Deforestation:**

- Forests act as carbon sinks, absorbing CO₂ from the atmosphere through photosynthesis. Deforestation (clearing forests for agriculture, logging, urbanization) not only releases stored carbon back into the atmosphere when trees are burned or decompose but also reduces the planet's capacity to absorb future CO₂ emissions.

3. Industrial Processes:

- Various industrial activities, such as cement production, chemical manufacturing, and metal smelting, release GHGs like CO₂, methane (CH₄), and fluorinated gases (F-gases, e.g., HFCs, PFCs, SF₆), which are extremely potent GHGs.

4. Agriculture and Livestock:

- **Methane (CH₄):** Livestock (especially cattle) produce methane through enteric fermentation. Rice cultivation in flooded paddies also releases significant amounts of methane.
- **Nitrous Oxide (N₂O):** The use of synthetic fertilizers in agriculture is a major source of nitrous oxide emissions.

5. Waste Management:

- Landfills produce methane as organic waste decomposes anaerobically. Incineration of waste can release CO₂.

These human activities have dramatically increased the atmospheric concentrations of GHGs beyond natural levels, trapping more heat and causing the planet to warm.

Discuss both natural and human-induced factors (of global warming and climate change).

Global warming and climate change are influenced by both natural processes and, predominantly, human activities.

Natural Factors:

These factors have historically caused fluctuations in Earth's climate over thousands to millions of years, but they do not account for the rapid warming observed in recent decades.

1. Volcanic Eruptions:

- Large volcanic eruptions can temporarily cool the Earth by releasing aerosols (sulfur dioxide) into the stratosphere, which reflect sunlight back into space.

However, they also release CO₂, but the amount is far less than human emissions over a year. Their cooling effect is short-lived (1-2 years).

2. Solar Variations:

- Changes in the sun's energy output (solar irradiance) can affect Earth's climate. Periods of higher solar activity can lead to slight warming, and vice versa. However, solar variations alone cannot explain the current warming trend, as solar output has not significantly increased in recent decades.

3. Orbital Changes (Milankovitch Cycles):

- Long-term variations in Earth's orbit around the sun, axial tilt, and wobble (precession) influence the amount and distribution of solar radiation received by Earth. These cycles are responsible for ice ages and interglacial periods over tens of thousands of years, but they operate on timescales too long to explain current rapid warming.

4. Ocean Currents:

- Ocean currents redistribute heat around the globe. Changes in major currents (e.g., El Niño-Southern Oscillation) can lead to short-term regional climate

variations but are not primary drivers of long-term global warming.

Human-Induced Factors (Anthropogenic Factors):

These are the dominant drivers of current global warming and climate change, primarily by increasing the concentration of greenhouse gases (GHGs) in the atmosphere, enhancing the natural greenhouse effect.

1. Burning of Fossil Fuels:

- **Carbon Dioxide (CO₂):** The largest contributor. Released from burning coal, oil, and natural gas for electricity, transportation, industry, and heating. CO₂ is a long-lived GHG, remaining in the atmosphere for centuries.

2. Deforestation and Land-Use Change:

- **CO₂:** Clearing forests for agriculture, urbanization, or logging releases stored carbon from trees and soil. It also reduces the planet's capacity to absorb CO₂.
- **Albedo Effect:** Changes in land cover (e.g., replacing forests with lighter-colored agricultural fields) can alter Earth's albedo (reflectivity), influencing temperature.

3. Industrial Processes:

- **CO₂, Methane (CH₄), Nitrous Oxide (N₂O), Fluorinated Gases (F-gases):** Emissions from cement production, chemical manufacturing, metal smelting, and the use of refrigerants and aerosols. F-gases, though less abundant, have a very high global warming potential.

4. Agriculture:

- **Methane (CH₄):** Produced by livestock (enteric fermentation) and rice cultivation in anaerobic conditions.
- **Nitrous Oxide (N₂O):** Released from the use of synthetic nitrogen fertilizers and manure management.

5. Waste Management:

- **Methane (CH₄):** Generated by the anaerobic decomposition of organic waste in landfills.

In summary, while Earth's climate has always changed due to natural forces, the unprecedented speed and scale of current global warming are overwhelmingly attributed to human activities, primarily the emission of greenhouse gases from the burning of fossil fuels and land-use changes.

What are the steps that can be taken at the level of an individual, family and society to mitigate climate change?

Mitigating climate change requires a multi-pronged approach involving concerted efforts at all levels: individual, family, and societal.

At the Individual Level:

1. Reduce Energy Consumption:

- **Unplug electronics:** Unplug chargers and appliances when not in use ("vampire power").
- **Use energy-efficient appliances:** Opt for appliances with high energy ratings.
- **Switch to LED lighting:** LEDs consume significantly less energy than incandescent bulbs.
- **Optimize heating/cooling:** Set thermostats to energy-saving temperatures, use natural ventilation.

2. Sustainable Transportation:

- **Walk, cycle, or use public transport:** Reduce reliance on private vehicles.
- **Carpool:** Share rides to reduce individual car emissions.

- **Consider electric vehicles:** If purchasing a car, choose electric or hybrid models.
- **Reduce air travel:** Flying has a high carbon footprint; consider alternatives or reduce frequency.

3. Dietary Changes:

- **Reduce meat consumption:** Especially red meat, as livestock farming is a major source of methane.
- **Eat local and seasonal food:** Reduces transportation emissions.
- **Minimize food waste:** Food waste in landfills produces methane.

4. Waste Reduction and Recycling:

- **Reduce, Reuse, Recycle:** Follow the waste hierarchy. Buy less, repair items, choose reusable products (bags, bottles).
- **Compost organic waste:** Reduces methane emissions from landfills.

5. Conscious Consumption:

- **Support sustainable businesses:** Choose products from companies committed to ethical and environmentally friendly practices.
- **Buy durable goods:** Reduce the need for frequent replacements.

- **Educate yourself:** Stay informed about climate change and sustainable practices.

At the Family Level:

1. Energy Efficiency at Home:

- **Insulate homes:** Improve insulation for better temperature regulation.
- **Install solar panels:** If feasible, generate renewable energy at home.
- **Regular appliance maintenance:** Ensures optimal energy use.

2. Responsible Consumption and Lifestyle:

- **Collective purchasing decisions:** Choose sustainable options for household goods.
- **Grow own food:** Start a small garden to reduce reliance on commercial agriculture.
- **Water conservation:** Practice water-saving habits (shorter showers, fixing leaks).

3. Education and Awareness:

- **Discuss climate change:** Educate family members, especially children, about its causes and solutions.
- **Lead by example:** Demonstrate sustainable behaviors.

4. Community Involvement:

- Participate in local clean-up drives, tree-planting initiatives, or advocacy groups.
- Encourage neighbors to adopt sustainable practices.

At the Society Level (Government, Businesses, Communities):

1. Policy and Regulation:

- **Carbon pricing:** Implement carbon taxes or cap-and-trade systems to incentivize emission reductions.
- **Renewable energy mandates:** Set targets for renewable energy adoption and provide incentives.
- **Strict emission standards:** For industries and vehicles.
- **Support for sustainable agriculture:** Promote organic farming, agroforestry, and reduced fertilizer use.
- **Forest protection and reforestation:** Implement policies to prevent deforestation and encourage tree planting.

2. Investment in Renewable Energy and Green Infrastructure:

- Shift from fossil fuels to solar, wind, hydro, and geothermal energy.

- Develop smart grids, public transport networks, and green buildings.

3. Research and Development:

- Invest in R&D for carbon capture technologies, energy storage, sustainable materials, and climate-resilient crops.

4. International Cooperation:

- Participate in global climate agreements and initiatives (e.g., Paris Agreement) to set ambitious targets and share technologies.
- Provide financial and technological support to developing nations for climate action.

5. Public Awareness and Education Campaigns:

- Launch nationwide campaigns to educate citizens about climate change and promote sustainable lifestyles.
- Integrate climate education into school curricula.

6. Circular Economy Principles:

- Promote policies that encourage reusing, repairing, and recycling materials to minimize waste and resource consumption.