Science, Technology and Society

COURSE CODE: B21SO06DE

Undergraduate Programme in Sociology
Discipline Specific Elective Course
Self Learning Material

SREENARAYANAGURU
OPEN UNIVERSITY

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The State University for Education, Training and Research in Blended Format, Kerala

SREENARAYANAGURU OPEN UNIVERSITY

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To increase access of potential learners of all categories to higher education, research and training, and ensure equity through delivery of high quality processes and outcomes fostering inclusive educational empowerment for social advancement.

Mission

To be benchmarked as a model for conservation and dissemination of knowledge and skill on blended and virtual mode in education, training and research for normal, continuing, and adult learners.

Pathway

Access and Quality define Equity.

Science, Technology and Society

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Semester - V

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(With Model Question Paper Sets)

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MESSAGE FROM VICE CHANCELLOR

Dear learner,

I extend my heartfelt greetings and profound enthusiasm as I warmly welcome you to Sreenarayanaguru Open University. Established in September 2020 as a state-led endeavour to promote higher education through open and distance learning modes, our institution was shaped by the guiding principle that access and quality are the cornerstones of equity. We have firmly resolved to uphold the highest standards of education, setting the benchmark and charting the course.

The courses offered by the Sreenarayanaguru Open University aim to strike a quality balance, ensuring students are equipped for both personal growth and professional excellence. The University embraces the widely acclaimed "blended format," a practical framework that harmoniously integrates Self-Learning Materials, Classroom Counseling, and Virtual modes, fostering a dynamic and enriching experience for both learners and instructors.

The University aims to offer you an engaging and thought-provoking educational journey. The UG programme in Sociology is designed as a coherent set of academic learning modules that generate interest in dissecting the social engineering process. Both theory and practice are covered using the most advanced tools in sociological analysis. Care has been taken to ensure a chronological progression in understanding the discipline. The curriculum provides adequate space for a linear journey through the historical concepts in sociology, catering to the needs of aspirants for the competitive examination as well. The Self-Learning Material has been meticulously crafted, incorporating relevant examples to facilitate better comprehension.

Rest assured, the university's student support services will be at your disposal throughout your academic journey, readily available to address any concerns or grievances you may encounter. We encourage you to reach out to us freely regarding any matter about your academic programme. It is our sincere wish that you achieve the utmost success.

Regards,
Dr. Jagathy Raj V.P. 01-07-2025

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BLOCK

Sociology of Science and Technology

UNIT 1

STS and PEST

Learning Outcomes

After the completion of this unit, the learner will be able to:

- describe the concept of Science, Technology and Society (STS)
- explain the concept of Public Engagement with Science and Technology (PEST)
- examine the interconnections between science, technology, and society

Prerequisites

Imagine you are sitting with your grandparents, and they begin telling you stories about life before mobile phones, before the internet, before online shopping or GPS. They walked miles to school, wrote letters instead of texting, and listened to the radio together in the evenings. Now, take a moment and look around you: your phone, the lights, the water filter, even the medicines you take; all of them are results of scientific discoveries and technological innovations. These changes did not happen in isolation. Science and technology do not grow on their own, like plants in a forest. They grow because of people, because of society. Scientists are part of society, just like farmers, artists, and teachers. What we choose to invent, how we use it, and who gets access to it all depend on culture, politics, the economy, and public opinion.

Why do some people protest against new dams or genetically modified crops? Why do some vaccines take time to gain public trust? This is where Public Engagement with Science and Technology (PEST) comes in. It is about understanding how people react to and interact with scientific advancements. In this unit, you will learn about the field of Science, Technology and Society (STS) Studies, a way of looking at science not just as knowledge in labs, but as something that shapes and is shaped by people. We will also look at PEST (Public Engagement with Science and Technology), which explores how the public talks back to science, by asking questions, showing support, raising concerns, or even resisting.

Keywords

Science, Technology, Public engagement, Ethics, Accountability, Objectivity

Discussion

1.1.1 Science, Technology and Society (STS) Studies

Let us start with a small question: Have you ever wondered why some technologies become a part of daily life quickly while others do not? Or why does scientific research often focus more on some diseases than others? This is where Science and Technology Studies (STS) come in. STS is a subject that helps us understand how science and technology are connected to society, politics, and culture, and how they all influence each other. We often think of science and technology as neutral or purely based on facts, right? But STS tells us something different. It says that science and technology are not just about experiments in labs or fancy machines; they are shaped by human values, interests, and power. In other words, they are not separate from society; they are a part of it.

For example, why is there more research on space exploration than on clean drinking water in some countries? It is not just a scientific choice; it is also a political and economic one. Or think about how mobile phones are designed. Who decides what features matter most? And who gets left out when designers do not consider people with disabilities or elderly users? STS teaches us that scientific knowledge is built by people, and often by experts who may see the world in a certain way. Their choices influence what becomes "true," what gets funding, and what gets ignored. That is why many scholars in STS use a social constructivist approach. This means they look at how society shapes what we call "science": how problems are defined, which solutions are accepted, and how some voices are heard while others are left out. In short, STS helps us see science and technology as social activities, full of meaning, power, and purpose, not just formulas and machines.

1.1.1.1 Development of STS

Phase 1: The Sociology of Scientific Knowledge

Imagine you have always been told that scientists are like detectives. They discover truths about the world by following a set of clear and logical steps like observation, experiments, and conclusions. But in the 1970s, a group of researchers began asking an important question: Is science really free from social influence, or is it shaped by human values, politics, and culture like everything else? This new way of thinking gave rise to what we now call the Sociology of Scientific Knowledge (SSK). Scholars in this field said, *"Let's not assume that scientific knowledge is automatically true just because it's labelled 'science'."* Instead, they examined how social factors -like institutions, funding, expert authority, and cultural context -affect what is accepted as "scientific truth." They believed that science is a social activity, not just a neutral, objective process.

Famous thinkers like David Bloor, Barry Barnes, Donald MacKenzie, and Bruno Latour argued that scientific "facts" are constructed through social interactions -in labs, through debates, and within communities of experts. For example, whether a new vaccine is accepted depends not only on its biology; it is also about public trust, government support, media coverage, and ethical concerns. This idea shocked many traditional scientists. It led to what we now call the "Science Wars" in the 1990s. One famous incident was the "Sokal Affair," where physicist Alan Sokal submitted a fake article to a social science journal, filled with jargon and nonsense, but written in academic language. The journal published it, and Sokal later revealed the hoax to criticise what he saw as poor academic standards in social science. This sparked a huge debate between scientists who defended the objectivity of science and social theorists who argued for the role of culture and power in shaping science.

Social Shaping of Technology

Soon, the focus of these debates expanded from science to technology. Two major books -*The Social Shaping of Technology* (1985) and *The Social Construction of Technological Systems* (1987) -argued against the idea of technological determinism -that technology evolves naturally and independently of human influence. Instead, these studies showed that human choices, values, and power structures shape every piece of technology. For instance, why are public toilets designed differently for men and women? Why is voice recognition software better at understanding some accents but not others? These are not just technical issues; they are social questions. This research opened the "black box" of technology to show how society and technology influence each other. Decisions made during the design process -like what features to include, who benefits from them, and who is left out -reveal the invisible politics and social assumptions built into our tools and systems.

So, what is the takeaway for us as sociology students?

- Science and technology are not just about cold facts; they are shaped by society.
- What we call "scientific truth" is created through human interaction, culture, and values.
- Technologies don't develop on their own; they reflect the choices, priorities, and power of those who design them.
- As future researchers, we must ask: Whose voices are heard in science and tech? Who is left out? What social realities do these systems create or reinforce?

Phase 2: Science Meets Society

Let's think about this: Who decides what counts as a scientific problem? And when science affects society, should the public be involved in those decisions? In the 1980s, scholars in Science and Technology Studies (STS) began shifting their focus. Instead of just asking, "Is scientific knowledge objective?" they asked, "How is scientific knowledge used in real-life public situations?" and "Why are ordinary people rarely involved in important science-related decisions?" This newer wave of STS was more political and aimed to bring public voices and values into science-related decision-making.

A famous example comes from Brian Wynne, a sociologist who studied public responses to nuclear technology in the UK. He pointed out that while scientists and policymakers only discussed the technical details of a proposed nuclear plant, locals were concerned about broader issues like how that technology might be used for weapons or whether transporting nuclear materials would endanger their communities. Wynne argued that science should not ignore such broader public concerns. Another case involved the Brent Spar oil platform. The UK government and Shell argued that dumping the platform in the deep sea was safe. But groups like Greenpeace saw it as a dangerous precedent that might make it easier to dump other hazardous materials, including nuclear waste, in the ocean. So, the disagreement wasn't just about facts; it was about framing the issue differently.

Science in Society: Who Decides What Matters?

All these debates revealed a key problem: Scientists and policymakers often define what counts as important and ignore or exclude the perspectives of ordinary people. STS scholars said this was not right; publics also have knowledge based on their daily experiences, values, and concerns. These insights deserve a place in science-related discussions. After many public controversies like BSE/mad cow disease, genetically modified (GM) food, and fluoride in drinking water, governments started to listen. In countries like the UK and across Europe, there was a shift from a "scientists know best" approach to a more democratic style of decision-making. Reports like the UK's *Science and Society* (2000) recommended that people should be involved in science discussions, not just experts. As a result, new ways of public participation were introduced: citizen juries, focus groups, consensus conferences, and deliberative polls. These were designed to let citizens express their views, ask questions, and share concerns about science and technology.

STS researchers also created powerful tools to study how science and society are connected:

- **Co-production (by Sheila Jasanoff)**: This means science and society shape each other. For example, our ideas about climate change influence science funding, and scientific reports influence policy and public opinion.
- **Civic Epistemology:** This refers to how different cultures or countries trust and use knowledge. For example, one country may trust government scientists, while another may rely more on NGOs or local experts.
- **Actor-Network Theory (ANT) (by Latour and Callon):** This approach treats not just people, but also technologies, documents, ideas, and tools as "actors" that all influence each other in a network.

Phase 3: Rethinking Public Participation in Science

Let's say your college organises a public discussion on a new technology, like using Artificial Intelligence in education. It sounds good, right? But what if your voice doesn't really change anything? That's the kind of question Science and Technology Studies (STS) scholars are now asking. In the recent phase of STS, there has been a shift from the assumption that, "Public engagement is always good" to deeper questions like: Does public participation actually work? When does it really help in making better decisions? Are all voices treated equally in these discussions?

Scholars like Harry Collins and Robert Evans have pointed out that not everyone in the public is the same. Some people might have special experience or knowledge, even if they're not scientists. So, should we treat all opinions equally in science-related decisions? They argue that we must distinguish between different types of expertise, such as the difference between a trained doctor and a patient who has lived experience. Another scholar, Alan Irwin, observed that governments and institutions often say they are open to public dialogue but still stick to expert-led models when making big decisions, especially in areas like health risks, climate change, or technology.

Upstream vs Downstream

Imagine you are asked for your opinion after a new technology is already made, like after a dam is built or a vaccine is launched. That's called a "downstream" conversation, where you are only allowed to talk about risks or safety. But sociologist Brian Wynne says this is too late! He believes people should be involved "upstream," at the beginning stages of science and technology. For example, why is this research being done? Who benefits? What values are being promoted? These are the real questions people should be discussing.

To help make science more democratic and responsive, two major methods were created:

1. **Constructive Technology Assessment (Netherlands):** A way to involve scientists, engineers, and the public early in the design and planning of new technologies.

2. **Real-Time Technology Assessment (USA):** This lets people give feedback while technology is still being developed, so changes can be made along the way.

Both methods show that it is possible to include different people in shaping innovation, not just reacting to it.

1.1.1.2 Science, Technology, and Society (STS) Studies in India

Since the 1980s, Science and Technology Studies (STS) has grown rapidly in India. It began with science activist groups in the 1970s and 1980s, who questioned how the Indian government used science and technology. Today, STS is a well-established field with many scholars and university departments studying science and innovation policies. A wave of student movements and critical thinkers launched STS in India. Activists inspired by Marxist, Gandhian, and environmental ideas started asking hard questions about scientific modernisation under post-colonial India. Early contributors included Damodar D. Kosambi, Irfan Habib, Ashis Nandy, Vandana Shiva, Claude Alvares, Shiv Visvanathan, and others.

Important institutions like the Centre for Interaction of Science and Society (established in 1970 at JNU but later closed) and NISTADS (National Institute of Science, Technology and Development Studies, founded in 1980) emerged as key hubs. After reopening in 1996 as JNU's Centre for Studies in Science Policy, these centres helped shape public debates on nuclear energy, listed peaceful science, and public dissent. The 1990s saw even richer discussions with scholars like Deepak Kumar, Dhruv Raina, S. Irfan Habib, Gyan Prakash, and others who brought postcolonial perspectives into science studies. Their work looked closely at India's unique history and culture in shaping science.

A major moment was India's own "Science Wars", a debate among scholars about whether science reflects universal truths or cultural biases. Meera Nanda's 2004 book *Prophets Facing Backward* fuelled this debate by defending Enlightenment ideas against cultural relativism. More recent voices like Abha Sur, Amit Prasad, Gita Chadha, Indira

Chowdhury, Pratik Chakrabarti, and many others continued exploring STS themes like gender, development, biotechnology, and global health in the early 2000s and beyond.

Over the last two decades, STS departments have multiplied across India. Some key examples:

- JNU's Centre for Studies in Science Policy (reopened in 1996)
- University of Hyderabad's Centre for Knowledge Culture and Innovation Studies (2006)
- Central University of Gujarat's Centre for Studies in Science, Technology & Innovation Policy (2009)

Even the IITs and IISERs now offer STS courses and house researchers specialising in science, innovation, and society. With at least five generations of scholars and more entering the field every year, STS in India is thriving and looking forward to a bright future.

1.1.2 Public Engagement with Science and Technology (PEST)

Let us imagine you hear about a new government plan to release genetically modified (GM) crops across the country. Who gets to decide if it is a good idea? Just scientists and politicians? Or should ordinary people like farmers, teachers, students, and local communities have a say too? That is where Public Engagement with Science and Technology (PEST) comes in. It's all about bringing the public into conversations about science and technology that affect their everyday lives -whether it's about vaccines, climate change, AI, or space exploration. This idea became more popular after people started realising that science shouldn't stay locked inside laboratories; it should connect with the real world and listen to the concerns of everyday citizens.

After World War II, science was seen as the ultimate solution to all problems -people trusted scientists, and governments poured money into research. But over time, that trust began to shake. By the 1980s and 1990s, people started asking tough questions: *Is science always right? Does it consider ordinary people's needs? Can it be influenced by politics or business?* This is when PEST really took off. The objective is to make science more democratic -to give citizens a seat at the table when big decisions about technology, health, or the environment are made.

1.1.2.1 Different Ways of Engagement

Public engagement happens in many forms. Sometimes it takes the form of a big public meeting or citizen jury where people debate a scientific issue. Other times, it is a small focus group or even citizen science, where volunteers help scientists collect data—like tracking rainfall, planting seeds, or spotting birds. Everyone uses different words to talk about public engagement. For example, some say "citizen science" when volunteers help scientists, while others use it for community-based research. Terms like "consensus conferences" or "deliberative forums" all describe group discussions about science, but they are not always used consistently.

To make things clearer, scholars now talk about four types of "publics":

1. **Volunteer Publics:** People who choose to get involved (like citizen scientists).
2. **Representative Publics:** A selected group of people that reflect society (like in surveys or juries).
3. **Stakeholder Publics:** Groups

with a direct interest (like farmers in a pesticide debate).

4. **Community Publics:** Local communities affected by a decision (like a village near a nuclear plant).

Each type of public plays a different role. Some bring personal experience, others bring local knowledge, and some represent wider society. That is what makes public engagement rich, but also complex.

1.1.2.2 Promise and Problems of PEST

In the early 2000s, there was a wave of excitement about public engagement with science. People believed that involving citizens in science-related decisions could make science more democratic, trustworthy, and useful to society. This idea gained popularity through several initiatives. For example, in the U.S., projects like the Center for Nanotechnology in Society encouraged public participation in new scientific areas like nanotechnology. International groups like ECAST (Expert and Citizen Assessment of Science and Technology) and the Citizen Science Association were also formed to promote more inclusive science.

One inspiring example came from Denmark, where the government introduced "consensus conferences"—events where ordinary people and scientists discussed topics like genetic engineering or climate change. These showed that when given the chance, the public could contribute meaningfully to science and policymaking. The Netherlands created Science Shops, where scientists helped the public solve local problems. Scholars like Alan Irwin talked about "citizen science," where communities and scientists worked together to build useful knowledge.

There was also a practical reason behind this shift. Traditional scientific expertise sometimes failed. After the Chernobyl nuclear disaster, for instance, experts underestimated the role of local knowledge. This led scholars like Brian Wynne to argue for including the public's perspective in risk management and decision-making. Overall, the hope was that more engagement would improve science and its relationship with society.

1.1.2.3 Challenges of Public Engagement

Let us take the example of the "GM Nation?" debate in the UK. Over 20,000 people participated in public meetings to discuss genetically modified food. Instead of creating a shared understanding, the debates made people more confident in their pre-existing views. So instead of changing minds, it ended up reinforcing divisions. Similarly, in the U.S., public conferences often failed to influence actual government policies. These examples showed that public engagement doesn't always work as planned. Sometimes, people don't listen to each other, organisers already have predetermined agendas, or public input is ignored altogether. Scholars began questioning whether public engagement was really effective or just a symbolic exercise.

Still, many believed public engagement was worth improving—not abandoning. Over time, efforts became more organised and thoughtful. For instance, in 2008, the National Citizens' Technology Forum (NCTF) in the U.S. brought together people in six cities to talk about nanotechnology in human enhancement. Studies showed that people learned a lot, became more informed, and even changed their views after participating. This gave hope that structured and respectful discussions could work. At the same time, scientists and communicators realised that the old way of talking to the public like just "telling them the facts" wasn't enough. This is called the deficit model, where scientists assume people oppose science because they lack knowledge. But this approach often backfires. People want to be included in decisions, not just told what to think.

As a response, new models were introduced:

- **The Consultation Model:** where people are asked their views but not always included in decisions.
- **The Engagement Model:** where people and experts genuinely work together.

Still, despite these models, the deficit way of thinking hasn't disappeared. Many scientists still prefer giving one-way information instead of listening and co-creating knowledge. Now, with so many ways to "engage the public," it's hard to decide which method works best and when. Scholars like Rowe and Frewer tried to make sense of this by listing different ways to involve people—from surveys to community-based research. Others, like Schrögel and Kolleck, created models like the "democracy cube" to map different engagement approaches based on who participates, how intense the participation is, and what goals are expected.

1.1.2.4 Ethics, Knowledge and Power in Public Engagement

When planning public engagement, three big questions must be asked:

1. The *Epistemic* Question: How do we know what we know?

This is about knowledge and understanding. Public engagement can help improve the quality of scientific work by bringing in diverse viewpoints and experiences. People from different backgrounds often notice things that experts might miss. Also, a wider variety of voices helps challenge assumptions and improve research reliability.

2. The *Ethical* Question: Is this fair and respectful?

Ethics deals with what is right or wrong. Are the participants treated with respect? Are their rights protected? Are the results shared honestly with them? Public engagement also involves ethical choices about how problems are framed, what questions are asked, and who gets to decide. These values shape not only the process but also the outcomes.

3. The *Political* Question: Who holds the power?

Politics is about representation and fairness. Who is included? Who gets to make decisions? Is the engagement really democratic? Public engagement is not just about collecting opinions—it is also about sharing power in a meaningful way. Some publics (like representative samples) are chosen for fairness. Others (like communities or stakeholders) bring deep, practical knowledge and personal investment.

1.1.2.5 Matching the Right Public to the Right Purpose

Let's look at how these public types perform across the three dimensions:

- Volunteers are helpful in collecting data (epistemic value), but they don't represent everyone (low political legitimacy). Their ethical value depends on how they're treated.
- Representative samples are strong in political representation and bring a range of ethical and epistemic views—but they're short-term and not always deeply invested.
- Stakeholders bring long-term interest and practical knowledge. But fairness and inclusion must be carefully managed, especially

when powerful and weaker groups are involved.

- Communities offer deep local insight and are essential for justice-based research. However, their role may be limited to that particular issue or area and may not represent wider societal views.

One important caution is not to confuse stakeholders with rights holders. For example, Indigenous peoples may have legal and historical rights over lands or resources. Calling them "stakeholders" ignores their sovereignty and reduces their power to just another "interest group." Engagement must respect these rights fully. Thus, not all public engagement is the same, and not all publics serve the same purpose. If your goal is to make a policy more democratic, using a volunteer group won't work. If you want to collect long-term data, using a representative sample won't help. Matching the right public to the right purpose is key. Knowing the strengths and limits of each kind of public helps researchers design more effective, fair, and meaningful engagement. When scientists consider the epistemic (knowledge), ethical (morality), and political (power and representation) aspects of engagement, they can set better goals and know how to measure success.

1.1.2.6 Kerala Sasthra Sahithya Parishad (KSSP) in Public Engagement with Science in Kerala

The Kerala Sasthra Sahithya Parishad (KSSP), established in 1962, is one of India's pioneering people's science movements. Its motto, *"Science for Social Revolution"*, reflects its commitment to democratizing science and using it as a tool for social change in Kerala. Initially started by a group of science writers and educators, KSSP evolved into a mass-based volunteer organization that popularises science among ordinary people through local language publications, street plays, exhibitions, and campaigns.

KSSP played a crucial role in bridging the gap between science and society. It has conducted science literacy campaigns, environmental awareness programmes, and public health initiatives across Kerala. One of its landmark movements was the Silent Valley Movement in the 1970s, where it combined scientific knowledge with grass-roots mobilization to protect biodiversity and successfully halt a proposed hydroelectric project.

KSSP has published over 1,500 science books in Malayalam, making complex scientific ideas accessible to the public. It also launched 'Eureka' magazine for children and 'Sasthra Keralam' for adults, promoting curiosity and critical thinking. The organization has influenced policy discussions on education, water conservation, and sustainable development in the state. Through its sustained efforts, KSSP has made Kerala a model for science communication and public engagement in India, inspiring similar movements across the country.

Recap

- STS (Science and Technology Studies) examines how science, technology, and society influence each other.
- Science and technology are not neutral; they are shaped by human values, politics, and social contexts.
- Scientific knowledge is socially constructed, meaning it's built through people, culture, and power.
- The Sociology of Scientific Knowledge (SSK) showed that what we accept as scientific truth is influenced by institutions, funding, and culture.
- The social shaping of technology argues that technologies are designed through social choices, not just technical progress.
- Actor-Network Theory (ANT) treats both humans and non-humans (like machines and documents) as actors in shaping scientific outcomes.
- Phase 2 of STS focused on including public voices in science-related decision-making processes.
- Public engagement in science allows citizens to participate in debates on important issues like GM food, climate change, and health.
- PEST (Public Engagement with Science and Technology) encourages democratic decision-making involving diverse groups such as citizens, communities, and stakeholders.
- Not all public engagement works well—sometimes it fails due to poor planning, lack of trust, or ignoring public input.
- Effective engagement must match the right kind of public (volunteers, stakeholders, communities) with the right purpose.
- Ethical, epistemic, and political concerns must be considered to make science more inclusive, fair, and meaningful for society.

Objective Questions

1. Define Science and Technology Studies (STS) in simple terms.

2. What does the Sociology of Scientific Knowledge (SSK) focus on?

3. Name any two scholars associated with the Sociology of Scientific Knowledge.

4. What is the main idea behind the Social Shaping of Technology?

5. What was the "Sokal Affair"?

6. What is meant by "co-production" in STS?

7. How does Actor-Network Theory (ANT) view technology?

8. What is the difference between upstream and downstream public engagement?

9. List any two forms of public engagement with science and technology.

10. What does the term "deficit model" mean in science communication?

11. Name one key Indian scholar in the field of STS and their contribution.

12. What are the three key questions to ask when planning public engagement in science?

Answers

1. STS is the study of how science and technology are connected to society, and how they influence and are influenced by culture, politics, and human values.

2. SSK explores how scientific knowledge is shaped by social, cultural, and political factors, not just logic or experiments.

3. David Bloor and Bruno Latour.

4. Technology is not neutral or automatic; it is shaped by social values, interests, and power structures.

5. The Sokal Affair was when physicist Alan Sokal published a fake paper to criticise the standards of social science journals.

6. Co-production means science and society shape each other at the same time.

7. ANT treats both human and non-human elements (like machines and texts) as equal actors in building scientific knowledge.

8. Upstream engagement involves the public early in science planning, while downstream happens after the technology is developed.

9. Citizen juries and consensus conferences.

10. The deficit model assumes the public opposes science only due to a lack of knowledge, and just needs to be informed.

11. Vandana Shiva – She critiqued modern science from ecological and feminist perspectives in India.

12. The epistemic question (about knowledge), the ethical question (about fairness), and the political question (about power and representation).

Assignments

1. Discuss how Science and Technology Studies (STS) challenge the idea that science is neutral and objective.

2. Explain the significance of the Sociology of Scientific Knowledge in understanding scientific truth.

3. Analyse how technologies reflect social values and power using relevant examples.

4. Evaluate the role of public engagement in science and technology decision-making.

5. Describe the development of STS in India and highlight contributions of key scholars.

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Suggested Reading

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UNIT 2

Little Science and Big Science

Learning Outcomes

After the completion of this unit, the learner will be able to:

- describe the key features of little Science and big science, including differences in scale, funding, and organisation of scientific work
- compare and contrast little science and big science by analysing the changes that occurred
- evaluate the advantages and limitations of both little science and big science

Prerequisites

Imagine stepping into a candle-lit study in the late 1700s. A man with ink-stained fingers bends over his notes, surrounded by dusty books, homemade instruments, and shelves of curious specimens. He is not part of a university. He is not funded by the government. He is simply… curious. This is *Little science*—personal, passionate, and often pursued in solitude or with a few close collaborators. Let us fast forward to the 20th century. You are now inside a buzzing, high-security research facility. Thousands of scientists are working together on computers, microscopes, and rockets. There is funding from governments, industries, and universities. What is the goal? To split the atom, explore space, or solve global health crises. Welcome to Big science—complex, collaborative, and powerful.

To understand how we went from the candle-lit room of a lone thinker to the buzzing global research lab filled with thousands of scientists, you will need to come prepared with a few essentials. Firstly, a basic understanding of how scientific ideas develop—from simple questions to experiments and finally to discoveries. Secondly, an awareness of how science and society influence one another, shaping the direction and impact of research. And finally, some background knowledge of key historical periods like the Scientific Revolution and the Industrial Revolution, which set the stage for major shifts in the way science is done.

Keywords

Manhattan project, Amateur scientist, Professional scientist, Science policy, Mega Science

Discussion

1.2.1 Little Science and Big Science

Have you ever wondered how science grew from the work of a few curious individuals to massive government-funded projects like space missions or nuclear research? To understand this transformation, physicist and historian Derek de Solla Price introduced two important terms in the 1960s: Little science and Big science. Little science refers to the way science was practiced before the modern era—mainly during the 18th and 19th centuries and even earlier. Back then, scientific work was carried out by individuals or small groups, often working from home or with the help of wealthy patrons. These scientists didn't have sophisticated labs or big budgets. Think of famous early thinkers like Aristotle, Galileo, or Newton. They observed nature, asked questions, and used reason to make sense of the world. Their work was based on curiosity and personal effort, and they often used simple tools.

As the world changed, especially during the 20th century, a new kind of science began to emerge—Big Science. This was science on a much larger scale. Now, instead of individuals working alone, entire teams of scientists worked together on projects that were supported by universities, industries, and governments. Big Science brought huge changes. Scientific work became more specialised, better funded, and more connected to politics, war, and industry. Two major examples of Big science are the Manhattan Project (which developed the atomic bomb during World War II) and the space race between the USA and the Soviet Union. These projects required thousands of experts, enormous budgets, and strong government support. The focus of science shifted from just understanding the world to using that knowledge to solve big problems and develop powerful technologies.

As Big science grew, science became more organised, but also more hierarchical; decisions were often made from the top down. This made science more structured but less independent. It became harder for amateur scientists, the people working outside formal institutions, to participate. Although science opened up more to women and minority groups, amateurs without formal training or funding were mostly pushed aside. However, some amateurs continued to make contributions, particularly in areas like astronomy, nature observation, or radio technology. And from the 1960s onward, social movements began to demand that the public have a say in scientific matters. Activists in areas like the environmental movement, the anti-nuclear movement, and the HIV/AIDS crisis worked to make science more accountable to the people it affects. For instance, AIDS activists didn't just protest—they learned about how drugs are tested and demanded changes in policies and medical research that would better serve patients.

These movements gave rise to what we now call Citizen Science—a new form of public participation in scientific research. Thanks to digital technology, thousands of volunteers can now assist in collecting and analysing data. Today, people from all walks of life are helping scientists study everything from bird migration to climate change to social trends. Let us also not forget that even before modern science, people across ancient civilisations were doing their own version of scientific thinking. In Ancient Greece, for example, thinkers like Plato and Aristotle observed nature and asked big questions. They used tools like deductive and inductive reasoning—methods which laid the foundation for the scientific method we use today. While they mixed ideas from religion, philosophy, and everyday life, their curiosity helped shape how humans understand the world.

Little Science was small-scale, personal, and driven by individual curiosity. Big Science, on the other hand, is large-scale, collaborative, and deeply connected to political and economic power. Both have played crucial roles in shaping modern science. Today, with the rise of citizen science, we may be seeing a new balance—where professionals and the public work together again, just like in the early days, but with the help of powerful modern tools.

Fig. 1.2.1: Manhattan Project in the USA is an example of Big Science
Source: https://psmag.com/tag/manhattan-project/

1.2.1.1 Differences between Little Science and Big Science

We have seen that science has never functioned in isolation. It has always been influenced by the social, economic, and political conditions of its time. As science progressed from the 18th century through the 20th century, its nature, scale, and organisation transformed significantly. The term *Little science* refers to the scientific activity conducted from the Enlightenment period through the 19th century. It was characterised by modest funding, small teams (often just individual researchers), and minimal institutional support. Scientists like Isaac Newton, Michael Faraday, and Charles Darwin operated largely independently, relying on private patrons, personal wealth, or small institutional grants. The scientific instruments were relatively simple, and discoveries often emerged from home laboratories or university departments.

Importantly, Little science operated within an epistemological culture that emphasised individual brilliance, curiosity, and empiricism. The professionalisation of science was still developing, and there was limited distinction between the amateur and the expert. Research questions were often inspired by philosophical inquiry and aimed at expanding knowledge rather than advancing state or industrial goals. Sociologically, this period reflected a relatively egalitarian structure of scientific production, with relatively open access to knowledge and communication through scholarly societies, journals, and letters. The 20th century brought dramatic changes. The two World Wars, especially World War II, highlighted the strategic importance of scientific research. Under this model, science became more institutionalised, expensive, and politically relevant.

Big Science is characterised by the following features:

1. **Large-Scale Funding:** Governments, especially in the USA and USSR, invested heavily in scientific research for national defence and technological supremacy.

2. **Team-Based Research:** Unlike individual-centred Little science, Big Science involved interdisciplinary teams and institutional networks.

3. **Advanced Infrastructure:** Laboratories, space agencies, and particle accelerators replaced the small-scale labs of the previous century.

4. **Bureaucratic Organisation:** Research became embedded in hierarchical systems involving administrative oversight, grant-writing, and accountability.

Big Science reflects a rational-bureaucratic shift described by Max Weber, where scientific labour increasingly followed formal procedures, regulations, and institutional hierarchies (Weber, 1978). It also corresponds with the rise of technocracy—where scientific knowledge is directly linked to state power and economic planning.

1.2.1.2 From Individual Curiosity to Institutionalised Knowledge

The transition from Little science to Big Science marks not only a change in scale but also a transformation in the role and function of science in society. In Little science, knowledge was pursued for its own sake. In Big science, knowledge production became aligned with broader goals—national security, economic development, and technological competition.

This shift has raised several sociological questions:

- Who controls the agenda of scientific research?

- How are resources distributed among disciplines?

- What ethical concerns arise when science becomes a tool of the state or industry?

Scholars like Robert K. Merton (1973) warned that the autonomy of science could be compromised under political or commercial pressure. Others like Bruno Latour (1987) explored how science, technology, and society co-produce each other, making science not just a cognitive but also a deeply social process.

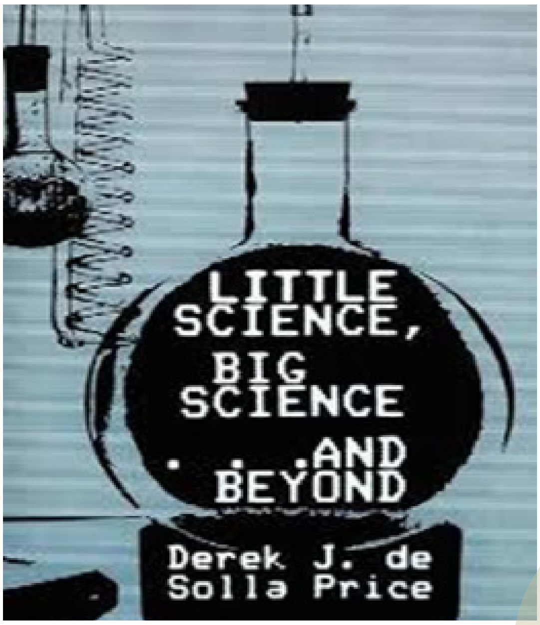
1.2.1.3 Implications for Sociology of Science

The Little vs Big Science distinction is particularly important for the sociology of science as it highlights how social structures, funding mechanisms, and political ideologies influence scientific knowledge. It underscores the idea that science is not a purely objective or value-free enterprise but one embedded in and shaped by its social context. Moreover, it demands critical engagement with how scientific authority is constructed and distributed. While Big science has produced monumental achievements—from the moon landing to the human genome project—it has also raised concerns about equity, accountability, and access to scientific knowledge.

Table 1.2.1 A comparison table between Little Science and Big Science

Aspect	Little Science (18th–19th Centuries)	Big Science (20th Century)
Scale of Work	Small-scale, individual or small group research	Large-scale projects with big teams of scientists
Funding	Self-funded or supported by wealthy patrons	Funded by governments, industries, and institutions
Place of Research	Often private homes, workshops, or small labs	Universities, government labs, research institutes
Goals	Curiosity-driven, general understanding of nature	Practical applications (e.g., weapons, space, health tech)
Technology Used	Simple tools, basic instruments	Advanced technology, complex machinery
Examples	Naturalists like Darwin, inventors like Newton	Manhattan Project (atomic bomb), NASA space programs
Public Participation	Some amateur involvement, more freedom	Less public involvement, more expert-driven, though citizen science is growing again
Knowledge Production	Based on personal observation and reasoning	Organized research with specialized roles and peer review
Nature of Science	Independent and flexible	Institutionalized and bureaucratic
Representation	Less formal, more open to amateurs	Formal structures; amateurs often excluded

1.2.1.4 Derek J. de Solla Price's Work on Little Science and Big Science



Little Science, Big Science and Beyond is a collection of lectures by Derek J. de Solla Price, the physicist and historian of science, first published in 1963. In this book, Price aims to examine science itself using scientific methods like measurement, hypothesis formulation, and analysis. He introduces the idea of studying science scientifically—a field now known as scientometrics. Price compares science to a gas, where individual scientists act like molecules with their own movements and interactions, contributing to a larger system. He argues that the growth of science, both in the number of scientists and the amount of published research, has followed an exponential pattern, meaning it has been doubling roughly every 10 to 15 years. This rapid growth means that a majority of all scientists who have ever lived were alive in each century—from 1700 onwards. This shows how quickly science has expanded in recent history.

However, Price also explains that exponential growth cannot continue forever. He suggests that the growth of science may shift to a logistic curve, where it grows quickly at first but then levels off due to limitations such as cost and resources. This transition helps explain the emergence of "Big Science", a modern form of science that involves large-scale institutions, government funding, and teamwork, unlike earlier "Little Science", which was often carried out by individuals or small groups with limited support. In one chapter, titled Galton Revisited, Price introduces ways to measure the productivity and impact of scientists. Drawing on earlier work by Francis Galton and Alfred Lotka, he suggests that a small number of scientists produce most of the scientific output—this is called the inverse-square law of productivity. Price also introduces the idea of "solidness," referring to the total output of a scientist's published work. He uses these concepts to support the idea that science can be studied statistically, much like economics.

Another important idea in the book is the role of scientific papers. Price explains that scientific papers are not just about spreading knowledge—they are also tools for claiming credit and establishing communication between scientists. Over time, citations (references to other papers) became a way to measure the importance and influence of a research work. This leads to the concept of "Invisible Colleges", which are informal networks of scientists, research institutions, journals, and conferences where ideas are exchanged. These networks help scientists connect across regions and disciplines, shaping the way science is organised and advanced.

In the final section, Price examines the cost and politics of modern science. He points out that the cost of doing science has been rising sharply—especially after World War II. The more scientists are hired, the higher the overall cost becomes due to salaries, equipment, and institutional needs. This results in a feedback loop where growth leads to higher costs, which may slow future expansion. Price also explores how some countries, like Japan, were experiencing rapid scientific growth at that time, while developed nations like the USA were reaching a saturation point. Lastly, Price introduces the term "mavericity," which means the ability of a scientist to think independently and come up with bold new ideas. He warns that Big Science, with its structured teams and strict funding goals, may limit this creativity. While Big Science brings organisation and resources, it may also reduce the freedom for individual scientists to innovate.

1.2.2 Little Science and Big Science in India

It has been argued that India needs to increase its support for both small-scale and large-scale scientific research in order to become a science and technology-driven economy. Small or "little" science refers to research done by small groups in universities and institutions, often using tabletop experiments or simulations. It has been the backbone of India's scientific progress so far and continues to be important for developing new ideas and training researchers. It has also been argued that big or "mega" science—large projects like the Chandrayaan mission and Mangalyaan mission, particle accelerators and gravitational wave observatories—is equally important. These projects require massive funding and collaboration but result in significant technological innovations, international recognition, and long-term benefits for both industry and education sectors.

Fig. 1.2.2: India's Chandrayaan Mission
Source: https://www.geofacts.in/

Critics often question the high costs of such large-scale science projects, especially in a developing country like India. However, it has been argued that these costs are not as substantial as they appear when compared to national budgets in other sectors like agriculture or defence. Moreover, big science has indirect benefits—such as spin-off technologies (like medical tools or the internet) and opportunities to train India's vast pool of students and young researchers.

India's current investment in research and development (R&D)—only about 0.66% of

GDP—is too low compared to scientifically advanced nations, which spend 2–4% of GDP. Without increasing this investment, India may miss the chance to lead in global science and technology. Despite growth in scale, India's investment in R&D remains limited. Gross domestic expenditure on R&D (GERD) was around 0.64 – 0.66% of GDP in 2020–21, far below global averages of 2–4% and peer nations like China (2.4%), South Korea (4.8%), and Israel (4.9%). In absolute terms, GERD increased from ₹39,437 cr (2007–08) to ₹1.24 lakh crores (2018–19), but the GDP share has remained under 1%.

Funding patterns show government agencies (DRDO, ISRO, DST, DBT, DAE) contributed more than half of GERD (54%), while private sector involvement is just 36%, compared to 65–70% in leading economies. This disparity underscores the need for boosting private investment and university–industry partnerships. Scholars argue that the success of big science projects depends not only on adequate funding but also on the availability of skilled human resources and the willingness of universities, civil society, and scientific academies to collaborate. At present, there is a gap between universities and elite research institutions, which needs to be bridged for national progress. Thus, the demand is that India must create a balanced ecosystem where small and big sciences support each other. The government, scientific bodies, and civil society all have roles to play in fostering trust, promoting informed discussion, and ensuring science serves both development and the public good. Investing in both kinds of science is not a luxury but a necessity for India's future.

Recap

- Little Science refers to science practiced before the 20th century, driven by individual curiosity, small budgets, and simple tools, often in home labs or informal settings.
- Big Science emerged in the 20th century, involving large-scale, team-based research projects funded by governments, industries, and institutions.
- Major examples of big science include the Manhattan Project and the space race, which required massive funding, expertise, and political will.
- Little Science valued personal effort and intellectual freedom, while Big Science brought bureaucracy, hierarchy, and institutional control, limiting amateur involvement.
- The rise of citizen science and public activism in the 1960s (e.g., during the AIDS crisis and environmental movements) brought back public participation in science.
- Derek J. de Solla Price's 1963 work "Little science, Big Science" introduced the idea of studying science using scientific methods, laying the foundation for scientometrics.

- Price showed that science grew exponentially from the 1700s, but predicted it would eventually level off due to resource constraints, leading to Big Science.
- He introduced concepts like the inverse-square law of productivity and "Invisible Colleges," highlighting how a few scientists produce most research and how informal networks shape science.
- Price warned that Big Science's structure might stifle creativity, reducing the "mavericity" or independent thinking that drives innovation.
- In India, Little science remains vital for training and small-scale innovation, while Big Science projects like Chandrayaan and Mangalyaan bring technological and global benefits.
- Critics of Big Science in India question its cost, but advocates argue it offers long-term returns, spin-off technologies, and boosts national pride and scientific capacity.
- Scholars call for a balanced ecosystem in India, where both Little and Big Science are supported through increased investment, institutional collaboration, and public engagement.

Objective Questions

1. Who introduced the terms *Little Science* and *Big Science* in the 1960s?
2. What type of research setting was typical in the era of Little science?
3. Name one major 20th-century project that exemplifies Big Science.
4. What role did governments play in the development of Big Science?
5. Which scientific approach was dominant in Little science: team-based or individual-centered?
6. What is the term for the modern public participation in scientific research?
7. What does Derek de Solla Price compare the exponential growth of science to?
8. What is the concept called where a few scientists produce most of the scientific output?

9. What term did Price use to describe informal scientific communities like journals and conferences?

10. What is *mavericity*, according to Price?

11. Name one example of a Big Science project undertaken by India.

12. What is the approximate percentage of GDP India currently spends on research and development?

Answers

1. Derek J. de Solla Price
2. Private homes, workshops, or small university labs
3. The Manhattan Project (or Space Race)
4. They provided large-scale funding and institutional support
5. Individual-centered
6. Citizen Science
7. A gas with molecules representing scientists
8. Inverse-square law of productivity
9. Invisible Colleges
10. The ability of scientists to think independently and creatively
11. Chandrayaan Mission
12. 0.66% of GDP

Assignments

1. Compare and contrast Little science and Big Science in terms of scale, funding, and organization.
2. Discuss the sociological implications of the transition from individual curiosity to institutionalized science.
3. Examine the role of government and industry in shaping Big Science.
4. Analyze Derek de Solla Price's views on the growth and limitations of modern science.
5. Evaluate the relevance of Citizen Science in making modern research more inclusive and democratic.

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2

BLOCK

Perspectives of Science and Technology

1

UNIT

Sociology of Science

Learning Outcomes

After the completion of this unit, the learner will be able to:

- understand the cognisance of science and technology
- familiarise themselves with how structural inequalities and systemic biases (e.g., the Matthew Effect) impact recognition, credibility, and access in the scientific community
- discuss the limitations of Merton's normative framework in contemporary scientific contexts, particularly in relation to commercialisation, competition, and institutional pressures.

Prerequisites

The global COVID-19 pandemic presented a high-stakes environment for scientific research, marked by urgency, uncertainty, and public scrutiny. Merton's sociology of science—especially the CUDOS norms—provides a useful lens to understand both the strengths and challenges faced by the scientific community during this time. In the early stages of the pandemic, scientists worldwide shared genomic data of the SARS-CoV-2 virus openly, allowing rapid development of vaccines and diagnostics. Preprint servers like medRxiv and bioRxiv flourished, reflecting a strong commitment to communal sharing of knowledge. However, tensions emerged as pharmaceutical companies pursued patents and profit, limiting access to some treatments and vaccines—challenging the ideal of communalism. COVID-19 highlighted the value of universal evaluation of scientific claims, irrespective of nationality or institutional affiliation. Yet, instances of vaccine nationalism and unequal recognition of scientific contributions from Global South researchers revealed that biases still permeate the system, contradicting Merton's principle of universalism. While many scientists worked altruistically to combat the pandemic, disinterestedness was questioned in cases where researchers or corporations stood to gain financially or politically.

The competition for funding, authorship, and media attention raised concerns about the integrity and impartiality of some research efforts. Peer review and critical evaluation were sometimes bypassed in the rush to publish results quickly. Several high-profile retractions (e.g., studies on hydroxychloroquine in The Lancet) showed the breakdown of organised scepticism under pressure. At the same time, scientific scepticism helped debunk misinformation and pseudoscience, reinforcing its continuing relevance. The COVID-19 crisis demonstrated both the enduring relevance and practical limitations of Merton's CUDOS norms in modern science. While many scientists adhered to these values under pressure, institutional, political, and economic factors often compromised them. This scenario underscores the importance of viewing Merton's framework not as a fixed ideal but as a dynamic model that must adapt to changing contexts, especially in a globalised, crisis-driven scientific landscape.

Keywords

Science, Intellect, Knowledge, Norms, Global

Discussion

2.1.1 Sociology of Science: Robert K. Merton

Robert K. Merton is widely regarded as one of the founding figures of the sociology of science. In contrast to the earlier view that science was a purely logical or individualistic pursuit, Merton argued that science is also a social institution, shaped by norms, roles, values, and organisational structures. His work integrates functionalist sociology into the study of science, examining how scientific norms and institutions contribute to the stability and progress of society. He focused not only on the cognitive content of science but also on the social conditions that facilitate or hinder its development. For Merton, science was both a rational-empirical method and a normatively regulated social activity.

The Normative Structure of Science (CUDOS)

The normative structure of science is often termed Mertonian norms. Merton proposed that science operates according to a distinctive normative ethos, which distinguishes it from other spheres of life. These norms are not legally enforced but are internalised by members of the scientific community to promote objectivity and integrity. Merton identified four main norms—often abbreviated as CUDOS:

a. **Communalism** : Scientific knowledge is seen as public property. Discoveries and findings should be shared openly for the benefit of the community. Individual scientists may gain recognition, but the knowledge itself must be accessible and collectively owned.

b. **Universalism** : Scientific claims should be evaluated based on impersonal criteria (logic, evidence, methods), not on the status, nationality, gender, or race of the scientist. This norm reinforces the idea of objectivity and equality in science.

c. **Disinterestedness** : Scientists are expected to act for the good of science and society, not for personal profit. While personal motivations may exist, the system rewards impartiality and honesty. Disinterestedness fosters trust in scientific outputs.

d. **Organised Skepticism** : Scientific ideas must be subje cted to rigorous scrutiny and critical evaluation. No claim is exempt from questioning. This institutionalised scepticism protects science from dogma and error.

Together, these norms form the moral foundation of the scientific enterprise, ensuring that it remains a self-correcting, cooperative, and progressive activity. Merton's norms emphasise that science is a social institution governed by ethical and cultural standards, not just technical procedures. They help explain how scientific communities maintain credibility, objectivity, and innovation. However, these norms have also faced critiques—especially in cases where economic, political, or institutional pressures lead to violations or conflicts of interest. Later scholars like Ian Mitroff argued that these norms are often in tension with counter-norms—for example, secrecy (especially in corporate or military-funded research) contradicts communalism. Nevertheless, Merton's framework remains foundational in understanding the ideal moral order of science.

Merton believed that the values of science are closely aligned with democratic values. Universalism and organised skepticism, for example, are also pillars of democratic governance. In contrast, authoritarian societies often suppress critical inquiry and transparency—conditions that hinder scientific progress. He argued that science flourishes in open societies, where there is freedom of thought, inquiry, and communication. This connection between scientific freedom and democratic institutions reinforces the view that science is deeply embedded in its broader political and cultural context.

2.1.1.1 Science as a Social Institution

Merton viewed science not merely as a collection of knowledge or technical methods but as a social institution with its own set of norms, roles, and organised practices. He emphasised that scientific development is influenced by societal contexts and cannot be understood in isolation from social structures. Merton introduced the concept of the Matthew Effect, referring to the phenomenon where well-known scientists often get more credit for research than lesser-known scientists, even when their contributions are similar. This concept highlights inequalities in scientific recognition and reward, which can impact the careers of emerging scholars and the development of science.

Merton argued that scientific growth is shaped by cultural values and institutional structures. He analysed how Puritan values in 17th-century England, such as discipline, hard work, and the pursuit of knowledge for societal benefit, created a fertile ground for the growth of modern science. This led to his idea of the "ethos of science" being influenced by broader cultural and historical factors. He explored how scientific roles and statuses are distributed in society, including hierarchies within the scientific community. He examined how rewards (e.g., prestige, funding, publication) and roles (e.g., mentor, peer reviewer, innovator) affect scientific productivity and collaboration. While Merton laid the groundwork for the sociology of science, his focus remained on the institutional framework and norms guiding scientific behaviour. Later scholars such as Thomas Kuhn and the Edinburgh School built upon and challenged Merton's work, emphasising the content and construction of scientific knowledge rather than just its institutional aspects.

Merton's approach is grounded in structural functionalism, where science is seen as a functionally necessary institution that maintains the adaptive capacity and progress of modern societies. Science, for him, serves not only as a generator of knowledge but also as a stabilising institution that aligns with broader social goals.

2.1.1.2 The Reward System

Merton emphasised that science, like other professions, is governed by a system of rewards and recognition. Scientific achievements are not rewarded with material wealth but through status and esteem—most notably through priority of discovery and authorship. The first to make a scientific discovery gains intellectual property rights in the form of recognition, which encourages openness and productivity in the field.

This led to the development of what is sometimes called the Matthew Effect. This became one of Merton's most famous contributions: the concept of the Matthew Effect, based on the biblical verse: "For to everyone who has, more will be given (Matthew 25:29)". It refers to the phenomenon where famous or senior scientists often receive disproportionate credit and resources, even when lesser-known scientists contribute equally or more.

This cumulative advantage leads to:

- Inequality in recognition and career advancement.
- Disproportionate allocation of funding and opportunities.
- The entrenchment of elite status in science.

For instance, if two researchers make a similar discovery, the more prestigious one is more likely to be cited, rewarded, or remembered. This reinforces scientific hierarchy and affects the career trajectory of early-career researchers. In scientific terms, the Matthew Effect describes how well-known scientists often receive disproportionate credit and visibility, even for collaborative work, while lesser-known contributors may be overlooked. It shows the stratification within science, where prestige and recognition often amplify themselves over time.

2.1.1.3 Priority Disputes in Science

Merton explored how scientists compete for priority in discoveries—being the first to publish or announce a finding is crucial. Priority confers prestige, recognition, and intellectual property, making it a central feature of scientific culture. This competitive drive can also lead to disputes over who discovered what and when, secrecy and strategic delays in sharing results, and pressure to publish quickly, sometimes at the cost of quality. Despite the ideal of disinterestedness, scientists often operate within highly competitive environments that incentivise individualism and speed.

2.1.1.4 Bureaucratization of Science

Merton examined the bureaucratization of science, especially with the rise of large-scale, institutionally funded research projects (often termed "Big Science"). While bureaucracy brings organisation and efficiency, it may also suppress creativity, limit freedom, and encourage conformity. Merton's analysis here offers a critique of the modern scientific-industrial complex. As science became more institutionalised, Merton observed a trend toward bureaucratization—the rise of large research organisations, formal procedures, and hierarchical management structures. He called this shift "Big Science". Consequences of bureaucratization include:

- Greater resources for complex research projects.
- Increased regulation and administrative control.
- Potential loss of individual creativity and autonomy.
- Dependence on state or corporate funding, leading to shifts in research agendas.

Merton was concerned that this might lead to the erosion of academic freedom and the dominance of instrumental over pure science.

2.1.1.5 Science and Social Stratification

Merton also analysed how science reflects and reproduces broader patterns of social inequality. Within scientific communities, there is a clear stratification system:

- Prestigious institutions and journals dominate influence.
- Access to funding and facilities is uneven.
- Marginalised groups (e.g., women, minorities) face systemic barriers.

He showed that inequalities in science are not purely merit-based but often influenced by social networks, institutional prestige, and historical privilege. His work laid the groundwork for more recent feminist and postcolonial critiques of science.

2.1.1.6 Criticism of Merton's Sociology of Science

Merton's sociology of science, while groundbreaking, has been subject to various critiques:

- **Idealism :** Critics argue that Merton's norms describe how science ought to function, not how it actually does. Empirical studies often find deviations from these norms.
- **Neglect of politics and power:** Merton underemphasised the role of ideology, economic power, and political interests in shaping science.
- **Gender and race blindness:** His work did not address gendered and racial inequalities within scientific institutions.
- **Overemphasis on consensus:** Functionalism tends to highlight harmony and order, downplaying conflict, contradiction, and dissent in scientific communities.

Nonetheless, these critiques have led to refinements and extensions of Merton's ideas rather than their outright rejection.

Robert K. Merton's contributions to the sociology of science remain foundational in understanding science not just as a body of knowledge but as a structured, value-laden, and socially embedded activity. His analysis of norms, institutions, inequalities, and reward systems offers deep insights into how science functions within society. While his framework has been expanded and critiqued over time, it continues to provide a rich basis for analysing contemporary developments in scientific practice, from the rise of corporate-funded research to the challenges of scientific misinformation. As science increasingly intersects with public policy, digital technology, and global challenges, Merton's call to examine the social dimensions of science remains more relevant than ever.

Merton's legacy is profound. His framework influenced not only empirical research on science but also theoretical developments in Science and Technology Studies (STS) and critical sociology.

Key developments inspired by Merton include:

- Thomas Kuhn's paradigm theory, which introduced historical and revolutionary elements to scientific progress.
- Bruno Latour's actor-network theory, which emphasised the role of non-human actors and the construction of facts.
- Feminist and postcolonial STS, which questioned the universality and neutrality of Western science.

While many scholars critique or move beyond Merton, his work remains a foundational reference in understanding how science operates within social structures.

2.1.2 Contemporary Discussions

Robert K. Merton's normative framework, especially the CUDOS norms (Communalism, Universalism, Disinterestedness, and Organised Skepticism), continues to serve as a foundational model for understanding the ethos of science. However, recent critiques have questioned the applicability of these ideals in the context of neoliberal transformations in scientific institutions. The commercialisation of research, the growing emphasis on competition, and the reliance on performance indicators like citations and funding have led to the erosion of these norms. For instance, communalism is undermined by patenting and proprietary data, disinterestedness is compromised by funding pressures and career incentives, and universalism is challenged by bias in peer review and systemic inequalities. Organised skepticism too suffers, as replication studies are undervalued and publishing "positive" results is often prioritised over critical evaluation.

Additionally, Merton's concept of the Matthew Effect has been revisited to highlight systemic inequalities within science, including gender bias, global disparities, and epistemic exclusion. Contemporary scholars argue that while Merton emphasised norms and institutional roles, his framework overlooked how scientific knowledge is socially constructed through networks of power, negotiation, and discourse. This led to the rise of post-Mertonian approaches like the Sociology of Scientific Knowledge (SSK) and Actor-Network Theory (ANT), which focus on how facts are co-produced by social, technical, and political actors. Despite these critiques, Merton's ideals still influence science policy, ethics, and open science movements today. Calls for open access, transparency, and replication reflect an enduring aspiration toward a more ethical and inclusive scientific practice, though adapted to the complex realities of the 21st-century research environment.

Recap

- Robert K. Merton's sociology of science offers a foundational framework for understanding science as a social and cultural process.
- Merton established science as a social institution, embedded within and shaped by broader societal norms and structures.
- He emphasised that scientific knowledge is socially produced, not purely the result of isolated individual genius.
- Science operates under a set of norms known as the CUDOS norms—Communalism, Universalism, Disinterestedness, and Organised Skepticism.
- Communalism means scientific discoveries should be publicly shared rather than privately owned.
- Universalism implies that scientific claims must be evaluated based on objective criteria, not the identity of the researcher.
- Disinterestedness expects scientists to work for the advancement of knowledge, not personal or financial gain.
- Organised skepticism requires all scientific claims to be critically examined and tested before being accepted.
- Merton introduced the Matthew Effect, where well-known scientists receive disproportionate recognition, reinforcing existing reputations.
- Merton showed that rewards and recognition in science are unequally distributed, shaping careers and research directions.
- Merton analysed how cultural values like Protestant ethics supported the rise of modern science in 17th-century England.
- Merton coined the concept of the "ethos of science", a value system that sustains scientific conduct and motivation.
- Merton stressed that science does not develop in isolation but in relation to economic, religious, and political forces.
- Merton work laid the foundation for the institutional analysis of science, focusing on roles, norms, and reward systems.
- Merton used a functionalist framework, viewing science as serving essential functions for the stability and progress of society.

- Merton showed that scientific innovation is influenced by both internal logic and external social factors.
- Merton highlighted the role of peer review and collaboration in maintaining the integrity and reliability of science.
- Merton examined how status hierarchies and gatekeeping affect access to publication, funding, and influence in the scientific field.
- Merton differentiated between the manifest functions (explicit goals) and latent functions (unintended outcomes) of scientific activity.
- Merton focus was largely on institutional structures, while later scholars like Kuhn moved toward analysing how knowledge itself is socially constructed.
- Merton's sociology of science remains foundational, influencing both the study of science policy and scientific practice across disciplines.

Objective Questions

1. Who is considered the founder of the sociology of science?
2. What is the term for Merton's scientific value system?
3. Which CUDOS norm refers to sharing scientific knowledge?
4. Which CUDOS norm stresses objectivity over personal bias?
5. What concept describes the over-recognition of famous scientists?
6. Which CUDOS norm emphasizes altruistic motives in science?
7. What term refers to the critical scrutiny of scientific claims?
8. What religious ethic did Merton link with the rise of modern science?
9. What sociological theory did Merton use to frame science?
10. What system evaluates and filters scientific publications?
11. What economic model is blamed for eroding CUDOS norms?

Answers

1. Merton
2. CUDOS
3. Communalism
4. Universalism
5. Matthew
6. Disinterestedness
7. Skepticism
8. Puritanism
9. Functionalism
10. Peer review
11. Neoliberalism

Assignments

1. Describe Robert K. Merton's concept of the normative structure of science. How do the CUDOS norms regulate scientific behaviour?
2. Outline the key contributions of Robert K. Merton to the sociology of science, with reference to the institutional and cultural factors he identified.
3. Critically analyse the relevance of Merton's CUDOS norms in the context of contemporary scientific practices such as commercial research, patenting, and private funding.
4. Evaluate the implications of the 'Matthew Effect' on scientific recognition and inequality. How does it challenge the ideal of meritocracy in science?

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2

UNIT

Social Function of Science

Learning Outcomes

After the completion of this unit, the learner will be able to:

- understand the historical and theoretical framework of how science functions as a transformative social force
- explain the relationship between science, capitalism, and social responsibility, recognising how economic systems can shape the direction, application, and accessibility of scientific knowledge
- analyse Bernal's perspective to contemporary global challenges

Prerequisites

J.D. Bernal's vision of the social function of science is remarkably relevant to contemporary society. He argued that science must move beyond serving capitalist interests and instead be consciously directed toward solving urgent human problems. Today, we see both the power of science to transform lives and the challenges posed by its misuse or commodification. The global COVID-19 pandemic highlighted science's potential when mobilised for public good—rapid vaccine development saved lives worldwide. Yet, as Bernal warned, economic inequality in vaccine distribution exposed how capitalist structures can undermine scientific ideals. Similarly, the climate crisis exemplifies Bernal's call for science to be a guiding force in social planning. Despite clear scientific consensus, political and economic resistance continues to delay meaningful action. Emerging technologies like artificial intelligence and automation reflect science's transformative capacity, but they also raise concerns about ethics, inequality, and surveillance. Bernal would argue that such progress must be aligned with human liberation and social equity. Movements promoting open science and knowledge sharing embody his ideal of science as a collective human heritage, challenging the privatisation of research. Furthermore, scientific misconduct and the influence of corporate funding reveal the dangers Bernal foresaw when science loses its social consciousness. He believed science must remain committed to truth and the collective good, not become a tool of profit. His ideas also underscore the importance of integrating scientific knowledge into governance and public policy—a need increasingly urgent in crises like climate change, pandemics, and technological disruption. In essence, Bernal's framework encourages us to see science not as a neutral or isolated pursuit but as a deeply social and political force. His call for a planned, ethical, and inclusive scientific enterprise serves as a crucial guide for addressing the complex challenges of the 21st century. Let us discuss and explore these ideas in detail.

Keywords

Science, Society, Marxism, Scientific planning, Capitalism, Social transformation, Knowledge

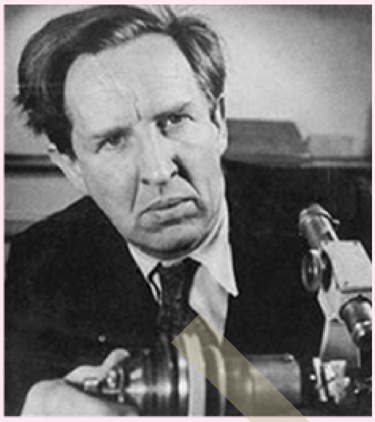
Discussion

J. D. Bernal (1901–1971) was a pioneering British scientist, Marxist thinker, and one of the earliest proponents of the sociology of science. His influential 1939 work, The *Social Function of Science*, is a foundational text that challenges the notion of science as a purely objective and autonomous activity. Instead, Bernal argued that science is deeply embedded in society, shaped by its economic structures, class relations, and political interests.

2.2.1 The Social Function of Science

Science today is widely acknowledged as a vital part of both our material life and the ideas that shape society. It provides tools to meet practical needs and offers a framework for understanding and organising our social lives. Beyond this, science also inspires hope in humanity's future by opening possibilities that can guide progress. To grasp science's role, we must consider it within the broad arc of human history. Bernal identifies three major transformations in human development: the emergence of society (marked by communication across generations), the rise of civilisation (centred on agriculture and trade), and the current scientific transformation, which is still ongoing and lacks a definitive name.

The first two revolutions—society and civilisation—took thousands of years to spread and develop, with civilisation stagnating in terms of quality until the Renaissance. However, by the 18th century, science and invention began to create changes more transformative than anything that came before. Initially tied to capitalism, science was seen as part of the broader process of progress and freedom. But Bernal argues that science's true potential surpasses that of capitalism and that genuine scientific advancement is fundamentally incompatible



John Desmond Bernal, was a prominent scientist and Marxist thinker, born on 10 May 1901 in Nenagh, County Tipperary, Ireland. He was the eldest of five children of Samuel George Bernal, a local farmer, and Elizabeth Miller, an American of Presbyterian background who converted to Catholicism before their marriage. Bernal was raised in the Catholic faith and sent to England for education at the age of ten. He initially attended Hodder, the preparatory school for Stonyhurst, a Jesuit public school, but later transferred to Bedford School, where science was part of the curriculum. In 1919, he secured a scholarship to Emmanuel College, Cambridge.

At Cambridge, Bernal was introduced to socialism by fellow student H. D. Dickinson and embraced Marxism by the end of 1919. He joined the Communist Party of Great Britain in 1923 and remained a committed Marxist throughout his life. During holidays in Ireland, he observed the political conflict and expressed republican sympathies, differing from his family's more conservative views. Academically, he pursued studies in mathematics and natural sciences, and as an undergraduate, independently derived the 230 space groups of crystallography using Hamiltonian quaternions. This early work caught the attention of Sir William Bragg at the Royal Institution, who accepted Bernal as a research student in 1923.

At the Royal Institution, Bernal worked on X-ray crystallography and successfully determined the structure of graphite and advanced the study of δ bronze. He also designed a commercially marketed X-ray diffraction recorder. In 1927, he returned to Cambridge as the first lecturer in structural crystallography and expanded his research to metal alloys and biological molecules. His X-ray studies on sterols, especially calciferol (vitamin D_2), revolutionised structural understanding and showcased crystallography's potential in organic chemistry. His groundbreaking work on proteins produced the first X-ray diffraction pattern of crystalline pepsin. Later, his analysis of the tobacco mosaic virus established its rod-like structure, a result later verified by electron microscopy.

In 1938, Bernal became professor of physics at Birkbeck College, London. During World War II, he joined the Ministry of Home Security's research department, contributing to the design of air-raid shelters. He later worked with Combined Operations Command on innovative projects, including floating ice airfields and the Mulberry harbours used in the Normandy landings. After the war, he returned to Birkbeck, where he led research on proteins, viruses, cement, and liquids, and personally pursued studies on the liquid state.

Bernal's strong communist views led to growing suspicion during the Cold War, making it harder for him to secure research funding. His defence of the controversial Soviet biologist Trofim Lysenko further distanced him from many in the scientific community. Despite this, he remained active in international peace movements, serving as founding vice-president of the World Peace Council in 1949 and maintaining close ties with Soviet leadership, including Nikita Khrushchev.

Recognised for his scientific achievements, Bernal was awarded the Royal Society's Royal Medal (1945), the U.S. Medal of Freedom with palms (1945), and the Lenin Peace Prize (1953). He became a Fellow of the Royal Society (FRS) in 1937 and was elected to numerous national science academies across Eastern Europe and Scandinavia. In 1922, he married Eileen Sprague, with whom he had two sons, Michael and Egan. He also had children from other relationships: Martin with Margaret Gardiner and Jane with Margot Heinemann.

After suffering a stroke in 1963, Bernal's health declined, and he passed away in London on 15 September 1971. His major works include The Social Function of Science (1939), Science in History (1954), and The Origin of Life (1967). His scientific and personal papers are housed in the Cambridge University Library, and a detailed bibliography appears in the Bibliographical Memoirs of Fellows of the Royal Society (1980, vol. 26).

with capitalist structures, which prioritise profit over collective benefit.

Science, in its full social function, demands a conscious and coordinated approach to managing all aspects of life. It offers the potential to eliminate dependence on the natural world, with future society limited only by its own decisions. While the path ahead is uncertain and full of challenges, the awareness of this potential will drive humanity forward. In this transitional era, science is one force among many — including economics and politics — but it holds unmatched power when it becomes aware of its social role.

Many of today's pressing issues—such as hunger, disease, forced labour, and war—are no longer unavoidable consequences of nature but outcomes of outdated political and economic systems. Science has the capacity to solve these problems, but this potential remains unrealised. Even deeper problems, like unpleasant work or chronic disease, could be addressed if society invested in science for human benefit. To ignore this potential is to neglect human welfare.

Eliminating problems is not enough; science must also help create better lives. It has largely avoided engaging with deeper human and social needs. Bernal calls for science to study not only nature but also society, helping humanity to distinguish between meaningful goals and illusory desires. Science must guide society not just by offering solutions but by shaping aspirations.

Currently, science and literary culture remain divided, but this separation is unsustainable. Cultural renewal depends on merging scientific thinking with other fields. However, this will require science itself to evolve—to become more capable of addressing novelty, change, and human complexity. While traditional science has excelled in stable, measurable systems, it struggles with unpredictability and newness, which are central to human affairs. As science becomes more entwined with culture and social life, it must expand its methods to accommodate these challenges.

This shift is already underway. Fields like biology have begun incorporating history and unpredictability, breaking from classical scientific assumptions. Bernal sees Marxism as a key framework for understanding this evolution. Marx's insights into economic and social change provide tools for analysing processes that involve novelty and development—areas where conventional scientific methods fall short. Marxism thus extends rational thinking into domains where science has typically lacked predictive power. Some view Marxism as a rigid doctrine, but Bernal emphasises it is a method, not a dogma. It allows scientists to understand the forces shaping science itself and positions science as a participant in social transformation. Unlike earlier scientific detachment, Marxism ties science to material and historical realities. This integration helps remove the metaphysical assumptions that have historically influenced scientific thought and reveals science's role as a driving force in societal evolution.

Ultimately, science should become central to radical social change. Capitalism maintains civilisation; science transforms it. Science's social function will be judged by whether its innovations serve human needs or merely reinforce inequality. As humanity moves through this transition, science must become a tool not of a privileged few but a shared asset of all people.

Science already demonstrates in practice how human collaboration can work without coercion. It functions on shared purpose, mutual respect, and honesty—values that can guide broader society. Scientists recognise that progress depends on the collective work of many, and their efforts are guided by truth, not authority. These lessons, though imperfectly learned, could become guiding principles for humanity. In this sense, science reflects the spirit of communism, not as an ideology, but as a model for how human cooperation can achieve freedom through understanding the material world.

2.2.1.1 Key Ideas in the Social Function of Science

Science as a Productive Force

Bernal emphasised that science is not just a pursuit of abstract knowledge, but a productive force that directly contributes to economic development, technological progress, and societal transformation. He saw science as part of the material base of society, closely linked with industry, agriculture, and the military.

Socially Situated Science

According to Bernal, science does not operate in a vacuum. Its priorities, funding, direction, and applications are all shaped by the social system—especially by the capitalist economy. He critiqued the privatisation of scientific knowledge and the alignment of research agendas with profit motives rather than human needs.

Planned Science for Public Welfare

Bernal advocated for centralised planning of scientific research to serve public welfare rather than private gain. He believed in a democratically controlled scientific enterprise, where the benefits of science would be directed toward solving social problems like poverty, disease, and inequality.

Science and War

Bernal highlighted the role of science in warfare, particularly during the interwar and World War II periods, arguing that under capitalism, science becomes militarised and serves destructive ends. This was a key motivation for his call to reorient science toward peace and social development.

2.2.2 Theoretical Connections in Sociology

Bernal's ideas are rooted in Marxist theory, particularly the view that the base (economic structure) determines the superstructure (institutions like science). He considered science a part of the forces of production and believed that the relations of production (capitalist ownership, for example) shape how science is organised and used. Whereas functionalist thinkers like Merton viewed science as a neutral, self-regulating institution guided by internal norms (e.g., CUDOS), Bernal emphasised the external, political-economic determinants of science. While Merton spoke of disinterestedness, Bernal saw most science as shaped by class interests and state agendas. Bernal's approach also aligns with critical theory, which seeks to uncover the power dynamics embedded in knowledge production. Like members of the Frankfurt School, he challenged the idea of scientific neutrality and emphasised the need for reflexive, socially responsible science.

2.2.3 Contemporary Relevance of Bernal's Ideas

a. **Science, Capitalism and Corporate Influence :** In the 21st century, Bernal's critique resonates in discussions about the commercialisation of science, where corporate funding, patents and intellectual property rights influence research priorities—often at the cost of public interest.

b. **Science in Climate Crisis and Health Inequality :** Bernal's call for planned, socially directed science is echoed in current movements for climate justice, public health equity and open science. The COVID-19 pandemic and global warming have shown how urgently science must align with collective welfare, not corporate profit.

c. **Militarisation and Surveillance Technologies :** The military use of scientific innovation, from AI-powered drones to cyber surveillance, mirrors Bernal's warning that science under capitalism can become an instrument of control and destruction, rather than liberation.

d. **Calls for Science Democratisation :** Modern science and technology studies (STS) scholars continue to push for participatory science, citizen engagement and decolonisation of scientific knowledge, all of which reflect Bernal's original vision of science serving society, not dominating it.

J. D. Bernal's The Social Function of Science remains a radical and visionary intervention in the sociology of science. By revealing the class character of scientific production and advocating for democratic control of knowledge, he laid the groundwork for later Marxist and critical approaches to science. His insights are highly relevant today, as society faces crises—ecological, health-related, and technological—that demand a science rooted in social responsibility, equity, and justice.

Recap

- Science is both a material and ideological force shaping modern society.
- It provides tools to meet human needs and concepts to organise social life.
- Science inspires hope by opening up possibilities for a better future.
- To understand science's role, we must view it within long-term historical change.
- Humanity has undergone three major transformations: society, civilisation, and now scientific transformation.
- Early civilisations developed slowly, while modern science has triggered rapid societal change.
- The Renaissance and Enlightenment marked the beginning of science-driven progress.
- Science initially developed alongside capitalism, but its goals now transcend capitalist structures.
- Scientific advancement requires conscious, planned control of social and economic life.
- Today's global problems—hunger, war, disease—are solvable with existing scientific knowledge.
- Much human suffering persists because science is not yet fully applied to social good.
- Science should not only remove evils but also create better, more meaningful ways of living.
- It must engage with human desires, values, and social aspirations—not just material production.
- There is an urgent need to bridge the gap between science and traditional culture.
- Science must evolve to deal with novelty, unpredictability, and complex human systems.
- Marxism offers a method for understanding science as part of dynamic social processes.

- Scientific detachment is limiting—science must see itself as a driver of social change.
- The future role of science is to provide unpredictable but necessary innovations.
- In its collaborative, non-hierarchical nature, science models the spirit of communism.
- Science must become the common intellectual heritage of all humanity, not a privileged elite.
- Science is a transformative social force that meets material needs and shapes human understanding, aspirations, and collective progress.
- Bernal argues science should be planned to solve human problems like poverty and disease, not serve capitalist profit.
- He identifies science as the third major human revolution, after society and civilization, with the potential to liberate humanity from natural and social constraints.
- The gap between science and culture must be closed by expanding scientific methods to deal with novelty, complexity, and social life.
- Marxism, for Bernal, provides a framework to understand science as historically situated and socially determined, and as a guide to mobilise it for human emancipation.
- Bernal sees Marxism as a framework to understand science as a historical, social tool for human emancipation.

Objective Questions

1. Who proposed that science is the third great revolution in human history?
2. Which ideology did Bernal align science with in terms of collaboration and purpose?
3. What was the first major human transformation according to Bernal?
4. What was the second major revolution described by Bernal?

5. Which economic system did Bernal claim is incompatible with the full development of science?

6. What does Bernal believe science can help eliminate, besides war and hunger?

7. What must science become to truly fulfil its social function?

8. What does Bernal identify as science's greatest strength — its ability to inspire?

9. Which concept does Bernal argue science must integrate with to handle novelty?

10. What does Bernal believe science should become for all of humanity?

11. Which historical period does Bernal associate with the beginning of modern scientific transformation?

12. What kind of problems does Bernal argue science must address beyond technical ones?

13. Which term describes the method of science that Bernal criticises for being too limited in handling human complexity?

14. What type of work does Bernal believe could be reduced with proper scientific application?

15. Which element of science does Bernal see as essential for future human development?

Answers

1. Bernal
2. Marxism
3. Society
4. Civilisation
5. Capitalism
6. Disease

7. Conscious
8. Hope
9. Culture
10. Heritage
11. Renaissance
12. Social
13. Isolation
14. Labour
15. Planning

Assignments

1. Describe the three major transformations in human history as outlined by J.D. Bernal.
2. Explain Bernal's view on the relationship between science and capitalism.
3. Critically examine Bernal's argument that science must become a conscious social force in order to serve humanity effectively.
4. Analyse Bernal's claim that Marxism provides a more effective framework than traditional science for addressing complex social change. Do you agree with this position? Why or why not?

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UNIT 3 Social Shaping of Technology

Learning Outcomes

After the completion of this unit, the learner will be able to:

- analyse the social, political, and cultural factors that influence the development and adoption of technology.
- evaluate key theoretical perspectives, Actor-Network Theory (ANT), and feminist critiques, in relation to technological development
- apply the Social Shaping of Technology framework to contemporary technological issues and debates

Prerequisites

In an age where artificial intelligence writes code, smartphones serve as personal assistants, and genetic editing promises to cure inherited diseases, it is easy to assume that technology evolves according to its own internal logic—driven purely by innovation, efficiency, and scientific advancement. However, the perspective of the Social Shaping of Technology (SST) challenges this deterministic view. It argues that technology does not simply emerge from laboratories and enter society as a neutral force. Rather, it is shaped by human choices, social structures, cultural values, political interests, and historical contexts.

The SST framework insists that technological development is a contested process, negotiated among actors with different levels of power and different visions of the future. Decisions about what technologies are developed, how they are implemented, and who benefits from them are deeply embedded in social relations. Technologies both reflect and reproduce existing inequalities of class, gender, race, and global power.

This perspective is crucial in understanding contemporary events. For example, debates over AI regulation reveal how ethical, political, and economic priorities shape the trajectory of machine learning tools. The global rollout of 5G networks is influenced not only by engineering prowess but also by geopolitical rivalries and corporate lobbying. During the COVID-19 pandemic, the uneven access to digital education and healthcare technologies exposed deep structural divides, showing that technology can amplify inequality as much as it can solve problems. Climate technologies, like carbon capture or green energy systems, are likewise embedded in political debates over who pays, who profits, and who controls the transition to sustainability.

By moving beyond simplistic narratives of progress, this chapter will explore how technologies are co-produced by society and in turn reshape it. Drawing from sociology, feminist theory, and Science and Technology Studies (STS), we will examine key case studies and theoretical tools that allow us to see technology not just as an object, but as a social process—a product of negotiation, struggle, and imagination.

Keywords

Technological determinism, Actor-Network Theory (ANT), Power, Gender, Technology, Co-production

Discussion

The Social Shaping of Technology (SST) is a critical theoretical framework that challenges the notion that technological development is an autonomous, linear process driven solely by internal scientific or technical logic. Instead, SST posits that technologies are shaped by a complex interplay of social, political, economic, cultural, and institutional factors. Popularised through the influential work edited by Donald MacKenzie and Judy Wajcman (1999), SST has provided a compelling alternative to technological determinism by arguing that the design, development, and use of technologies are inherently social processes.

2.3.1 From Technological Determinism to Social Shaping

Traditional views of technology, often referred to as technological determinism, assume that technology evolves according to its own logic and in turn drives societal change. SST critiques this linear model by illustrating that society plays a pivotal role in shaping technology itself. In SST, the relationship between technology and society is bidirectional: not only does technology influence society, but societal values, power structures, and institutional contexts influence technological pathways.

2.3.1.1 Key Principles of SST

Technological Choice and Contingency: Technologies are not inevitable; multiple design paths exist. The choice among alternatives is influenced by social factors such as economic interests, gender norms, labour relations, and cultural values.

- **Interpretative Flexibility:** Technologies are interpreted differently by various social groups. What constitutes "success" or "failure" in a technology can vary significantly depending on who is assessing it.
- **Socio-Technical Systems:** Technologies are embedded in broader systems that include people, institutions, laws, and infrastructures. The success of a technology depends as much on these systems as on technical innovation.
- **Power and Politics in Design:** Technologies embody social relations. Their design and implementation often reflect the priorities of dominant social groups, embedding political assumptions and reinforcing existing power structures.

2.3.2 Integration with Broader Theoretical Frameworks

SST aligns with Marxist critiques that view technology as shaped by capitalist imperatives to control labour, increase surplus value, and maintain class domination. Marxist theorists argue that technological innovation is driven by the pursuit of profit and capital accumulation, often at the cost of workers' autonomy and social welfare. SST builds on this insight by exploring how capitalist interests shape not only what technologies are developed but also how they are implemented and for whom. For example, automation technologies introduced in manufacturing are often designed not just for efficiency but for reducing labour costs and weakening workers' bargaining power. SST reveals how such decisions are embedded in class relations and capitalist dynamics, making technological development a terrain of struggle between capital and labour.

Feminist scholars have enriched SST by highlighting how gender shapes and is shaped by technological design and use. Feminist critiques point out that many technologies—from domestic appliances to medical devices—have been designed with implicit gender assumptions. SST aligns with these critiques by analysing how women's needs, perspectives, and labour have often been marginalised in technological decision-making processes. Feminist STS scholars like Donna Haraway and Judy Wajcman argue that technology is not gender-neutral. For instance, reproductive technologies have profoundly affected women's autonomy but are also sites of medical control and surveillance. Similarly, the gendering of computing and engineering fields reflects deep-seated societal biases that SST helps to unpack.

SST also supports the feminist call for participatory design, ensuring that women and other marginalised groups have a voice in shaping technologies that impact their lives. The emphasis on "situated knowledge"—knowledge produced from specific social standpoints—is a cornerstone of both feminist theory and SST. Feminist theory has been instrumental in deepening and expanding the framework of the Social Shaping of Technology (SST). While SST challenges technological determinism by arguing that social factors influence how technologies are designed, developed, and used, feminist theory brings a critical lens to the ways in which gender—along with race, class, and sexuality—shapes technological systems.

Feminist scholars highlight how power, exclusion, and embodiment are embedded within technological development and everyday usage.

2.3.2.1 Key Feminist Contributions to SST

- **Technology is not gender-neutral:** Feminist scholars like Judy Wajcman, Donna Haraway, and Cynthia Cockburn argue that technologies often reflect masculine values, assumptions, and priorities. SST frameworks are enriched by this perspective, as they begin to question whose social values shape technological design.

- **Gendered design and labour:** Technologies, particularly in the workplace or the home, have historically been shaped around male experiences and professional norms. Feminist SST studies show how women's labour—paid and unpaid—has been marginalised or invisibilised in the design and use of technologies (e.g., in domestic appliances, clerical automation, or reproductive healthcare).

- **Situated knowledge:** A central feminist epistemology, this concept (developed by Haraway) argues that all knowledge, including scientific and technical knowledge, is shaped by specific social positions. SST benefits from this insight by rejecting claims of technological objectivity and recognising the standpoints from which technologies are produced and interpreted.

Reproductive Technologies, tools like IVF, hormonal contraception, and genetic screening raise critical feminist questions about control over women's bodies, medical authority, and autonomy. SST enriched by feminism investigates how these technologies reflect societal attitudes toward motherhood, family, and gender roles. Workplace automation: Feminist SST examines how computerisation and digitalisation in clerical work disproportionately affected women, reinforcing gender hierarchies under the guise of efficiency. For example, office technologies in the 1980s reduced the skill content of secretarial work and increased surveillance.

Digital Platforms and AI, feminist critiques of algorithmic design and digital infrastructure point out how online platforms often reproduce offline gender and racial biases. SST scholars working with feminist theory analyse how design teams (often male-dominated) encode discriminatory assumptions into supposedly "neutral" technologies.

2.3.2.2 Feminist Methodologies in SST

Participatory design, feminist scholars advocate for inclusive, participatory approaches where users—especially marginalised groups—are involved in the design and evaluation of technologies that affect them. This shifts the SST framework from analysis to intervention.

Ethics of care, feminist ethics influence SST by emphasising relationality, responsibility, and interdependence in technology development. This approach critiques the dominance of rational, efficiency-driven models that ignore emotional and social impacts.

2.3.2.3 Contemporary Applications

- **Smart Home Devices:** Feminist SST critiques how voice assistants like Alexa or Siri are often assigned female voices, reinforcing stereotypes about women as subservient or supportive.

- **Healthcare Algorithms:** Diagnostic tools and treatment plans can be biased due to male-centred datasets, neglecting women's specific health needs—highlighting the need for intersectional feminist approaches in tech development.

- **STEM and Tech Workplaces:** Feminist SST analyses how workplace cultures and educational pipelines systematically exclude women and minorities from participating in tech creation.

Feminist theory enriches the Social Shaping of Technology by making visible the gendered assumptions, exclusions, and power relations embedded in technological systems. It challenges both the myth of neutrality in tech and the universality of the "user." Feminist SST does not just deconstruct but also offers visionary frameworks for reimagining more just, inclusive, and equitable technological futures. It aligns with the broader SST aim of democratising technology, while adding the crucial dimension of embodied, intersectional social justice.

2.3.4 Actor-Network Theory (ANT): Expanding the Social Shaping Perspective

Actor-Network Theory (ANT), primarily developed by Bruno Latour, Michel Callon, and John Law, is a conceptual approach within Science and Technology Studies (STS) that redefines how we understand the construction and dynamics of technological systems. ANT challenges the traditional human-centred view of social theory by arguing that both human and non-human actors (machines, algorithms, institutions, texts) are integral participants in shaping outcomes in technological and scientific networks.

Actors and Actants: ANT treats both people and objects as "actors" or "actants", capable of exerting agency within a network. For example, a smartphone, a user, the app store, and developers are all actors shaping how mobile technology is used and evolves.

Networks: Technology emerges from heterogeneous networks—dynamic associations between people, machines, regulations, and knowledge systems. Stability in technology results not from inherent superiority, but from the strength and alignment of the network.

Translation: The process by which actors align the interests of others in the network. This involves negotiation, persuasion, and compromise—where a successful technology reflects successful translation.

Black-boxing: When a technology becomes widely accepted and its complexities are no longer questioned (e.g., the internet, electricity), it is said to be "black-boxed." ANT seeks to open these black boxes and examine how they were constructed.

2.3.5 ANT vs. SST

While SST emphasises social and institutional factors that shape technology, ANT goes further by dissolving the boundary between the social and the technical. ANT doesn't presume society shapes technology or vice versa—it assumes they co-produce each other through continuous interaction within networks.

Table 2.3.1 Difference between SST and ANT

Feature	SST	ANT
Focus	Social shaping of tech	Networked shaping by humans + non-humans
View of Technology	Socially constructed	Relational product of networks
Agency	Primarily human	Distributed among all actors
Method	Sociological analysis of context	Symmetrical tracing of associations

2.3.5.1 ANT in Contemporary Contexts

1. **Social Media Algorithms:** ANT helps unpack how platforms like Instagram or TikTok aren't just shaped by user preferences or corporate goals—but also by the algorithms themselves, which behave like non-human actors influencing content exposure and engagement.

2. **Smart Cities:** Technologies like traffic sensors, surveillance cameras, and urban planning algorithms co-construct the logic of smart governance. ANT reveals how citizens, data infrastructures, and political agendas entangle in shaping urban life.

3. **Pandemic Technology:** During COVID-19, tracing apps, vaccines, public health policies, and viruses themselves were all actors in a constantly evolving global network. ANT enables an understanding of how these entities reshaped social behaviours, governance, and even scientific norms.

ANT has been critiqued for its apolitical stance, often being accused of treating all actors equally without adequately addressing power, inequality, or justice. This is where SST, Marxism, and Feminism offer corrective lenses—introducing critical attention to how structures of power and marginalisation shape who or what gets to be a powerful actor in networks.

2.3.5.2 Integrating ANT with Other Theories

ANT can be enriched by Marxist insights into class, labour, and capitalist relations. While ANT focuses on network-building, Marxism highlights who owns and controls these networks—and why. Feminist STS critiques ANT's initial neglect of embodied experience, care work, and gendered hierarchies. Feminists have adapted ANT to include situated knowledges and challenge technological neutrality, especially in health tech, domestic tech, and reproductive systems.

Social Shaping of Technology is foundational to Science and Technology Studies. It shares STS's focus on co-construction of society and technology and extends it with an emphasis on materiality, politics, and institutional contexts. Actor-Network Theory (ANT) within STS complements SST by emphasising the role of both human and non-human actors in shaping technological outcomes.

2.3.6 Case Studies in SST

MacKenzie and Wajcman's anthology includes case studies that illustrate how seemingly neutral technologies are shaped by social dynamics:

Office Automation and Gender: Office technologies like word processors and data entry systems were developed and marketed in ways that reinforced traditional gender roles, shaping women's employment in clerical work.

Military Technology: Weapons systems and military hardware development are driven not only by technical feasibility but by political interests, strategic doctrines, and defence industry lobbying.

Reproductive Technologies: Devices such as the contraceptive pill or the IUD have been shaped by broader discourses on women's health, family planning, and state policy.

2.3.7 Contemporary Debates and Applications

Artificial Intelligence and Algorithmic Bias: Contemporary concerns about AI reflect SST's insights—AI systems often replicate societal biases, such as racism or sexism, due to biased data or skewed design processes.

Surveillance Technologies: The social shaping of surveillance tech in policing, workplace monitoring, and consumer tracking reflects political priorities and economic motivations more than neutral technological advancement.

Climate Technologies: Debates around geoengineering and green energy highlight SST's emphasis on political choices in technological design. Questions arise around who benefits from certain technologies and whose interests are sidelined.

The Social Shaping of Technology framework invites a more nuanced and democratic understanding of technological development. By rejecting deterministic narratives and emphasising the mutual shaping of society and technology, SST opens space for critical inquiry and participatory decision-making in science and innovation. As we navigate increasingly complex socio-technical futures, SST offers valuable tools for ensuring that technology serves broader human and social needs rather than narrow interests. Its integration with Marxist and feminist theories further expands its critical scope, enabling scholars and practitioners to examine how class, gender, and power relations are encoded in technological systems.

Recap

- SST challenges technological determinism by emphasising that technology is not autonomous but shaped by society.
- The relationship between society and technology is bidirectional—each influences and co-constructs the other.
- Technologies emerge from social, political, economic, and cultural contexts, not just scientific logic.

- SST stresses that technological choices are contingent—multiple possible paths exist for any invention.
- Interpretative flexibility means different social groups can ascribe different meanings and uses to the same technology.
- Technologies are embedded in socio-technical systems, which include people, institutions, and infrastructures.
- SST highlights that technological design embodies values and politics, reflecting the interests of dominant groups.
- Feminist contributions to SST show how gender roles and inequalities shape and are shaped by technology.
- Technologies in the home and workplace often reinforce traditional gender norms, especially in reproductive and clerical tech.
- Feminist scholars advocate for participatory design to include marginalised voices in shaping technology.
- SST aligns with Marxist theory by exposing how capitalist interests drive technological development and labour control.
- Automation often reflects capitalist goals of efficiency and profit, not just neutral progress.
- SST is foundational to Science and Technology Studies (STS) and is closely linked with theories like Actor-Network Theory.
- Technologies like AI and surveillance systems replicate social biases, illustrating SST in contemporary debates.
- Military and defence technologies are shaped by political agendas and not merely technical necessity.
- Reproductive technologies are sites of power, control, and social values about gender, family, and autonomy.
- SST argues for the co-production of science, technology, and society—none are neutral or independent.
- Contemporary climate technologies highlight political contestation and inequities in technological choices.
- SST critiques the exclusion of user perspectives, especially from women and the global South, in tech development.

- The goal of SST is to democratise technology—to ensure that tech serves social good, not just elite or commercial interests.

Objective Questions

1. What theory does SST oppose?
2. Which social theory does SST align with regarding class and labour?
3. Who co-edited *The Social Shaping of Technology* (1999)?
4. Which feminist scholar is known for *TechnoFeminism*?
5. What kind of system includes both people and technology?
6. What concept refers to different meanings given to the same technology?
7. Which feminist theorist wrote *Simians, Cyborgs, and Women*?
8. What analytical method treats both humans and non-humans as actors?
9. What kind of bias is often embedded in AI systems?
10. What social factor often shapes reproductive technologies?
11. Which economic system does SST critique for influencing technological development?
12. What kind of design involves all stakeholders, especially marginalised groups?
13. Which school of thought argues for situated knowledge and social location?
14. What term describes the mutual construction of society and technology?
15. What is the dominant cultural concept SST critiques in relation to science and tech?

Answers

1. Determinism
2. Marxism
3. Wajcman
4. Wajcman
5. Socio-technical
6. Flexibility
7. Haraway
8. ANT (Actor-Network Theory)
9. Racism
10. Gender
11. Capitalism
12. Participatory
13. Feminism
14. Co-production
15. Neutrality

Assignments

1. Critically analyse how feminist theory contributes to the understanding of technological development through the lens of the Social Shaping of Technology framework.

2. Evaluate the role of capitalist interests in shaping technological trajectories, using examples from AI, automation, or surveillance systems.

3. Describe the key principles of the Social Shaping of Technology framework with appropriate illustrations.

4. Explain the shift from technological determinism to the Social Shaping of Technology perspective in science and technology studies.

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BLOCK 3

Science in India

UNIT 1

Science, Technology and Social Dimensions

Learning Outcomes

After the completion of this unit, the learner will be able to:

- explore the major scientific contribution of ancient Indian civilization
- identify key milestones such as the Green Revolution, Space mission and nuclear development
- assess the underrepresentation of women in STEM fields
- discuss how caste inequalities impact participation in India's community

Prerequisites

Do you know about one civilisation that pioneered the concept of zero, performed complex surgeries thousands of years ago, and built observatories to track celestial movements with remarkable precision? This is the story of India's scientific journey—a legacy that stretches from ancient brilliance to cutting-edge modern innovation. We explore the milestones of Indian science, beginning with early achievements in mathematics, astronomy, medicine, and metallurgy. It examines how colonial rule disrupted traditional knowledge systems but also gave rise to a generation of Indian scientists who left a global impact. Post-independence, India emerged as a scientific powerhouse through institutions like ISRO, IITs, and DRDO, leading to major achievements such as the Green Revolution, space missions like Mangalyaan and Chandrayaan, and nuclear development. Yet, despite these advances, the scientific community still reflects deep inequalities. The underrepresentation of women and marginalised caste groups highlights the challenges that remain. We invite a reflection on both the triumphs and exclusions in India's scientific landscape and how a more inclusive future can be shaped through equity, representation, and innovation.

Keywords

Aryabhata, Sushruta Samhita, Jantar Mantar, Green revolution, Mangalyaan, SWATI portal

Discussion

India's scientific journey offers a rich tapestry of achievements, challenges, and transformations from the ancient to the modern era. The early innovations in mathematics, astronomy, and medicine laid a strong foundation for global scientific thought, with concepts like zero, advanced surgical techniques, and precise astronomical calculations originating from Indian scholars. However, colonial rule disrupted these indigenous knowledge systems, replacing them with Western scientific models while simultaneously sidelining traditional practices. Despite this, Indian scientists during the colonial and post-independence periods contributed significantly to global fields such as physics, chemistry, and space science. Institutions like ISRO, DRDO, and the IITs played critical roles in shaping India's modern scientific identity, leading to milestones such as the Green Revolution, nuclear advancements, and successful space missions like Mangalyaan. Yet, this progress has been uneven, with persistent gender and caste-based exclusions highlighting the need for more inclusive policies. The underrepresentation of women and marginalised communities in science reflects deep-rooted societal structures that still limit access and opportunity. Addressing these gaps is crucial not only for equity but also for ensuring that India's scientific growth draws from its population's full diversity and potential.

3.1.1 Scientific Foundations: India's Legacy before Independence

India's early civilizations, notably the Indus Valley Civilization (3300–1300 BCE), made remarkable advancements in urban planning, metallurgy, and trade. Cities like Mohenjo-Daro and Harappa featured grid layouts, drainage systems, and public baths. The civilization excelled in metallurgy, producing high-quality copper and bronze tools, and established standardized weights and measures to support trade. Lothal, a key port city, boasted the world's oldest known artificial dock.

During the classical period, India made significant contributions in mathematics, astronomy, and medicine. Aryabhata calculated the value of π and proposed the Earth's rotation on its axis, while India developed the concept of zero and the decimal system. Additionally, India's expertise in metallurgy produced high-quality Wootz steel, and the Iron Pillar of Delhi from the Gupta period is known for its corrosion resistance, demonstrating advanced metalworking skills.

Ancient Indian scholars made notable contributions to mathematics and astronomy. Baudhayana, around the 8th century BCE, presented an early version of the Pythagorean Theorem in the Baudhayana Sulba Sutra. By the time of the Yajurveda (1200–900 BCE), the concept of large numbers, including up to a trillion, was well-established. India also developed the Hindu-Arabic numeral system, including zero, which was later conveyed to the Arab world and Europe. In astronomy, the Vedanga Jyotiṣa, attributed to Lagadha and dating from the 5th century BCE, outlined celestial phenomena such as lunar and solar months, eclipses, and constellations, reflecting a sophisticated understanding of the cosmos. The Sushruta Samhita, an Ayurvedic text from the 6th century BCE, detailed surgical techniques like cataract surgery and the use of surgical instruments, and identified types of diabetes linked to youth and obesity, alongside advanced procedures like otoplasty and rhinoplasty.

In the medieval period, India excelled in architecture, military technology, and scientific research. The Mysorean rockets, developed in the late 18th century under the rule of King Hyder Ali and his son Tipu Sultan, were iron-cased rockets used effectively in warfare against the British East India Company. These rockets influenced European rocketry, leading to the development of the Congreve rocket in 1805. Architecturally, India saw the construction of grand temples and stepwells, showcasing advanced engineering and artistic skills. The Jantar Mantar observatories, built by Maharaja Jai Singh II, featured instruments for precise astronomical measurements. These advancements reflect India's rich heritage in science and technology, demonstrating a legacy of innovation that has influenced global advancements. In the medieval period, India's rich legacy in science and technology predates colonial rule, with advancements spanning metallurgy, mathematics, astronomy, engineering, and medicine. These contributions, often overshadowed by colonial narratives, laid foundational principles that influenced global scientific thought.

India's pre-independence period saw remarkable contributions across a variety of fields. Ancient mathematicians such as Aryabhata, Brahmagupta, and Bhāskara II made groundbreaking advances in the decimal system, zero, algebra, and trigonometry. In medicine, the Sushruta Samhita detailed surgical techniques like cataract surgery and rhinoplasty, while Charaka's work expanded knowledge on diseases. India's metallurgical achievements, like the corrosion-resistant Iron Pillar of Delhi and Wootz steel, exemplified advanced metallurgy.

India's expertise also extended to architecture and engineering, with cities like Mohenjo-Daro showcasing advanced urban planning and drainage systems. The country's global trade networks facilitated knowledge exchange, with exports like Wootz steel and diamonds influencing other regions. Despite colonial challenges, ancient India's scientific and technological legacy continues to shape modern practices, with its innovations in mathematics, medicine, and engineering still recognised worldwide.

In the modern period, the Kingdom of Mysore developed iron-cased rockets under the leadership of Hyder Ali and Tipu Sultan in the realm of military technology. These rockets were used effectively in warfare against colonial forces, marking a significant advancement in military technology. In medicine, ancient texts like the Sushruta Samhita and Charaka Samhita laid the foundation for surgical practices and pharmacology. The practice of Ayurveda emphasised holistic health and the use of natural remedies. Despite colonial efforts to marginalise these systems, they persisted and continue to influence health practices today. Architectural and engineering feats included the construction of stepwells and dams, reflecting advanced hydraulic engineering.

The Jantar Mantar observatories, built by Maharaja Jai Singh II in the 18th century, are examples of sophisticated astronomical instruments designed to measure time and celestial events. The colonial period, while introducing Western scientific education, also led to the undervaluation of indigenous knowledge systems. However, figures like Sir Syed Ahmad Khan promoted translating scientific works into vernacular languages, bridging the gap between Western and Indian scientific thought. Post-independence, India has continued to build upon this rich legacy, contributing significantly to global scientific progress.

In the colonial period, the Indian Post Office was established under the Post Office Act XVII of 1837, granting the Governor-General of India the exclusive right to convey messages within East India Company's territories. This development marked a significant step in communication infrastructure during the colonial period. Additionally, the British constructed an extensive railway network in India, facilitating both strategic and commercial purposes. The British education system introduced during this era exposed many Indians to Western institutions, leading to the emergence of notable scholars such as Jagadish Chandra Bose, Prafulla Chandra Ray, Satyendra Nath Bose, Meghnad Saha, Prasanta Chandra Mahalanobis, C. V. Raman, Subrahmanyan Chandrasekhar, Homi J. Bhabha, Srinivasa Ramanujan, Vikram Sarabhai, Har Gobind Khorana, Harish-Chandra, Abdus Salam, and E. C. George Sudarshan. These individuals significantly contributed to various fields, including physics, mathematics, and biology.

During the colonial era, there was extensive interaction between colonial and native sciences. Western science became associated with nation-building efforts, particularly as it addressed necessities in agriculture and commerce. Indian scientists also made notable appearances throughout Europe, contributing to the global scientific community. By the time of India's independence, colonial science had assumed importance within the Westernised intelligentsia and establishment.

A notable event in the history of science occurred on August 18, 1868, when French astronomer Pierre Janssen observed a solar eclipse in Guntur, Madras State (now in Andhra Pradesh), in British India. During this observation, Pierre Janssen discovered the element helium in the solar spectrum, marking the first identification of an extraterrestrial element. This discovery expanded our understanding of the universe beyond Earth. India is globally recognised for its scientific rigor and potential. The country has a rich history in scientific endeavours, from ancient traditions like Ayurveda to modern achievements in various scientific fields. The post-independence period witnessed significant advancements, with India making notable progress in areas such as nuclear technology, space exploration, and information technology. These achievements reflect India's commitment to scientific development and its growing influence in the global scientific community.

Fig 3.1.1 Jantar Mantar Observatory, Jaipur

3.1.2 From Green Revolution to Space Missions: India's Technological Milestones

In 1947, India faced significant challenges in agriculture, lacking research on crop yield potential, irrigation systems, fertilizers, pesticides, and agricultural equipment. The government prioritised scientific research to advance agriculture, leading to the Green Revolution in the 1960s. This initiative, led by agricultural scientist M. S. Swaminathan, introduced high-yielding varieties of seeds, improved irrigation, and increased fertilizer use, transforming India from a food importer to a self-reliant nation in food grain production.

The Planning Commission, established in 1950, set investment levels and prescribed priorities, dividing funds between agriculture and industry. Between 1947 and 1962, industrial production increased by 94%, and the installed power-generating capacity rose by 79 million kilowatts. The Defence Research and Development Organisation (DRDO) was formed in 1958 to enhance military technology, and the Steel Authority of India Ltd. (SAIL) was established in 1973 to manage integrated steel plants.

To promote higher education in science and technology, the Indian government established the IITs throughout the nation. The first IIT was inaugurated on 18 August 1951 at Kharagpur in West Bengal by Education Minister Maulana Abul Kalam Azad. Modelled after the Massachusetts Institute of Technology, IIT Kharagpur began with ten departments and has since grown into a leading institution in engineering and technology education.

In the 1960s, India developed close ties with the Soviet Union, enabling the Indian Space Research Organisation (ISRO) to advance its space research programme. This collaboration led to the establishment of the Thumba Equatorial Rocket Launching Station and the launch of India's first satellite, Aryabhata, in 1975. Simultaneously, India pursued nuclear technology, culminating in its first nuclear test, "Smiling Buddha," in 1974 at Pokhran.

In 1981, India initiated its Antarctic Programme with the first expedition to Antarctica. This led to the establishment of the Dakshin Gangotri station in 1983, which was later decommissioned in 1990. In 1989, the Maitri station was established and continues to serve as a hub for scientific research in Antarctica. In 1991, India and the European Union agreed to bilateral cooperation in science and technology, leading to joint research and development initiatives. India also became an associate member of the European Organization for Nuclear Research (CERN) in 2017, enhancing its participation in global scientific projects.

The Indian economy underwent significant reforms in 1991, leading to rapid growth in information technology, biotechnology, and other sectors. Cities like Bengaluru emerged as global hubs for technology and innovation. The establishment of biotech parks and the Department of Biotechnology in 1986 further bolstered research and development in medical and agricultural applications. Between 2000 and 2015, India's output of scientific papers increased fourfold, surpassing countries like Russia and France in the number of publications per year. However, challenges remain in terms of research quality and citation impact. India's research and development spending grew to US$17.2 billion in 2020–2021, reflecting a continued commitment to scientific advancement.

The Government of India has passed four policy documents on science and technology:

- Science Policy Resolution 1958
- Technology Policy Statement 1983

- Science and Technology Policy 2003
- Science, Technology, and Innovation Policy 2013

India took advantage of space exploration. India's Mars Orbiter Mission (Mangalyaan), launched by ISRO on 5 November 2013, made India the first Asian nation to reach Mars orbit and the first to succeed on its first attempt. The Chandrayaan programme, which began with Chandrayaan-1 in 2008, discovered water on the Moon, while Chandrayaan-2 in 2019 was partially successful due to a lost connection with its Vikram lander. Chandrayaan-3, a follow-up mission, is planned in collaboration with Japan's JAXA. The Gaganyaan mission, designed to send Indian astronauts into space, is currently in development, delayed by the COVID-19 pandemic. Additionally, the Thirty Meter Telescope (TMT), an international project supported by India and other nations, aims to build a huge observatory in Hawaii.

India has started many scientific institutions and has provided all the facilities in this field. The establishment of India's three major science academies—Indian Academy of Sciences (IAS), National Academy of Sciences, India (NASI), and Indian National Science Academy (INSA)—between 1930 and 1935 marked a significant development in the country's scientific landscape during the pre-independence era. The IAS was founded in 1934 by Nobel laureate C.V. Raman in Bengaluru, aiming to promote progress in pure and applied sciences and represent Indian scientific work internationally. NASI, established in 1930 by Meghnad Saha in Allahabad, is the oldest science academy in India, focusing on advancing and applying science for societal welfare.

INSA (Indian National Science Academy), founded in 1935 in New Delhi, evolved from the National Institute of Sciences of India, intending to promote science in India, represent Indian science internationally, and advise the government on scientific matters. These academies played pivotal roles in shaping India's scientific community, providing platforms for research, collaboration, and policy influence, and reflecting a collective vision to advance science and contribute to the nation's development.

Fig 3.1.2 Chandrayaan-3

3.1.3 Gender Equation in Indian Science

Women in Indian science, technology, engineering, and mathematics (STEM) sectors remain significantly underrepresented. Despite comprising about 40% of science PhD graduates, women account for only 16.6% of researchers in scientific establishments, a figure notably lower than the global average of 28.4%. This disparity is even more pronounced in academia, where women make up just 13.5% of faculty across 98 universities and institutes, with engineering faculties exhibiting the sharpest gender gap at 9.2%.

Institutions like the IITs, the Indian Institute of Science (IISc), and the Indian Space Research Organisation (ISRO) exemplify this trend; for instance, no woman has ever headed ISRO since its inception in 1963. The systemic barriers contributing to this underrepresentation include societal biases, a lack of support during critical career transitions, and a toxic work environment that often leads women to exit STEM. Factors contributing to the gender gap include deeply ingrained gender stereotypes that discourage girls from pursuing science and mathematics from an early age, limited access to mentorship and role models, and the disproportionate burden of domestic responsibilities placed on women. Moreover, recruitment and promotion practices in many institutions often lack gender sensitivity, and implicit bias can affect hiring, funding, and publication opportunities. The absence of supportive policies such as flexible work arrangements, maternity leave, and childcare facilities further hampers retention. Together, these factors create a leaky pipeline, where the number of women progressively diminishes at higher levels of academic and professional advancement in STEM fields.

The underrepresentation of women in Indian science is influenced by multiple interrelated factors. Cultural norms often prioritise women's roles as caregivers, leading to career interruptions, particularly during childbearing years. Gender bias in recruitment and evaluation is prevalent, with studies indicating that women face discrimination in hiring and performance assessments. A Kelly Global Workforce Insights survey found that 81% of women in STEM in India perceive gender bias in performance evaluation. Additionally, the lack of supportive infrastructure, such as inadequate workplace facilities and support systems for women, discourages long-term career commitment. Toxic work environments, including instances of sexual harassment and a lack of accountability, lead many women to exit academia prematurely. These systemic barriers collectively hinder women's progression into research and leadership roles in Indian science.

To address the underrepresentation of women in science, the Government of India has implemented several initiatives. The Women Scientists Scheme-A (WOS-A) facilitates the re-entry of women scientists into research after career breaks, offering opportunities to resume their scientific careers. The Gender Advancement for Transforming Institutions (GATI) programme promotes gender equity in STEM institutions through policy reforms and accountability measures. Additionally, programmes like Vigyan Jyoti and KIRAN encourage young girls and women to pursue careers in science and engineering. Despite these efforts, challenges persist, and many women continue to exit the field due to systemic inequities and a lack of support.

On February 11, 2024, the National Institute of Plant Genome Research (NIPGR) launched the Science for Women: A Technology & Innovation (SWATI) Portal to address the gender gap in India's science, technology, engineering, mathematics, and medicine (STEMM) sectors. Developed under the leadership of Dr. Subhra Chakraborty, the portal serves as an interactive database that profiles Indian women across various stages of their careers, from students to senior scientists. It includes individuals in academia, industry, entrepreneurship, and alternative careers such as science journalism. The portal is publicly accessible, allowing women to create and update their profiles, thereby enhancing visibility and recognition. By compiling data on women's participation in science, the SWATI Portal aims to inform policy-making and promote gender equity in scientific research.

Table 3.1.1 Students' Gender Representation
(Source: AISHE 2021–22: All India Survey on Higher Education)

Students' Gender Representation in Higher Indian Institutions			
SL No	**Category**	**Male (%)**	**Female (%)**
1	Overall Enrollment	52%	48%
2	Undergraduate (UG)	51%	49%
3	Postgraduate (PG)	44%	56%

The SWATI Portal is a significant step toward bridging the gender gap in Indian science by enhancing visibility, fostering connections, and supporting policy initiatives aimed at achieving gender equity in STEM fields. By providing a platform for women to showcase their work, connect with peers, and access resources, the portal helps dismantle the systemic barriers that have historically hindered women's full participation in science. However, sustained efforts are required to create an inclusive and supportive environment that encourages women to not only enter but also thrive in the scientific community.

Fig 3.1.3 SWATI Portal

3.1.4 Exclusion and Access: Caste in the Landscape of Indian Science

Despite legal provisions aimed at promoting equality, the caste system continues to significantly influence India's scientific institutions, leading to the underrepresentation and marginalisation of individuals from Scheduled Castes (SCs), Scheduled Tribes (STs), and Other Backward Classes (OBCs). Data from 2019 reveal that Dalits comprised only 6% to 14% of doctoral students at premier institutes like IITs , while the Indian Institute of Science (IISc) admitted 12% Dalit researchers in 2020. However, this representation sharply declines among faculty members; for instance, IIT Bombay and IIT Delhi reported no Dalit professors in 2020. This disparity is further exacerbated by systemic barriers such as caste-based discrimination, lack of institutional support, and a shortage of mentorship for marginalised caste students.

Several factors contribute to the underrepresentation of marginalised castes in science. Economic disparities often prevent students from these communities from accessing quality education and coaching required for clearing the entrance test into elite institutions. Once admitted, they face cultural and social alienation, with instances of caste-based discrimination reported within academic settings. For example, Dalit students have experienced exclusion from academic events and have been subjected to derogatory remarks questioning their merit. Moreover, the prevalent belief that merit should be the sole criterion for admissions and appointments often undermines the necessity of affirmative action. This perspective disregards the historical and structural disadvantages faced by marginalised communities and perpetuates existing inequalities.

The lack of diversity in scientific institutions has profound implications for research and innovation. Diverse perspectives are crucial in addressing a wide range of scientific questions and in ensuring that research outcomes are inclusive and applicable to all sections of society. The underrepresentation of marginalised castes limits the scope of scientific inquiry and perpetuates a narrow worldview. To foster a more inclusive scientific community, it is imperative to implement policies that go beyond mere representation. Institutions must create supportive environments that address the unique challenges faced by marginalised caste students and researchers. This includes providing mentorship, promoting cultural sensitivity, and ensuring that affirmative action policies are effectively enforced. Additionally, there is a need for ongoing dialogue and training to combat caste-based discrimination and to promote an understanding of its detrimental effects on scientific progress.

Beyond numerical representation, caste-based discrimination manifests in various facets of academic life. At IIT Chennai, a controversial decision to establish separate entrances and wash basins for vegetarian and non-vegetarian students in a mess facility sparked allegations of untouchability. Students from the Ambedkar-Periyar Study Circle condemned the move, likening it to caste-based segregation prevalent in upper-caste households. Similarly, at IISc, the dominance of Brahmin and upper-caste scientists is evident, with Dalits and OBCs constituting only 4.15% of the academic staff.

India's scientific institutions, including premier institutes like IIT, Indian Institute of Science ,Education and Research (IISER) and the Indian Institute of Science (IISc), exhibit a stark underrepresentation of marginalised caste groups, despite policies intended to promote inclusivity. Data indicate that less than 1% of professors at these institutions belong to Scheduled Castes (SCs) or Scheduled Tribes (STs), a stark contrast to the mandated 15% reservation for SCs and 7.5% for STs. Such figures highlight systemic barriers that persist despite affirmative action policies.

The dominance of upper-caste individuals in academic and research roles perpetuates a cycle of exclusion, where the experiences and perspectives of marginalised communities are underrepresented. This lack of diversity extends to research funding, where between 2016 and 2020, 80% of recipients of the Department of Science and Technology's INSPIRE Faculty Fellowships were from privileged castes, with just 6% from SCs and less than 1% from STs. The absence of caste-based data collection further obscures the extent of this inequality, making it challenging to implement effective interventions. These disparities underscore the need for more robust and transparent policies to ensure equitable representation and opportunities for all caste groups in India's scientific community.

Recap

- India pioneered concepts like the zero, decimal system, pi calculation (by Aryabhata), and medical texts like Sushruta Samhita detailing surgeries.
- The Indus Valley Civilization featured grid-based cities, drainage systems, and metallurgy, indicating early scientific thinking.
- Works like Vedanga Jyotiṣa and contributions by Baudhayana, Brahmagupta, and Bhāskara II advanced trigonometry, algebra, and astronomical models.
- India developed Wootz steel and Mysorean rockets under Tipu Sultan, which later influenced European rocketry.
- British rule suppressed indigenous systems like Ayurveda and replaced them with Western science, marginalizing traditional knowledge.
- Figures like Jagadish Chandra Bose, C.V. Raman, Srinivasa Ramanujan, and Homi Bhabha gained global recognition despite colonial constraints.
- Green Revolution (1960s) led by M. S. Swaminathan, transformed India's agricultural sector through scientific innovations, making the country self-sufficient.
- The Indian Space Research Organisation (ISRO) launched Aryabhata (1975), Chandrayaan, and Mangalyaan, marking milestones in lunar and Martian exploration.
- India conducted its first nuclear test in 1974 ("Smiling Buddha"), asserting scientific and strategic autonomy.
- IITs, ISRO, DRDO, and science academies (like IAS and INSA) shaped post-independence science and technology.
- Women are underrepresented in STEM, comprising only 16.6% of researchers, facing cultural and institutional barriers despite government schemes like WOS-A and GATI.
- SWATI Portal (2024) is a platform launched to profile and promote Indian women in STEMM fields, aiming to increase visibility and policy support.
- Marginalized communities, especially Dalits and Adivasis, are severely underrepresented in top institutions like IITs and IISc, with systemic barriers and discrimination still prevalent.
- Addressing gender and caste disparities is crucial for equitable scientific progress, innovation, and representation in India's scientific landscape.

Objective Questions

1. Who built the Jantar Mantar observatories?
2. Which Indian scientist calculated the value of pi?
3. What is the name of India's first satellite?
4. Who led India's Green Revolution?
5. What ancient text details cataract surgery?
6. What is the name of India's first Mars mission?
7. Which academy was founded by C.V. Raman?
8. What was India's first nuclear test called?
9. Which organization launched Chandrayaan?
10. What portal tracks women in Indian science?

Answers

1. Jai Singh II
2. Aryabhata
3. Aryabhata
4. M. S. Swaminathan
5. Sushruta Samhita
6. Mangalyaan
7. IAS
8. Smiling Buddha
9. ISRO
10. SWATI

Assignments

1. Discuss the contributions of ancient Indian civilizations to the fields of mathematics, astronomy, and medicine. Provide specific examples.
2. Explain the impact of colonial rule on indigenous scientific knowledge systems in India. How did colonial education influence modern science in India?
3. Evaluate the role of Indian scientists in shaping India's modern scientific identity during the colonial and post-independence periods. Mention at least five key figures.
4. Describe the objectives and achievements of India's space missions, including Chandrayaan, Mangalyaan, and Gaganyaan.
5. Analyze the underrepresentation of women in Indian science and discuss the major initiatives introduced to address this issue.
6. What role did institutions like IITs, ISRO, and DRDO play in India's post-independence scientific development? Illustrate with examples.
7. How does caste-based exclusion affect participation and representation in Indian scientific institutions? Suggest measures for improving inclusivity.

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4

BLOCK

Science and Technology as a Concern of Sociology

1

UNIT

Technological Governance : Technocracy, Space and Control

Learning Outcomes

After the completion of this unit, the learner will be able to:

- describe the impact of technology on life, work and communication in modern society
- explain the concept of Panopticon and its relationship to modern forms of digital surveillance
- identify examples of surveillance in everyday life
- discuss the pros and cons of surveillance, regarding safety, privacy, and freedom

Prerequisites

Late one night, Aarav sat in his room, playing a game on his tablet when a strange message popped up on his screen: “You are being watched.” He froze. Was it part of the game or something else? He looked around. His smartwatch blinked, the camera on his laptop glowed faintly, and even the streetlights outside flickered in a pattern he hadn’t noticed before. It was like the whole world had eyes, silently watching every move through cameras, apps, and digital systems designed to track and collect data. Aarav had stumbled into the hidden world of technospace, a giant digital maze where every tap, swipe, and step could be traced. Behind the glowing screens were powerful and influential technocrats, who didn’t wear crowns or carry swords but ruled quietly with data and codes. And watching from the shadows were invisible watchers surveillance systems tracking every move, like digital detectives. This chapter will help you understand a hidden world of technology, where widgets monitor, and experts make quiet decisions.

Keywords

Technospace, Technocracy, Surveillance, Social sorting, Big data, Data privacy

Discussion

Today, our lives happen in two worlds simultaneously the real, physical world and the digital world where we enter through screens. This blending is called technospace, where daily activities like learning, working, shopping, and socialising often happen online. But technology is not just a tool we use it also shapes how we think, behave, and relate to others. Through a sociological lens, we can understand that science and technology are shaped by people, culture, values, and power, and they can also affect society significantly. While digital life brings speed and convenience, it also raises concerns like screen addiction, loss of privacy, inequality, and control over information. New technologies like virtual reality and the metaverse are blurring the line between what is real and what is virtual.

4.1.1 Technospace

Technospace is a special space where technology, science, and business come together and help people work, share ideas, and create new things. Imagine a place where inventions, learning, and teamwork connect. This is known as technospace. It's not a physical space like a room, but more like a system where things like the creation of new tools, discovering science, and running companies are linked. In this space, knowledge and creativity are super important, and they help society grow, especially in today's world where ideas and information matter more than just physical stuff.

Technospace started growing in the mid-1900s when science and technology began to change fast. New inventions like smart screens, better communication tools, and software helped turn everyday places like classrooms and offices into high-tech zones where people could work and learn better together. Also, governments and experts made innovative plans and rules to support this space by helping researchers, inventors, and industries work closely. So, technospace is like a powerful web of people, ideas, and tools working together to build a smarter, more intelligent, and more connected world.

The idea of technospace has changed significantly over time as technology improved and people's needs evolved. Before 2000, meeting spaces mainly relied on simple tools like whiteboards, flipcharts, and a few bulky, expensive video displays that were difficult to use. In the early 2000s, as flat screens and projectors became more affordable and effective, it became easier for people to collaborate, even from a distance. This shift allowed schools, offices, and other everyday places to start using more advanced digital tools. Later, with the rise and advancement of video calling apps like Zoom and smart systems to control screens and devices, technospaces became more user-friendly, efficient, and accessible, enabling people to work and connect from almost anywhere.

Some thinkers started using bigger ideas like the technosphere a word that means all the machines (devices) and tools connected to human life worldwide. It helps people understand how technology shapes everything, even the environment. One such thinker is Peter Haff, a geologist and engineer, who introduced the concept of the technosphere to describe the global system of technological processes and infrastructure that humans have created. He explained that this tech-filled world can sometimes limit our choices, like how pollution or climate change affects the Earth, because we become dependent on complex systems we can't easily control. There were also fun digital projects like TechnoSphere, where people created virtual animals that lived in a computer world, helping scientists and students learn about ecosystems and how digital environments can reflect real world systems.

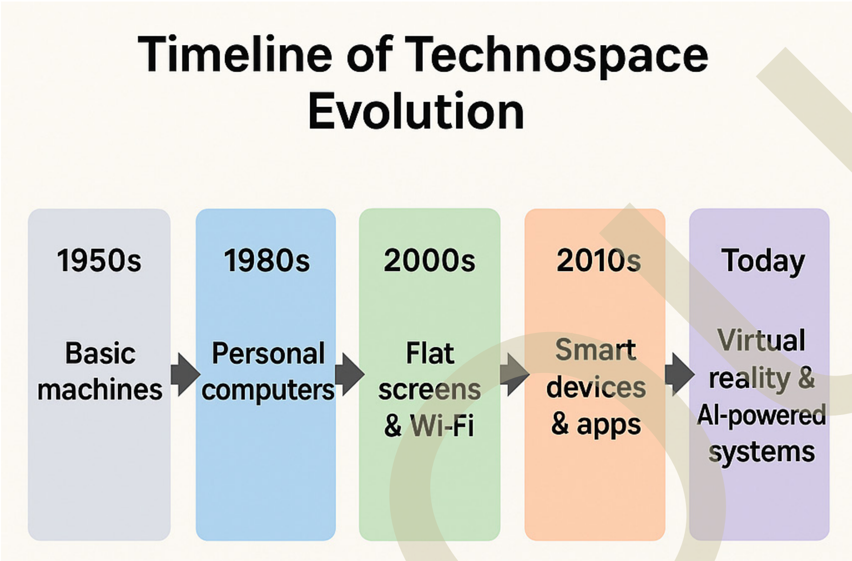

Fig.4.1.1 Timeline representing technospace evolution

Technospace is more advanced than ever, but there are problems. Sometimes, the tools don't work the same everywhere, and some people find them hard to use. Others worry that depending too much on technology might hurt the planet or make people feel less free. So even though technospace has come a long way, people are still trying to make it better and fairer for everyone. In technospaces, personal and shared technologies differ in how they are used and managed. Personal devices, like laptops or phones, usually belong to one person and can be set up just the way they like, often used for both work and fun. Shared devices, like tablets or other electronic gadgets used in hospitals or stores, are used by many people and don't belong to anyone in particular. These shared e-gadgets are made to be tough and easy for everyone to use. The users themselves manage personal devices, while shared ones need special precautionary measures to ensure they're charged, working properly, and ready for the next person. In short, personal tech is all about one person's needs, while shared tech is made for groups to use smoothly and fairly. Now let's look at how technology doesn't just help us communicate or learn but also influences who gets to lead and make decisions in society. This brings us to the idea of technocracy.

4.1.2 Technocracy

Technocracy is a way of running a country or an organisation where experts, like scientists, engineers, or economists, make decisions instead of elected politicians. These experts, called technocrats, are chosen because they know a lot about certain subjects. Instead of just doing what most people want, they use facts, data, and science to decide what's best. Technocracy became popular during hard times, like the Great Depression, when people hoped that smart experts could fix problems better than politicians. The word "technocracy" comes from two Greek words: *tekhne*, meaning skill, and *kratos*, meaning power so it basically means "rule by skill."

Technocracy has existed in different forms throughout history. The idea goes as far back as ancient times when the philosopher Plato imagined a society led by wise rulers. In the 1900s, as technology and industry grew, thinkers like Thorstein Veblen and William Henry Smyth said governments would work better if run by experts. During the Great Depression, a man named Howard Scott led a movement that wanted engineers to run the economy using energy instead of money. Although this idea didn't last long, it returned in places like Italy and Greece during economic crises, when leaders brought in experts to help fix the problems. Today, people even discuss whether artificial intelligence could help run parts of government but critics warn that this might leave regular people out of important decisions.

Did You Know?

Kerala is India's first state aiming to become fully digital! With major IT hubs like Technopark, Infopark, and Cyberpark, Kerala supports over a thousand tech companies and thousands of jobs related to AI, animation, and cybersecurity. Projects like KFON provide free internet to poor families, while Akshaya Centres teach digital skills across the state. With smart cities, digital science parks, and a strong focus on education and innovation, Kerala is leading the way in building a people-friendly digital future.

Frederick Taylor's ideas also helped shape the vision of technocracy. He introduced scientific management, a system that focused on improving efficiency through careful planning and study. Taylor believed in breaking tasks into small goals, evaluating them with data, and finding the best way to get things done. His "time and motion" studies helped cut down waste and improve speed ideas that technocrats later applied to how governments and societies could be run. His focus on logic, facts, and rejecting old ways of doing things inspired early technocrats to think society could be managed like a well-organised machine.

Taylor also believed that the most skilled people should be chosen for important jobs, not just anyone. This matched the technocratic belief that experts, not politicians, should lead. His ideas influenced significant movements like Fordism and the Efficiency Movement, which aimed to make factories and governments more efficient. While Taylor primarily focused on industry, his ideas about planning and control played a big part in shaping how technocrats imagined running whole countries.

Technocracy and democracy are quite different in how they choose leaders and make decisions. In a democracy, leaders are selected by the people in elections and are often picked for their popularity or ideas. In a technocracy, leaders are selected because they are experts. Technocrats focus on long-term solutions using research, while democratic leaders may focus more on short-term goals to keep voters happy. Also, democratic leaders are held responsible through elections, but technocrats aren't, so they may not always represent what the people want.

One good thing about technocracy is that it can solve big problems quickly. In emergencies like health crises or economic problems experts can act fast and wisely using science and data. They try to use resources well and plan for the future, not just make popular choices. However, some people fear that this system can be unfair because it leaves out regular people who don't get to vote or have a say. Technocrats try to be fair by following ethical rules and sometimes talking to experts in ethics to make thoughtful decisions, but without public involvement, people may feel left out or ignored.

There have been times when technocracy didn't work well. In the 1930s, the U.S. technocracy movement failed because its ideas were too confusing and didn't make sense to most people. In countries like Pakistan, governments led by experts or technocrats sometimes fail to address fundamental issues such as tax reforms or agricultural development, especially in rural areas. In the Soviet Union and China, leaders like Stalin and Mao made huge plans without listening to local communities, which caused major issues like famines. Even the carefully planned city of Brasília in Brazil ended up with problems some parts were too crowded, while others stayed empty proving that expert ideas don't always match real-life needs.

India has used technocracy in many ways to improve government services. For example, the Aadhaar digital ID system helps people access services more easily. Apps like CoWIN for vaccines and UPI for digital payments show how technology can simplify daily life. India's NITI Aayog works with data and tech experts to plan for the country's future. Inspired by places like Singapore and China, India also builds smart cities and better infrastructure. Even in the early 1900s, engineer Mokshagundam Visvesvaraya helped modernise India through city planning and dam building. Still, some worry that these tech-based ideas can leave out poor or rural people who don't have phones or internet. So, while India is using technology to improve government work, it's important to ensure everyone benefits.

Kerala provides a strong example of technocracy in India, showcasing how expert-led governance and technology can improve public services. Through initiatives like the Kerala State IT Mission (KSITM), the state has led in e-governance, becoming India's first "digital state" with widespread internet use and mobile connectivity. Projects such as e-Health Kerala, e-Krishi, and e-Office have enhanced healthcare, agriculture, and administration through digital tools. Kerala's pandemic response, praised for its effectiveness, reflected a mix of technocratic planning and grassroots participation. The state also invests in future sectors like biotechnology and life sciences, reinforcing its commitment to data, science, and expert-driven development. Kerala's example shows that when balanced with public involvement, technocracy can drive inclusive and efficient progress.

4.1.3 Surveillance

The word "surveillance" comes from French and means "watching over." It's made from two parts: sur- meaning "over" and veiller meaning "to watch." These words come from older Latin words like vigilare, which means "to stay alert" or "be watchful." The word first came into existence in English around 1799, during the French Revolution, when groups were set up to watch people who might be against the government.

Surveillance, or watching people, has existed for a long time. Ancient rulers used spies to discover what enemies or even their people were doing. The Bible tells the story of King David observing Bathsheba in private, which, while not formal surveillance, shows that watching others without their consent has long been seen as a misuse of power. Over time, humans created tools to help with surveillance, starting with spyglasses and later using cameras, satellites, GPS, and computers. Today, a lot of surveillance happens through digital systems that can track where people go and what they do online.

4.1.3.1 Surveillance Society

A surveillance society is a world where people are constantly monitored through cameras, computers, phones, and the internet. Both governments and private companies collect personal data like where people go, what they search, or what they buy to maintain security, sell products, and manage systems more efficiently. This trend became more intense after events like the 9/11 attacks, when many countries expanded surveillance in the name of safety. Tech giants such as Facebook and Google collect vast amounts of user data, often sharing it with governments, which creates a powerful network where public and private entities cooperate in tracking individuals. While this kind of surveillance can support law enforcement and national security, it also raises serious concerns about fairness, transparency, and personal freedom.

The idea of a surveillance society gained attention in the 1980s with the rise of computers, and thinkers like George Orwell had already warned of such dangers in works like 1984. Surveillance is not just about stopping criminals; it's also about controlling and managing everyday citizens. Historical examples like the ECHELON programme developed by countries in the "Five Eyes" intelligence alliance show how entire populations can be monitored, not just suspects. This mass surveillance became more widely known when whistleblowers like Edward Snowden revealed how extensive and secretive government spying had become. Popular culture through books, movies, and documentaries continues to explore the risks and moral questions surrounding such constant monitoring.

Living in a surveillance society affects how people behave. Knowing they are being watched, individuals may avoid searching certain topics or expressing their opinions online, even if they are doing nothing wrong. This "chilling effect" can make people feel unsafe sharing their thoughts, weakening free speech and democracy. Companies often collect detailed personal data like clicks, searches, and purchases without consent, using it to predict and influence future actions. The power imbalance between the watchers (governments and corporations) and the watched (ordinary people) can lead to exploitation and loss of autonomy. Everyday devices like phones, smartwatches, and apps constantly gather personal information, further eroding privacy and putting democratic freedoms at risk.

Modern surveillance relies on a wide range of technologies. CCTV cameras are everywhere in streets, stores, and schools and many now use facial recognition software. Internet surveillance tools like PRISM and ECHELON allow governments to monitor emails, chats, and search histories. Social media platforms track users' likes, posts, and behaviours, while Artificial Intelligence (AI) processes this data to spot patterns and make predictions. Phones can be tracked by signals, and fake cell towers can intercept calls and messages. Biometric systems like fingerprint, facial, or iris scanners are used to identify people in airports, offices, or public spaces. Other tools, such as GPS tracking, satellites, drones, smart home devices, and even hidden microphones, also gather data. While these technologies can help in areas like crime prevention or emergency response, they raise deep concerns about how much control individuals have over their own information, and how far surveillance should go in a free society.

4.1.3.2 Social Sorting and Predictive Analytics

Social sorting is when computers and surveillance systems, like security cameras, websites, or shopping apps, collect lots of information about people and use it to group them based on things like gender, race, or how they behave. These groups might be labelled as "safe" or "risky," and this can change how people are treated in real life. For example, some job websites might show better jobs to certain people and leave others out because the computer assumes that they won't be a good match even if that's not true or fair.

These systems often use "predictive analytics," which means they try to guess what someone will do in the future by looking at their past actions. This method can hurt people who are already mistreated, like women or people from specific communities, by making it harder for them to get good jobs, homes, or education. Even though these tools are supposed to help make fast decisions, they sometimes repeat the same unfair treatment from the past like when governments used old surveys to keep some groups in control. That's why we need to raise questions about fairness and privacy when machines start deciding who gets what in life.

4.1.3.3 From Panopticon to Modern Digital Surveillance

The Panopticon, first imagined by Jeremy Bentham as a prison where one guard could watch all inmates without them knowing when they were being observed, was meant to encourage good behaviour through constant, invisible surveillance. Michel Foucault later reinterpreted this idea as a symbol of how modern societies control people not just through physical observation, but by making them internalise rules and monitor themselves in schools, workplaces, and daily life. In today's digital world, this idea has evolved further into a "digital Panopticon," where cameras, apps, social media, and data-tracking systems carry out surveillance. These tools often collect personal data and influence behaviour without people realising it.

During events like the COVID-19 pandemic, such surveillance became normal, and now people also watch themselves sharing personal details online and adjusting their actions because they know they might be watched. Unlike Bentham's single guard or Foucault's institutional control, modern surveillance is run by algorithms and smart systems that predict and shape behaviour silently and automatically. Some thinkers argue that Foucault's Panopticon no longer fully explains this complex digital control, and newer ideas like Deleuze's "societies of control" may better capture how power now works through flexible, ever-changing digital networks that influence how we live, act, and see ourselves.

4.1.3.4 State Surveillance vs. Corporate Surveillance

State surveillance and corporate surveillance are two distinct but increasingly interconnected forms of monitoring people. State surveillance is mainly used for national security, law enforcement, and governance, often involving mass data collection that citizens cannot opt out of. It's typically justified in the name of public safety and is supposed to be accountable to citizens through laws and democratic institutions, though oversight is often weak. In contrast, corporate surveillance is driven by profit it involves collecting personal data to sell targeted ads, influence buying behaviour, and create detailed consumer profiles. While people can theoretically avoid corporate surveillance by not using certain services, it's increasingly difficult in a world where most daily activities involve digital platforms. Corporations answer to shareholders, not the public, and their surveillance methods, though less coercive than governments, can still shape behaviour through economic and cultural influence.

These two forms of surveillance often overlap, creating a robust data collection network. Governments sometimes work with large tech companies, using tools like artificial intelligence and big data to track individuals. Agencies like the NSA may access data from platforms like Google and Facebook, making it hard to tell whether it's the state or private companies doing the watching. This partnership raises significant concerns about privacy, as it blurs lines of responsibility and reduces transparency. As people become more accustomed to constant surveillance, they may stop noticing or questioning it, which can erode democratic values and individual freedom. Despite claims by governments that they are protecting citizens, and companies saying they are offering convenience, both contribute to a system where people are always being watched. This shows the urgent need for stronger regulations and ethical guidelines to safeguard rights and freedoms.

Corporate surveillance, in particular, deeply affects people's everyday behaviour. Companies track what we search, click on, and even how we feel, using that data to manipulate our choices such as showing ads that play on emotions like stress or sadness. This can make people feel tricked or controlled, and some even change how they behave online to avoid being watched. There are cases of unfair treatment, like companies charging different prices based on browsing history or income level, or using data from fitness trackers to change health insurance costs. Platforms like *Facebook* have experimented with emotional manipulation, and companies like Uber have used data to pressure drivers into less favourable work. Even though people react in different ways some avoid certain websites or apps, while others feel helpless or unsure of how to protect themselves many feel that their privacy and freedom are being threatened. This is why clear, fair rules and better awareness are essential to ensure technology empowers people instead of exploiting them.

4.1.3.5 Surveillance Capitalism

Surveillance capitalism is a term made popular by Harvard professor Shoshana Zuboff in her book *The Age of Surveillance Capitalism*. She explains how big tech companies like google and facebook collect much more personal data than necessary. This extra data, called "behavioural surplus," is used to predict what people might do next and then sold to advertisers. But it doesn't stop there. These companies design apps and websites in ways that quietly influence people's behaviour, guiding them to act in certain ways. Zuboff calls this a "hive" society, where people are being subtly controlled without realising it. She also introduces the idea of "Big Other" a powerful, invisible system of companies that constantly watch and gather data, not just to control like "Big Brother" in George Orwell's book 1984, but for profit, without asking permission or being held accountable. Zuboff warns that this threatens freedom and democracy because it gives too much power to a few companies and takes away people's ability to make their own choices.

Surveillance capitalism is very different from traditional capitalism. Instead of selling goods like clothes or food, it makes profit by watching people and collecting their personal information such as their search history, online clicks, and even location data. In this system, people aren't treated as customers but as raw material, since their data is what's being sold. This data is often collected secretly to shape how people think, feel, and act all to earn more money. People lose control over their information because the companies, not individuals, decide how the data is used. This kind of business doesn't just use machines to produce things it uses people's lives, thoughts, and behaviours, often without their full knowledge.

4.1.3.7 Resistance and Digital Rights Movements

The digital rights movement is a worldwide effort to make sure people's basic rights are protected when using the internet and new technologies. These rights include keeping personal information private, speaking freely online, and having fair access to digital tools like the internet and computers. As more of our lives move online, this movement ensures that powerful companies and governments don't misuse people's data or silence their voices. Organisations like Access Now and Change.org fight for these rights by pushing for fair internet rules and stopping online surveillance. Even some tech companies are joining the effort, although it's important to keep checking if they are doing enough.

Despite these efforts, the movement faces many challenges. Governments and companies often collect personal information without permission, using tools like facial recognition or spyware to monitor people secretly. Posts can be unfairly blocked or deleted, and online spaces are sometimes filled with bullying, fake news, and cybercrimes that especially hurt women and minorities. New technologies like artificial intelligence can also be used in harmful ways, and many people worldwide still don't have access to the internet or digital devices, creating a digital divide that leaves some communities behind.

Even with these problems, people worldwide are finding innovative and creative ways to resist. They use secure apps like Signal and Virtual Private Network (VPN) to protect their privacy and share safety tips with others. Groups like Tactical Tech in Berlin teach people how to stay safe online, and campaigns like #DigitalResistance use creative actions like flying paper planes to protest surveillance. There have been real victories too, such as Europe's "Reclaim Your Face" campaign, Brazil's CryptoRave event, and global attention from the Pegasus spyware scandal, which showed how governments spied on innocent people. This led to pressure from human rights groups and tech companies like Apple and WhatsApp to demand stronger protections. Everyone even kids can take part by learning about internet safety, speaking up, joining campaigns like #KeepItOn, and sharing tools and ideas to help build a digital world that is fair, safe, and free for all.

Recap

- Technospace is a virtual environment where technology, science, and business intersect to create innovation and connectivity.
- Technocracy is governance by experts who use data and scientific methods to make decisions rather than relying on popular vote.
- Surveillance means watching people, and in modern times, this often occurs digitally through cameras, apps, and sensors.

- The Panopticon, originally a prison design, has evolved into a metaphor for modern digital surveillance where people modify behaviour knowing they are being watched.
- Predictive analytics and social sorting can lead to unfair treatment by categorising people based on biased data.
- State surveillance focuses on national security, while corporate surveillance aims for profit by collecting user data for advertising.
- Surveillance capitalism monetises personal data by manipulating behaviours without users' full consent or awareness.
- Digital rights movements resist mass surveillance and advocate for internet privacy, free expression, and equal access.
- Countries vary in privacy laws, with the EU's GDPR being one of the most protective frameworks globally.
- In India, states like Kerala show how technocracy can enhance public services through digital innovation when combined with community participation.

Objective Questions

1. What term refers to treating people as data points in digital capitalism?
2. Which thinker conceptualised the Panopticon?
3. What system was used by the NSA to monitor online communications?
4. What kind of analytics is used to guess future behaviours?
5. What is the name of the movement opposing facial recognition in Europe?
6. Who popularised the concept of "Surveillance Capitalism"?
7. What term describes grouping people based on data in surveillance systems?
8. Who reinterpreted the Panopticon in the context of modern society?
9. What is the name of India's planning think tank using tech and data?

Answers

1. Surveillance
2. Jeremy Bentham
3. PRISM
4. Predictive Analytics
5. Reclaim
6. Shoshana Zuboff
7. Social Sorting
8. Foucault
9. NITI Aayog

Assignments

1. Explain the concept of technospace and how it shapes modern life.
2. Discuss the historical evolution of technocracy and its relevance in today's governance.
3. Describe the Panopticon model and its transformation into modern digital surveillance.
4. Evaluate the impact of surveillance on democracy and personal freedom.
5. How do personal and shared technologies differ in technospaces?
6. What is surveillance capitalism, and how does it affect individuals and society?
7. Analyse the role of predictive analytics in social sorting and its consequences.

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UNIT 2

Social Media and Cybernetic Social Movements

Learning Outcomes

After the completion of this unit, the learner will be able to:

- understand the sociological dimensions of social media
- differentiate between social space and virtual space
- discuss the role of technology in shaping new forms of social movements
- explore the transformative potential and limitations of digital activism

Prerequisites

In the heart of Chhattisgarh state lies a small village rewriting the story of rural India. Once an ordinary village with dusty roads and quiet evenings, 'Tulsi' has become India's "Instagram Village" and "YouTube Capital." Here, more than a thousand villagers aren't just farmers or shopkeepers; they're vloggers, influencers, and digital creators. Their fields might grow crops, but their phones harvest likes, shares, and subscriptions. This unexpected digital revolution began in 2018 when two young men, Jai and Gyanendra Shukla, launched a YouTube channel called Being Chhattisgarhiya. What followed was nothing short of a movement. Today, around 25% of Tulsi's 4,000 residents are full-time content creators. The village has over 40 active YouTube channels, and many creators earn up to ₹40,000 a month proving that social media is not just entertainment; it's employment, empowerment, and evolution.

As the world becomes more connected, Tulsi is a shining example of how digital platforms reshape social spaces, turning even the country's most remote corners into virtual stages. These platforms blur the lines between the real and the virtual, private and the public. They're not just tools but new social spaces where identity is formed, stories are shared, and collective action begins. This chapter examines how social media is changing the way we connect with others, create communities, and even stand up for what we believe in. We will learn about social space, virtual space, and online movements where things like hashtags can lead to big changes and the internet becomes a powerful tool for speaking out.

Keywords

Social media, Social space, Virtual space, Digital resistance, Cyber activism, Online identity

Discussion

The way people talk and build communities has changed a lot because of new technology and how we live today. Before, people mainly talked through letters, newspapers, landline phones, or in person. Now, we use social media, messaging apps, and video calls, making communication faster and easier but sometimes also confusing. Everyone can now pick what news or videos they want to see, which is great but also makes it harder to know what's true. Today, people can join communities online based on hobbies or ideas, not just where they live, and many groups mix both online and face-to-face meetings to stay connected. It's important for everyone to be kind, honest, and careful with what they share, especially since wrong information can spread quickly. Despite all these changes, people still want to feel like they belong and are heard, so learning how to listen, talk, and trust each other is more important than ever.

Digital technologies are changing how people see themselves, connect with others, and understand the world around them. Online, we can create and share different versions of ourselves through photos, videos, or posts sometimes making us feel like we're wearing a "digital mask" to get likes or approval. While we get to meet people from all over the world and learn new things, it can also be confusing when we try to keep up with trends that may not match who we are. Culture is also changing fast because the internet lets music, fashion, and ideas travel across borders in seconds, creating fun mixes of styles but also making it harder for small or local cultures to stay strong.

At the same time, power is shifting. Earlier, only prominent leaders or the news could spread messages widely, but now anyone can speak out online. This helps people fight for their rights and share their stories. However, there are risks too our personal data can be watched, and the apps we constantly use might only show us what they think we want to see. Behind the scenes, computer algorithms decide which posts, videos, or people show up on our screens, giving tech companies control. So while the digital world gives us new chances to express ourselves and work together, it's also essential to be careful, stay true to ourselves, and ensure no one is left out.

4.2.1 Social Media

Social media is a group of websites and apps that help people talk, share, and connect with others online. These platforms let people create profiles, post pictures or videos, write messages, and react to others through likes, comments, or shares. Social media works on phones, tablets, and computers, and allows people to stay in touch with family, friends, and even strangers from anywhere in the world. There are many different types of social media platforms. Some are made for connecting with friends or coworkers, like Facebook and LinkedIn. Others, like Instagram, TikTok, and YouTube, are used to share videos and photos. Platforms like X (formerly Twitter) and Threads are for quick messages and news updates. Messaging apps like WhatsApp and Telegram are for chatting with people directly, and Reddit or Discord are for group discussions. Some platforms like Pinterest are made for collecting and sharing ideas and images.

As of 2024, over five billion people use social media, spending more than two hours a day on it. People use social media to socialise, watch videos, get news, do business, and support important causes. Companies use it to advertise and talk to customers, while influencers use it to create content, grow their followers, and earn money. The most popular platforms today include Facebook, YouTube, WhatsApp, Instagram, and TikTok, each with millions or even billions of users around the world. Even though social media is great for staying connected and sharing ideas, it has downsides too. It can affect mental health, especially in kids and teens, and it can spread false information. Some people also worry about privacy and how their data is being used. Still, social media continues to grow and shape how we live, work, and communicate every day.

4.2.1.1 Risks Associated with Early Exposure to Social Media

Many kids use social media even when they are too young, and this can expose them to harmful content like violent videos, sexual images, hate speech, dangerous challenges, or posts about drugs and self-harm. Seeing these things can make kids feel scared, sad, confused, or even depressed, and it can lead to nightmares, mood changes, or copying dangerous behaviour without understanding the risks. Sometimes they get addicted to watching inappropriate content, which affects their school and health, and they may also face bullying or strangers trying to harm them online. This happens a lot because many kids lie about their age to join social media, and the apps treat them like adults, showing them unsafe content. That's why it's important for parents to talk to their kids about what they see online, help them understand what's safe, and guide them to use the internet in a healthy and age-appropriate way.

Brain Rot: When Too Much Screen Time Steals Your Focus!

Did you know?

Spending too much time scrolling through videos or playing games online can lead to something people jokingly call "brain rot"! It's not a real medical term, but it describes that foggy, tired feeling you get when your brain's been fed too much fast content and not enough real thinking. When our minds are constantly entertained without a break, it can make it harder to focus, learn, or stay motivated. The best cure? Step away from the screen, go outside, read something cool, or get creative your brain will thank you!

Social media often shows pictures of people that are edited or filtered to look perfect, making kids and teens feel bad about how they look. When they always see these "perfect" bodies and happy lives all the time, they start to compare themselves and feel like they're not good enough. This can cause stress, sadness, low self-esteem, and even lead to problems like eating disorders or depression. Influencers make it worse by showing off fancy lifestyles and ideal looks that are hard or impossible to achieve. Boys and girls can feel this pressure, and many young people use filters or change their photos to fit in. Spending more time on social media makes these feelings stronger, so it's important to remember that most of what we see online isn't real and doesn't define our worth.

4.2.1.2 The Pressure to Conform in Digital Spaces

Social media gives people quick rewards like likes, comments, and shares, which make them feel happy and accepted but also make them want more and more attention. This works like a game that gives prizes and makes it hard to stop. For kids and teens, it can become a big problem because they start to care too much about what others think of their posts. If they don't get enough likes, they might feel sad, anxious, or even depressed. They may change how they act or look online just to get more approval, forgetting who they really are. Instead of enjoying real-life moments, they might focus too much on taking the "perfect" photo or video to share. Over time, this need for online approval can make people feel less confident and more worried about fitting in, leading to unhealthy thoughts and low self-esteem.

Social media can make people feel bad about themselves because it often shows only the best parts of others' lives, like vacations or successes, which can make users compare their real lives to these perfect moments. This can lead to feelings of jealousy, sadness, or not feeling good enough. Spending too much time online can also make people feel lonely or isolated, as they might spend more time looking at their phones than hanging out with friends or family. Some people also feel anxious or sad because they worry about missing out on fun events or not getting enough likes or comments on their posts. The way people use filters and editing tools to look perfect online can also make people feel pressured to look a certain way, causing more stress and confusion about what's real. These problems are especially strong for teens and young adults but can affect anyone who spends too much time on social media.

4.2.2 Social space

A social space is any real or online place where people come together to talk, play, work, or share things. This can be a park, a street, a library, a home, a school, a shopping mall, or even a place on the internet like a game or social media app. Some spaces are open to everyone, like public parks, while others are more private, like someone's house or a school building. Social spaces can look very different, but what makes them special is that they are made for people to connect, communicate, and spend time together.

Sociologists like Émile Durkheim and Henri Lefebvre explained that social spaces are not just empty places where things happen they are created by how people live, work, and interact. Lefebvre believed that people and their relationships shape all space, and in turn, spaces help shape how people feel, behave, and live their daily lives. These spaces also carry rules, habits, and emotions, like how we act politely at school or cheer loudly at a football game. They can be shaped by many things, such as culture, technology, gender roles, or laws, and they change over time.

Social spaces are very important because they help us understand how our world works. They influence how people treat each other, how groups are formed, and even how people feel about themselves and others. For example, online spaces have made talking to people far away easier, but they've also changed how we connect. Some spaces may include everyone, while others may keep some people out based on wealth, gender, or background. This shows that social spaces can include fairness or unfairness based on how they are built and used.

4.2.3 Virtual Space

A virtual space is a digital world where people can interact with each other and the environment through computers, smartphones, or special devices like VR headsets. These spaces differ from simple websites because they allow users to explore, communicate, and even create things in real-time. For example, you might see and talk to other people represented by avatars, play games, or attend virtual meetings. Virtual spaces can be used for work, school, entertainment, and social events. They're often designed to feel immersive, and you can customise your experience to make it more personal. These digital spaces are accessible from anywhere and can be accessed using the internet.

4.2.3.1 Gamification

Gamification is when game-like features, like points, badges, and challenges, are added to non-game environments to make them more fun and engaging. In virtual spaces, this helps people stay motivated and keep coming back because they get rewards for participating and completing tasks. It can make boring tasks feel fun, like turning them into games with progress bars or rewards. Gamification also helps people learn better by breaking big tasks into smaller, more enjoyable steps. It encourages teamwork and socialising through challenges and group activities, making users feel like they're part of a community. Users who customise their profiles or spaces feel more connected to the virtual world. Indeed, gamification makes virtual spaces more interactive and enjoyable, keeping users engaged and returning for more.

4.2.3.2 Hyperreality and the Collapse of Offline/Online Boundaries

Jean Baudrillard, a thinker, came up with the idea of hyperreality, which means that sometimes it's hard to tell what's real and what's fake. In a hyperreal world, copies of real things like pictures, videos, or theme parks can feel more real than the original. For example, when you play in a video game or visit a theme park, it feels real even though it's all designed by people and not based on actual events or nature. Baudrillard said that when we get used to these fake versions, or simulations, we start living in a world full of signs and symbols that no longer connect to the real world. A simulacrum is a copy that doesn't have any real thing behind it it just exists on its own, and people accept it as real.

This is especially true today because of technology, social media, and entertainment. On apps like Instagram or Facebook, people show the best parts of their lives often edited or filtered and over time, those online versions of themselves can seem more real than who they are in person. People get caught up in likes, shares, and comments, and that becomes part of how they feel good about themselves. Artificial intelligence and virtual worlds add to this, making fake experiences (like talking to a chatbot or watching a deepfake video) feel real. The internet has become a place where we make friends, share ideas, and build identities even if we never meet in real life.

Because of this, the boundary between online and offline life is disappearing. We now live in a world where it's hard to tell what's true and what's not, because fake things can feel more real than real ones. This can make people prefer the online world over the physical one, which Baudrillard warned could lead to losing touch with reality. In this hyperreal world, the virtual doesn't just copy reality it becomes a new kind of reality on its own, changing how we understand truth, identity, and connection.

4.2.3.3 Embodiment, Anonymity, and the Politics of Virtuality

In virtual spaces, embodiment refers to how people use digital avatars or bodies to represent themselves. Even though these virtual worlds were once thought to be places where people could escape their physical identities, recent studies show that our real-world characteristics, like gender or race, can still influence how we act and interact online. Avatars become extensions of ourselves, allowing us to experiment with identity, but they also carry over biases from the physical world. The way we present ourselves in these virtual spaces can blur the line between who we are in reality and who we are in the digital world, creating a "derivative self" influenced by our intentions and the virtual environment.

Anonymity in virtual spaces can be empowering, as it allows users to explore different aspects of their identity without the constraints of their physical bodies. However, it also has its risks. The ability to change or hide our digital bodies can lead to the manipulation of identities, making it easier for harmful actions like identity theft or impersonation to happen. The lack of proper identity verification in virtual spaces also raises concerns about trust and accountability, making it harder to know who we are interacting with and whether they are being truthful.

The politics of virtuality refer to the power dynamics and social inequalities that exist in online spaces. These virtual environments are not neutral; they often reflect and reinforce the biases and power structures found in the real world. For example, many virtual spaces assume that users will have dominant identities, such as being white or male, which can marginalise people with different backgrounds. In addition, the design and rules of these spaces often do not consider the needs of marginalised groups, resulting in less inclusive environments. Addressing these issues requires conscious efforts to create virtual spaces that are more diverse and equitable, with attention to representation, access, and how technology can challenge social inequalities.

Virtual spaces present new opportunities for self-expression and connection. Still, they also bring forward many of the same challenges in the real world, such as biases and unequal power structures. To create truly inclusive virtual environments, designers must prioritise diverse representation, stronger identity protections, and ongoing reflection on how technology can either reinforce or challenge social inequalities.

4.2.3 Cybernetic Social Movements

Cybernetic social movements are groups of people who use the internet, social media, and other digital tools to work together for change. Unlike older movements that often have one big leader, these movements are organised like a web where everyone can join, share ideas, and help in their own way. People mix online actions like sharing posts, signing petitions, or using hashtags with real-life events like marches and meetings. Movements like #MeToo and Black Lives Matter became powerful by using social media to spread stories and gather support from around the world. These kinds of movements are smart and flexible they listen to what's happening, make changes, and keep growing. They reach across different countries and cultures, using technology to connect people quickly. Even though they are powerful, they can face problems too. Sometimes, it's hard to make decisions or stay focused because they don't have one clear leader. Also, big tech companies can block their pages or limit their reach. Still, cybernetic social movements help everyday people get involved and make their voices heard, even with just a click or post.

There have been many strong examples of these movements. In India, The India Against Corruption Movement in 2011 used social media to bring millions together to fight corruption. The Net Neutrality campaign in 2015 helped protect fair internet access. The Right to Information (RTI) movement used websites to spread awareness and demand more openness from the government. Around the world, people used hashtags like #MeToo to fight sexual harassment and #YoSoy132 in Mexico to speak out against unfair media. Even before apps like Instagram or Twitter were common, people were already using emails, websites, and other digital tools like in the Fight for Housing in 2006 or the Cyberfeminism movement in the 1990s to stand up for justice. These examples show how technology can bring people together to create change and make the world fairer.

4.2.3.1 Rise of Digital Activism and Hashtag Movements

Hashtag movement is when people use hashtags on social media to speak up about important issues and bring others together to create change. It's powerful because anyone with internet access can join, no matter where they live or who they are. A simple post, like, or share can help a topic go viral, making more people aware of it. Hashtags also create online communities where people support one another, share stories, and organise real-life actions like protests or fundraisers. Because it's easy to join, hashtag activism helps many people get involved and feel heard.

Many popular hashtag movements have made a big difference in the real world. Movements like #BlackLivesMatter brought global attention to racism and police violence, while #MeToo gave people the courage to speak out against sexual harassment. Others, like #ClimateStrike and #NeverAgain, pushed for action on climate change and better gun laws. The #IceBucketChallenge raised millions for ALS research, and #BringBackOurGirls highlighted the kidnapping of Nigerian schoolgirls. These examples show how online voices, when united by a common cause, can lead to real and lasting change.

Hashtag movements usually begin in the "emergence phase" when something unfair or upsetting happens and people want to raise awareness. Someone creates a hashtag, and as influencers and public figures begin to use it, it spreads quickly. The movement then reaches the "peak popularity" stage, where the hashtag trends on social media, appears in the news, and inspires real-life actions. Online communities form and people feel connected through their shared goal. Over time, however, the hashtag's meaning may shift a process called "hashtag drift" as people start using it in different or unrelated ways.

Eventually, a hashtag may become less popular as attention shifts to other issues, or it might lead to the creation of lasting organisations or changes in laws and culture this is known as the "decline" or "institutionalisation" phase. Even if people stop using the hashtag often, the movement can leave behind a powerful impact. While hashtag activism has its challenges like limited action beyond social media, spread of misinformation, or government interference it remains an important tool for raising voices, building awareness, and pushing for a better world, especially when online support turns into real-life action.

4.2.3.2 Decentralised and Networked Resistance

Digital movements work without one main leader. Instead, they are decentralised, which means people share ideas, make decisions together, and help in their own way. It's like a big team where everyone plays a part. People stay connected through group chats, apps, or websites, and often use safe tools like encrypted messages to protect their privacy. This makes the movement stronger and harder to stop, even if someone tries to block part of it.

What makes them powerful is how fast they can spread information, try new ideas, and include voices worldwide. Thanks to tools like social media and peer-to-peer networks, anyone can join from anywhere even without meeting in person. Movements like Black Lives Matter, the Occupy protests, and the Cypherpunks show how strong this kind of teamwork can be. While they grow fast and react quickly to new events, they also face challenges like staying organised or keeping people involved. Still, they are an important way for people to stand up to unfairness online and offline.

4.2.3.4 Examples of Cybernetic Movements

Many people around the world have used the internet and social media to come together and stand up for important causes. These digital movements often begin with just one person or a small group, but they can grow quickly and reach millions. They help people share their stories, learn from each other, and ask for change. Here are three powerful examples of such movements that show how technology can help people work together for a better world.

a. #MeToo

The #MeToo movement began in 2006 when activist Tarana Burke started it to support people, especially women and girls, who had experienced sexual violence. But it became really famous in 2017 when actress Alyssa Milano used the hashtag on social media after serious accusations were made against Hollywood producer Harvey Weinstein. Millions of people around the world began sharing their own stories of being hurt or harassed, making #MeToo a global movement that demanded respect, safety, and fairness for everyone, especially women. The hashtag spread into many languages, and in places like India, it led to big conversations about how women were being treated at work and how unfair court decisions were making things worse for survivors.

The movement led to many changes. For example, some powerful men lost their jobs after being accused, and women replaced many. In the U.S., laws were made to protect people from being harassed at work, and more companies started paying attention to how they treat their employees. Some behaviours, like making inappropriate jokes, still happen, but people are now more aware and speak up more often. In India, the movement grew strong in 2018, with women in Bollywood, media, and politics sharing their stories. Activists there said that women, especially in villages, need education and money of their own to stay safe and strong.

b. Arab Spring

The Arab Spring was a big wave of protests that started in December 2010 in Arab countries because people were tired of unfair leaders, poverty, and corruption. It all began in Tunisia, when a man named Mohamed Bouazizi set himself on fire after being mistreated by the police. His death made many people angry, and they started protesting for freedom and better lives. The movement quickly spread to places like Egypt, Libya, Yemen, Syria, and Bahrain. The leaders were removed from power in some countries, like Tunisia, Egypt, Libya, and Yemen. But in others, like Syria and Libya, it led to terrible wars. Only Tunisia became a democracy, while other countries returned to strict rule facing violence. These protests showed how powerful people's voices can be, and how hard it is to change things when leaders don't want to give up control.

People joined the Arab Spring because they had been living under unfair and strict governments for a long time. Leaders wouldn't allow free speech, punished people who disagreed, and kept most of the money and power for themselves. Many young people didn't have jobs or enough money, and food and living costs kept going up. These problems made people feel frustrated and hopeless. A lot of young people used social media to talk, share ideas, and plan protests together. When Bouazizi's story spread, it became a symbol of everything that was wrong, and people across many countries stood up to say, "Enough is enough." So the Arab Spring happened because of a mix of unfair governments, poverty, no jobs, rising prices, and the way people used the internet to come together.

c. Fridays for Future

Fridays for Future (FFF) is a worldwide youth movement that started in 2018 when a Swedish teenager named Greta Thunberg began skipping school on Fridays to protest outside her country's parliament for stronger action on climate change. She shared her protest online, inspiring millions of students and adults around the world to join her. The movement grew fast through social media and became famous for school strikes and big global protests calling on leaders to stop using polluting fuels and switch to clean energy. FFF wants governments to follow science, protect the planet, and keep global warming below 1.5°C. Over 14 million people in more than 7,500 cities have taken part. The movement has won big awards and helped make climate change a top issue in politics. Anyone can join by striking, sharing online, or helping with campaigns because, as Greta says, "Everybody is welcome. Everybody is needed."

4.2.3.5 Challenges: Surveillance, Misinformation, and Platform Censorship

Cybernetic social movements use the internet and social media to unite people and create change. These movements are decentralised, meaning anyone can join and help. People use phones, computers, and apps to share ideas, organise events, and spread awareness about issues like injustice and inequality. They might share videos, start hashtags, or even use hacking to protest. However, these movements face challenges. It can be hard to stay united because the internet connects so many people, confusing the message. Governments and companies can watch what activists do online, making them feel unsafe. Not everyone has access to the internet or knows how to use it, leaving some people out. Also, some people only engage by liking posts or sharing content without doing anything real, which is called "slacktivism." Big tech companies also control what people see, limiting the movement's reach. Despite these problems, these movements keep growing and finding new ways to bring about change.

i. Surveillance

Surveillance, primarily through digital tools and AI, poses a major threat to online movements. Governments and corporations can track people's activities online, potentially intimidating activists and discouraging participation. This is known as the "chilling effect." Surveillance also allows authorities to shut down protests, arrest leaders, or disrupt movements before they can gain traction. Even when activists use privacy tools or code words, surveillance technologies constantly improve, making it harder to stay hidden. In response, movements must use more secure technology, build stronger networks, and push for digital rights to resist these challenges.

ii. Misinformation

Misinformation refers to false or inaccurate information shared by people who believe it to be true. Unlike disinformation, which is deliberately designed to mislead, misinformation spreads unintentionally. It can include rumours, outdated facts, or misunderstood research, and it often spreads rapidly on social media, messaging apps, or news outlets. Misinformation can have harmful effects, such as influencing public health (e.g., spreading false health advice), affecting elections, and eroding trust in institutions. It spreads quickly, especially when people don't have complete information or when it comes from sources that seem credible. To combat this, it's crucial to promote media literacy, support fact-checking, and encourage critical thinking. By helping people evaluate information carefully, movements can protect their message and maintain focus on their goals.

iii. Platform Censorship

Platform censorship occurs when social media companies or websites remove or block certain content, often in an effort to follow laws, maintain safety, or prevent harmful material. This can include the removal of hate speech, violence, misinformation, or political criticism. While this can help keep platforms safe, it raises concerns about freedom of speech. Social media users often feel frustrated when their content is removed without clear explanations, especially in cases of political or controversial topics. Many believe in free speech, even when they disagree with the opinions shared, and they want more transparency from platforms about how they decide what to censor. Some people avoid censorship by changing their language, using emojis, or finding alternative platforms with fewer restrictions. Others look for ways to access blocked content or move to sites where free speech is better protected.

Governments justify internet censorship by arguing that it is necessary for national security, protecting citizens, or stopping the spread of misinformation. For example, they may block terrorism-related content, hate speech, or fake news. Sometimes, they also restrict access to foreign websites to protect local businesses or prevent piracy. However, critics argue that these reasons can be used to silence political opponents or minority groups, and that the definitions of harmful content are often too vague. Also, decisions to remove content are usually made without enough transparency. In some cases, tech companies comply with government censorship to keep operating in certain countries, leading to more control over online speech.

Technology can be helpful and harmful, depending on how we use it. It can improve life by giving more people access to information, helping them speak up, learn new things, and participate in decisions that affect everyone. But if only a few powerful people or companies control it, they can use it to spy on others, spread lies, and create unfairness. In today's world, people don't always need to gather in big crowds to take action they can use phones and social media to come together and speak out quickly. This gives more people, even those usually left out, a chance to be heard. But it can also lead to problems, like people only pretending to care or being tricked by false stories. That's where sociologists come in they study how people use technology and how it changes the way we live, talk, and work together.

They help ensure technology is used fairly and safely, so it helps everyone, not just a few. This way, we can build a better digital world for all.

Recap

- Social media has transformed how people communicate, share, and connect across the globe, impacting personal lives, businesses, and activism.
- Social space refers to any physical or virtual environment where people interact, shaped by culture, norms, and power structures.
- Virtual space is a digital realm where users can interact in real time through avatars, chats, or immersive platforms like virtual reality.
- Gamification adds game-like elements to digital spaces, enhancing user engagement and learning through rewards and challenges.
- Hyperreality, a concept by Baudrillard, describes how digital representations can feel more real than reality, blurring truth and fiction.
- Digital embodiment and anonymity allow people to experiment with identities but also carry over real-world biases and pose risks like impersonation.
- Cybernetic social movements are decentralised and tech-driven, enabling people to organise for change through hashtags, posts, and online campaigns.
- Hashtag activism turns simple symbols into global calls for justice (e.g., #MeToo, #BlackLivesMatter), often leading to real-world action and policy changes.
- Challenges like surveillance, misinformation, and censorship complicate online activism, yet digital platforms continue to be vital for collective resistance.

Objective Questions

1. Who introduced the concept of hyperreality?
2. What term describes digital rewards like points and badges in non-game settings?
3. What kind of movements combine online and offline activism?
4. Which global movement started by Greta Thunberg focuses on climate change?
5. What word refers to an online copy without an original?
6. What type of media allows two-way communication?
7. Which movement in 2011 in India protested against corruption?
8. Which psychological issue is worsened by social media among teens?
9. What is the fear of missing out on online events commonly known as?
10. What is the term for false but unintentional information spread online?

Answers

1. Baudrillard
2. Gamification
3. Hybrid
4. FridaysForFuture
5. Simulacrum
6. Social Media
7. IndiaAgainstCorruption

8. Depression
9. FOMO
10. Misinformation

Assignments

1. How does social media blur the boundaries between public and private spaces in modern society?
2. Compare and contrast social space and virtual space using examples.
3. Evaluate the benefits and drawbacks of early exposure to social media among children and adolescents.
4. Analyse Jean Baudrillard's concept of hyperreality in the context of digital and virtual identities.
5. Explain the role of gamification in enhancing user engagement in virtual spaces.
6. How do cybernetic social movements differ from traditional social movements? Provide examples.
7. Describe the phases of a hashtag movement and how it leads to institutional change.
8. Critically examine the challenges faced by cybernetic movements such as surveillance and censorship.

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BLOCK

Technological Intervention: Challenges & Responses

UNIT 1

Challenges of Technological Advancements

Learning Outcomes

After the completion of this unit, the learner will be able to:

- assess how scientific knowledge and technological artefacts are socially constructed and embedded within cultural and political contexts
- analyse the legal and ethical dilemmas surrounding the development and use of science and technology
- explore feminist critiques of mainstream science and understand how gendered assumptions shape scientific practices and institutions
- discuss the ideological underpinnings and power structures that influence the production, dissemination, and acceptance of scientific knowledge

Prerequisites

To understand the challenges posed by technological interventions in society, a foundational grasp of the sociology of science and technology is necessary. A basic understanding of how knowledge is produced, legitimised, and disseminated within social contexts is essential. Prior exposure to classical sociological theories especially those focusing on institutions, power, ideology, and culture assists in critically engaging with the idea that science and technology are not neutral or value-free but are socially embedded. Familiarity with the social construction of knowledge, as discussed by scholars like Thomas Kuhn, Bruno Latour, and David Bloor, equips one to question scientific "objectivity" and explore the ways in which cultural, political, and historical factors shape technological developments. Moreover, an introductory knowledge of feminist theory and postcolonial perspectives assists in understanding critiques that highlight exclusionary practices in science, particularly those based on gender, race and geography.

It is also important to reflect on the ethical and legal dimensions of science and technology and consider how institutional and societal responses to these challenges vary across contexts. Engaging with questions like "Whose knowledge counts?" and "Who benefits from technological progress?" fosters a critical and reflective mindset. This preparation enables an examination of science not merely as a body of facts but as a socio-political enterprise with real-world implications. In exploring the complex interplay between science, technology, and society, this unit delves into the multi-layered challenges that emerge from technological interventions.

Keywords

Actor network theory, Scientific objectivity, Situated knowledge, Feminist epistemology, Technological citizenship, Knowledge hierarchies

Discussion

Technology does not exist in isolation; it is deeply embedded in society, politics, and economic systems. Sociologists analyse the social construction of technology, investigating how different ideologies influence technological development, adoption, and impact. The ideological challenges of technology are critical in understanding power dynamics, social inequality, cultural shifts, and digital transformation in modern society. This unit explores how capitalism, neoliberalism, technocracy, nationalism, and algorithmic biases shape technology and, in turn, influence social structures, institutions, and interactions.

5.1.1 Cognitive Challenges and the Social Construction of Knowledge

The cognitive dimension involves questioning the assumption that scientific knowledge is purely objective or universally valid. As argued by Kuhn (1962) in The Structure of Scientific Revolutions, paradigms shape what is considered "valid" science, highlighting the historical and cultural embeddedness of knowledge. David Bloor's *Sociology of Scientific Knowledge* (SSK) further asserts that all knowledge including scientific knowledge emerges within a socio-cultural framework, thus confronting traditional positivist views. Knorr Cetina echoes this through her concept of the contextual nature of knowledge production, emphasising that what is considered 'true' in science is often contingent on institutional practices and negotiated realities within laboratories and research settings. This aligns with the keyword "situated knowledge", challenging the myth of detached objectivity.

5.1.1.1 What is a Cognitive Challenge?

Cognitive challenges refer to the difficulties and complexities in understanding how knowledge is formed, validated, and legitimised especially within scientific and technological domains. Traditionally, knowledge has been viewed as objective, cumulative, and universal. However, contemporary science challenge this view by proposing that knowledge is socially constructed and shaped by culture, politics, language, power relations, and the contexts in which it is produced.

This approach brings forth cognitive challenges in terms of:

- Understanding how "facts" are made, not found
- Identifying whose knowledge is privileged or marginalised
- Questioning the neutrality of science

These challenges are central to the *Sociology of Scientific Knowledge* (SSK), which emphasises that cognition is not merely mental, but also social and contextual.

> The *Sociology of Scientific Knowledge* (SSK) is a subfield within the sociology of science that studies the social processes involved in the production, validation, and dissemination of scientific knowledge. It challenges the notion that science is purely objective or autonomous and instead argues that scientific knowledge is socially constructed influenced by cultural norms, political contexts, institutional structures, historical circumstances, and interpersonal interactions.

5.1.1.2 Features of the Cognitive Challenge

1. **Contextuality of Knowledge :** Knowledge production depends on historical, institutional, and social settings. A scientific theory is understood differently in different eras or regions.
2. **Tacit Knowledge :** As Polanyi argued, much of scientific practice involves non-verbalised, intuitive, or experience-based knowledge that is hard to formalise.
3. **Reflexivity :** Scientists are part of the social world and bring their own biases and worldviews into their work. This calls for self-awareness in knowledge creation.
4. **Constructivism :** Science does not simply discover facts but constructs them through methodologies, instruments, and social consensus.
5. **Cognitive Authority :** Who has the right to claim something as "truth" in science? This involves trust in institutions, degrees, and systems of expertise.

5.1.1.3 Cognitive Dimensions in Contemporary Issues

Public Understanding of Science question vaccines, climate change, and GMOs due to differing cognitive authorities and perceived value systems behind them.

1. **AI and Data Ethics** : Algorithms reflect the assumptions and biases of their creators. Therefore, AI becomes a cognitive artefact shaped by social values.
2. **Science Education Curricula:** Now emphasise critical thinking, awareness of scientific controversies, and the plurality of knowledge systems.

3. **Media and Misinformation:** The rise of misinformation illustrates how the public's cognitive trust is fragmented posing a key challenge in techno-scientific societies.

4. **Knowledge Inequality:** Western scientific frameworks often marginalise Indigenous knowledge systems. This creates epistemic injustice a major cognitive and ethical challenge.

5.1.1.4 Shifting Paradigms in Science and Research

1. **Cognitive Pluralism:** Emphasising the acceptance of multiple ways of knowing scientific, traditional, experiential, and spiritual.

2. **Decolonization of Science:** Re-examines how science has historically sidelined non-western knowledge and advanced towards epistemic inclusivity.

3. **AI-Epistemology Interface :** As AI systems begin to generate knowledge (e.g., ChatGPT), questions arise about how machines construct and validate knowledge introducing new cognitive paradigms.

4. **Citizen Science:** Science will increasingly rely on non-experts, blurring the boundary between cognitive authority and public participation.

Cognitive challenges force us to rethink the nature of scientific knowledge, moving beyond the binary of true/false or objective/biased. They draw attention to how knowledge is produced, by whom, and under what conditions. In a globalised, digital world, understanding these challenges is essential for navigating the intersection of science, society, and technology. It allows us to build more inclusive, reflexive, and socially responsible knowledge systems.

5.1.2 Legal and Ethical Dilemmas in Technological Advancement

As technologies evolve rapidly ranging from biotechnology to artificial intelligence societies face pressing ethical and legal dilemmas. Issues such as data privacy, genetic engineering, and environmental degradation raise questions about technological citizenship and public accountability. Merton's Normative Structure of Science includes values such as universalism and communalism. However, real-world practices often diverge, leading to cognitive dissonance and ethical ambiguity. The regulatory frameworks governing scientific practice frequently lag behind innovation, leaving legal institutions to navigate uncharted territories. Authors like Sismondo and Lewenstein stress that science communication and public engagement are crucial in navigating these complexities. The ethical challenge, then, is not only about 'what can be done' technologically but also 'what should be done' socially.

Technological advancement, while revolutionary, raises complex legal and ethical dilemmas that challenge established norms of governance, privacy, justice, and societal well-being. These dilemmas are deeply intertwined with power dynamics, social inequalities, and epistemological uncertainties, as studied within the Sociology of Scientific Knowledge (SSK) and Science and Technology Studies (STS). Legal frameworks often lag behind technological innovation, resulting in regulatory gaps, conflicting jurisdictions, and unclear liability. Technologies such as AI, gene editing (CRISPR), surveillance systems, and automated decision-making introduce new forms of risk and legal ambiguity.

5.1.2.1 The Intersection of Law, Ethics, and Technological Innovation

1. **Accountability and Liability:** In the case of autonomous vehicles or AI-driven diagnostics, assigning responsibility for harm or error is not straightforward. Sismondo points to how legal institutions struggle to address non-linear, multi-agent technological systems.

2. **Data Privacy and Consent:** Surveillance capitalism (e.g., Google, Facebook) has raised questions about the commodification of personal data. Latour's Actor–Network Theory helps understand how data flows between human and non-human actors, complicating notions of control and consent.

3. **Intellectual Property and Access** - Ethical and legal disputes over patenting of life forms (e.g., GMOs) and life-saving drugs highlight economic and moral exclusions. Harding critiques how Western legal systems support corporate monopolies on biotechnologies at the expense of global justice.

5.1.3 Feminist Interventions

Feminist critiques have powerfully exposed the gendered assumptions underlying scientific inquiry. Scholars like Sandra Harding, Donna Haraway, and Evelyn Fox Keller argue that science has historically marginalised women's experiences and perpetuated masculine ways of knowing. Haraway's notion of "situated knowledge" highlights that all knowledge is partial and shaped by one's social positioning, directly challenging the illusion of a neutral, detached observer. Feminist epistemology, as developed in works like *Feminism and Science*, seeks to broaden the scope of scientific inquiry by incorporating diverse voices, particularly women and other marginalised groups. Rajeswari Sunder Rajan and Richa Thomas document how Indian women scientists experience epistemic exclusions, adding a crucial postcolonial perspective. The keyword "gender and science" here becomes a lens to examine both access and agency within scientific institutions.

5.1.3.1 Feminist Challenges in Science and Technology

Feminist scholars argue that science and technology have historically been shaped by patriarchal structures, androcentric biases, and exclusionary practices that marginalise women and non-binary individuals. The feminist challenge to science and technology is not merely about increasing women's participation but about questioning the very foundations of scientific knowledge, methodologies, and institutional practices. Feminist critiques highlight the gendered nature of scientific knowledge, where dominant paradigms reflect masculine perspectives and values. These critiques call for an inclusive, reflexive, and equitable approach to science that acknowledges diverse perspectives, particularly those from historically oppressed groups.

5.1.3.2 Gender, Power, and Knowledge in Science

1. Androcentrism in Scientific Knowledge

Traditional scientific inquiry has been shaped by masculine norms, often framing objectivity, rationality, and detachment as "universal" values. Feminist scholars such as Sandra Harding and Evelyn Fox Keller argue that these values ignore the social and political dimensions of knowledge. Example: Biology textbooks historically described the sperm as active and the egg as passive, reinforcing gendered stereotypes in scientific narratives.

> Androcentrism refers to a perspective in which male experiences, values, and norms are treated as the default or universal standard, often marginalising or ignoring women's experiences. This concept is commonly critiqued in feminist theory, sociology, and gender studies. Androcentrism can be seen in language, media, science, history, and social institutions where male viewpoints dominate, and female perspectives are considered secondary or "other." It reinforces gender inequality by portraying men as the norm and women as deviations. Challenging androcentrism involves recognising and valuing diverse gender perspectives to build more inclusive and equitable knowledge, systems, and representations in society.

2. Gender Bias in Research and Data

Women's bodies, health concerns, and experiences have been underrepresented or misrepresented in medical and technological research. Clinical trials often exclude women, leading to drugs and treatments designed primarily for men. Example: Heart disease symptoms in women were historically overlooked because research focused predominantly on male patients.

3. Exclusion from STEM Fields

Women and non-binary individuals face structural barriers in STEM (Science, Technology, Engineering, and Mathematics) due to systemic gender discrimination, hostile work environments, and insufficient institutional support. Feminist scholars advocate for inclusive STEM education and affirmative policies to address this imbalance. Example: The Matilda Effect (coined by Margaret Rossiter) describes how women scientists' contributions are systematically ignored or attributed to their male colleagues.

4. Feminist Epistemology: Questioning Objectivity

Feminists challenge the "view from nowhere", which assumes knowledge is neutral and objective. Instead, they propose "situated knowledge," arguing that all knowledge is shaped by the social and political location of the knower. Standpoint Theory suggests that marginalised groups (women, non-binary people, indigenous communities) have an epistemic advantage in understanding social realities.

5. Algorithmic and AI Bias

Feminist scholars highlight how AI systems reinforce existing social inequalities, including gender bias. Feminists argue for intersectional AI ethics that consider race, gender, and class in algorithmic design. Example: Facial recognition software often misidentifies women and people of colour due to biased training datasets.

6. The Gendered Impact of Technology

Technologies are not neutral; they are designed within patriarchal and capitalist systems. Reproductive technologies, genetic engineering, and surveillance tools disproportionately affect women and marginalised communities. Feminists call for ethical technology policies that prioritise social justice.

7. Ecofeminism and Sustainable Science

Ecofeminists like Vandana Shiva argue that modern science has contributed to environmental destruction by promoting exploitative capitalist models. Women, especially those in the Global South, have been disproportionately impacted by environmental degradation and climate change. Example: Feminist-led movements for indigenous and women-centred environmental knowledge systems offer sustainable alternatives to exploitative scientific practices.

Standpoint Theory is a feminist sociological approach that asserts knowledge is shaped by one's social position, especially from the perspective of marginalised groups. Developed by scholars like Dorothy Smith and Patricia Hill Collins, it argues that individuals from oppressed communities possess unique insights into social structures because they experience inequality firsthand. Unlike dominant perspectives rooted in privilege, standpoints reveal hidden power dynamics. In the context of development and globalisation, standpoint theory critiques Western-centric policies and highlights the importance of local, gendered, and grassroots knowledge in creating inclusive and equitable development models. It promotes a more just and representative understanding of society.

5.1.4 Ideological and Political Dimensions of Science and Technology

The ideological challenge lies in recognising how science and technology often reflect and reinforce dominant power structures. Bruno Latour and Bourdieu show how scientific practices are deeply entangled with networks of authority, resource distribution, and institutional power. Actor–Network Theory (ANT), as elaborated by Latour, dismantles the binary between society and technology, suggesting that non-human actors (like machines and software) also play a role in shaping outcomes. Andrew Pickering and Visvanathan further question the myth of value-neutral science, pointing out that scientific practices are shaped by ideology, be it nationalism, capitalism, or militarism

The social construction of knowledge refers to the idea that knowledge is not merely discovered but created through social interactions, cultural norms, and historical contexts. It emphasises that what we accept as "truth" or "reality" is shaped by collective agreements within a society. Thinkers like Peter Berger and Thomas Luckmann argue that knowledge is produced and maintained through language, institutions, and everyday practices. This perspective challenges the notion of objective knowledge, highlighting how power, ideology, and social context influence what is considered valid. Thus, knowledge is dynamic, context-dependent, and often reflects the interests and values of dominant social groups.

Ashis Nandy critiques the hegemonic ideology of modern science, suggesting that colonial and nationalist forces have co-opted science for control rather than emancipation. Similarly, Meera Nanda reveals how science is weaponised in cultural nationalism, calling for critical vigilance. The ideological challenge, thus, is to distinguish knowledge hierarchies from democratic science that serves the public good.

5.1.4.1 Reflexivity and the Role of Society

A central theme across these challenges is reflexivity the ability of science to examine its own assumptions and social effects. As Pierre Bourdieu suggests, scientists must recognise their positionality within the field and the structural forces shaping their practices. The public understanding of science and mechanisms for technological citizenship must foster inclusive debates on policy, access, and responsibility.

Actor–Network Theory (ANT) is a sociological and philosophical framework developed by scholars like Bruno Latour, Michel Callon, and John Law. ANT explores how human and non-human entities such as people, institutions, technologies, and objects interact to form networks that shape social outcomes. It rejects the separation of society and nature, arguing that agency is distributed across both. In the context of development and globalisation, ANT helps analyse how technologies like ICT, policy frameworks, and global markets collaborate with human actors to influence developmental trajectories. ANT offers a dynamic, relational understanding of power, innovation, and change within complex socio-technical systems.

5.1.4.2 Ideological Challenges in Science & Technology

1.Capitalist Ideology and the Commodification of Technology

Modern technological advancements are largely driven by capitalist market forces, where innovation is guided by profit motives rather than social welfare. Corporate monopolies (Google, Amazon, Facebook, Apple, Microsoft) dominate the tech landscape, raising concerns about digital colonialism, data exploitation, and unequal access. Example: Big Pharma and medical technology patents life-saving drugs and treatments remain unaffordable due to profit-driven intellectual property laws.

2. Neoliberalism and the Digital Economy

Neoliberal ideology promotes deregulation, privatisation, and minimal government intervention, affecting access to technology. Example: The gig economy (Uber, Swiggy, Zomato, Fiverr), driven by digital platforms, exploits workers while offering no social security benefits. Surveillance capitalism highlights how tech corporations manipulate user data for behavioural control and commercial profit.

3. Technocratic Ideology and the Myth of Neutrality

Technocracy is the belief that scientific experts and engineers should govern society rather than elected representatives. This ideology assumes that technology can solve all social problems, ignoring structural inequalities, cultural contexts, and ethical considerations. Example: AI-driven governance models, where automated systems decide public policies, neglect the human element of democracy.

4. Nationalism, State Control, and Digital Sovereignty

Governments use technology to reinforce nationalist ideologies, state surveillance, and digital authoritarianism. Example: China's "Great Firewall" restricts digital freedom, promoting state-controlled narratives while censoring dissent. Countries invest in cyber warfare and digital nationalism to assert technological sovereignty and geopolitical dominance.

5. Ideological Bias in AI and Algorithms

AI systems are trained on historically biased data, reinforcing racism, sexism, and classism. Example: Predictive policing algorithms disproportionately target marginalized communities, reflecting systemic biases in law enforcement. Feminist and critical theorists argue that algorithms are not neutral; they reproduce and amplify existing ideological biases.

6. Technological Determinism vs. Social Constructivism

Technological Determinism: The belief that technology independently drives social change, ignoring human agency. Social Constructivism: Argues that technology is shaped by cultural, political, and economic forces, not just scientific progress. Example: The ICT revolution in India did not automatically reduce inequalities digital divide and class barriers still exist.

7. Postmodern and Critical Theory Perspectives

Postmodernist critiques (Michel Foucault, Lyotard) argue that technology is a tool of power and control, rather than progress. Critical theorists question who controls knowledge production in the digital age and how it shapes political consciousness.

5.1.4.3 Future Directions and Responses to Ideological Challenges

Democratization of Technology – Open-source movements, decentralized networks, and commons-based peer production (e.g., Wikipedia)

AI Ethics and Inclusive Innovation – Developing fair, transparent, and accountable AI systems that reduce ideological bias

Technological Justice Movements – Advocating for data privacy, digital rights, and equitable access to technological resources

Public Policy and Regulation – Striking a balance between innovation, ethical considerations, and social welfare.

Table 5.1.1 Typology of Challenges in Science and Technology

Challenge Type	Definition	Key Features/ Examples	Key Thinkers and Theories
Cognitive	Issues related to how knowledge is created, validated, and understood.	Algorithmic bias- Epistemic bubbles- Social construction of knowledge	SSK (Bloor, Barnes)- Berger & Luckmann: *Social Construction of Reality*
Legal	Legal systems lag behind in regulating emerging technologies.	Data privacy gaps- Gig economy & labour rights- Liability for AI decisions	Durkheim: Law evolves with society- Marx: Law serving capitalist interests
Ethical	Moral dilemmas in tech use in sensitive areas.	Biased AI in hiring/ policing- Issues of fairness, consent, and dignity	Foucault: *Biopower* and surveillance- Weber: Rationalization in bureaucracies

Feminist	Gendered impacts and exclusions in science & tech.	Male bias in design (e.g., digital assistants)- Women's underrepresentation in STEM	Sandra Harding: *Standpoint Epistemology*- Donna Haraway: *Cyborg Manifesto*
Ideological	Tech shaped by dominant ideologies; reinforces power structures.	Surveillance capitalism- Technological determinism- State & corporate control	Marx: Technology as ideology tool- Gramsci: *Cultural hegemony* in media/tech

Recap

- Technological interventions shape not only what we know but how we come to know it. They raise questions about knowledge bias, algorithmic control, and epistemic justice.
- Laws often lag behind rapid technological growth, creating regulatory grey areas. Issues like data privacy, AI liability, and digital rights remain unresolved globally.
- Tech advancements challenge core ethical values such as autonomy, consent, and fairness. Moral responsibility in AI decisions and surveillance is a growing concern.
- Feminist scholars reveal how science and tech have historically excluded and marginalised women's perspectives. They call for inclusive, gender-aware approaches in research and innovation.
- Technology often reflects dominant ideologies like capitalism, patriarchy, or nationalism. It can reinforce inequality or become a tool of social control.
- Technologies are part of networks involving both humans and non-humans. This makes tech a social actor with influence over social behaviour.
- Cognitive, legal, ethical, feminist, and ideological challenges often overlap. A change in one dimension often impacts the others.
- Gendered assumptions are embedded in technology design and function. Feminist critiques demand accountability and inclusivity in technological development.

- Public responses to science are shaped by cultural, emotional, and political factors. Cognitive dissonance emerges when tech conflicts with social beliefs.
- Scientific agendas are shaped by political ideologies and cultural narratives. Nationalism, religion, or economic interests often guide science policy.
- Sociology encourages questioning of who controls technology and for whose benefit. It fosters reflexivity to imagine more equitable tech futures.

Objective Questions

1. Who introduced the concept of the 'Matthew Effect' in science?
2. Which sociologist is associated with Actor-Network Theory?
3. Who authored *The Science Question in Feminism*?
4. Which feminist scholar wrote *Has Feminism Changed Science*?
5. What kind of knowledge does SSK explore?
6. Who wrote *Laboratory Life* with Latour?
7. Which ideology often influences science policy decisions?
8. Which term describes gendered roles in scientific metaphors (e.g., egg and sperm)?
9. What is the key concern in legal debates over AI?
10. Which social institution is critiqued in *The Death of Nature* by Merchant?

Answers

1. Merton
2. Latour
3. Harding
4. Schiebinger
5. Constructivist
6. Woolgar
7. Nationalism
8. Stereotypes
9. Liability
10. Science

Assignments

1. Critically evaluate the cognitive challenges posed by Artificial Intelligence in scientific knowledge production using examples from contemporary technology.
2. Discuss the legal and ethical dilemmas that emerge from data surveillance and digital privacy using sociological frameworks.
3. Examine how feminist perspectives challenge the traditional understanding of science as gender-neutral. Include examples from Indian contexts where possible.
4. Analyse how ideological influences shape scientific research agendas and technology policy in India.
5. Compare and contrast the constructivist view of science with positivist approaches, drawing on the Sociology of Scientific Knowledge (SSK).

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2

UNIT

Digital Technology and Pandemic

Learning Outcomes

After the completion of this unit, the learner will be able to:

- discuss the sociological dimensions of digital technology usage during the COVID-19 pandemic
- analyse how digital technologies shaped public health responses, communication, education, and labour during the crisis
- examine the digital divide and its implications for social inequality and access during the pandemic
- explore the role of state, corporate, and scientific actors in shaping narratives and policies around technological intervention

Prerequisites

Understanding the role of digital technology during the COVID-19 pandemic requires a basic awareness of how technology operates not merely as a set of tools but as embedded within social, cultural, and political systems. Familiarity with foundational concepts in sociology, such as social institutions, inequality, and power relations, as well as introductory ideas from Science and Technology Studies (STS), like the co-production of science and society and the constructivist view of scientific knowledge, is beneficial.

It is also helpful to have a contextual understanding of the global and Indian responses to the pandemic particularly how digital tools were employed in areas like healthcare (e.g., contact tracing apps), education (e.g., online learning platforms), and governance (e.g., digital surveillance and vaccine registration portals). Prior exposure to discussions around digital literacy, access disparities, and ethical challenges in technological use further enhances critical engagement with the material.

To encourage critical reflection, one should consider: Who had access to digital services during the pandemic and who was excluded? How did gender, caste, and class shape experiences of digital connectivity? Can technology be both a tool of empowerment and control? By drawing on these questions, digital responses to the pandemic can be examined not as neutral or purely technical interventions but as socially and politically mediated processes with long-term implications.

Keywords

Digital technology, COVID-19, Digital divide, Surveillance technology, Social inequality, Social construction of technology (SCOT), Techno-solutionism

Discussion

The COVID-19 pandemic refers to the global outbreak of the novel coronavirus (SARS-CoV-2), first identified in Wuhan, China, in late 2019. It rapidly spread worldwide, leading the World Health Organization (WHO) to declare it a pandemic in March 2020. Characterised by symptoms like fever, cough, and breathing difficulties, COVID-19 significantly impacted public health, economies, and daily life. Governments imposed lockdowns, travel bans, and social distancing measures to curb transmission. The pandemic exposed healthcare challenges and deepened existing social inequalities, while also accelerating the use of digital technology in areas such as remote work, education, telemedicine, and public health communication.

5.2.1 Digital Technology and the COVID-19 Pandemic

The COVID-19 pandemic was not merely a health crisis; it was a social turning point that exposed and transformed the relationship between society and digital technology. As nations grappled with lockdowns, restricted mobility, and overwhelmed health systems, digital tools emerged as critical infrastructures for survival, governance, and communication. However, their usage also revealed deeper sociological undercurrents ranging from inequality and surveillance to ethical concerns and shifting power dynamics.

1. Sociological Dimensions of Digital Technology Usage

The sociological study of technology, as emphasized by theorists like Bijker and Law, suggests that technological artefacts are not neutral tools but are embedded with values, assumptions, and power relations. During the pandemic, the mass adoption of contact-tracing apps, digital health records, and virtual platforms reflected a techno-centric response to a socio-medical crisis. These technologies became sites of negotiation between safety, autonomy, and control making visible the intricate interplay between society, technology, and institutions.

Latour's Actor-Network Theory further helps us understand how digital tools like Aarogya Setu in India became nodes in a larger socio-technical network linking individuals, mobile devices, state policies, and epidemiological data. These digital assemblages redefined how individuals experienced the pandemic and how states managed populations.

2. Shaping Public Health, Education, Communication, and Labour

Digital technologies played a crucial role in shaping public health interventions enabling data tracking, vaccine registrations, and the dissemination of medical advisories. But their impact went beyond health. The rapid transition to online education platforms created new learning environments, while also highlighting stark disparities in digital access. The labour market also underwent significant transformation. Remote work, gig platforms, and automation replaced many traditional forms of employment. While these shifts offered flexibility and continuity, they also reinforced precarity and technological dependency. As Pickering argues, science and technology must be seen as cultural practices, subject to societal context and human resistance. In terms of communication, digital media enabled both community-building and disinformation. The spread of rumours, conspiracy theories, and anti-vaccine propaganda highlighted the limitations of digital literacy and the challenges of algorithm-driven information systems.

3. The Digital Divide and Social Inequality

The pandemic amplified the digital divide defined not just by access to devices and the internet, but also by digital literacy, affordability, and sociocultural constraints. In India, the closure of schools led to millions of children, especially girls and those from rural or poor households, falling behind in education. Feminist scholars such as Sandra Harding and Donna Haraway have long pointed out that science and technology are not immune to gendered biases. Access to digital spaces during the pandemic was shaped by patriarchal norms, economic disparities, and urban-rural divides. Moreover, the standpoint epistemology promoted by feminist theorists challenges the assumption that technology is universally accessible or beneficial. Women's experiences particularly in terms of digital surveillance, online harassment, and unpaid domestic labour demonstrate how the pandemic's technological shift exacerbated existing inequalities.

> The Digital Divide refers to the gap between individuals, communities, or nations that have access to modern information and communication technologies (ICTs) and those that do not. This divide is influenced by factors such as economic inequality, geographic location, education, gender, and infrastructure availability. During the COVID-19 pandemic, the digital divide became more pronounced as access to online education, telemedicine, and digital services became essential. Those without reliable internet or digital literacy were disproportionately affected, deepening social and economic disparities. Addressing the digital divide is crucial for inclusive development and ensuring equal participation in an increasingly digital world.

4. The Role of State, Corporate, and Scientific Actors

The pandemic response saw increased involvement of state agencies, tech corporations, and scientific institutions in shaping digital interventions. From vaccine rollouts to contact tracing, technology was framed as a neutral solution to public problems. However, David Hess reminds us that science and technology are also sites of cultural and political contestation. Government partnerships with private tech firms, such as those involved in data collection and AI-powered health diagnostics, raise questions about transparency, data ownership, and accountability. Joerges argues that artefacts can embody political decisions seen clearly when the state mandated the use of certain apps or linked digital health passes with mobility rights. The Science and Technology Studies (STS) approach by Visvanathan and Nandy urges us to consider multiple epistemologies and resist homogenised narratives. This is vital when digital solutions developed in elite urban contexts are applied uniformly to diverse and unequal populations.

5. Ethical, Feminist, and Ideological Challenges

The increased reliance on digital tools raised numerous ethical concerns particularly around surveillance, consent, and data privacy. Apps that tracked movement or collected health data often lacked robust mechanisms for user control or redress. These interventions, while framed as necessary for public health, blur the boundaries between civic responsibility and state overreach. From a feminist and postcolonial perspective, the dominant techno-solutionism during the pandemic mirrored a top-down, patriarchal, and technocratic approach. As Thomas and Keller highlight, ethical responses to technological crises must involve inclusive participation, local knowledge systems, and critical engagement with power structures. The ideology of digital progress masked the dispossession and marginalisation experienced by those outside the digital fold women, tribal communities, informal workers, and the elderly. Technological interventions must therefore be critically examined for whose interests they serve and whose voices they silence.

6. Techno-Social Transformations and Shifting Boundaries

The pandemic marked an acceleration of techno-social transformations. Workplaces moved online, public services became digital-first, and social interactions were mediated through screens. These changes altered the relationship between public and private life. Homes simultaneously became offices, schools, and health clinics reshaping family dynamics, labour roles, and emotional well-being. This blurring of boundaries also led to increased surveillance within the private sphere whether through workplace monitoring software or health-tracking apps. Bourdieu's Science of Science and Reflexivity provides a lens to reflect on how scientific authority and technological rationality redefined the boundaries of acceptable behaviour and self-governance during the crisis. Community engagement and localised science communication can offer alternatives to centralised, one-size-fits-all technological solutions. Such models highlight the potential for more democratic and participatory technological futures.

Drawing from the Social Construction of Technology (SCOT) the pandemic highlighted how technologies are not neutral artefacts but are embedded with social intentions, shaped by the needs, biases, and power structures of their developers and users. For instance, India's *Aarogya Setu* app, aimed at contact tracing and self-assessment, was framed as a public health tool. However, concerns around surveillance, data privacy, and inclusivity emerged, especially when the app became mandatory for access to public spaces and services.

Bruno Latour's Actor-Network Theory (ANT) is also relevant here. It urges us to view technology not in isolation but as part of a web of relations between human and non-human actors. The pandemic saw an expansion of these networks connecting citizens, smartphones, algorithms, health databases, and policy frameworks. These assemblages made possible the coordination of lockdowns, vaccine registrations, and movement tracking but also made visible deep inequalities in who could participate in these networks.

5.2.2 The Digital Divide and Technological Access

Digital technology refers to electronic tools, systems, and devices that generate, store, or process data. These include computers, smartphones, the internet, artificial intelligence, cloud computing, and other innovations that enable fast communication, automation, and access to information. Unlike analog systems, digital technologies convert information into binary code (0s and 1s), allowing efficient storage, transfer, and manipulation of data. In modern society, digital technology influences almost every aspect of life, including education, healthcare, business, and social interactions. It also shapes how we work, learn, shop, and connect, making it a powerful force in global technological advancement.

The digital divide, a term that reflects the unequal access to digital tools and the internet, became starkly evident during the pandemic. As education shifted online, millions of students particularly in rural or economically marginalised communities were left behind due to a lack of smartphones, stable internet, or digital literacy. The work of scholars like Sandra Harding and Donna Haraway, who emphasise standpoint epistemology and feminist critiques of science, helps us understand how class, gender, and geography intersect to shape experiences with digital technologies. For example, women in lower-income households were more likely to be excluded from digital platforms, either due to a lack of ownership of devices or sociocultural restrictions. This gendered aspect of technological access echoes the feminist arguments that science and technology often ignore the lived experiences of marginalised populations.

5.2.3 Surveillance, Biopolitics, and Algorithmic Control

The pandemic saw the rise of biopolitical governance through technology, where the state extended its control over bodies via digital tools. This is consistent with Michel Foucault's notion of surveillance and power though not listed in your references, his influence permeates works like Latour's ANT and Bourdieu's Science of Science and Reflexivity. Health status, travel history, and location data became inputs for algorithmic decisions on mobility and access. While these measures were justified in the name of public safety, they raised important questions about consent, digital rights, and the normalization of surveillance. The sociological study of artefacts as political becomes important here. Technology, especially during emergencies, often carries embedded political agendas. Who decides how digital data is collected, stored, and used? Whose voices are heard in the design of these tools? These are central concerns raised in David Hess's multicultural and reflexive approach to science.

5.2.4 Misinformation, Trust, and Digital Literacy

Another challenge was the spread of misinformation, or the so-called infodemic. Despite access to vast information online, many communities found it difficult to distinguish credible sources. This points to the importance of scientific literacy and public engagement with science. Mistrust in vaccines, conspiracy theories, and religious or cultural skepticism around health measures exposed the limits of digital communication when it is not supported by socio-cultural understanding and participatory dialogue.

Technological Resilience vs. Human Vulnerability

On the other hand, digital platforms did offer significant benefits enabling remote work, online education, virtual healthcare (telemedicine), and emotional support networks. Pickering's Science as Practice and Culture highlights how technological practices are always situated within broader cultures of adaptation and resistance. In India, digital grassroots movements such as those by the Kerala Sastra Sahitya Parishad played a key role in making science communication more inclusive during the pandemic, demonstrating how local, community-based tech engagement can foster resilience.

The COVID-19 pandemic offered a real-time case study in how digital technology becomes a site of both promise and peril. From a sociological standpoint, it is clear that technology cannot be divorced from the social conditions in which it operates. Access, trust, inequality, and ethics all shape how digital tools function in times of crisis. As science and technology continue to influence public life, particularly during emergencies, it becomes essential to approach them not just through technical efficacy but through a critical, inclusive, and socially aware framework.

Recap

- The pandemic made digital technology a vital medium for communication, work, and survival. It became the bridge between isolation and engagement in an otherwise locked-down world.
- With schools and colleges shut, education migrated online, exposing deep-rooted inequalities in access to devices, internet, and digital literacy. This shift challenged traditional classroom dynamics and widened the urban-rural education gap.
- Digital platforms enabled virtual consultations, contact tracing, and vaccination drives. However, digital illiteracy and poor connectivity excluded large sections of society from these benefits.
- The pandemic normalised remote work through digital tools like Zoom, Teams, and Slack. While it offered flexibility for some, it also blurred boundaries between work and personal life, especially for women.
- The unequal distribution of digital resources became starkly visible during the pandemic. Class, caste, gender, and geography determined one's access to digital technology and, thereby, to opportunities.
- Governments employed apps like Aarogya Setu for surveillance under the guise of public health. This raised concerns about data privacy, consent, and long-term misuse of digital records.

- Women's increased domestic workload and limited access to personal digital devices revealed gendered exclusions in digital engagement. Feminist scholars argue that technology is not neutral but shaped by power.
- Scientific discourse around COVID-19 was often mediated through digital platforms controlled by the state and corporations. This highlighted how power influences what becomes accepted as "scientific truth."
- The home turned into a multi-functional space office, classroom, and clinic reshaping notions of private and public. This transformation invites new sociological interpretations of space and social roles.
- Social media became a space for emotional solidarity, resource sharing, and activism. However, it also bred misinformation, panic, and polarization in crisis communication.
- COVID-19 marked a turning point where digital integration into daily life accelerated beyond return. Sociologically, this demands ongoing critique of how technology mediates inequality, identity, and power.

Objective Questions

1. What kind of divide became more visible due to unequal access to online learning during COVID-19?
2. Which form of communication was most used for remote work during the pandemic?
3. What type of platforms were used widely for online classes during lockdown?
4. Which sector saw a significant rise in digital consultations during the pandemic?
5. Which surveillance technology was used by many governments to track COVID cases?
6. What is the term for working from home using digital devices?
7. What online service became crucial for food and grocery delivery?

8. Which term refers to the lack of internet access in rural areas?
9. What kind of tools helped in virtual mental health counselling?
10. What social media platform was widely used for awareness during the pandemic?

Answers

1. Digital
2. Zoom
3. LMS
4. Healthcare
5. Apps
6. Telework
7. E-commerce
8. Connectivity
9. Chatbots
10. Twitter

Assignments

1. Discuss how the COVID-19 pandemic has accelerated the integration of digital technology in education and its implications for social inequality in India.
2. Analyse the concept of the digital divide in the context of remote healthcare and telemedicine during the pandemic.
3. Critically evaluate the role of state surveillance and contact-tracing apps during COVID-19 from a sociological and ethical perspective.
4. Examine how gendered experiences shaped the use of digital platforms for work and communication during lockdown.
5. Explore the interplay between science, state policy, and digital technology in managing public health narratives during the COVID-19 crisis.

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6

BLOCK

Science- Society Interface in Kerala

UNIT 1

Science and Technology in Kerala

Learning Outcomes

After the completion of this unit, the learner will be able to:

- examine the historical development of science and technology in Kerala
- analyse the origins and objectives of the rationalist movement in Kerala
- discuss the concept of people's science movements and their relevance in Kerala

Prerequisites

A background in Kerala's social and cultural history, including key reform movements and the contributions of leaders like Sree Narayana Guru and Ayyankali, is essential. Knowledge of the Indian renaissance and reform movements, such as the Brahma Samaj and Arya Samaj, helps contextualise the rise of rationalism in Kerala. Understanding the concept of scientific temper, as emphasised by Jawaharlal Nehru, and the role of nationalist movements in challenging superstition and unscientific beliefs is crucial. Additionally, familiarity with grassroots movements and their role in science popularisation and policy change will provide a strong foundation for comprehending the significance of People's Science Movements in Kerala.

Keywords

ISRO, Mangalyan, Chandrayan, Akshaya centers, ICT, Bio-technology, Rationalist movement

Discussion

Kerala, often called "God's Own Country," has made impressive progress in integrating science and technology into its development journey. The state is known for its forward-thinking approach, especially in space research, Information Technology, biotechnology, and renewable energy. With institutions such as the Vikram Sarabhai Space Centre (VSSC) and the Indian Institute of Space Science and Technology (IIST), Kerala has significantly contributed to India's advancements in space exploration. The state has become a hub for interdisciplinary research, agricultural innovation, and marine biodiversity studies, thanks to institutions like National Institute for Interdisciplinary Science and Technology (NIIST), Kerala Agricultural University and Centre for Marine Living Resources and Ecology (CMLRE). Kerala's emphasis on e-governance and initiatives like Technopark and Infopark showcase its commitment to blending technology with everyday life. This harmonious integration of traditional wisdom and modern technology makes Kerala a sustainable and innovative development leader.

6.1.1 Space, Science, and Technology Institutions

a. ISRO

The Indian Space Research Organisation (ISRO) is India's national space agency, known for its groundbreaking achievements in space exploration and technology development. Established in 1969 under the visionary leadership of Dr. Vikram Sarabhai, ISRO has played a pivotal role in transforming India into a global space power. Its mission is to harness space technology for national development while advancing scientific research and exploration. ISRO's headquarters are in Bengaluru, Karnataka, but its impact is felt across India, including Kerala, which is home to several key facilities. The Vikram Sarabhai Space Centre (VSSC) in Thiruvananthapuram is the backbone of ISRO's satellite launch vehicle programme. It has been instrumental in developing launch vehicles such as PSLV (Polar Satellite Launch Vehicle) and GSLV (Geosynchronous Satellite Launch Vehicle), enabling India to launch numerous satellites for various applications. Another notable facility in Kerala is the Liquid Propulsion Systems Centre (LPSC), which specialises in developing liquid propulsion systems for rockets and spacecraft. These technologies have powered ISRO's ambitious missions, including Chandrayaan (India's lunar exploration programme) and Mangalyaan (Mars Orbiter Mission), showcasing the agency's capability to undertake complex interplanetary missions.

ISRO's achievements extend beyond launch vehicles and interplanetary missions. It has significantly contributed to satellite technology, providing vital communication, navigation, earth observation, and disaster management services. Projects like the NavIC satellite navigation system and Radar Imaging Satellite (RISAT) series for remote sensing have profoundly impacted India's infrastructure and economy. One of ISRO's most celebrated missions is the Chandrayaan series, which marked India's entry into lunar exploration. Chandrayaan-1, launched in 2008, discovered water molecules on the Moon, while Chandrayaan-2 aimed to explore the lunar surface in greater detail. The Mars Orbiter Mission (Mangalyaan), launched in 2013, was another landmark achievement, making India the first Asian country to reach Mars orbit and one of the most cost-effective missions in the world. ISRO is also focused on human spaceflight with its Gaganyaan mission, which aims to send Indian astronauts (Gagannauts) into space. This ambitious project highlights ISRO's determination to push the boundaries of space exploration. Through its consistent achievements, ISRO has strengthened India's position in the global space community and inspired a new generation of scientists, engineers, and space enthusiasts. Its vision of using space technology for societal benefits has had a transformative impact on India's development.

b. IIST

The Indian Institute of Space Science and Technology (IIST), established in 2007, is a premier academic and research institution in Thiruvananthapuram, Kerala. It was founded under the Department of Space, Government of India, aiming to meet the growing demand for trained space science and technology professionals. The institute is regarded as the first in Asia and specialises exclusively in offering courses and research opportunities in space science and allied disciplines. IIST offers a range of programmes, including undergraduate, postgraduate, and doctoral courses, which are meticulously designed to align with the needs of the Indian Space Research Organisation (ISRO). Undergraduate programmes like B.Tech in Aerospace Engineering and Avionics are tailored to provide students with a strong foundation in engineering principles.

In contrast, advanced postgraduate courses and research programmes delve into specialised areas such as materials science, astrophysics, and propulsion systems. The institute is pivotal in equipping students with hands-on experience through its collaboration with ISRO. Students actively participate in research and development projects and contribute to real-world space missions. This unique integration of education and practical exposure ensures that graduates from IIST are well-prepared to tackle the challenges of modern space exploration and innovation.

IIST also fosters an environment of academic excellence by engaging in cutting-edge research. The faculty and students are involved in projects spanning satellite technology, launch vehicle development, space systems design, and interplanetary mission studies. Their contributions have bolstered India's position as a primary global space research and exploration player. A significant aspect of IIST's vision is to promote interdisciplinary research by collaborating with national and international institutions. This allows the institute to remain at the forefront of technological advancements and facilitates knowledge exchange in robotics, artificial intelligence, and space-based communication systems. The institute encourages innovation through its state-of-the-art infrastructure, which includes advanced laboratories, research facilities, and simulation centres. These resources empower students and researchers to experiment and develop new technologies, often leading to groundbreaking discoveries in space science.

One of the distinctive features of IIST is its placement programme, which directly links students with ISRO. Many of its graduates are absorbed into ISRO's workforce, contributing to the nation's space missions, including Chandrayaan, Mangalyaan, and Gaganyaan. This seamless transition from education to employment sets IIST apart from other institutions. Beyond academics, IIST strongly emphasises fostering creativity and curiosity among its students. It organises workshops, seminars, and competitions, encouraging young minds to think outside the box and explore innovative solutions to complex problems. IIST's commitment to education and research is complemented by its broader mission to contribute to India's self-reliance in space technology. The institute addresses the nation's needs by nurturing a new generation of scientists and engineers, inspiring global collaboration in scientific endeavours. The Indian Institute of Space Science and Technology is a beacon of excellence in space education and research. Its contributions to the Indian space programme and its focus on fostering innovation make it a cornerstone in the nation's journey towards becoming a leader in space exploration. Its role is not just limited to academic achievements but extends to shaping the future of space science in India and beyond.

c. NIIST

The National Institute for Interdisciplinary Science and Technology (NIIST), based in Thiruvananthapuram, Kerala, is one of India's leading research institutions. Operating under the Council of Scientific and Industrial Research (CSIR), NIIST has a distinguished legacy of contributing to scientific innovation and addressing challenges in various fields. Initially established in 1975 as the Regional Research Laboratory (RRL), the institution was renamed NIIST in 2007 to better reflect its broad, interdisciplinary focus. NIIST is dedicated to conducting high-quality research in diverse areas such as materials science, chemical sciences, environmental technology, process engineering, and agro-processing. The institute is well-known for its state of the art facilities, which enable cutting-edge research and the development of innovative technologies. It hosts advanced laboratories, pilot plants, and experimental setups supporting fundamental scientific inquiry and applied research for industrial use. Materials science is one of NIIST's core research areas. The institute has developed advanced materials for applications ranging from energy storage to environmental sustainability. For instance, researchers work on nanomaterials, functional polymers, and composite materials that find use in renewable energy systems, including batteries and fuel cells. This work is critical in addressing global energy challenges and promoting sustainability.

NIIST has contributed to the development of new catalysts, speciality chemicals, and green chemical processes in chemical sciences. These innovations help industries transition to more efficient and environmentally friendly production methods. Moreover, the institute collaborates with industries to scale laboratory findings into commercially viable solutions, strengthening the link between science and industry. NIIST is also a pioneer in environmental science and technology. Researchers focus on water treatment, air pollution control, and waste management. The institute has developed technologies for sustainable water purification and the utilisation of industrial waste, contributing significantly to environmental conservation and resource optimisation. Agro-processing research is another critical area at NIIST. The institute has significantly developed value-added technologies for spices, oilseeds, and other agricultural products. By enhancing these products' quality and shelf life, NIIST's innovations benefit farmers and the food processing industry, contributing to economic growth in agricultural regions. The interdisciplinary approach at NIIST extends to process engineering, where researchers integrate knowledge from various fields to develop efficient, scalable industrial processes. These projects often involve collaborations with other CSIR laboratories, academic institutions, and industries, fostering a spirit of teamwork and innovation.

NIIST is also deeply committed to human resource development. It offers training and research opportunities for postgraduate and doctoral students, nurturing the next generation of scientists and engineers. Many students who complete their studies at NIIST make valuable contributions in academia, research, and industry. In addition to its research and training activities, NIIST engages in knowledge dissemination through seminars, workshops, and conferences. These events provide a platform for scientists, researchers, and industry leaders to share insights and collaborate on solving pressing challenges. NIIST also works on projects of national importance, aligning its research with India's developmental goals. NIIST is a beacon of scientific excellence and innovation in Kerala and beyond. Its contributions to materials science, environmental conservation, agro-processing, and chemical engineering underscore its role as a critical player in addressing societal challenges. By blending research with real-world applications, NIIST continues to uphold its mission of advancing science and technology for the betterment of society.

d. Technopark and Infopark

Kerala's tech infrastructure stands out as a vital component of the state's economic development, with Technopark in Thiruvananthapuram and Infopark in Kochi leading the way. These IT hubs have transformed the state into a prominent destination for technology and innovation, contributing significantly to India's IT revolution. Technopark, established in 1990, is India's first IT park and one of the largest in the country. Spanning over 760 acres, it provides world-class facilities to over 450 companies, ranging from global IT giants to emerging start-ups. The park's modern infrastructure, including high-speed internet, uninterrupted power supply, and eco-friendly workspaces, has made it an ideal environment for IT professionals and entrepreneurs.

Infopark, located in Kochi, was inaugurated in 2004 and quickly became a key player in Kerala's IT landscape. Spread across 160 acres, it hosts more than 200 companies and is a hub for software development, IT-enabled services, and outsourcing. Its strategic location near Cochin International Airport has made it accessible to global clients, attracting multinational corporations such as Wipro, Cognizant, and TCS. Both Technopark and Infopark prioritise innovation through their dedicated incubation centres. These centres support start-ups by providing resources, mentorship, and collaborative spaces. They nurture creativity and entrepreneurship, enabling Kerala-based start-ups to compete globally.

The parks have significantly contributed to employment generation in Kerala. Together, they have created thousands of direct and indirect jobs, attracting skilled professionals nationwide. This influx of talent has also boosted related sectors like real estate, education, and transportation, fuelling the state's economy. Beyond their economic impact, Technopark and Infopark are known for their sustainability initiatives. They incorporate eco-friendly practices such as rainwater harvesting, green buildings, and waste management, ensuring a minimal environmental footprint. These efforts align with Kerala's broader focus on sustainable development. Education and training are integral to the success of these IT hubs. Both parks collaborate with academic institutions to bridge the skill gap by offering training programmes, workshops, and internships. This ensures that the local workforce is well-equipped to meet the demands of the ever-evolving IT industry. The global recognition of Technopark and Infopark has positioned Kerala as an emerging technology destination. Their success has attracted investments from international companies, fostering collaborations that boost Kerala's standing on the global stage. They also contribute to the state's IT exports, generating substantial revenue.

The social impact of these hubs is profound. They have empowered the local population by creating an environment that promotes digital literacy, innovation, and entrepreneurship. This, in turn, has contributed to Kerala's reputation as a progressive and development-oriented state. Technopark and Infopark exemplify Kerala's commitment to leveraging technology for economic growth and societal transformation. Their emphasis on innovation, sustainability, and community development sets them apart as models for IT parks nationwide. These hubs drive the state's technological growth and inspire its vision for a future powered by knowledge and innovation.

6.1.2 E-Governance and Digital Transformation in Kerala

Kerala has pioneered e-governance initiatives, with the Akshaya project standing out as a transformative effort. Launched in 2002, Akshaya aimed to bridge the digital divide by promoting e-literacy and providing access to government services through Information and Communication Technology (ICT). This initiative has played a crucial role in empowering citizens and enhancing transparency in governance. The Akshaya project established a network of over 2,650 Akshaya Centres across Kerala, ensuring that even the most remote areas have access to digital services. These centres act as Common Service Centres (CSCs), offering a wide range of services, including Aadhaar enrolment, utility bill payments, ration card applications, and e-filing of taxes. By bringing these services under one roof, Akshaya has made government processes more accessible and efficient for citizens. One of the key achievements of the Akshaya project is its contribution to making Kerala the first e-literate state in India. The initiative has educated millions on basic computer skills through digital literacy programmes, enabling them to navigate the digital world confidently. This has improved individual capabilities and fostered a culture of digital inclusion.

Akshaya, Kerala, has implemented several other e-governance initiatives to streamline public services. The e-District project, for instance, integrates various government departments to provide services such as certificates, licences, and grievance redressal services online. This has significantly reduced the time and effort required by citizens to access essential services. The state has also implemented the Service and Payroll Administrative Repository for Kerala (SPARK), an integrated personnel management system for government personnel. SPARK ensures transparency and efficiency in payroll and administrative processes, benefiting both employees and the administration. Kerala's e-governance efforts extend to the healthcare sector through the e-Health project. This initiative provides a centralised database of healthcare information, enabling efficient delivery of medical services and better management of healthcare resources. It also facilitates online appointment booking and citizens' access to medical records.

The state has leveraged information and communication technology (ICT) to improve agricultural practices through initiatives such as the Agriculture Information Management System (AIMS). This platform offers real-time data on crop patterns, livestock health, and weather conditions, helping farmers make informed decisions and enhancing agricultural productivity. Kerala's e-governance infrastructure is supported by the Kerala State Wide Area Network (KSWAN), which connects government offices across the state. This robust network ensures seamless communication and data exchange, enabling the efficient delivery of e-governance services. The success of Kerala's e-governance initiatives lies in their citizen-centric approach. By prioritising accessibility, transparency, and efficiency, these projects have transformed how government services are delivered. They have also empowered citizens by giving them the tools and knowledge to participate actively in governance. Kerala's Akshaya project and other e-governance initiatives have set a benchmark for the rest of the country. By harnessing the power of technology, the state has improved governance and enhanced the quality of life for its citizens. These efforts reflect Kerala's commitment to building a digitally inclusive and progressive society.

6.1.3 Scientific Research and Sustainable Development

Agriculture and Research

Kerala Agricultural University (KAU) is a beacon of agricultural innovation and research in India and is strongly committed to promoting sustainable agricultural practices. Established in 1971 and headquartered in Thrissur, KAU plays a pivotal role in addressing the challenges faced by the agricultural sector, particularly in Kerala's unique agro-climatic conditions. Its efforts aim to ensure food security, environmental sustainability, and economic viability for farmers. KAU primarily focuses on sustainable farming systems that balance ecological, social, and economic dimensions. The university emphasises integrated nutrient management, organic farming, and crop diversification practices. These approaches enhance soil health and productivity and reduce the dependency on chemical inputs, making farming more environmentally friendly. KAU has been instrumental in developing innovative technologies and solutions tailored to Kerala's agricultural landscape. For instance, the university has introduced high-yielding and disease-resistant crop varieties, particularly rice, coconut, and spices, which are staple crops in the region. These advancements have significantly improved the resilience of farmers to climate change and pest outbreaks.

The university also prioritises research in agro-processing and value addition, enabling farmers to maximise their income. By developing technologies for processing and preserving agricultural produce, KAU helps reduce post-harvest losses and opens up new market opportunities for farmers. This is particularly important for Kerala, where spices and plantation crops play a significant economic role. KAU's commitment to sustainability also extends to water and soil management. The university conducts extensive research on efficient irrigation techniques, soil conservation methods, and the use of bio-fertilisers. These initiatives aim to optimise resource utilisation while minimising environmental degradation, ensuring long-term agricultural productivity. In addition to research, KAU plays a vital role in capacity building and knowledge dissemination. The university trains farmers, agricultural officers, and students in sustainable farming practices through extension programmes. These programmes include workshops, field demonstrations, and distributing educational materials, ensuring that the latest advancements reach the grassroots level.

Kerala Agricultural University collaborates with national and international organisations to address global agricultural challenges. Its partnerships with institutions like ICAR (Indian Council of Agricultural Research) and FAO (Food and Agriculture Organization) facilitate the exchange of knowledge and resources, enabling the university to stay at the forefront of agricultural innovation. The university's focus on organic farming has gained significant attention recently. KAU has developed comprehensive guidelines and technologies for organic cultivation, promoting natural inputs and eco-friendly pest management techniques. This aligns with Kerala's broader vision of establishing a hub for organic agriculture. KAU's efforts are not limited to traditional farming practices. The university is actively involved in exploring modern agricultural technologies such as precision farming, hydroponics, and vertical farming. These innovations are particularly relevant in urbanisation and shrinking agricultural land, offering sustainable solutions for food production. Kerala Agricultural University remains a cornerstone of agricultural research and education in Kerala. Its unwavering commitment to sustainable practices, farmer empowerment, and technological innovation has driven it to transform the state's agricultural landscape. By addressing local and global challenges, KAU continues to play a crucial role in shaping the future of agriculture.

Marine Research

The Centre for Marine Living Resources and Ecology (CMLRE), located in Kochi, Kerala, is a leading institution under the Ministry of Earth Sciences, Government of India. Established in 1998, CMLRE focuses on the sustainable management and conservation of marine biodiversity within India's Exclusive Economic Zone (EEZ). Its mission is to explore, assess, and sustainably utilise marine living resources while ensuring the ecological balance of marine ecosystems. CMLRE plays a pivotal role in conducting systematic surveys and assessments of marine biodiversity. Using advanced technologies and research vessels such as the Fishery Oceanographic Research Vessel (FORV) Sagar Sampada, the centre collects valuable data on marine species, their habitats, and the environmental factors affecting them. This information is crucial for understanding marine ecosystems' dynamics and developing conservation strategies. One of the key programmes undertaken by CMLRE is the Marine Living Resources (MLR) programme. This initiative focuses on mapping and inventorying commercially exploitable marine resources, such as fish stocks, crustaceans, and molluscs. By studying the response of these resources to environmental changes, the programme aims to develop ecosystem-based models for sustainable fisheries management.

CMLRE is also involved in cutting-edge research on deep-sea ecosystems. The centre studies deep-sea fishery resources, bioluminescent plankton, and benthic organisms found in the continental slope areas. These efforts contribute to discovering new species and understanding deep-sea biodiversity, which remains one of the least explored frontiers of marine science. In addition to biodiversity studies, CMLRE addresses pressing environmental issues such as harmful algal blooms and marine pollution. The centre's research helps identify the causes and impacts of these phenomena, enabling the development of mitigation strategies to protect marine ecosystems and coastal communities. CMLRE's work extends to the development of application-oriented technologies. For example, the centre has explored the production of pearls from black-lip pearl oysters and the development of antifouling compounds from marine organisms. These innovations have potential applications in aquaculture and marine industries, contributing to economic growth.

The centre actively collaborates with national and international organisations to enhance its research capabilities. Partnerships with institutions like the National Institute of Oceanography (NIO) and global marine research networks facilitate knowledge exchange and the adoption of best practices in marine conservation. CMLRE is dedicated to capacity building and knowledge dissemination. It organises training programmes, workshops, and seminars for researchers, students, and policymakers. These initiatives aim to raise awareness about marine conservation and equip stakeholders with the skills needed to address marine environmental challenges. The centre also maintains a comprehensive marine biodiversity and ecosystem studies data repository. This database is a valuable resource for researchers, policymakers, and conservationists, supporting evidence-based decision-making for marine resource management. The Centre for Marine Living Resources and Ecology is at India's marine research and conservation forefront. Its multidisciplinary approach, combining biodiversity studies, environmental monitoring, and technological innovation, ensures the sustainable management of marine resources. By addressing scientific and societal needs, CMLRE plays a vital role in safeguarding India's marine ecosystems for future generations.

6.1.4 Renewable Energy

Kerala has emerged as a leader in renewable energy adoption, leveraging its natural resources to promote sustainable energy solutions. The state has made significant investments in solar, wind, and hydropower projects, aligning with its vision of reducing carbon emissions and achieving energy self-sufficiency. These initiatives are driven by the Kerala State Electricity Board (KSEB) and the Agency for Non-conventional Energy and Rural Technology (ANERT), which play pivotal roles in implementing renewable energy programmes. Solar energy is a key focus area for Kerala, with numerous projects aimed at harnessing the abundant sunlight in the region. The state has implemented rooftop solar programmes under the "Soura" initiative, encouraging households and institutions to install solar panels.

Additionally, Kerala has explored innovative solutions like floating solar photovoltaic (FSPV) systems, which utilise water bodies such as reservoirs and dams for solar power generation. These projects not only address land constraints but also enhance energy efficiency. Wind energy is another promising avenue for renewable energy in Kerala. The state has identified high-potential wind zones, particularly in Palakkad and Idukki. Although the current installed capacity of wind power is relatively modest, efforts are underway to expand this sector through public-private partnerships and advanced wind turbine technologies. These initiatives aim to tap into Kerala's untapped wind energy potential, estimated to be over 2,000 MW.

Given the state's abundant water resources, hydropower has been a cornerstone of Kerala's energy strategy for decades. Major hydropower projects, such as the Idukki and Sabarigiri dams, contribute significantly to the state's electricity supply. In recent years, Kerala has focused on modernising its hydropower infrastructure to improve efficiency and reduce environmental impacts. Small and micro-hydropower projects are also being developed to cater to local energy needs in remote areas. Kerala's commitment to renewable energy extends to biomass and waste-to-energy projects. The state has initiated programmes to convert agricultural and organic waste into biogas and electricity, providing a sustainable solution for waste management. These projects generate clean energy and create additional income streams for farmers and rural communities. The state has also integrated renewable energy into its power grid. Advanced energy storage systems and innovative grid technologies are being deployed to ensure the stability and reliability of the electricity supply. These measures are crucial for managing the intermittent nature of renewable energy sources like solar and wind.

Robust policy frameworks and financial incentives support Kerala's renewable energy initiatives. The state government offers subsidies and tax benefits to encourage the adoption of renewable energy technologies. Additionally, Kerala collaborates with national and international organisations to secure funding and technical expertise for its renewable energy projects. Education and awareness campaigns are vital in Kerala's renewable energy journey. The state conducts workshops, training programmes, and public outreach initiatives to promote the benefits of renewable energy and encourage community participation. These efforts have helped foster a culture of sustainability and environmental responsibility among the people of Kerala.

The social and economic impact of renewable energy adoption in Kerala is profound. The state has lowered its carbon footprint and improved air quality by reducing dependence on fossil fuels. Renewable energy projects have also generated employment opportunities and stimulated economic growth, particularly in rural areas. Kerala's investments in solar, wind, and hydropower projects underscore its commitment to a sustainable future. The state addresses its energy needs by harnessing renewable energy and sets an example for others to follow. Kerala's holistic approach, combining innovation, policy support, and community engagement, ensures that renewable energy remains a cornerstone of its development strategy.

6.1.5 Health and Biotechnology

Advances in biotechnology have revolutionised health and medicinal plant research, offering innovative solutions to some of the most pressing challenges in healthcare. By integrating cutting-edge technologies such as genetic engineering, tissue culture, and bioinformatics, biotechnology has unlocked the potential of medicinal plants, which have been used in traditional medicine for centuries. These advancements have paved the way for developing novel therapeutics and healthcare innovations. Medicinal plant research has greatly benefited from biotechnological tools.

Techniques like genetic modification and tissue culture allow scientists to enhance the production of bioactive compounds in plants. These compounds, such as alkaloids, flavonoids, and terpenoids, are the foundation of many modern drugs. By optimising the cultivation of medicinal plants under controlled conditions, biotechnology ensures a sustainable supply of these valuable resources while reducing the pressure on wild populations. The application of omics technologies, including genomics, proteomics, and metabolomics, has further advanced medicinal plant research. These approaches enable researchers to identify and analyse the genes, proteins, and metabolites involved in the biosynthesis of therapeutic compounds. This knowledge not only aids in discovering new drugs but also helps improve the efficacy and safety profiles of existing ones.

In healthcare, biotechnology has ushered in the era of precision medicine. By leveraging genetic information, clinicians can tailor treatments to individual patients, optimising therapeutic outcomes and minimising adverse effects. Gene-based therapies, such as CRISPR-Cas9, have shown promise in treating genetic disorders, cancers, and rare diseases, offering hope to patients with limited options. Biotechnology has also transformed vaccine development. The advent of mRNA vaccines, as seen during the COVID-19 pandemic, highlights the speed and adaptability of biotechnological approaches. These vaccines can be developed and scaled up rapidly, making them invaluable in responding to emerging infectious diseases. Another area of innovation is regenerative medicine, where biotechnology plays a crucial role in developing tissue engineering and stem cell therapies. These advancements have the potential to repair or replace damaged tissues and organs, addressing conditions such as spinal cord injuries, heart disease, and degenerative disorders.

Biotechnology has also contributed significantly to the development of advanced diagnostic tools. Techniques like liquid biopsies and molecular imaging enable the early detection and monitoring of diseases, improving patient outcomes. Additionally, wearable biosensors and point of care devices have made healthcare more accessible and personalised. Integrating artificial intelligence (AI) with biotechnology has further enhanced healthcare innovations. AI-driven algorithms analyse vast datasets to identify patterns and predict disease progression, aiding in developing targeted therapies. This collaboration between AI and biotechnology is shaping the future of healthcare. Despite these advancements, challenges remain in ensuring equitable access to biotechnological innovations. Ethical considerations, regulatory frameworks, and affordability are critical factors that need to be addressed to ensure that the benefits of biotechnology reach all segments of society. The convergence of biotechnology with health and medicinal plant research has transformed the landscape of modern medicine. By combining the power of nature and technology, these advancements promise to improve patient outcomes, address global health challenges, and pave the way for a healthier future.

6.1.6 Education and Awareness

Kerala has consistently prioritised science education and awareness as a cornerstone of its development strategy. The state's efforts in promoting scientific thinking and curiosity start at the grassroots level, ensuring students, teachers, and the broader community actively foster a science-driven culture. One of the most notable initiatives in this area is the establishment of science parks across Kerala. These parks provide an interactive and engaging environment for students to explore scientific concepts. With hands-on exhibits, live demonstrations, and experiential learning opportunities, science parks aim to demystify complex scientific ideas, making them accessible and engaging young minds. This is particularly effective in nurturing an early interest in science and technology. Kerala's education system integrates science awareness programmes into the school curriculum. Initiatives like "Sasthraposhini" and "Sasthrapadham" encourage scientific inquiry among students. These initiatives include science exhibitions, model-making competitions, and quizzes, which provide platforms for students to showcase their creativity and understanding of scientific principles. Another critical initiative is the Children's Science Congress, organised annually to inspire young scientists. This event allows students to present their research and innovative ideas nationally, fostering problem-solving skills and a deeper understanding of real-world scientific applications. Such platforms promote science education and build confidence and analytical thinking among participants.

Kerala State Council for Science, Technology, and Environment (KSCSTE) is pivotal in coordinating and funding various science education and awareness programmes. The council organises workshops, seminars, and lectures for students and teachers, emphasising the importance of staying updated with the latest developments in science and technology. Additionally, it provides grants for research and educational projects that align with the state's vision for scientific progress. Mobile science labs and exhibitions have been introduced in rural areas to ensure that students in remote locations have equal access to scientific learning. These mobile units travel to schools and community centres, bringing interactive exhibits and demonstrations. This approach has significantly reduced the urban-rural divide in science education, making it more inclusive and equitable. Kerala also emphasises the training of teachers in science education. Regular professional development workshops equip teachers with the latest pedagogical tools and techniques. This ensures that the quality of science teaching remains high, enabling teachers to inspire students effectively.

Public science awareness campaigns are another integral part of Kerala's efforts. National Science Day and World Environment Day are celebrated enthusiastically, involving students, educators, and the general public. These campaigns highlight the relevance of science in addressing societal and environmental challenges, motivating citizens to adopt scientific thinking in their daily lives. In higher education, Kerala encourages research and innovation through funding and scholarships. Institutions such as IISER and CUSAT offer advanced programmes in science and technology, nurturing the next generation of scientists and researchers. Collaborative efforts with industries further enhance the practical application of scientific knowledge. Kerala's science education and awareness initiatives reflect its commitment to building a knowledge-based society. By focusing on inclusivity, innovation, and interaction, the state inspires students to pursue careers in science and technology. It empowers its citizens to make informed decisions for a sustainable and prosperous future.

6.1.7 The Rationalist Movement (*Yukthivadi Prasthanam*)

The Rationalist Movement, Yukthivadi Prasthanam in Kerala, is a significant socio-cultural reform movement that emerged in the early 20th century. It was deeply rooted in rationalism, scientific temper, and humanism, challenging societal superstitions, caste-based discrimination, and religious orthodoxy. The movement was pivotal in shaping Kerala's progressive outlook and fostering a culture of critical thinking and social equality. The movement gained momentum with the publication of *Yukthivadi* (The Rationalist) in 1929, the first rationalist journal in Malayalam. Edited by prominent figures like Sahodaran Ayyappan, M. Ramavarma Thampan, and C. Krishnan, the journal became a platform for promoting rationalist ideas and critiquing irrational beliefs. It emphasised reason, evidence-based knowledge, and the rejection of dogmas, inspiring a generation of thinkers and reformers.

Sahodaran Ayyappan, a leading figure, advocated for social reforms such as inter-caste dining and the abolition of untouchability. His famous slogan, "No Religion, No Caste, No God," encapsulated the essence of the movement. Ayyappan's efforts to dismantle caste hierarchies and promote social harmony were met with resistance, but they laid the foundation for a more inclusive society. The Rationalist Movement also intersected with Kerala's broader renaissance movement, which sought to address social injustices and promote education and equality. Rationalist leaders collaborated with other reformers, including Narayana Guru and Ayyankali, to challenge oppressive practices and empower marginalised communities. This synergy amplified the impact of the movement and broadened its reach.

Education played a central role in the movement's strategy. Rationalists emphasised the need for scientific education and critical thinking to combat ignorance and superstition. They organised public lectures, debates, and campaigns to spread awareness about rationalist principles and encourage people to question traditional beliefs. The movement's influence extended to literature and the arts, inspiring writers, poets, and playwrights to explore rationalism and social justice themes. Works by authors like C.V. Kunhiraman and M.C. Joseph reflected the movement's ideals and contributed to the cultural transformation of Kerala. These literary contributions helped popularise rationalist ideas and foster a spirit of inquiry. Over time, the movement evolved to address contemporary challenges, including pseudoscience and communalism. Organisations like the Kerala Yukthivadi Sangham (KYS) continue to uphold the movement's legacy by promoting scientific temper and secular values. They organise events, publish journals, and engage in activism to counter misinformation and advocate for evidence-based policies.

The movement's impact on Kerala's social fabric is evident in its progressive policies, high literacy levels, and social awareness. Rationalist ideals have influenced the state's governance, education, and public health approach, making Kerala an inclusive and sustainable development model. Despite its achievements, the movement has faced criticism and opposition from conservative and religious groups. However, its resilience and adaptability have ensured its relevance in addressing modern societal issues. The movement remains vital in Kerala's ongoing journey toward equality and enlightenment.

6.1.8 People's Science Movement

People's Science Movement (PSM) in India represent a unique combination of social reform and scientific outreach, aiming to popularise science and foster a scientific temper among the masses. These movements emerged as a response to the need to bridge the gap between scientific advancements and their accessibility to everyday people. Rooted in ideals of rationalism, secularism, and social justice, PSM have played a transformative role in addressing societal challenges through the lens of science and technology.

One of India's earliest and most influential PSM is the Kerala Sasthra Sahithya Parishad (KSSP), founded in 1962. KSSP began as a literary movement to promote science writing in Malayalam but soon evolved into a broader platform for science education and activism. It focused on empowering communities by addressing environmental conservation, public health, and education through scientific awareness. KSSP's campaigns, such as the Silent Valley Movement to protect biodiversity, exemplify the intersection of science and social action. PSM have also been instrumental in promoting literacy and education. Initiatives like Bharat Gyan Vigyan Samiti (BGVS) have worked to eradicate illiteracy by integrating scientific concepts into adult education programmes. These efforts enhance literacy rates and instil critical thinking and problem-solving skills among learners, enabling them to make informed decisions in their daily lives.

The emphasis on environmental sustainability is another hallmark of PSM. Movements like the Tamil Nadu Science Forum (TNSF) and the Pondicherry Science Forum have actively engaged in campaigns to address deforestation, water conservation, and climate change. By engaging local communities in these initiatives, PSM ensure that scientific interventions are practical and culturally relevant. Healthcare is another area where PSM have made significant contributions. They have organised vaccination, nutrition, and sanitation awareness campaigns, particularly in rural and underserved areas. These efforts have played a crucial role in dispelling myths and misconceptions about health practices and improving public health outcomes.

PSM also focus on promoting gender equality and social inclusion. By encouraging women and marginalised groups to participate in science education and activism, these movements challenge traditional norms and empower individuals to contribute to societal progress. This inclusive strategy ensures that the benefits of scientific advancements are equitably distributed. The use of innovative communication methods is a defining feature of PSM. These movements employ creative strategies to engage diverse audiences, from street plays and folk songs to mobile science exhibitions. This approach makes science both accessible and fosters a sense of curiosity and wonder among people of all ages.

Collaboration and networking underpin the success of PSMs. Networks like the All India People's Science Network (AIPSN) bring together various regional movements to share resources, ideas, and best practices. This collective effort amplifies the impact of individual movements and strengthens the overall PSM ecosystem.

Despite their achievements, PSM face limited funding, resistance from conservative groups, and the need to adapt to rapidly changing technological landscapes. However, their resilience and commitment to their core values ensure that they remain relevant and impactful in addressing contemporary issues. People's Science Movement in India exemplify the power of science as a tool for social transformation. These movements empower individuals and communities to address pressing challenges and build a more equitable and sustainable future by democratising access to scientific knowledge and fostering a culture of inquiry.

Recap

- Kerala has significantly contributed to science and technology, which are vital to India's progress.
- The Indian Institute of Space Science and Technology (IIST) in Thiruvananthapuram, established by ISRO, stands as Asia's first space university, fostering innovation in space science.
- NIIST, the National Institute for Interdisciplinary Science and Technology, conducts cutting-edge research in diverse fields like materials science, environmental technology, and agro-processing, addressing real-world challenges.
- Kerala's IT hubs, Technopark and Infopark, provide world-class infrastructure for hundreds of companies, driving job creation and transforming the state into a significant destination for technology and innovation.
- The state leads in e-governance with initiatives like Akshaya, significantly enhancing public service delivery, digital literacy, and transparency for its citizens.
- Kerala is deeply committed to sustainable development, evidenced by its focus on innovative agricultural research and marine conservation, and its strong push for renewable energy sources.
- Revolutionising healthcare, Kerala leverages biotechnology for precision medicine, vaccine development, and advanced diagnostics, alongside a dedicated focus on health and medicinal plant research.
- Kerala's education system integrates science awareness programmes into the school curriculum.

- The Kerala State Science and Technology Museum and the Priyadarsini Planetarium encourage scientific curiosity and public engagement.
- People's movement emerged as a response to the need to bridge the gap between scientific advancements and their accessibility to ordinary people.
- The Rationalist movement was pivotal in shaping Kerala's progressive outlook and fostering a culture of critical thinking and social equality.
- The Rationalist Movement also intersected with Kerala's broader renaissance movement, which sought to address social injustices and promote education and equality.

Objective Questions

1. What is the primary function of the Indian Space Research Organisation (ISRO)?
2. Where is the Indian Institute of Space Science and Technology (IIST)?
3. What is the primary focus of the National Institute for Interdisciplinary Science and Technology (NIIST)?
4. What are the key pillars of e-governance development in Kerala?
5. Which renewable energy sources are extensively utilised in Kerala?
6. How does renewable energy benefit society?
7. What is the primary focus of marine research in Kerala?
8. Why is education and awareness important for scientific advancement?
9. What do People's Science Movement (PSM) aim to achieve?
10. Which institution is a key player in promoting marine research in Kerala?

Answers

1. Satellite development, space exploration.
2. Thiruvananthapuram
3. Chemical sciences, materials, process engineering, and environmental technology.
4. Accessibility, efficiency, and transparency in public services.
5. Solar, wind, hydroelectric, and biomass energy.
6. Lowers energy costs and decreases dependence on fossil fuels.
7. Exploring marine biodiversity and fishery resources.
8. Fosters innovation and encourages informed decision-making.
9. Promotes scientific temper and addresses socio-economic issues.
10. Central Marine Fisheries Research Institute

Assignments

1. Describe the complementary roles of the Vikram Sarabhai Space Centre (VSSC) and the Indian Institute of Space Science and Technology (IIST) within Kerala. How do these two institutions collectively strengthen India's capabilities in space exploration and technology development?
2. Elaborate on how the Akshaya project went beyond just providing e-literacy to become a cornerstone of e-governance in Kerala.
3. Considering the efforts of Kerala Agricultural University (KAU) and NIIST's agro-processing research, how is Kerala addressing challenges in agriculture to ensure both food security and environmental sustainability?
4. Discuss the methods and strategies employed by the Rationalist Movement to challenge societal superstitions, caste discrimination, and religious orthodoxy.
5. Focusing on the Kerala Sasthra Sahithya Parishad (KSSP), describe its evolution from a literary movement to a broad platform for science education and activism.

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3. Pillai, K. R. (1993). Science for social action? Achievement and dilemmas of a development movement—The Kerala Sastra Sahitya Parishad. *Indian Journal of Political Science*, *54*(3), 406-408.

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3. Kerala Sastra Sahitya Parishad. (1984). *Science as a social activism*. KSSP.

SREENARAYANAGURU OPEN UNIVERSITY

Model Question Paper (SET- I)

QP CODE: ………   Reg. No :...................

Name: ………………

FIFTH SEMESTER BA SOCIOLOGY EXAMINATION

DISCIPLINE SPECIFIC ELECTIVE

B21SO06DE - SCIENCE, TECHNOLOGY AND SOCIETY(CBCS - UG)

2022-23 - Admission Onwards

Time: 3 Hours   Max Marks: 70

SECTION A

Answer any **ten** *questions of the following. Each question carries* **one** *mark.*

(10 × 1 = 10 Marks)

1. Bruno Latour and Steve Woolgar are associated with which theory?
2. Who coined the term "surveillance capitalism"?
3. The Green Revolution in India was led by which agricultural scientist?
4. What is the code name given for India's first nuclear test?
5. Which sociologist viewed science as a neutral, self-regulating institution guided by internal norms like CUDOS?
6. Who is the author of *The Social Function of Science*?
7. Expand KSSP.
8. Who introduced the terms "Little Science" and "Big Science"?
9. mRNA vaccines became popular during which pandemic?
10. Who coined the slogan "No Religion, No Caste, No God"?
11. Expand STEM.
12. Which Indian mathematician calculated the value of pi and proposed the Earth's rotation on its axis?

13. Which was India's first satellite, launched in 1975?

14. Which portal is aimed at creating a single online platform representing Indian Women and Girls in STEMM

15. Who introduced the concept of Hyperreality?

SECTION B

Answer any **ten** *questions of the following. Each question carries* **two** *marks.*

(10×2 =20 Marks)

16. Define technological determinism.

17. What is situated knowledge ?

18. Digital Divide.

19. What was the purpose of the Aarogya Setu app?

20. What does Actor-Network Theory (ANT) study?

21. What is the primary mission of ISRO?

22. List any two biotechnological techniques used to enhance medicinal plants.

23. What is "Citizen Science"?

24. What is the main goal of Science and Technology Studies (STS)?

25. What is the Matthew Effect?

26. What is the core argument of the Social Shaping of Technology (SST)?

27. List two key cities of the Indus Valley Civilization known for urban planning.

28. What is technospace?

29. What is social media?

30. What is gamification?

SECTION C

Write a short note on any **five** *questions of the following. Each question carries* **four** *marks.*

(5×4 = 20 Marks)

31. Explain how economic disparities and cultural alienation contribute to the underrepresentation of marginalized castes in Indian science.

32. Explain the relationship between democracy and technocracy.

33. Discuss how hyperreality is manifested through social media and modern technology.

34. What are some common ethical dilemmas associated with biotechnology and AI?

35. How has Technopark and Infopark contributed to employment generation and the overall economic growth of Kerala?

36. How does science parks enhance student engagement in Kerala?

37. Describe the aims of the Rationalist Movement.

38. Briefly describe two policy documents passed by the Government of India on science and technology.

39. Explain how the Green Revolution transformed India's agricultural sector.

40. Discuss the major contributions of Kerala Sasthra Sahitya Parishad.

SECTION D

Answer any **two** *questions of the following. Each question carries* **ten** *marks.*

(2×10 =20 Marks)

41. Analyse how the Akshaya project transformed Kerala into an e-literate state and enhanced transparency in governance.

42. Explain the origin, objectives, and significance of People's Science Movements in India.

43. Evaluate the importance and challenges of the digital rights movement in resisting modern surveillance practices.

44. Critically analyse Robert K. Merton's framework for understanding science as a social institution. Discuss its strengths and limitations in explaining the relationship between science and society.

SREENARAYANAGURU OPEN UNIVERSITY

Model Question Paper (SET- II)

QP CODE: ……… Reg. No :..................

Name: ………………

FIFTH SEMESTER BA SOCIOLOGY EXAMINATION

DISCIPLINE SPECIFIC ELECTIVE

B21SO06DE - SCIENCE, TECHNOLOGY AND SOCIETY(CBCS - UG)

2022-23 - Admission Onwards

Time: 3 Hours Max Marks: 70

SECTION A

Answer any **ten** *questions of the following. Each question carries* **one** *mark.*

(10 × 1 = 10 Marks)

1. Which government initiative aims to facilitate the re-entry of women scientists into research after career breaks?
2. Which is India's first IIT inaugurated in 1951?
3. J.D Bernal was influenced by which ideological framework?
4. Give an example of cybernetic social movement.
5. The concept of feminist objectivity was developed by?
6. Who introduced the concept of situated knowledge?
7. Expand ISRO.
8. What is called a copy that doesn't have any real thing ?
9. Who discovered the element helium in the solar spectrum during an observation in Guntur, Madras State, in 1868?
10. Which ancient Indian civilization is noted for its urban planning, including grid layouts and drainage systems?
11. Which theoretical framework challenges the notion that technological development is an autonomous, linear process?

12. Game-like features to non-game environments to make them more fun and engaging is called?
13. When people use hashtags on social media to raise awareness about important issues and unite others to create social or political change is called?
14. The term “standpoint epistemology” is linked with which feminist scholar?
15. Which initiative in Kerala encourages households and institutions to install rooftop solar panels?

SECTION B

Answer any **ten** *questions of the following. Each question carries* **two** *marks.*

(10×2 =20 Marks)

16. What is the Sociology of Scientific Knowledge (SSK)?
17. What is the difference between upstream and downstream public engagement?
18. List two government agencies that contribute significantly to R&D funding in India.
19. How does SST challenge technological determinism?
20. What is Panopticon prison model?
21. What is hashtag drift?
22. Define techno-solutionism.
23. What is standpoint epistemology?
24. List two e-governance initiatives in Kerala.
25. What is the primary focus of the Centre for Marine Living Resources and Ecology (CMLRE)?
26. List two science promotion initiatives in Kerala schools.
27. What is the deficit model in public engagement?
28. What is scientometrics?
29. Define the sociology of science according to Merton’s perspective.
30. What societal and cultural norms contribute to the underrepresentation of women in Indian science?

SECTION C

Write a short note on any **five** *questions of the following.*
Each question carries **four** *marks.*

(5×4 = 20 Marks)

31. Explain the impact of mobile science exhibitions in rural Kerala.

32. How did biotechnology revolutionise diagnostics?

33. Explain how digital technologies were used to manage the COVID-19 pandemic.

34. Discuss the cognitive challenges in the acceptance and understanding of scientific knowledge

35. Briefly explain how technospace has evolved from the 1900s to the present.

36. Discuss ancient India's contributions to mathematics and astronomy, citing specific examples.

37. How does Bernal's view of science differ from that of Merton?

38. Describe the core values of the scientific ethos and their significance.

39. Explain the key differences in goals and technology used between Little Science and Big Science.

40. Explain how the pressure to conform operates in digital spaces, particularly for kids and teens.

SECTION D

Answer any **two** *questions of the following. Each question carries* **ten** *marks.*

(2×10 =20 Marks)

41. Analyse the role of digital technology during the COVID-19 pandemic and discuss its benefits and challenges.

42. Elaborate on the pivotal role of the Indian Space Research Organisation (ISRO) in transforming India into a global space power, citing specific missions and their impact.

43. Compare and contrast the Social Shaping of Technology (SST) with Actor-Network Theory (ANT).

44. Discuss the pervasive issue and reasons for gender underrepresentation in Indian science, technology, engineering, and mathematics (STEM) sectors and discuss the initiatives that the Government of India has undertaken to address this challenge.

സർവ്വകലാശാലാഗീതം

വിദ്യയാൽ സ്വതന്ത്രരാകണം
വിശ്വപൗരരായി മാറണം
ഗ്രഹപ്രസാദമായ് വിളങ്ങണം
ഗുരുപ്രകാശമേ നയിക്കണേ

കൂരിരുട്ടിൽ നിന്നു ഞങ്ങളെ
സൂര്യവീഥിയിൽ തെളിക്കണം
സ്നേഹദീപ്തിയായ് വിളങ്ങണം
നീതിവൈജയന്തി പാറണം

ശാസ്ത്രവ്യാപ്തിയെന്നുമേകണം
ജാതിഭേദമാകെ മാറണം
ബോധരശ്മിയിൽ തിളങ്ങുവാൻ
ജ്ഞാനകേന്ദ്രമേ ജ്വലിക്കണേ

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