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Q13

Why is nanotechnology one of the key technologies of the 21st century? Describe the salient features of Indian Government's Mission on Nanoscience and Technology and the scope of its application in the development process of the country.

UPSC Civil Services Mains 2016 · GS III · 12 marks · Indian Economy

Indian Economy and issues relating to planning, mobilization of resources, growth, development and employment.

Core demand of the question

- Explain why nanotechnology is treated as a key twenty-first-century technology
- Describe the Indian Nano Mission's aims and institutions
- Map where nano tools can serve health, water, energy, and industry in India's development

Revision summary

Nano-scale materials behave differently, so they sit at the centre of medicine, electronics, water, and energy.

India's Nano Mission (2007, DST) funds people, characterisation centres, basic science, and applications.

Development uses include filters, diagnostics, solar and battery materials, and industrial coatings.

Agriculture and food uses need caution on residue and unknown toxicity.

- **A key technology is also a key regulatory task:** worker safety and waste, not only patents.

Introduction

Nanotechnology works at a scale of about **one to one hundred nanometres**, where materials show new strength, electrical, and chemical behaviour. That is why it sits beside information technology and biotechnology as a **platform of this century: one set of tools can touch medicine, water, energy, textiles, and defence. India answered with the Mission on Nano Science and Technology (Nano Mission) under the Department of Science and Technology from 2007.**

Body**Why it is a key technology of this century**

- At nano scale, **surface area rises** and quantum effects appear, so a small mass can catalyse, sense, or carry a drug in ways bulk chemistry cannot.
- **It converges with biotech and information technology:** a lab-on-chip, a targeted cancer particle, or a better lithium electrode is often a nano device.

- **Economic stakes are large:** electronics, coatings, composites, and pharmaceuticals will embed nano parts whether India makes them or imports them.
- **Strategic stakes are real:** sensors, lightweight armour, and filtration matter for security and for disaster response.
- **Risks are also why it is "key":** unknown toxicity, worker exposure, and waste mean a country that only consumes nano products will still face the harm without the skill to regulate.

Salient features of the Nano Mission

- Launched in **2007** as a successor to the Nano Science and Technology Initiative, with DST as the nodal department and a **Nano Mission Council** to steer it.
- **Human resources:** teaching programmes, fellowships, and chairs so India is not only a user of imported nano goods.
- **Infrastructure:** centres of excellence, shared characterisation facilities (electron microscopes, clean rooms) that a single university cannot buy alone.
- **Basic research** in nano science together with **application** projects in water, energy, health, and security.
- **Industry linkage** and public-private projects so laboratory particles become a filter, a coating, or a diagnostic, not only a paper.
- **International collaboration** and a regulatory conversation on standards and safety, still thinner than the research spend.
- The Twelfth Plan continued and enlarged the Mission so the 2007 start did not remain a one-Plan experiment.

Scope in India's development process

- **Health:** targeted drug delivery, better imaging, implants, and low-cost diagnostics for tuberculosis and other high-burden diseases if regulation and trials are honest.
- **Water:** nano-filtration and silver or other antimicrobial coatings for rural drinking water and for industrial effluent - high development value if sludge toxicity is managed.
- **Energy:** better solar cells, fuel-cell membranes, hydrogen storage, and battery electrodes that support the same renewable targets discussed elsewhere in this paper.
- **Agriculture:** slow-release nano-fertiliser and pesticide can cut dose; they also raise food-safety questions that **FSSAI** and environment rules must face before cheerleading.
- **Textiles and materials:** stain-resistant and stronger fibres for a large export industry; nano-composites for lighter vehicles and aircraft parts.
- **Environment:** sensors for air and water pollutants in cities.
- **Caution:** without **occupational safety, life-cycle tests, and labelling**, nano development can export risk to workers and rivers. Public laboratories and the Mission should fund toxicology as seriously as patents.

Flow diagram

Nanoscale platform -> New properties convergence strategy
Nano Mission 2007 DST -> People and shared labs
Nano Mission 2007 DST -> Water health energy materials
Water health energy materials -> Development uses
Toxicology regulation -> Development uses

Conclusion

Nanotechnology is a key twenty-first-century platform because one scale of matter now redesigns medicine, water, energy, and materials. **India's Nano Mission (2007)** built people, shared labs, and application projects under DST. Development gains will come in filters, diagnostics, and energy devices - and will last only if safety and Indian manufacturing rise with the papers.

Facts & figures

Nanometre scale

Roughly one to one hundred nanometres: the size range where surface and quantum effects change material behaviour.

Nano Mission 2007

Mission on Nano Science and Technology, Department of Science and Technology, with a Nano Mission Council.

Centres of excellence

Shared high-end characterisation and fabrication facilities funded so many groups can use one microscope or clean room.

Platform technology

A tool-set that feeds many sectors at once, similar to information technology or biotechnology.

Nano-filtration

Membrane and particle methods that can treat water; a high-priority application for Indian public health if sludge is handled.

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