

# UNIT 11

## RECENT DEVELOPMENTS IN PHYSICS

*'There's Plenty of Room at the Bottom: An Invitation to Enter a New Field of Physics'*

-Richard Feynman

### Learning Objectives

In this unit the students are exposed to

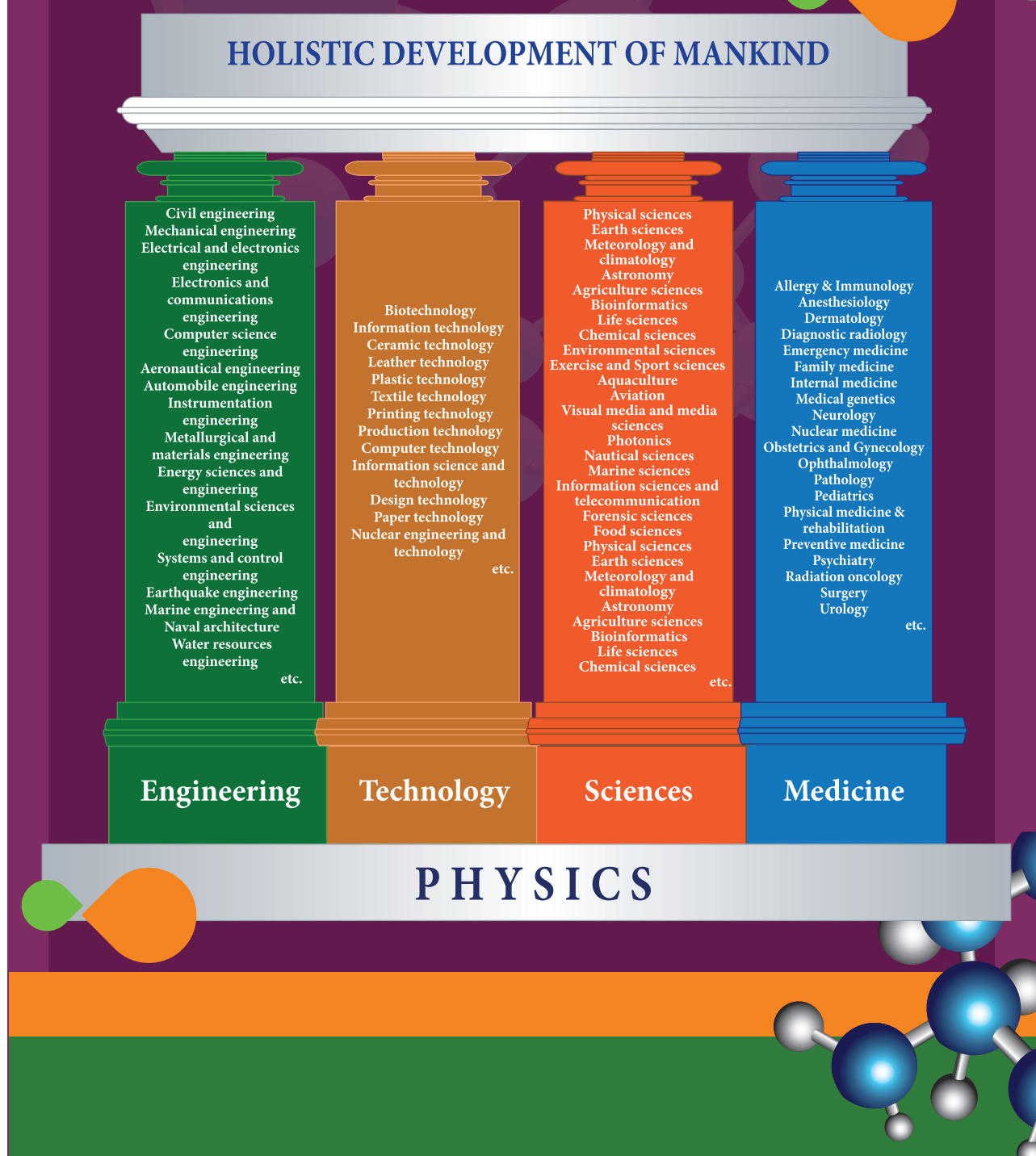
- Importance of physics for the development in all spheres
- Physics as the basic building block for engineering and technology
- Nanoscience and nanotechnology
- Physics in robotics
- Principles of physics in medical diagnosis and therapy
- Realise that the foundation to explore recent developments is covered in higher secondary physics
- Students are equipped to face challenges in higher education comfortably and confidently



### 11.1 Introduction

Physics is the basic building block for science, engineering and technology as depicted in Figure 11.1 (Refer XI Physics, 1.3). The fast developing fields like Nanoscience and Nanotechnology, Robotics and Medical diagnosis and therapy are briefly brought out for the students to appreciate the application of physics in these areas. This unit exposes the salient physics principles covered in the higher secondary physics as the foundation for technology break through. In addition, with the adequate exposure to basic physics at the school level, students are motivated to pursue higher education confidently in all fields related to science, engineering, technology and medicine.

**Figure 11.1 Physics is the building block for science, engineering, technology and medicine**  
(Not for examination)



## 11.2 Nanoscience and Nanotechnology

### 11.2.1

#### Nanoscience

Nanoscience is the study of structures and materials on the scale of nanometers. Nano means one-billionth of a meter that is  $10^{-9}$  m.

If matter is divided into such small objects the mechanical, electrical, optical, magnetic and other properties change.

#### Nanotechnology

Nanotechnology is a technology involving the design, production, characterization, and applications of nano structured materials.

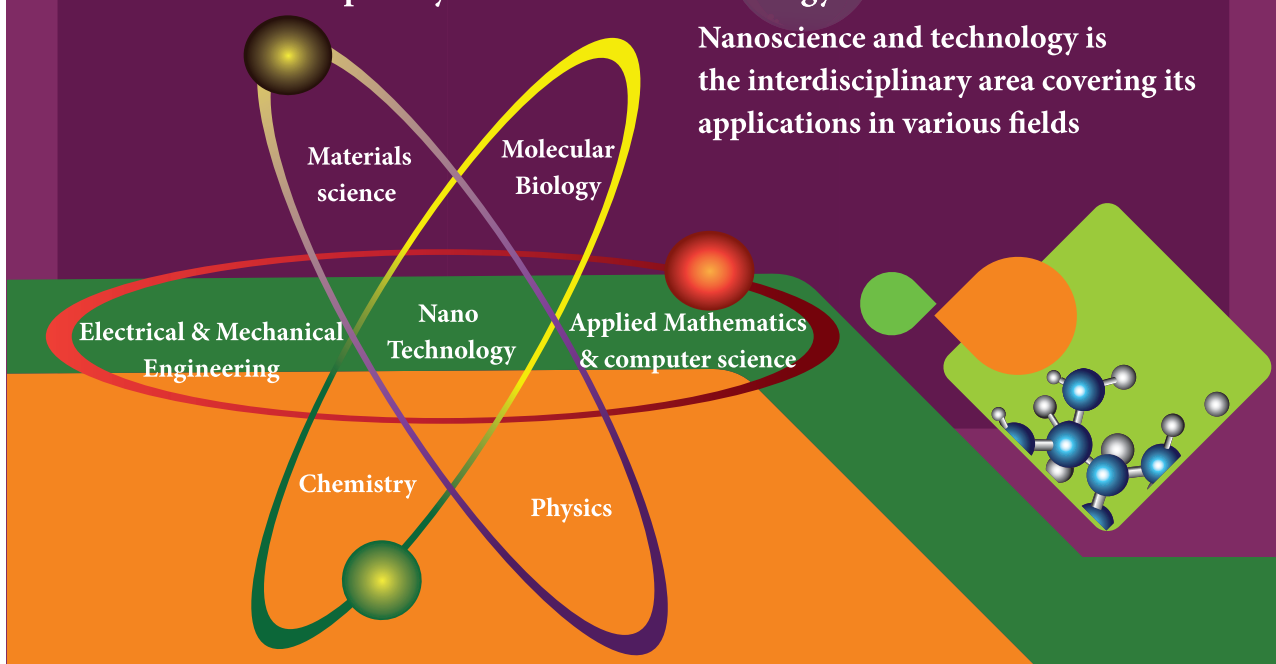
#### Nanoparticles

The solids are made up of particles. Each of the particle has a definite number of atoms, which might differ from material to material. If the particle of a solid is of size less than 100 nm, it is said to be a 'nano solid'. When the particle size exceeds 100 nm, it is a 'bulk solid'. It is to be noted that nano and bulk solids may be of the same chemical composition. For example, ZnO can be both in bulk and nano form. Though chemical composition is the same, nano form of the material shows strikingly different properties when compared to its bulk counterpart.

In the nano scale dimensions (reduced dimensions), two important phenomena govern nano properties. They are quantum confinement effects and surface effects. Students can explore these effects in higher education and the explanation is avoided at school level.

### 11.2.2 Interdisciplinary nature of Nanotechnology

Nanoscience and technology is the interdisciplinary area covering its applications in various fields





### 11.2.3 Nano in Nature

Nanoscale structures existed in nature long before scientists began studying them in laboratories.

#### A few examples

#### Object

A single strand of DNA, the building block of all living things, is about three nanometers wide.

single strand DNA

double strand DNA

Nano in Nature

#### Mimic in laboratories

Manipulation of colours by adjusting the size of nano particles with which the materials are made.

#### Object

The scales on the wings of a morpho butterfly contain nanostructures that change the way light waves interact with each other, giving the wings brilliant metallic blue and green hues.



Nano in Nature

#### Object

Peacock feathers get their iridescent coloration from light interacting with 2 dimensional photonic crystal structures just tens of nanometers thick.

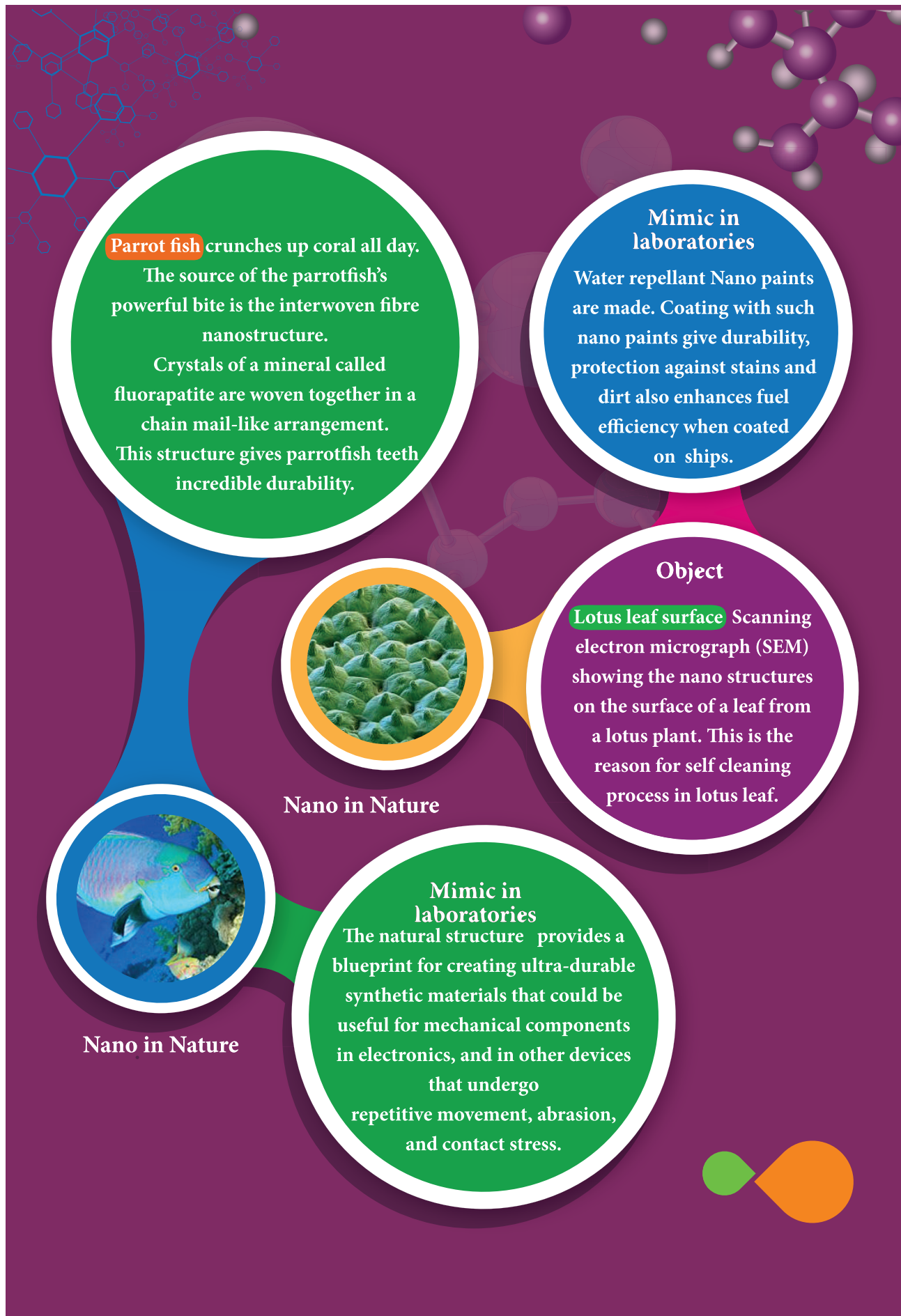
Nano in Nature

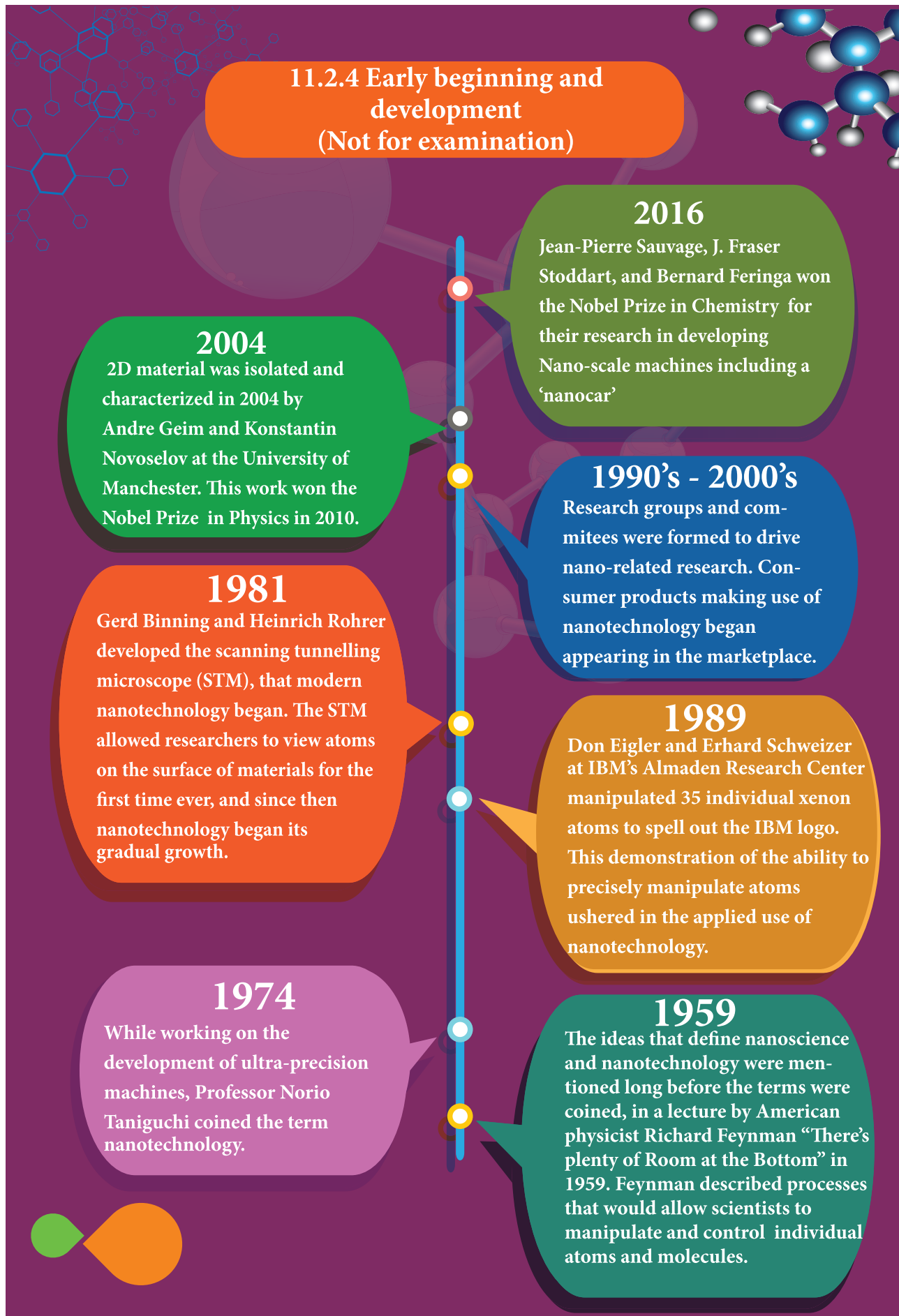
#### Mimic in laboratories

Similar nano structures are made in lab to glow in different colors.



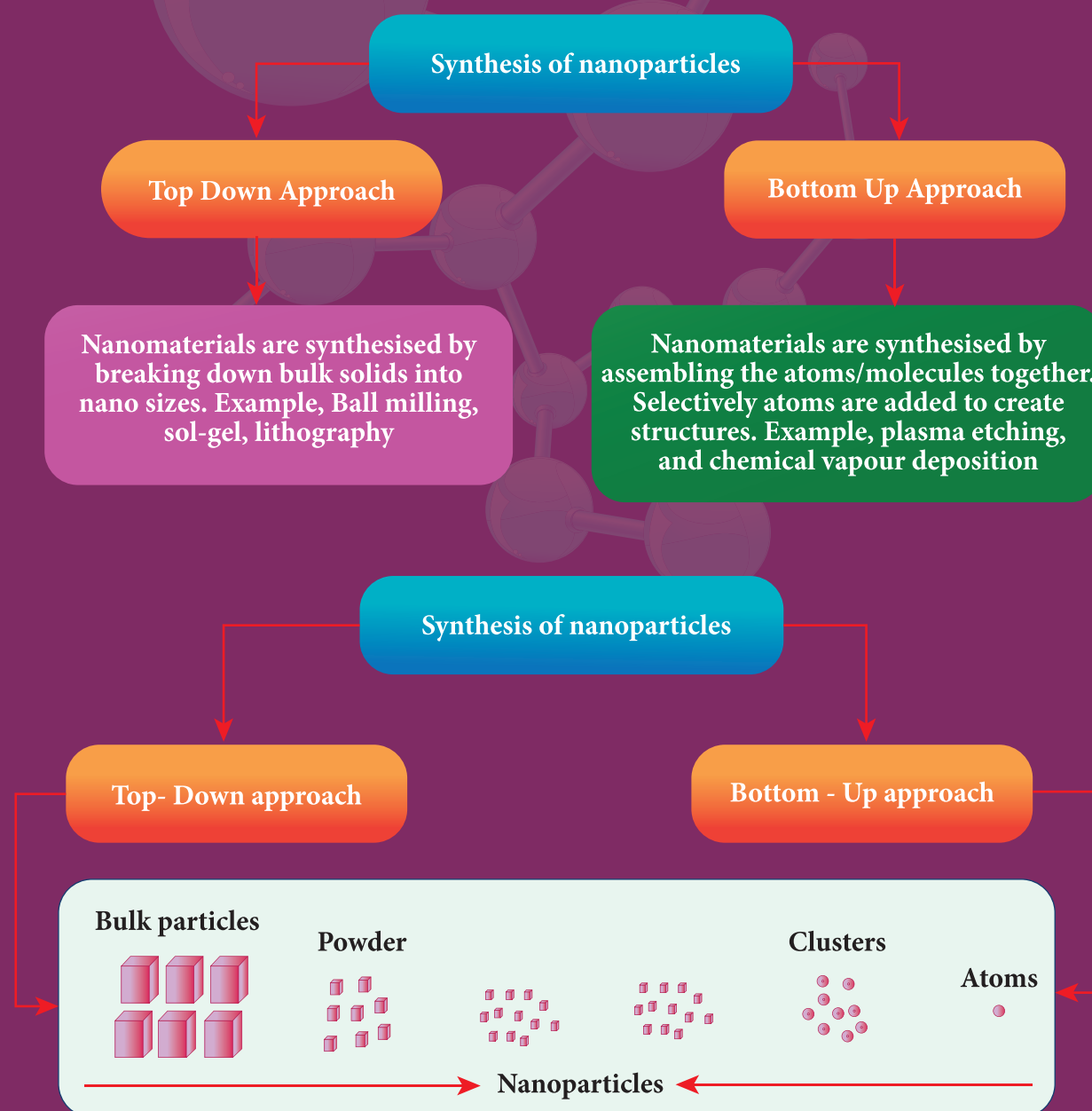






## 11. 2.5 Nano in laboratories

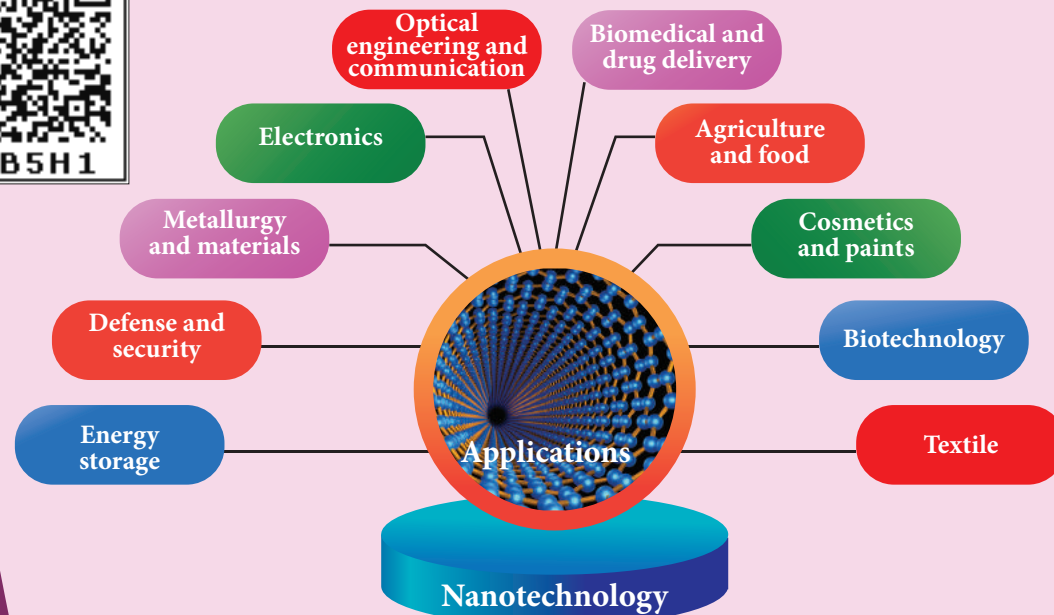
The nanostructures made in the laboratory mimic some of nature's amazing nanostructures. As the nanostructures are so small, specialized methods are needed to manufacture objects in this size range. There are two ways of preparing the nanomaterials, top down and bottom up approaches.



Due to the vast available methods the details are avoided at this level.



### 11.2.6 Applications of Nano technology



### Applications of nanomaterial based products in differernt areas

<b>Automotive industry</b> <ul style="list-style-type: none"><li>• Lightweight construction</li><li>• Painting (fillers, base coat, clear coat)</li><li>• Catalysts</li><li>• Tires (fillers)</li><li>• Sensors</li><li>• Coatings for wind-screen and car bodies</li></ul>	<b>Chemical industry</b> <ul style="list-style-type: none"><li>• Fillers for paint systems</li><li>• Coating systems based on nanocomposites</li><li>• Impregnation of papers</li><li>• Switchable adhesives</li><li>• Magnetic fluids</li></ul>	<b>Engineering</b> <ul style="list-style-type: none"><li>• Wear protection for tools and machines (anti blocking coatings, scratch resistant coatings on plastic parts, etc.)</li><li>• Lubricant-free bearings</li></ul>
<b>Electronic industry</b> <ul style="list-style-type: none"><li>• Data memory</li><li>• Displays</li><li>• Laser diodes</li><li>• Glass fibres</li><li>• Optical switches</li><li>• Filters (IR-blocking)</li><li>• Conductive, antistatic coatings</li></ul>	<b>Construction</b> <ul style="list-style-type: none"><li>• Construction materials</li><li>• Thermal insulation</li><li>• Flame retardants</li><li>• Surface-functionalised building materials for wood, floors, stone, facades, tiles, roof tiles, etc.</li><li>• Facade coatings</li><li>• Groove mortar</li></ul>	<b>Medicine</b> <ul style="list-style-type: none"><li>• Drug delivery systems</li><li>• Active agents</li><li>• Contrast medium</li><li>• Medical rapid tests</li><li>• Prostheses and implants</li><li>• Antimicrobial agents and coatings</li><li>• Agents in cancer therapy</li></ul>



<b>Textile/fabrics/ non-wovens</b> <ul style="list-style-type: none"><li>• Surface-processed textiles</li><li>• Smart clothes</li></ul>	<b>Energy</b> <ul style="list-style-type: none"><li>• Fuel cells</li><li>• Solar cells</li><li>• Batteries</li><li>• Capacitors</li></ul>	<b>Cosmetics</b> <ul style="list-style-type: none"><li>• Sun protection</li><li>• Lipsticks</li><li>• Skin creams</li><li>• Tooth paste</li></ul>
<b>Food and drinks</b> <ul style="list-style-type: none"><li>• Package materials</li><li>• Storage life sensors</li><li>• Additives</li><li>• Clarification of fruit juices</li></ul>	<b>Household</b> <ul style="list-style-type: none"><li>• Ceramic coatings for irons</li><li>• Odors catalyst</li><li>• Cleaner for glass, ceramic, floor, windows</li></ul>	<b>Sports/ outdoor</b> <ul style="list-style-type: none"><li>• Ski wax</li><li>• Antifogging of glasses/goggles</li><li>• Antifouling coatings for ships/boats</li><li>• Reinforced tennis rackets and balls</li></ul>

### 11.2.7 Possible harmful effects of nanoparticles

The research on the harmful impact of application of nanotechnology is also equally important and fast developing. The major concern here is that the nanoparticles have the dimensions same as that of the biological molecules such as proteins. They may easily get absorbed onto the surface of living organisms and they might enter the tissues and fluids of the body.

The adsorbing nature depends on the surface of the nanoparticle. Indeed, it is possible to deliver a drug directly to a specific cell in the body by designing the surface of a nanoparticle so that it adsorbs specifically onto the surface of the target cell.

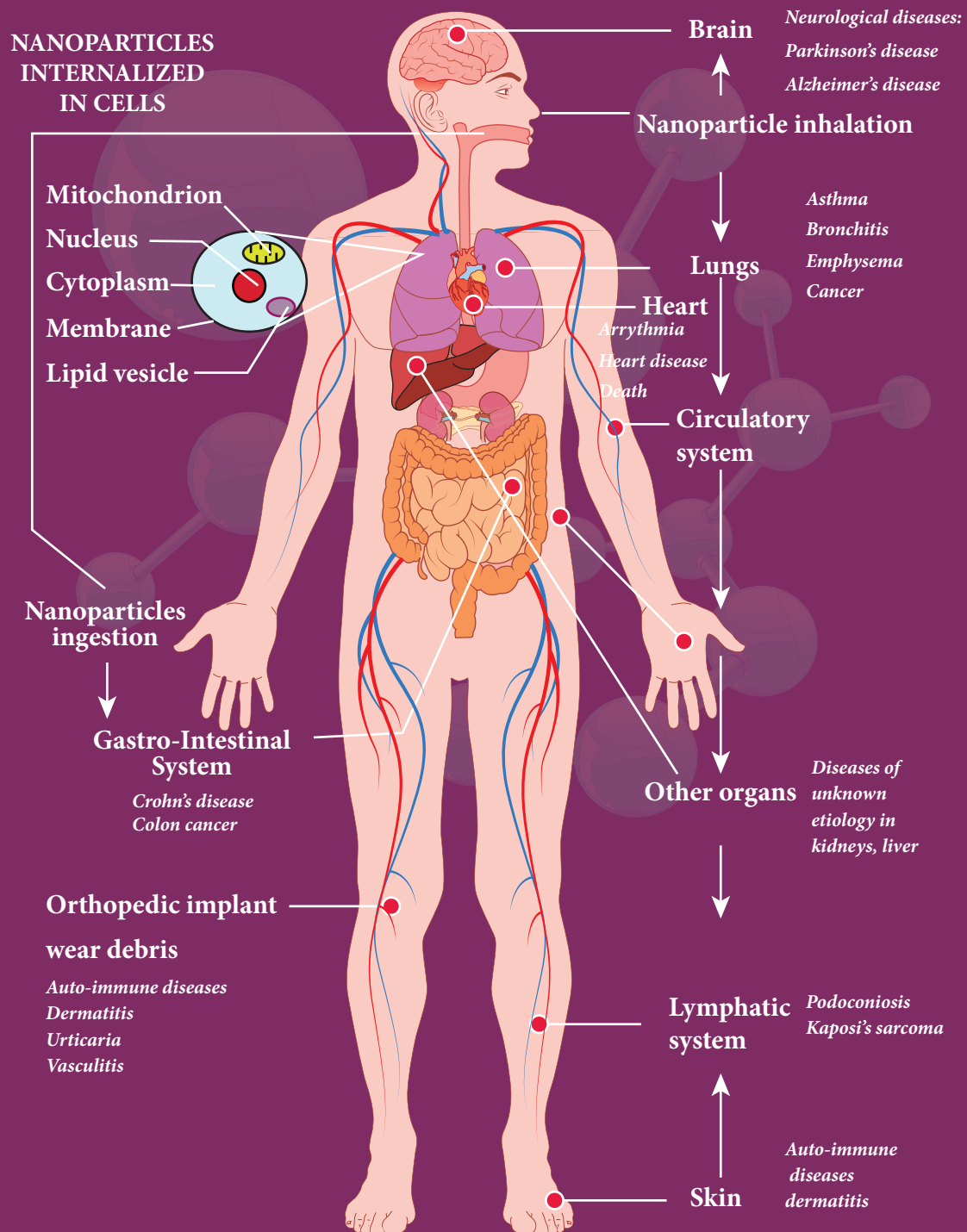
The interaction with living systems is also affected by the dimensions of the nanoparticles. For instance, nanoparticles of a few nanometers size may reach well inside biomolecules, which is not possible for larger nanoparticles. Nanoparticles can also cross cell membranes. It is also possible for the inhaled nanoparticles to reach the blood, to reach other sites such as the liver, heart or blood cells.

Researchers are trying to understand the response of living organisms to the presence of nanoparticles of varying size, shape, chemical composition and surface characteristics.



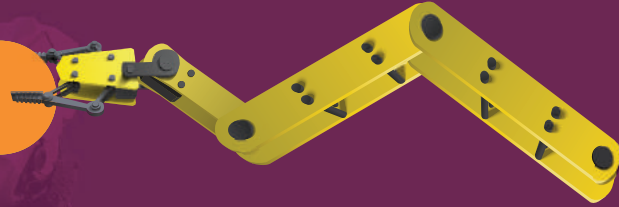


## DISEASES ASSOCIATED TO NANOPARTICLE EXPOSURE (Not for examination)



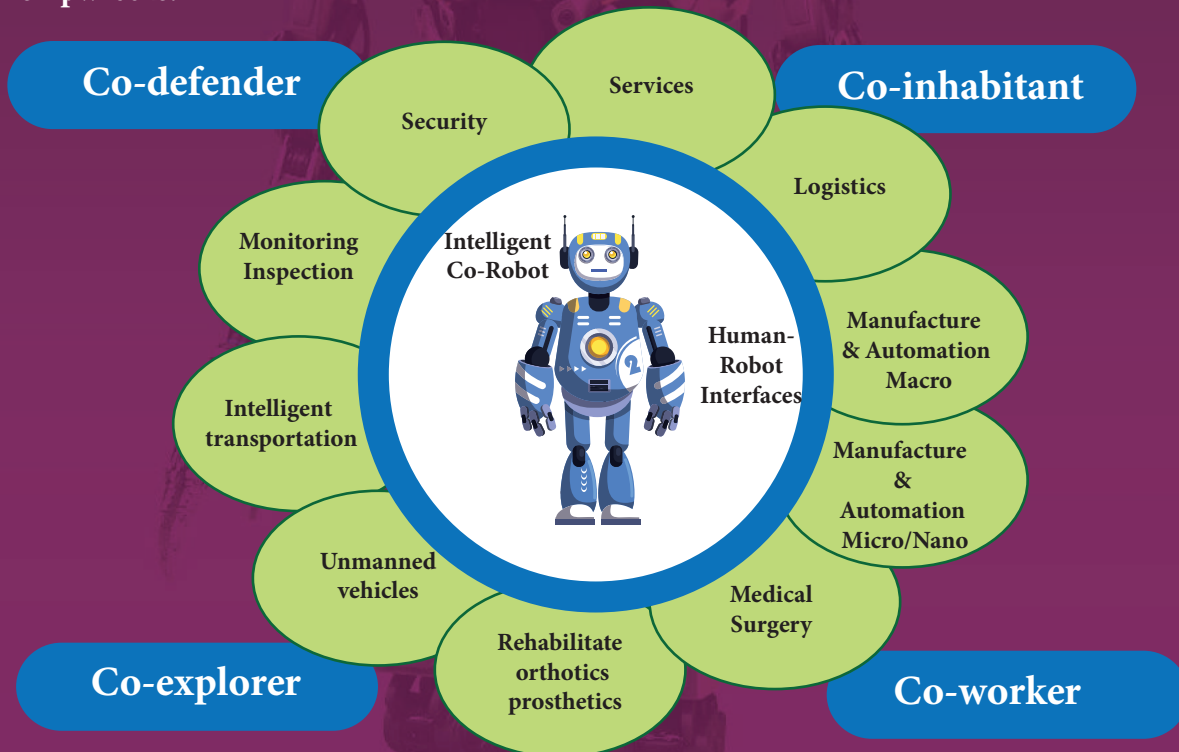


## 11.3 Robotics



### 11.3.1 What is robotics?

Robotics is an integrated study of mechanical engineering, electronic engineering, computer engineering, and science. Robot is a mechanical device designed with electronic circuitry and programmed to perform a specific task. These automated machines are highly significant in this robotic era. They can take up the role of humans in certain dangerous environments that are hazardous to people like defusing bombs, finding survivors in unstable ruins, and exploring mines and shipwrecks.



In 1954, George Devol invented the first digitally operated programmable robot called Unimate. George Devol and Joseph Engelberger, the father of the modern robotics industry formed the world's first robot company in 1956. In 1961, Unimate, was operated in a General Motors automobile factory for moving car parts around in New Jersey.



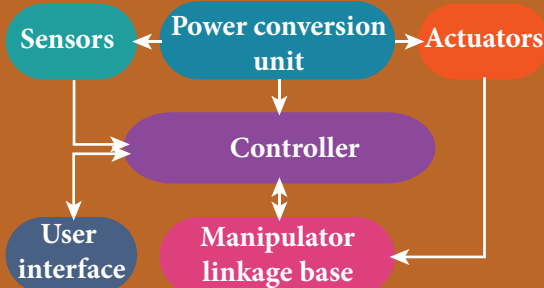
### 11.3.2 COMPONENTS OF ROBOTICS

The robotic system mainly consists of sensors, power supplies, control systems, manipulators and necessary software.

Most robots are composed of 3 main parts:

1. **The Controller** - also known as the "brain" which is run by a computer program. It gives commands for the moving parts to perform the job.
2. **Mechanical parts** - motors, pistons, grippers, wheels, and gears that make the robot move, grab, turn, and lift.
3. **Sensors** - to tell the robot about its surroundings. It helps to determine the sizes and shapes of the objects around, distance between the objects, and directions as well.

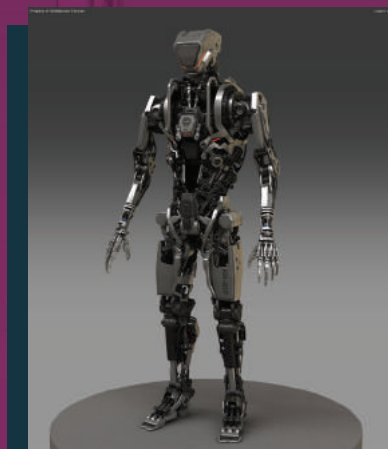
#### Key components



### 11.3.3 TYPES OF ROBOTS

#### HUMAN ROBOT

Certain robots are made to resemble humans in appearance and replicate the human activities like walking, lifting, and sensing, etc.

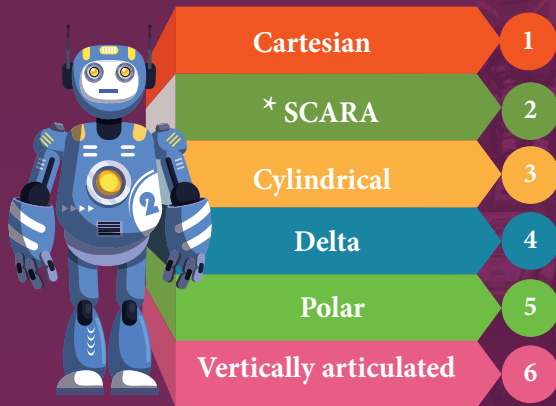


1. **Power conversion unit:** Robots are powered by batteries, solar power, and hydraulics.
2. **Actuators:** Converts energy into movement. The majority of the actuators produce rotational or linear motion.
3. **Electric motors:** They are used to actuate the parts of the robots like wheels, arms, fingers, legs, sensors, camera, weapon systems etc. Different types of electric motors are used. The most often used ones are AC motor, Brushed DC motor, Brushless DC motor, Geared DC motor, etc.
4. **Pneumatic Air Muscles:** They are devices that can contract and expand when air is pumped inside. It can replicate the function of a human muscle. They contract almost 40% when the air is sucked inside them.
5. **Muscle wires:** They are thin strands of wire made of shape memory alloys. They can contract by 5% when electric current is passed through them.
6. **Piezo Motors and Ultrasonic Motors:** Basically, we use it for industrial robots.
7. **Sensors:** Generally used in task environments as it provides information of real-time knowledge.
8. **Robot locomotion:** Provides the types of movements to a robot. The different types are
  - (a) Legged
  - (b) Wheeled
  - (c) Combination of Legged and Wheeled Locomotion
  - (d) Tracked slip/skid



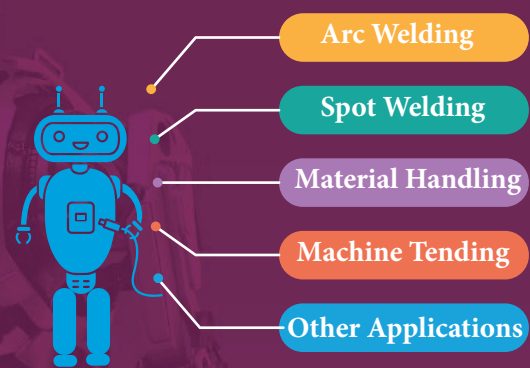
## INDUSTRIAL ROBOTS

### Six main types of industrial robots

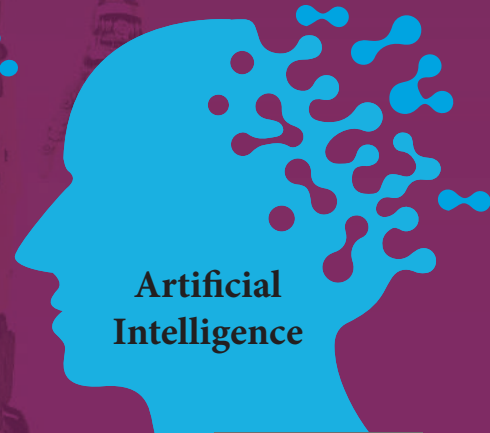


\*Selective Compliance Assembly Robot Arm

### Six-axis robots are ideal for



## Artificial Intelligence



Artificial  
Intelligence

The aim of artificial intelligence is to bring in human like behaviour in robots. It works on

1. Face recognition
2. Providing response to player's actions in computer games
3. Taking decisions based on previous actions
4. To regulate the traffic by analyzing the density of traffic on roads.
5. Translate words from one language to another







### 11.3.4 Applications

Outer space: Exploring stars, planets etc., investigation of the mineralogy of the rocks and soils on Mars, analysis of elements found in rocks and soils.

Mars Rovers of NASA



Twin Mars Rovers



Mars Pathfinder Mission



Litter robot



Welding



Cutting



Assembling



Vacuum Cleaners



Packing



Transport



Surgery



Weaponry



Lawn mowing



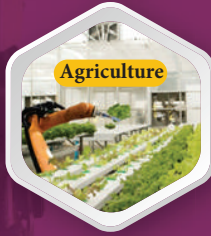
Laboratory



Underwater



Hospitals



Agriculture



Pool cleaning



Nanorobots

The size of the nano robots is reduced to microscopic level to perform a task in very small spaces. However, it is only in the developmental stage. The future prospects of it are much expected in the medical field: Nano-robots in blood stream to perform small surgical procedures, to fight against bacteria, repairing individual cell in the body. It can travel into the body and once after the job is performed it can find its way out. Chinese scientists have created the world's first autonomous DNA robots to combat cancer tumours.



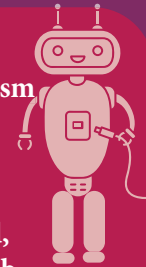


### Materials used to make robots

For robots, aluminum and steel are the most common metals. Aluminum is a softer metal and is therefore easier to work with, but steel is several times stronger. In any case, because of the inherent strength of metal, robot bodies are made using sheet, bar, rod, channel, and other shapes.

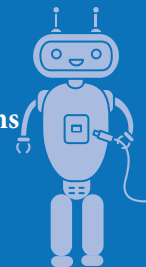
### 11.3.5 Advantages of Robotics

1. The robots are much cheaper than humans.
2. Robots never get tired like humans. It can work for 24 x 7. Hence absenteeism in work place can be reduced.
3. Robots are more precise and error free in performing the task.
4. Stronger and faster than humans.
5. Robots can work in extreme environmental conditions: extreme hot or cold, space or underwater. In dangerous situations like bomb detection and bomb deactivation.
6. In warfare, robots can save human lives.
7. Robots are significantly used in handling materials in chemical industries especially in nuclear plants which can lead to health hazards in humans.



### 11.3.6 Disadvantages of Robotics



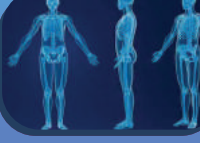

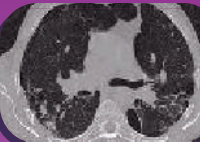

1. Robots have no sense of emotions or conscience.
2. They lack empathy and hence create an emotionless workplace.
3. If ultimately robots would do all the work, and the humans will just sit and monitor them, health hazards will increase rapidly.
4. Unemployment problem will increase.
5. Robots can perform defined tasks and cannot handle unexpected situations.
6. The robots are well programmed to do a job and if a small thing goes wrong it ends up in a big loss to the company.
7. If a robot malfunctions, it takes time to identify the problem, rectify it, and even reprogram if necessary. This process requires significant time.
8. Humans cannot be replaced by robots in decision making.
9. Till the robot reaches the level of human intelligence, the humans in work place will exit.







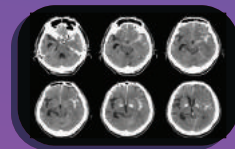
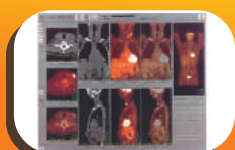
## 11. 4 Physics in medical diagnosis and therapy

Medical science very much revolves around physics principles. Medical instrumentation has widened the life span due to the technology integrated diagnosis and treatment of most of the diseases. This modernisation in all fields is possible due to efficient application of fundamental physics.

### 11.4.1 The development in medical field has been proportional to the evolution of physics as indicated below (Not for examination)

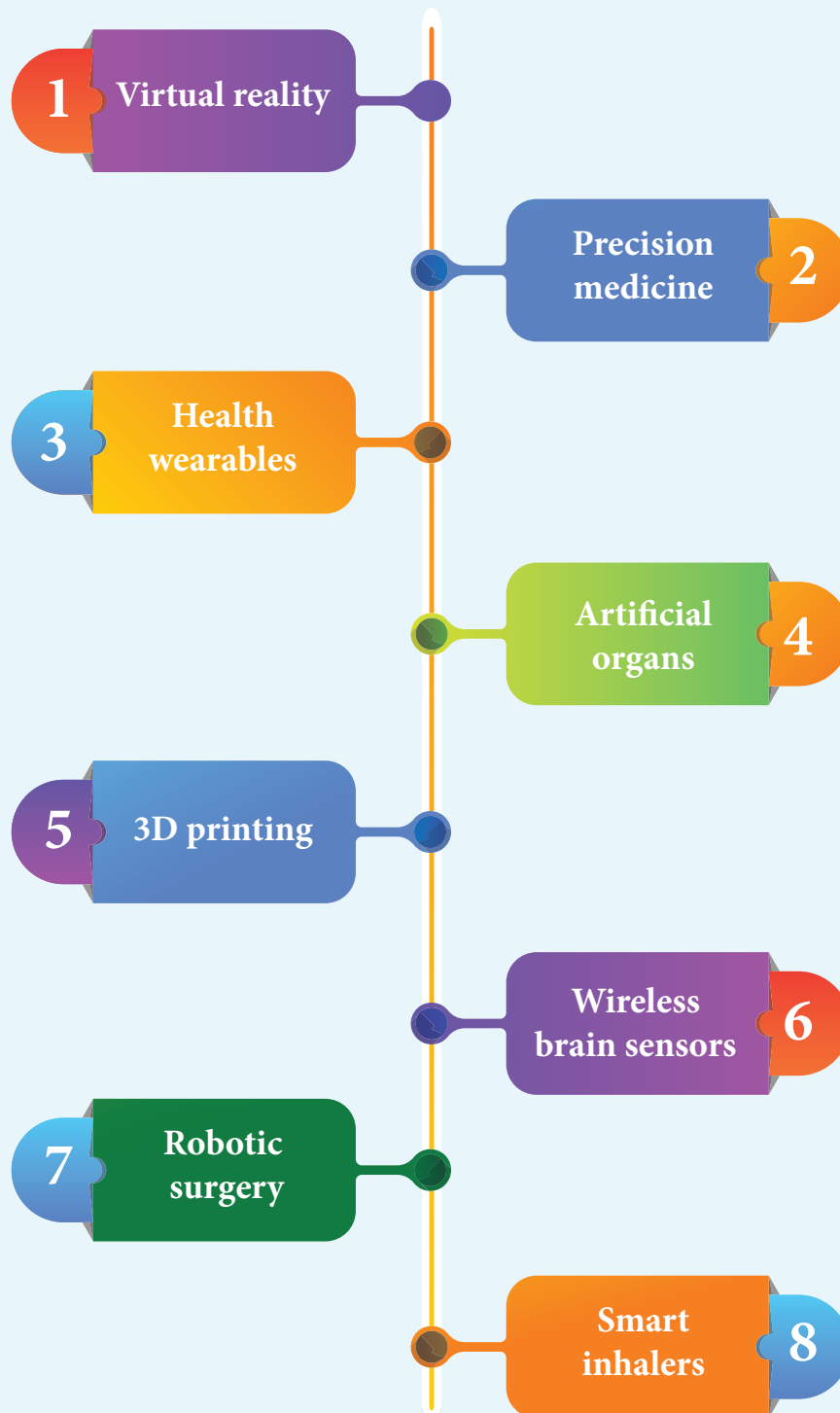
	Year	Invention in physics (Inventors)	Technique used in medicine	Image
1	1895	X-rays (Wilhelm Conrad-Röntgen)	Radiology-Xray imaging	
2	1896 and 1898	Theory of Radioactivity (Antonie Henri Becquerel, Pierre Curie and Marie Cuire)	Radioisotope imaging Nuclear Medicine	
3	1934	Artificial Radioactivity (Joliot and Irene Curie)	Scintigraphy	
4	1950	Echography & Sonography	Ecography	
5	1979	X-ray computed tomography (Cormack and Hounsfield)	Computed Tomography (CT)	
6	1952	Nuclear Magnetic Resonance (NMR) (Felix Bloch and Edward Purcell)	Magnetic Resonance Imaging (MRI)	



	Year	Invention in physics (Inventors)	Technique used in medicine	Image
7	1934	Artificial Radioactivity (Joliot and Irene Curie)	Positron Emission Tomography	
8	1940's	Optical fibre	Endoscopy, Biomedical sensors	
9	1960	LASER	Surgical instrument and diagnosis tool	
10	1959	Nanotechnology	Nanomedicine Drug delivery	
11	2005	Dual Source Computed Tomography (DSCT)	Computed Tomography (CT)	
12	1998	Nuclear medicine (David Townsend, Ronald Nutt)	Fusion Imaging Techniques (PET-CT, PET-MR)	



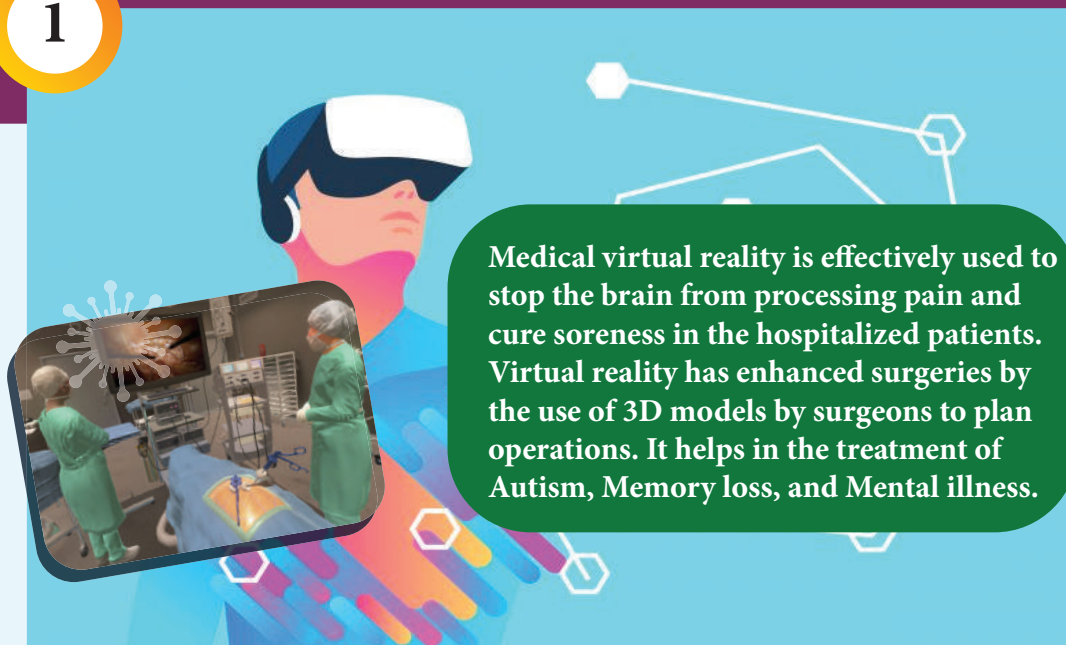
#### 11.4. 2 The recent advancement in medical technology includes



The innovation in medical diagnosis has taken leaps and bounds due to the integration of technology and basic physics. A few of such advancements are discussed.

## 1. Virtual reality

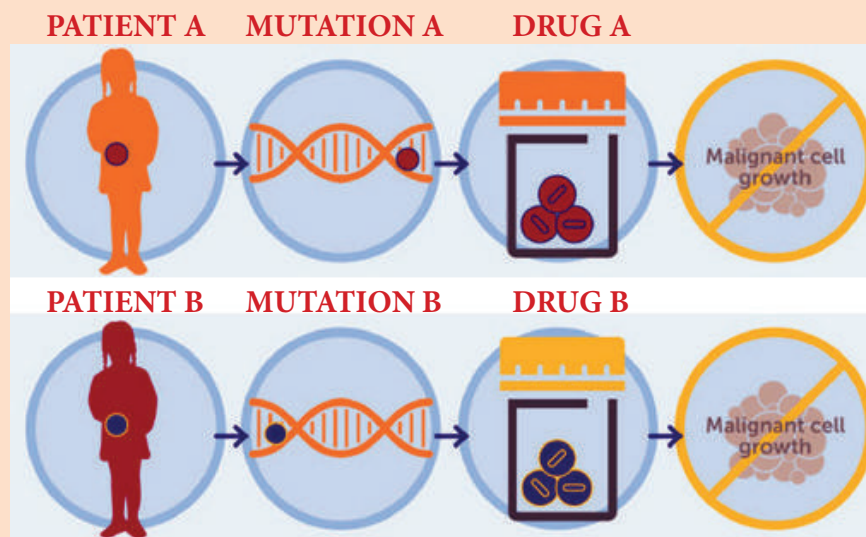
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2

## 2. Precision medicine

Precision medicine is an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person. In this medical model it is possible to customise healthcare, with medical decisions, treatments, practices, or products which are tailored to the individual patient.





### 3

### 3. Health wearables

A health wearable is a device used for tracking a wearer's vital signs or health and fitness related data, location, etc. Medical wearables with artificial intelligence and big data provide an added value to healthcare with a focus on diagnosis, treatment, patient monitoring and prevention.



#### NOTE

**Big Data:** Extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations, especially relating to human behaviour and interactions.

### 4

### 4. Artificial organs

An artificial organ is an engineered device or tissue that is implanted or integrated into a human. It is possible to interface it with living tissue or to replace a natural organ. It duplicates or augments a specific function or functions of human organs so that the patient may return to a normal life as soon as possible.



## 5

## 5. 3D printing

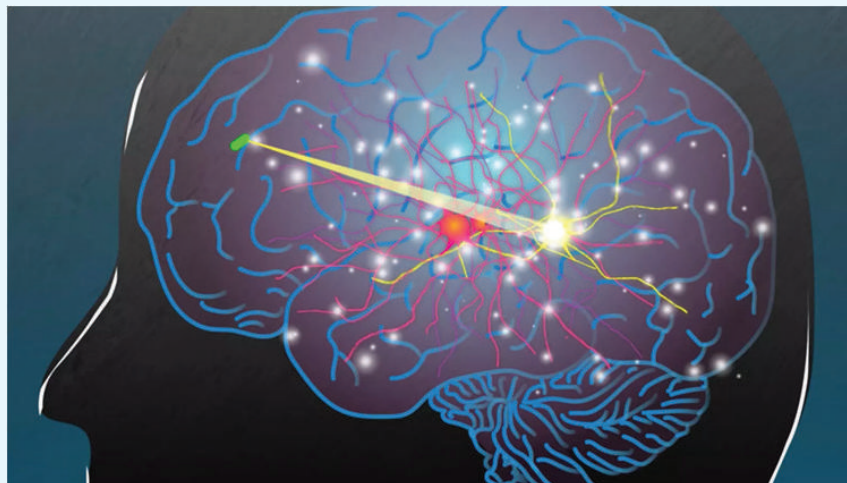
Advanced 3D printer systems and materials assist physicians in a range of operations in the medical field from audiology, dentistry, orthopedics and other applications.



## 6

## 6. Wireless brain sensors

Wireless brain sensors monitor intracranial pressure and temperature and then are absorbed by the body. Hence there is no need for surgery to remove these devices.



## 7

## 7. Robotic surgery

Robotic surgery is a type of surgical procedure that is done using robotic systems. Robotically-assisted surgery helps to overcome the limitations of pre-existing minimally-invasive surgical procedures and to enhance the capabilities of surgeons performing open surgery.



## 8

## 8. Smart inhalers

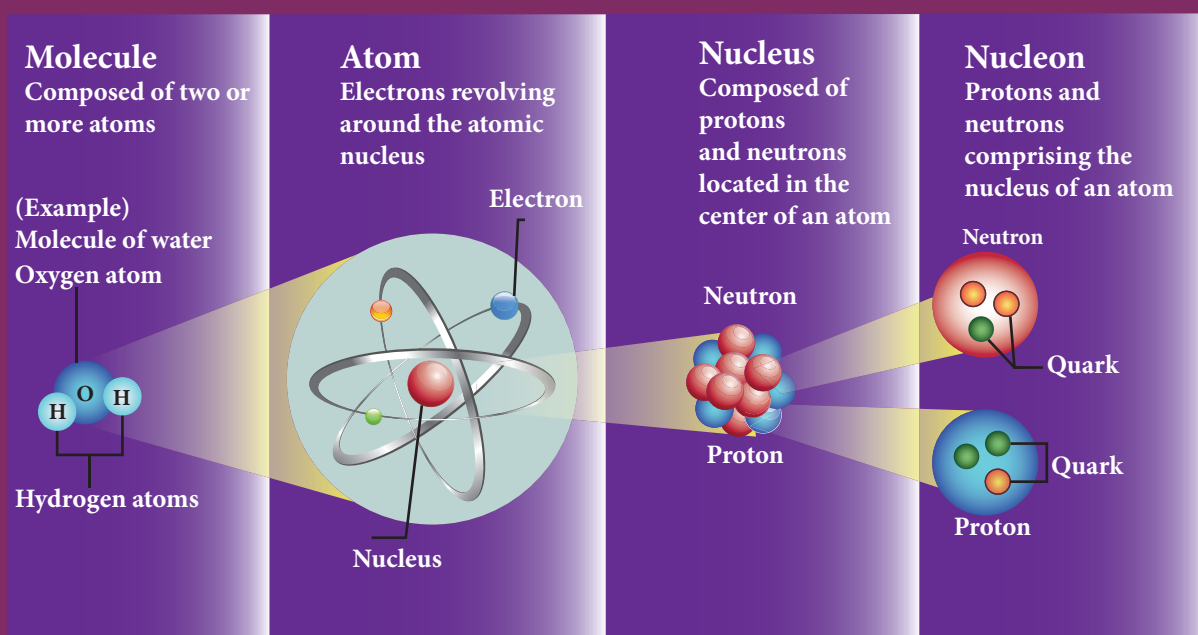
Inhalers are the main treatment option for asthma. Smart inhalers are designed with health systems and patients in mind so that they can offer maximum benefit. Smart inhalers use bluetooth technology to detect inhaler use, remind patients when to take their medication and gather data to help guide care.



## Other recent developments in physics

### Particle Physics

Particle physics deals with the theory of fundamental particles of nature and it is one of the active research areas in physics. Initially it was thought that atom is the fundamental entity of matter. In 1930s, it was established that atoms are made up of electrons, protons and neutrons.



In the 1960s, quarks were discovered and it was understood that proton and neutron are made up of quarks. In the meantime, the particle physics research gained momentum and has grown exponentially both in theoretical and experimental perspective. Later it was found that the quarks interact through gluons. It is the field which received more number of noble prizes. Recently in the year 2013, famous 'Higgs particles' also known as "God" particles were discovered and for this, Peter Higgs and Englert received noble prize in physics. It is the 'Higgs particle' which gives mass to many particles like protons, neutrons etc.





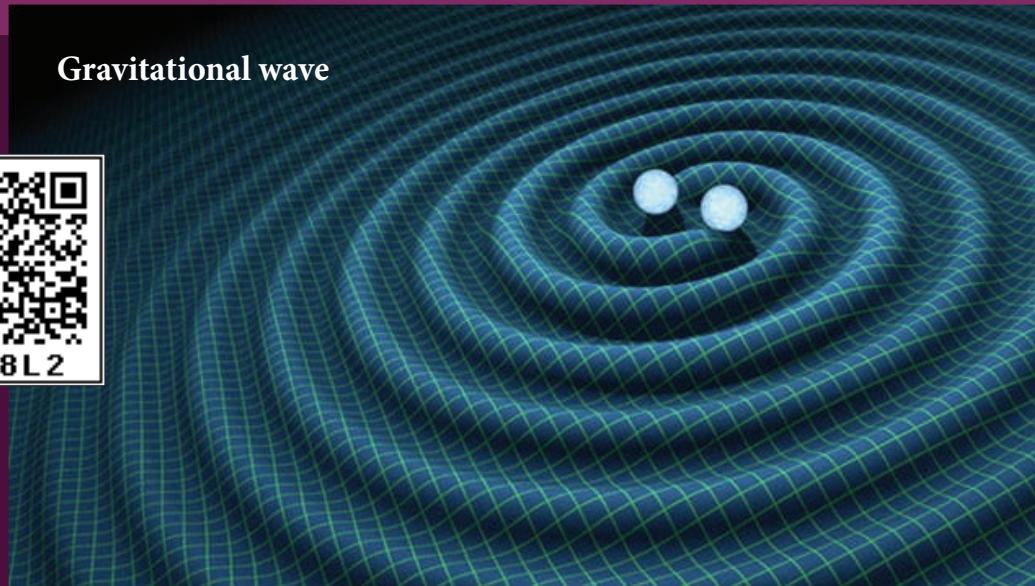


## Cosmology

Cosmology is the branch that involves the origin and evolution of the universe. It deals with formation of stars, galaxy etc. In the year 2015, the existence of “gravitational waves” was discovered and noble prize was awarded for this discovery in the year 2017.

Gravitational waves are the disturbances in the curvature of space-time and it travels with speed of light. Any accelerated charge emits electromagnetic wave. Similarly any accelerated mass emits gravitational waves but these waves are very weak even for masses like earth. The strongest source of gravitational waves are black holes. The discovery of gravitational waves made it possible to study the structure of black holes since it is the strongest source of gravitational waves. In fact, the recent discoveries of gravitational waves are emitted by two black holes when they merge to a single black hole. In fact, Albert Einstein theoretically proposed the existence of ‘gravitational waves’ in the year 1915. After 100 years, it is experimentally proved that his predictions are correct.

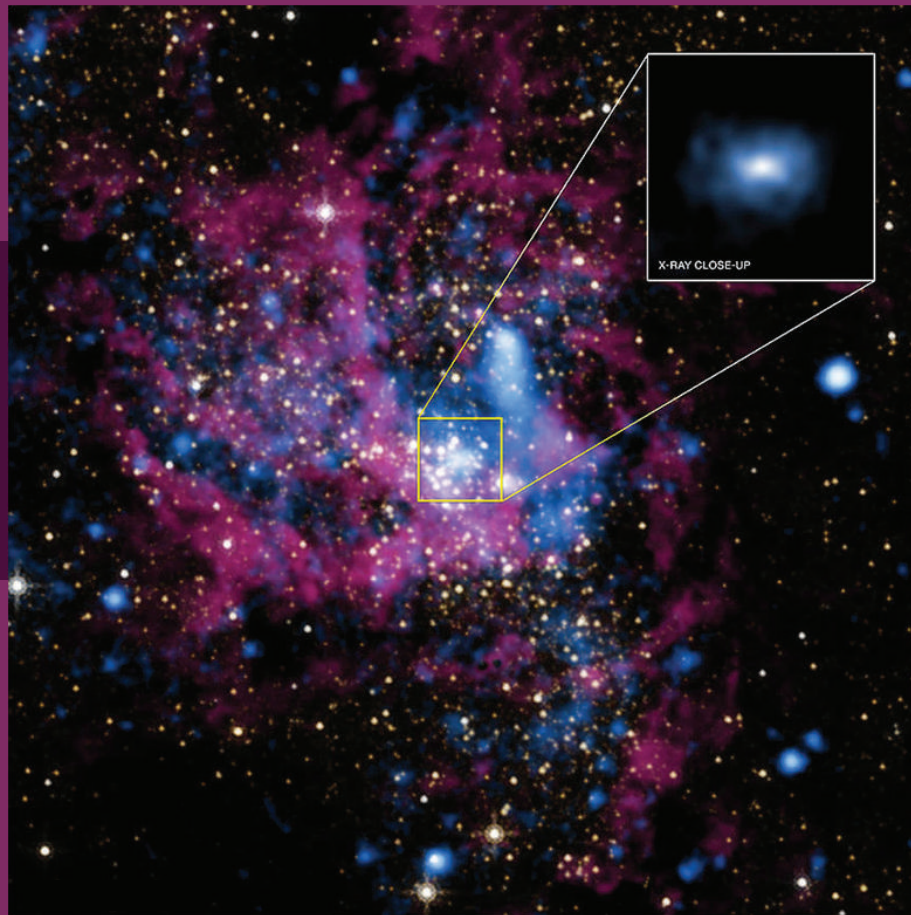
Gravitational wave



Black holes are end stage of stars which are highly dense massive object. Its mass ranges from 20 times mass of the sun to 1 million times mass of the sun. It has very strong gravitational force such that no particle or even light can escape from it. The existence of black holes is studied when the stars orbiting the black hole behave differently from the other stars. Every galaxy has black hole at its center. Sagittarius A\* is the black hole at the center of the Milky Way galaxy.







**Black hole sagittarius A<sup>\*</sup>**

The famous physicist Stephen Hawking worked in the field of black holes.



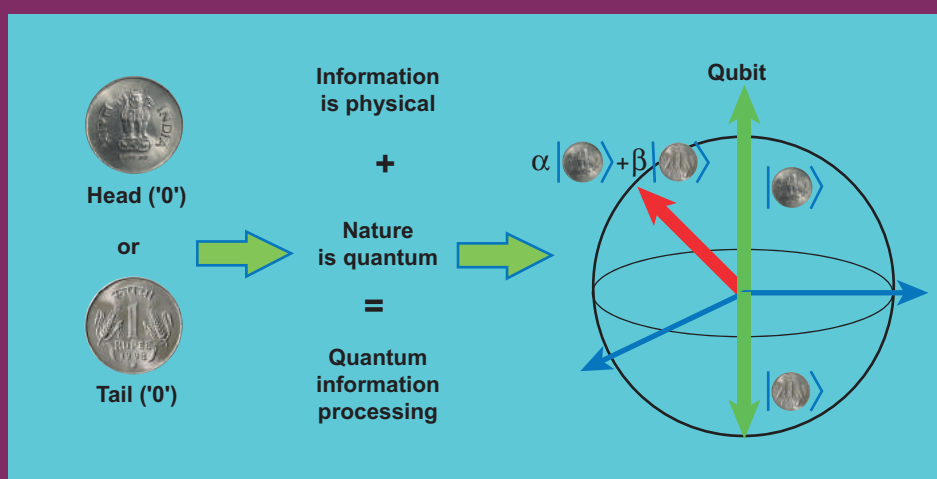
**Actual photograph of a super massive black hole M87<sup>\*</sup>**

Super computers and eight telescopes stationed on five continents (EVENT HORIZON TELESCOPE) were used to develop a huge data to accomplish this. It has once again confirmed the Einstein's theory of general relativity.



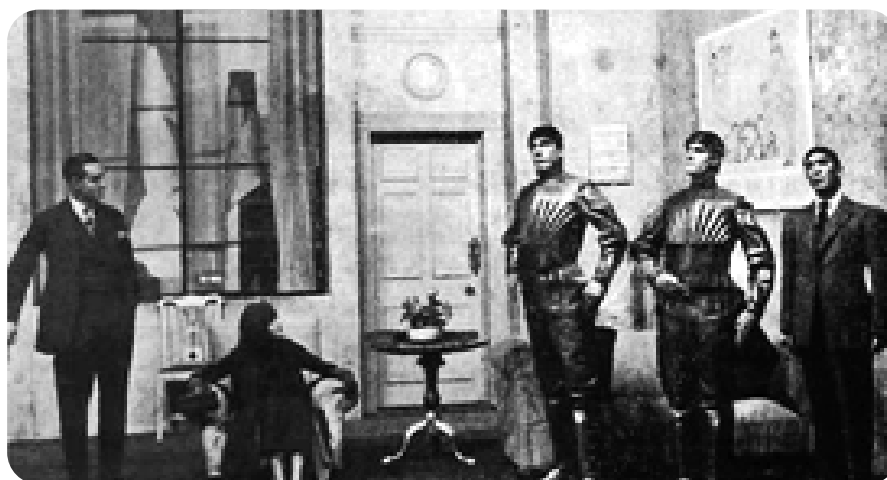
## Quantum information theory (Not for examination)

It is another fast developing research area which deals with improving the information storage using quantum computers. The present computers store information in the form of 'bits' but quantum computers store information in the form of 'qubits'. 'qubit' refers to quantum bit and it is the basic unit of quantum information. Classical bit implies either 0 or 1. But qubit not only includes 0 or 1 and also linear superposition of 0 and 1. This technology reduces the calculating time exponentially. This research field has very promising application in future.



Many striking innovations and discoveries originate from scientific fictions.

Robots are also no exception to this. The word robotics was derived from the word robot. It was introduced in the play 'Rossum Universal Robots' by the Czech writer Karel Capek in 1920. The word robot comes from the Slavic word rabota, which means labour or work. The play begins in a factory that makes artificial people called robots. They looked like creatures that can be mistaken for humans (picture shown). These characters were very similar to the modern ideas of androids.



(A scene from the play Rossum Universal Robots, showing three robots)

## SUMMARY

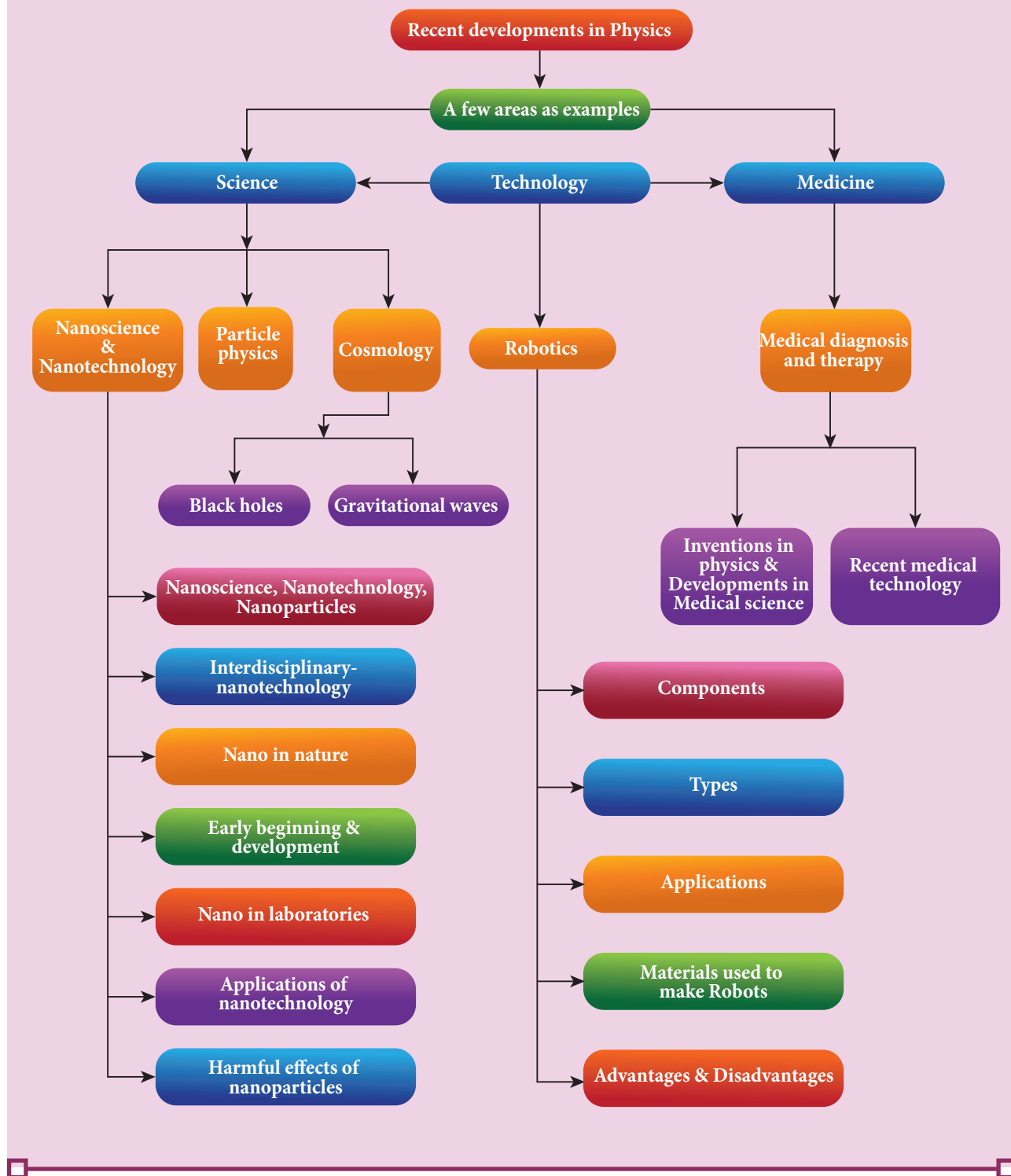
- Salient physics principles (covered in the higher secondary physics) are the foundation for technology break through.
- Physics is the basic building block for Science, Engineering, Technology and Medicine. Nano science is the science of objects with typical sizes of 1–100 nm.
- Nano means one-billionth of a metre that is  $10^{-9}$  m.
- Nanotechnology is a technology involving the design, production, characterization, and applications of nano structural materials.
- If the particle of a solid is of size less than 100 nm, it is said to be a ‘nano solid’.
- When the particle size exceeds 100 nm, it forms a ‘bulk solid’.
- Nano form of the material shows strikingly different properties when compared to its bulk counterpart.
- Quantum confinement effects and surface effects are the two important phenomena that govern nano properties.
- Nanoscience and technology is the interdisciplinary area covering its applications in various fields.
- Nano scale structures existed in nature long before scientists began studying them in laboratories.
- There are two ways of preparing the nanomaterials, top down and bottom up approaches.
- Nanotechnology applications cover various fields.
- The major concern with nano application is that the nanoparticles have the dimensions same as that of the biological molecules such as proteins.
- Nano particles can easily get absorbed onto the surface of living organisms and they might enter the tissues and fluids of the body.
- The adsorbing nature depends on the surface of the nanoparticle.
- It is possible to deliver a drug directly to a specific cell in the body by designing the surface of a nanoparticle.
- Nanoparticles of a few nanometers size may reach well inside biomolecules, which is not possible for larger nanoparticles.
- Nanoparticles can also cross cell membranes.
- The inhaled nanoparticles reach the blood and that may also reach other sites such as the liver, heart or blood cells.
- Robotics is an integrated study of mechanical engineering, electronic engineering, computer engineering, and science.
- Robot is a mechanical device designed with electronic circuitry and programmed to perform a specific task.
- The robotic system mainly consists of sensors, power supplies, control systems, manipulators and necessary software.



- The key components of a robot are Power conversion unit, Actuators, Electric motors, Pneumatic Air Muscles, Muscle wires, Piezo Motors and Ultrasonic Motors, Sensors, and Robot locomotion.
- Six main types of industrial robots are Cartesian, SCARA, Cylindrical, Delta, Polar and Vertically articulated robot.
- Six-axis robots are ideal for Arc Welding, Spot Welding, Material Handling, Machine Tending.
- Five major fields of robotics: Human-robot interface, Mobility, Manipulation, Programming and Sensors.
- The aim of artificial intelligence is to bring in human like behavior in robots.
- Artificial intelligence works on face recognition, providing response to players' actions in computer games, taking decisions based on previous actions, regulating the traffic by analyzing the density of traffic on roads and translate words from one language to another.
- Materials used to make robots: aluminum and steel are the most common metals.
- Aluminum is a softer metal and is therefore easier to work with.
- Steel is several times stronger.
- Due to the inherent strength of metal, robot bodies can be made using sheet, bar, rod, channel, and other shapes.
- Robots have many advantages in various applications but also have several disadvantages.
- In outer space robots are used for exploring stars, planets etc., investigation of the mineralogy of the rocks and soils on Mars, analysis of elements found in rocks and soils.
- Household robots are used as vacuum cleaners, floor cleaners, gutter cleaners, lawn mowing, pool cleaning, and to open and close doors.
- Industrial Robots are used for welding, cutting, robotic water jet cutting, robotic laser cutting, lifting, sorting, bending, manufacturing, assembling, packing, transport, handling hazardous materials like nuclear waste, weaponry, laboratory research, mass production of consumer and industrial goods.
- Nano-robots are being developed to be in the blood stream to perform small surgical procedures, to fight against bacteria, repairing individual cell in the body.
- The development in medical field has been proportional to the evolution of physics.
- The recent medical technology includes virtual reality, precision medicine, health wearables, artificial organs, 3D printing, wireless brain sensors, robotic surgery, smart inhalers.
- Particle physics deals with fundamental particles of nature. Protons and neutrons are made of quarks.
- Cosmology is the branch that involves the origin and evolution of the universe.
- Accelerated mass emits gravitational waves which are very weak.
- Black holes are the strongest source of gravitational waves.



## CONCEPT MAP



## EVALUATION



### I Multiple Choice Questions

1. The particle size of ZnO material is 30 nm. Based on the dimension it is classified as
  - a) Bulk material
  - b) Nanomaterial
  - c) Soft material
  - d) Magnetic material
2. Which one of the following is the natural nanomaterial.
  - a) Peacock feather
  - b) Peacock beak
  - c) Grain of sand
  - d) Skin of the Whale
3. The blue print for making ultra durable synthetic material is mimicked from
  - a) Lotus leaf
  - b) Morpho butterfly
  - c) Parrot fish
  - d) Peacock feather
4. The method of making nanomaterial by assembling the atoms is called
  - a) Top down approach
  - b) Bottom up approach
  - c) Cross down approach
  - d) Diagonal approach
5. "Sky wax" is an application of nano product in the field of
  - a) Medicine
  - b) Textile
  - c) Sports
  - d) Automotive industry



6. The materials used in Robotics are
  - a) Aluminium and silver
  - b) Silver and gold
  - c) Copper and gold
  - d) Steel and aluminum
7. The alloys used for muscle wires in Robots are
  - a) Shape memory alloys
  - b) Gold copper alloys
  - c) Gold silver alloys
  - d) Two dimensional alloys
8. The technology used for stopping the brain from processing pain is
  - a) Precision medicine
  - b) Wireless brain sensor
  - c) Virtual reality
  - d) Radiology
9. The particle which gives mass to protons and neutrons are
  - a) Higgs particle
  - b) Einstein particle
  - c) Nanoparticle
  - d) Bulk particle
10. The gravitational waves were theoretically proposed by
  - a) Conrad Rontgen
  - b) Marie Curie
  - c) Albert Einstein
  - d) Edward Purcell

### Answers

- |      |      |      |      |       |
|------|------|------|------|-------|
| 1) b | 2) a | 3) c | 4) b | 5) c  |
| 6) d | 7) a | 8) c | 9) a | 10) c |



## II Short answers

1. Distinguish between Nanoscience and Nanotechnology.
2. What is the difference between Nano materials and Bulk materials?
3. Give any two examples for “Nano” in nature.
4. Mention any two advantages and disadvantages of Robotics.
5. Why steel is preferred in making Robots?
6. What are black holes?
7. What are sub atomic particles?

## III Long Answers

1. Discuss the applications of Nanomaterials in various fields.
2. What are the possible harmful effects of usage of Nanoparticles? Why?
3. Discuss the functions of key components in Robots?
4. Elaborate any two types of Robots with relevant examples.
5. Comment on the recent advancement in medical diagnosis and therapy.

## BOOKS FOR REFERENCE

1. Pradeep, T. Nano Essential Understanding Nano Science and Nanotechnology, McGraw Hill Education, India 2007.
2. Rita John, Solid State Physics, McGraw Hill Education, India 2016
3. Asim K Das, Mahua Das, An Introduction to Nano Science and Nano technology, CBS Publishers and Distributors Pvt Ltd, India 2017.
4. Jerrold T. Bushberg, J. Anthony Seibert, The Essential Physics of Medical Imaging, Wolters Kluwer, Lippin Cott Williams & Wilkins 2012
5. Brian R Martin, Particle Physics, Kindle edition, 2011
6. B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday, Textbook of Nanoscience and Nanotechnology, Springer, Universities Press, 2013



## ICT CORNER

### Recent developments in physics

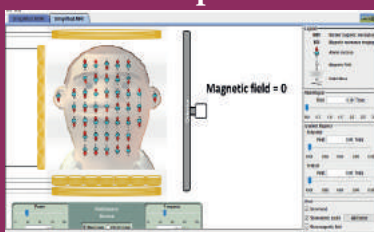
In this activity you will be able to (i) observe the changes in the nuclear spins of the hydrogen nuclei of your water molecules due to the external magnetic field (ii) find out the resonance frequency that promote a resultant photon.

#### Topic: MRI scan

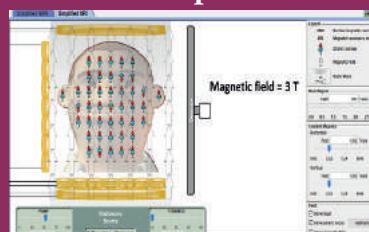
#### STEPS:

- Go to '<https://phet.colorado.edu/en/simulation/legacy/mri>' page and download simplified MRI java file. Or go to Google → Phet → simulation → Physics → simplified MRI and download the java file.
- Open simplified MRI java file. Select simplified MRI tab.
- Observe the nuclear spins of the hydrogen nuclei present in the water molecules in brain (blue is the hydrogen nuclei). Are they aligned in same direction? What happens when you change the external magnetic field? Are they aligned in the same direction under external field? Discuss the reason.
- Now adjust the frequency bar. For a particular frequency, hydrogen nuclei emit radio waves from left to right and find out the frequency when the nuclei start broadcasting radio waves. This is resonance frequency.
- Add a tumour. Adjust the resonance frequency slightly to produce the strongest signal from the tumour. Record the tumour resonance frequency. Is there a shift?
- With the help of shift in resonance frequency, tumour inside the brain can be calculated.

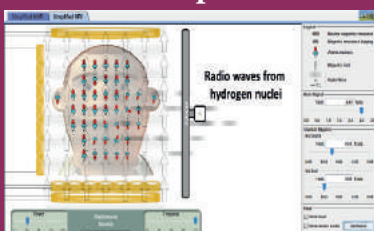
Step1



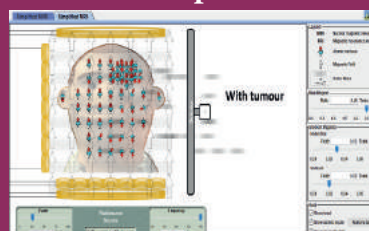
Step2



Step3



Step4



#### Note:

Install Java application if it is not in your browser.

#### URL:

<https://phet.colorado.edu/en/simulation/legacy/mri>

\* Pictures are indicative only.

\* If browser requires, allow **Flash Player** or **Java Script** to load the page.



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## GLOSSARY

### கலைச்சொற்கள்

- |                                      |   |
|--------------------------------------|---|
| 1. Acceptance angle                  | - ஏற்புக்கோணம்                                    |
| 2. Acceptor energy level             | - ஏற்பு அணு ஆற்றல் மட்டம்                         |
| 3. Activity                          | - செயல்பாடு                                       |
| 4. Amplitude modulation              | - வீச்சுப் பண்பேற்றம்                             |
| 5. Analyser                          | - பகுப்பான்                                       |
| 6. Anti fouling coating              | - கறைபடியா மேற்பூச்சு                             |
| 7. Anti particle                     | - எதிர்த்துகள்                                    |
| 8. Apparent depth                    | - தோற்ற ஆழம்                                      |
| 9. Astigmatism                       | - ஒரு தளப்பார்வை                                  |
| 10. Attenuation                      | - வலுவிழப்பு                                      |
| 11. Automotive industry              | - வாகனத் தொழில்                                   |
| 12. Auto-immune disease              | - நோய் எதிர்ப்பு சக்திக்கு எதிரான நோய்            |
| 13. Band gap energy                  | - பட்டை இடைவெளி ஆற்றல்                            |
| 14. Barrier potential                | - அரண் மின்னழுத்தம்                               |
| 15. Baseband signal                  | - அடிக்கற்றை சைகை                                 |
| 16. Biasing                          | - சார்பளித்தல்                                    |
| 17. Binding energy                   | - பிணைப்பாற்றல்                                   |
| 18. Bipolar junction transistor      | - இருமுனைச் சந்தி டிரான்சிஸ்டர்                   |
| 19. Boolean Algebra                  | - பூலியன் இயற்கணிதம்                              |
| 20. Brain tumor                      | - மூளைக்கட்டி                                     |
| 21. Bright fringe                    | - பொலிவுப்பட்டை                                   |
| 22. Broadcasting station             | - ஒலிபரப்பும் நிலையம்                             |
| 23. Carrier concentration            | - ஊர்தி செறிவு                                    |
| 24. Carrier signal                   | - ஊர்தி சைகை                                      |
| 25. Central bright fringe            | - மையப்பொலிவுப்பட்டை                              |
| 26. Characteristic x-rays            | - சிறப்பு x கதிர்கள்                              |
| 27. Chemical Vapour Deposition (CVD) | - வேதிவினை நீராவி படிவு (அ) வேதி ஆவி படிக்கமக்கல் |
| 28. Classical electrodynamics        | - செவ்வியல் மின்னியக்கவியல்                       |
| 29. Collector-base junction          | - ஏற்பான் - அடிவாய் சந்தி                         |
| 30. Computed Tomography              | - கணினி வரைவி                                     |
| 31. Concave lens                     | - குழிலென்ஸ்                                      |
| 32. Concave mirror                   | - குழி அடி  |
| 33. Continuous x-rays                | - தொடர் x கதிர்கள்                                |
| 34. Convex lens                      | - குவிலென்ஸ்                                      |



35. Convex mirror	- குவி அடி
36. Critical angle	- மாறுநிலைக்கோணம்
37. Cut-off region	- முறிவுப் பகுதி
38. Dark fringe	- கரும்பட்டை
39. Decay mode	- சிதைவுப் பாணி
40. Depletion region	- இயக்கமில்லா பகுதி
41. Diffraction	- விளிம்புவிளைவு
42. Diffusion current	- விரவல் மின்னோட்டம்
43. Digital and analog signal	- இலக்கமுறை மற்றும் தொடர் சைகை
44. Discrete	- பிரிநிலை
45. Dispersion	- நிறப்பிரிகை
46. Distance of closest approach	- அணுகும் மீச்சிறு தொலைவு
47. Donor energy level	- கொடை அணு ஆற்றல் மட்டம்
48. Doping	- மாதூட்டல்
49. Drift current	- இழுப்பு மின்னோட்டம்
50. Droplet	- திவலை
51. Duality	- இருமைப்பண்பு
52. Dynamic resistance	- மாறு மின்தடை
53. Electron-hole recombination	- எலக்ட்ரான் - துளை மறு இணைவு
54. Electron current	- எலக்ட்ரான் மின்னோட்டம்
55. Electron emission	- எலக்ட்ரான் உமிழ்வு
56. Electrostatic lens	- நிலை மின்புல லென்ஸ்
57. Emitter-base junction	- உமிழ்ப்பான் - அடிவாய் சந்தி
58. Emitter current	- உமிழ்ப்பான் மின்னோட்டம்
59. Energy band diagram	- ஆற்றல் பட்டை வரைபடம்
60. Endoscopy	- அக உள்நோக்கி
61. Excitation energy	- கிளர்வு ஆற்றல்
62. Extrinsic	- புறவியலான
63. Feedback circuit	- பின்னூட்டச் சுற்று
64. Fiber optic communication	- ஒளி இழைத் தகவல் தொடர்பு
65. Field emission	- புல உமிழ்வு
66. Focal length	- குவியத்தொலைவு
67. Forward current gain	- முன்னோக்கு மின்னோட்டப்பெருக்கம்
68. Frequency modulation	- அதிர்வெண் பண்பேற்றம்
69. Fringe width	- பட்டை அகலம்
70. Fuel cell	- எரிபொருள் மின்கலன்
71. Glass slab	- கண்ணாடிப்பட்டகம்
72. Global Positioning System	- உலகளாவிய நிலை அறிவும் அமைப்பு
73. Ground State / excited state	- தரை நிலை / கிளர்ச்சி நிலை
74. Ground wave propagation	- தரை அலை பரவல்
75. Hole current	- துளை மின்னோட்டம்
76. Hypermetropia	- தூரப்பார்வை
77. Impact parameter	- மோதல் காரணி
78. Impurity atoms	- மாசு அணுக்கள்





79. Interference	- குறுக்கீட்டு விளைவு
80. Intrinsic	- உள்ளார்ந்த
81. Knee voltage	- பயன்தொடக்க மின்னழுத்தம்
82. Light emitting diode	- ஒளி உமிழ் டையோடு
83. Line of sight communication	- நேர்க்கோட்டுப்பார்வை தகவல் தொடர்பு
84. Load current	- பளு மின்னோட்டம்
85. Load resistance	- பளு மின்தடை
86. Logic gates	- தர்க்க வாயில்கள் (லாஜிக் கேட்டுகள்)
87. Looming	- நிழல் தோற்றம்
88. Magnetic lens	- காந்தப் புலலென்ஸ்
89. Magnification	- உருப்பெருக்கம்
90. Majority charge carriers	- பெரும்பான்மை மின்னூட்ட ஊர்திகள்
91. Marginal rays	- ஓரக்கதிர்கள்
92. Matter waves	- பருப்பொருள் அலைகள்
93. Maximum secondary voltage	- பெரும துணை மின்னழுத்தம்
94. Minority charge carriers	- சிறுபான்மை மின்னூட்ட ஊர்திகள்
95. Mirage	- கானல் நீர்
96. Mobile communication	- செல் பேசி தகவல் தொடர்பு
97. Moderator	- தணிப்பான்
98. Myopia	- கிட்டப்பார்வை
99. Near point focusing	- அண்மைக் குவி நிலை
100. Negative space charge region	- எதிர்மின்திரள் பகுதி
101. Normal focusing	- இயல்பு குவி நிலை
102. Nuclear fission	- அணுக்கரு பிளவு
103. Nuclear fusion	- அணுக்கரு இணைவு
104. Optical fiber	- ஒளிஇழை
105. Optoelectronic devices	- ஒளியியல் மின்னணு சாதனங்கள்
106. Paraxial rays	- அண்மை அச்சக்கதிர்கள்
107. Peak inverse voltage	- பெரும புரட்டு மின்னழுத்தம்
108. Phase	- கட்டம்
109. Phase modulation	- கட்டப் பண்பேற்றம்
110. Photo conductive cell	- ஒளிமின் கடத்து மின்கலம்
111. Photoelectric emission	- ஒளிமின் உமிழ்வு
112. Photoelectrons	- ஒளி எலக்ட்ரான்கள்
113. Photo emissive cell	- ஒளிமின் உமிழ்வு மின்கலம்
114. Photosensitive material	- ஒளி உணர் பொருள்
115. Photosensitive materials	- ஒளி நுண் உணர்வு பொருட்கள்
116. Photo voltaic cell	- ஒளி வோல்டா மின்கலம்
117. Polariser	- தளவிளைவாக்கி
118. Polarization	- தளவிளைவு
119. Positive and negative logic	- நேர் மற்றும் எதிர் தர்க்கம்
120. Positive space charge region	- நேர் மின்திரள் பகுதி
121. Potential barrier	- மின்னழுத்த அரண்
122. Power of lens	- லென்சின் திறன்





123. Presbyopia	- வெள்ளெழுத்து
124. Prism	- முப்பட்டகம்
125. Prosthetics	- செயற்கைமூட்டு
126. Pulsating output	- துடிப்பு வெளியீடு
127. Quantization	- குவாண்டமாக்கல்
128. Radioactive recombination	- கதிர்வீச்சு மறுஇணைவு
129. Radio isotope imaging	- கதிர்வீச்சு ஐசோடோப்பு பிம்பம்
130. Radiology	- கதிரியக்கச் சிகிச்சை
131. Radiology X-ray imaging	- கதிரியக்க ஊடுகதிர் பிம்பம்
132. Rectification	- திருத்துதல்
133. Rectifier efficiency	- திருத்தியின் பயனுறுதிறன்
134. Reflection	- ஒளி எதிரொளிப்பு
135. Refraction	- ஒளிவிலகல்
136. Refractive Index	- ஒளிவிலகல் எண்
137. Repeater	- மறு ஒலிபரப்பி
138. Resolution	- பிரித்தறிதல்
139. Resolving Power	- பிரிதிறன்
140. Reverse saturation current	- பின்னோக்கு செறிவு மின்னோட்டம்
141. Robot	- இயந்திர மனிதன்
142. Robotic surgery	- இயந்திரமனித அறுவைசிகிச்சை
143. Scanning Tunneling Microscope (STM)	- துளைக்கும் வரிக்கண்ணோட்ட நுண்ணோக்கி
144. Scattering	- ஒளிச்சிதறல்
145. Secondary emission	- இரண்டாம் நிலை உமிழ்வு
146. Sensor	- உணர்வி
147. Skip distance	- தாவுத் தொலைவு
148. Skip zone	- தாவு மண்டலம்
149. Sky wave propagation	- வான் அலை பரவல்
150. Space wave propagation	- வெளி அலை பரவல்
151. Specific Charge	- மின்னூட்ட எண்
152. Stopping potential	- நிறுத்து மின்னழுத்தம்
153. Surface barrier	- பரப்பு அரண்
154. Thermionic emission	- வெப்பஅயனி உமிழ்வு
155. Threshold frequency	- பயன்தொடக்க அதிர்வெண்
156. Total Internal reflection	- முழு அக எதிரொளிப்பு
157. Transmitting antenna	- பரப்பும் விண்ணலைக்கம்பி
158. Wavefront	- அலைமுகப்பு
159. Wireless brain sensor	- கம்பியில்லா மூளை உணர்வி
160. Work function	- வெளியேற்று ஆற்றல்



Solved examples



Competitive Exam corner



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