Contents

ROBOTICS[1]

The origin of the word 'robot' is in the Czech word '*robota*' meaning either a slave or a mechanical item that would help its master. A robot is an intelligent machine that can perform tasks either on its own or with guidance. Today, robots are guided by computer and electronic programming. They can be autonomous or semi-autonomous.

Robotics involves several disciplines such as mechanical engineering, computer engineering, electronics engineering. Since robots are designed to carry out the tasks that are often done by humans, such as assembling parts in a manufacturing plant, few aspects of robotics come under the purview of artificial intelligence.

Today Robots do reconnaissance and they ferry loads. They carry out violent attacks and they save lives. Military robots are sparking a revolution, both on and off the battlefield. Today Military Robots constitute a $6 billion market.

Historical Background of Robotics

- ✓ The earliest example of robotics comes from China's **water clocks** that date back to 6th century BC.
- ✓ There are 4th century records of use of the stop-watch for imposing a time limit on clients' visits in Athenian brothels in Greek.

[1] This document has been prepared with the help of the following sources:

1. **Wikipedia** under Creative Common Sharealike License
2. **Science Daily** (www.sciencedaily.com)
3. **Ministry of Information Technology**, Government of India
4. **Ministry of Earth Sciences**, Government of India.
5. **Ministry of Science and Technology,** Government of India
6. **Press Information Bureau**
7. **Nano-Letters**
8. **The Times of India**
9. **Current Science,** A publication of Indian Academy of Sciences

- ✓ Hero of Alexandria (10–70 AD) is known to have created numerous "programmable" automated devices, including one that allegedly could speak.
- ✓ The credit for developing **first programmable humanoid robot** goes to Arab Muslim inventor **Al-Jazari** in 1206.
- ✓ Then, we know about the **Leonardo's robot** which refers to a humanoid automaton designed by ***Leonardo da Vinci*** around the year 1464, discovered in his sketchbooks in late 1950s.
- ✓ In the wake of the industrial revolution the first programmable loom controlled by punch cards was developed in France in 1720s.
- ✓ In 1801, Card programmable **Jacquard loom** was introduced in France for mass production.
- ✓ In 1822, Babbage completed the difference engine for automatic computation of tables in England.
- ✓ In 1830's **The Automat,** a cam programmable lathe was invented by Spencer in the USA.
- ✓ In 1892 Motor operated crane with a gripper for removing ingots from a lumace was patented by Babbitt in- the USA.
- ✓ From the third quarter of the 18th century, Industrial Revolution in England started and this brought the age of **spinning genny**, power looms and steam engine. The most important initial developments were as follows:
    - Richard Arkwright developed water frame.
    - James Hargreaves developed Spinning Jenny
    - Samuel Crompton developed Spinning Mule
- ✓ In 1921 Karel Capek's play, **A.U.A.** was staged in London when the word **robot** was popularized.
- ✓ In 1938/39, a programmable paint-spraying machine was developed by Pollard in the USA.
- ✓ In 1941 and 1942, Isaac Asimov formulated the **Three Laws of Robotics**, and in the process of doing so, coined the word "robotics".
- ✓ In 1944, Howard Aiken developed the **Mark 1** computer, an electro-mechanical automatic sequence control calculator, a joint venture of IBM and Harvard, at Harvard.
- ✓ In 1946, Eckert and Mauchly developed the ENIAC, the first large electronic computer, at the University of Pennsylvania in collaboration with the US Army.
- ✓ In 1948 "**Cybernetics**"-An Integrated concept of communication and control (feedback) was introduced by Norbert Weiner.
- ✓ In 1951, a general-purpose digital program storage device for controlling Automatic Machine Tools was developed by Lippel in the USA.
- ✓ A remote controlled teleperator with an articulated arm called **Electrical Manipulation Device** was developed by Goertz, under the auspices of the US Atomic Energy Commission.
- ✓ In 1952, IBM's first commercial computer, the 701, was marketed.
- ✓ In 1954, the first robot with point to point control and an electronic playback memory was developed by Devol In the USA.
- ✓ In 1956, The **Idea of Artificial Intelligence** was floated at the **Dartmouth Conference**.
- ✓ In 1959, first commercially available robot was sold by Planet Corporation. USA.
- ✓ In 1971, "Structured light" vision system was developed at Stanford and IBM. WAVE-the first robot programming language to automatically plan smooth trajectories and which could use rudimentary force and touch sensing to control a manipulator was developed at Stanford.

- ✓ In 1972, Force Vector Assembly Concept-using forces as inputs to a servo controller to guide parts assembly was developed at Cambridge, Massachusetts.
- ✓ In 1973, Device for controlling automation along a predetermined path-the control system for the T3, the first commercially available minicomputer controlled robot was developed at Cincinnati Milacron.
- ✓ In 1974, First version of **AL**-a robot programming language for real-time control of concurrent multiple devices with sensory/motor control was developed at Stanford.
- ✓ In the same year, a **Three legged walking machine** was built at the University of Wisconsin.
- ✓ In 1976, **Viking 1** robot rover, built by NASA, landed on Mars.
- ✓ Voyagers 1 and 2 were launched in 1977 to explore the solar system. The 30 year old robotic space probes **still** continue to transmit data back to earth and are approaching the heliopause and the interstellar medium.
- ✓ The **SCARA**, Selective Compliance Assembly Robot Arm, was created in 1978 as an efficient, 4-axis robotic arm. Best used for picking up parts and placing them in another location, the SCARA was introduced to assembly lines in 1981.
- ✓ IBM released its first personal computer (PC) in 1981; the name of the computer was responsible for popularizing the term "personal computer".
- ✓ In 1984, **Cyc**, a project to create a database of common sense for artificial intelligence, was started in 1984 by Douglas Leant. The program attempts to deal with ambiguity in language, and is still underway.
- ✓ Chess playing programs **HiTech** and **Deep Thought,** developed by Carnegie Mellon University defeated chess masters in 1989.
- ✓ In 1989 only, a hexapodal robot named **Genghis** was revealed by MIT in 1989 which became famous for being made quickly and cheaply due to construction methods.
- ✓ In 1994, the **Cyberknife** (a stereotactic radiosurgery performing robot) represented a faster method of performing surgery with equivalent accuracy to one done by human doctors.
- ✓ In 1996, Honda's **P2** humanoid robot was first shown. P2 stands for "Prototype Model 2", and was an integral part of Honda's humanoid development project; over 6 feet tall, P2 was smaller than its predecessors and appeared to be more human-like in its motions.
- ✓ On July 4, 1997, **Sojourner,** small robot weighing some 10 kilograms performed semi-autonomous operations on the surface of Mars as part of the Mars Pathfinder mission; equipped with an obstacle avoidance program. Sojourner was capable of planning and navigating routes to study the surface of the planet. Sojourner's ability to navigate with little data about its environment and nearby surroundings allowed the robot to react to unplanned events and objects. Sojourner was the second space exploration rover to reach another planet (after Viking-1) , and the first to be deployed. The Sojourner sent 550 photographs to Earth and analyzed the chemical properties of 16 locations near the Lander.
- ✓ In 1997, IBM's chess playing program **Deep Blue** beat the then World Chess Champion Garry Kasparov playing at the "Grandmaster" level.
- ✓ In 1998, the **P3** humanoid robot was revealed by Honda as a part of the company's continuing humanoid project.

- ✓ In 1999, Sony introduced the **AIBO**, a robotic dog capable of interacting with humans, the first models released in Japan sold out in 20 minutes.
- ✓ In 2000, Honda revealed the most advanced result of their humanoid project , named **ASIMO**. ASIMO is capable of running, walking, communication with humans, facial and environmental recognition, voice and posture recognition, and interacting with its environment.
- ✓ In 2000, Sony also revealed its **Sony Dream Robots**, small humanoid robots in development for entertainment.
- ✓ In April 2001, the **Canadarm2** was launched into orbit and attached to the International Space Station. In 2001 only, the Unmanned Aerial Vehicle Global Hawk made the first autonomous non-stop flight over the Pacific Ocean from California to Australia in 22 hours. In 2002, Roomba, a robotic vacuum cleaner, was first released in 2002 by the company iRobot.[In 2004, Cornell University revealed a robot capable of self-replication; a set of cubes capable of attaching and detaching, the first robot capable of building copies of itself.
- ✓ In 2003, Mars rovers **Spirit and Opportunity** landed on the surface of Mars.
- ✓ In 2005, Honda revealed a new version of its ASIMO robot, updated with new behaviors and capabilities.
- ✓ In 2006, Cornell University revealed its **"Starfish" robot,** a 4-legged robot capable of self modeling and learning to walk after having been damaged.
- ✓ In 2007, Google announced its **Lunar X Prize**, which offers 30 million dollars to the first private company which lands a rover on the moon and sends images back to earth.
- ✓ Today, **Robonaut 2,** the latest generation of the astronaut helpers, launched to the space station aboard space shuttle Discovery on the STS-133 mission. It is the first humanoid robot in space, and although it's primary job for now is teaching engineers how dexterous robots behave in space, the hope is that through upgrades and advancements, it could one day venture outside the station to help spacewalkers make repairs or additions to the station or perform scientific work.

Three Laws of Robotics

The word Robotics was coined by science fiction writer Isaac Asimov. Asimov and John W. Campbell created the "Three Laws of Robotics" which are a recurring theme in his books. The three laws are as follows:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey any orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

General structure

A robotic system is an integrated whole of parts or subsystems. A system has a specified goal or output for a given set of Inputs. A system may have many goals as well. A robot combines many subsystems that Interact among themselves as well as with the environment in which the robot works.

The mechanical structure of robot is basically a kinematic chain formed of links. This kinematic chain works like human skeleton where links work as bones. The links work with the help of the actuators which replace muscles. There are joints which have one or more degrees of freedom. Thus due to the resemblance to living

organisms such as insects, mammals and human, a new area of research opens in robotics called **Biomechanics**.

Some of the most important components of the robots are as follows:

1. A base, which can be fixed or mobile.
2. A manipulator arm with several degrees of freedom
3. An end-effecter or gripper holding a part or a tool.
4. Drives or actuators causing the manipulator arm or end-effecter to move In a space.
5. Controller with hardware and software support for giving commands to the drives.
6. Sensors to feed back the information for subsequent actions of the arm or gripper as well as to Interact with the environment In which the robot is working.
7. Interfaces connecting the robotic subsystems to the external world.

The robots use electric motors out of which some are steppers. The stepper motors don't freely spin but rotate in discrete steps, as commanded by controllers. The electrical stimulation is provided by the Electroactive polymers.

Types of Robots

At present there are 2 main types of robots, based on their use: general-purpose autonomous robots and dedicated robots.

General-purpose autonomous robots can perform a variety of functions independently. They typically can navigate independently in known spaces, handle their own re-charging needs, interface with electronic doors and elevators and perform other basic tasks. Like computers, general-purpose robots can link with networks, software and accessories that increase their usefulness. They may recognize people or objects, talk, provide companionship, monitor environmental quality, respond to alarms, pick up supplies and perform other useful tasks. General-purpose robots may perform a variety of functions simultaneously or they may take on different roles at different times of day. Some such robots try to mimic human beings and may even resemble people in appearance; this type of robot is called a humanoid robot. The dedicated robots are the robots that are specialized in some functions such as military robots.

Automated guided Vehicles (AGVs)

- ✓ Automated guided vehicles are the Mobile robots, which have markers or wires in the floor, or using vision or lasers.
- ✓ They are used to transport goods around large facilities, such as warehouses, container ports, or hospitals.

Intelligent AGVs (i-AGVs)

- ✓ Intelligent AGVs are designed for people-friendly workspaces. Examples are SmartLoader, SpeciMinder, ADAM,Tug and MT 400.
- ✓ 3D scanners or other means of sensing the environment are used to eliminate cumulative errors in dead-reckoning calculations of the AGV's current position.

Space Probes

- ✓ Almost every unmanned space probe ever launched was a robot. Some were launched in the 1960s with very limited abilities, but their ability to fly and land (such as Luna 9) is an indication of their status as a robot.
- ✓ Voyager probes, Sojourn, Galileo probes are examples of Space Robots.

Telerobots

- ✓ Telerobot is controlled from a distance by a human operator. Examples are a laparoscopic surgery robot, robots that are used in disabling a bomb, devices such as Longpen to sign books remotely, Teleoperated robot aircraft, like the Predator Unmanned Aerial Vehicle.

Military Robots

The **Predator Unmanned Aerial Vehicle**s are the pilotless drones that can search terrain and fire on targets. Other examples are iRobot's **Packbot** and the Foster-Miller **TALON** which were used in Iraq and Afghanistan by the U.S. military to defuse roadside bombs or improvised explosive devices (IEDs).

- ✓ Over 2,000 such trained robots are been deployed in Afghanistan. That means one out of 50 troops there is a robot.
- ✓ Their objective is to aid humans—with reconnaissance, carrying loads and attacks—and also, more importantly, to save them.
- ✓ Besides detecting and disarming improvised explosive devices (IEDs), some robots are born to die. They enter suspicious-looking zones before a soldier, and investigate it with their multiple cameras and sensors.
- ✓ This also implies getting killed (destroyed) if necessary, thereby saving a more precious human life.
- ✓ Packbot's maker iRobot has sold over 4,000 military robots. This number is only going to grow. After all, robots cost less than humans, are more accurate, do not suffer stress or psychological consequences, and are easier to replace.

Note: The US Department of Defense wants to replace one-third of its forces with robots by 2015 (Times of India). About 65 countries already use military robots—in the form of unmanned aerial, ground or underwater vehicles—or are in the process of doing so. Market research firm ABI Research predicts the market for military robots will grow from $5.8 billion last year to cross $8 billion in 2016.

- ✓ Some Military robots include the **SWORDS** robot which is currently used in ground-based combat. It can use a variety of weapons and there is some discussion of giving it some degree of autonomy in battleground situations.
- ✓ **Unmanned combat air vehicles** (UCAVs), which are an upgraded form of UAVs, can do a wide variety of missions, including combat. UCAVs are being designed such as the Mantis UCAV which would have the ability to fly them, to pick their own course and target, and to make most decisions on their own.

The Evolution of Military Robots

Today drones, dogs and even "insect spies", robots have been an invaluable asset to soldiers on and of the battlefield. The US Department of Defense wants to replace one-third of its forces with robots by 2015. The progress so far can be judged by the following examples:

- ✓ **Unmanned Tanks:** Although blueprints of unmanned underwater vehicles were available during World War I, military robots are said to have first been "used" during World War II in the form of wireless remote-controlled unmanned tanks (tele tanks by USSR and German Goliath tanks).
- ✓ **Drones:** The first major drone was the Predator, which was used to fly over areas and collect information. This started in the Cold War days, but has been modified and continues to be used in

various forms for various purposes by everybody, including Middle-Eastern countries. The Lightning Bug was used during the Vietnam War. Then came Aquila by Lockheed Martin, used in the Gulf War.

- ✓ **Unmanned aerial vehicles:** The arrival of GPS technology gave a big push to UAVs in the 1990s—they could go anywhere now. General Atomics had its new modified RQ-1 Predator and Northrop Grumman's RQ-4 Global Hawk gathered on-time information on everything from air defences to refugee movements as part of NATO air operations against Serbia during the 1999 Kosovo conflict.
- ✓ **Others :** More recent (on land) milestones include Packbot, Talon, which work like tanks and BigDog, which lugs the army's load through rugged terrain. The Packbot was recently sent to Japan to help in rescue efforts in the aftermath of the nuclear disaster
- ✓ **BIGDOG:** This huge bot dog-donkey is designed to carry loads of over 300 pounds, and can run, hike, dance and climb without falling or slipping.
- ✓ **CHEETAH:** Like the real cat, this bot will boast of incredible running speed and agility. Could be used to locate humans in burning buildings.
- ✓ **PETMAN:** Built by the US army to test chemical protection clothing, it walks, runs and crawls. It can perhaps be used in emergency rescue missions

India and Robotics

The scientific temperament of ancient Indians is evident from their understanding of mathematics, astronomy, the biological response to herbal medicines and technological attainments confined in mining of ores, metal extraction and alloying techniques and in the erection of a large number of old monuments and temples, architecture and town planning, ship building technology etc.

But Indians were unable to keep pace with the progressive science because of the adverse political and economic conditions. After Independence, India focused on expansion of her industrial base in 1950s. In this era, many big public sector companies such as HMT (Hindustan Machine Tools) and many private sector companies were started which gave a significant boost to the machine tools sector. In 1985, the first National Convention of Production

In 1960s, a conference "Engineers on Robotics and Robot Applications" was organized by the Institution of Engineers (India) in Calcutta. Bhabha Atomic Research Centre had developed a 6-axes multipurpose robot around 1984. This robot weighs about 300 kg and can move an end-of-arm load of 10 kg including that of the end effecter.

BARC has also set up separately a Division of Robotics and Remote Handling for this purpose.

CAIR

In October 1986, Centre for Artificial Intelligence and Robotics (CAIR)[2] was established under DRDO with its research focus was initially in the areas of Artificial Intelligence (AI), Robotics, and Control systems.

- ✓ In November 2000, R&D groups working in the areas of Command, Control, Communications & Intelligence (C3I) systems, Communication and Networking, and communication secrecy in Electronics and Radar Development Establishment (LRDE) were merged with CAIR. It is located in Bangalore.
- ✓ CAIR has developed a variety of controllers and manipulators for Gantry, SCARA and other types of robots.

[2] Inputs from Official website of CAIR

- ✓ These were supplied to Public Sector Units such as HAL and sister DRDO labs. CAIR has gone on to develop a prototype **Unmanned Ground Vehicle** (UGV) with the aim of attaining autonomous capability. This involved in-house construction of mobile robot platforms, integration of infrared sensors with the vehicle, and the development and integration of path planning software. An useful offshoot of this work was the development of an intelligent wheelchair that would help physically challenged people both in hospitals and homes.
- ✓ One version of the wheelchair could be operated using human voice commands. Another was equipped with a camera system to get information about the surrounding space for its path planning.
- ✓ Other robots developed by CAIR are for Non-destructive testing, Ammunition loading, and Hot slug manipulation. Both wheeled and legged miniature mobile robots have been developed.

ACYUT

ACYUT which literally means *imperishable* , is India's first indigenously developed hominoid robot. It was developed at BITS Pilani. ACYUT was followed by ACYUT-2 with better performance and incorporation of some more developments. Humanoid AcYut 4 designed by BITS Pilani students is the latest humanoid robot, which with 98 cm height and 7.2 kgs weight, is autonomous, and has been a major change from its earlier model, AcYut 3 which is semi-autonomous. In weightlifting competition, the robot had been given the task to lift the we to a particular height and move 40 cms, then it had to lift the weight 15 cm higher than the previous position and move another 40 cms to successfully finish the task. All these tasks had to be completed in 2 minutes. AcYut 4 performed these tasks in 1 minute 40 seconds to receive repeated applause from the spectators every time it performed the feat. It's a world record.

SmartNav

ISO is building the 'SmartNav' robot for India's Chandrayan-II Moon Mission. The robot will assist astronauts in their navigation around the moons surface, provide real-time pictures and record data. Its a two-legged robot, fitted with sophisticated sensors and high-resolution cameras. SmartNav is capable of recording information and images using laser beams. The robot has been designed and put together at a cost of Rs 2 million, under the guidance of Susmit Sen, head center for robotics at IIT-Kanpur.

Robonaut 2

Recently we read in the newspapers that **NASA's humanoid robot** "Robonaut 2" has finally awakened in space. Ground controllers turned Robonaut for the first time since it was delivered to the International Space Station in February 2011. The test involved sending power to all of Robonaut's system. Here is a brief info:

- Robonauts are part of humanoid robotic development project conducted by the Dextrous Robotics Laboratory at NASA's Johnson Space Center (JSC) in Houston.
- The latest in the series is R2 or Robonaut-2.
- It was delivered to the International Space Center by STS-133 in Feb 2011.
- It has been designed to assist with crew.
- It is 4 times faster than its predecessor R1, is more dexterous, and includes a deeper and wider range of sensing.

HRP-4

HRP stands for **Humanoid Robotics Project**. It is a project for development of general domestic helper robots, sponsored by Japan's Ministry of Economy, Trade and Industry (METI) and New Energy and Industrial Technology Development Organization (NEDO), spearheaded by Kawada Industries and supported by the National Institute of Advanced Industrial Science and Technology (AIST) and Kawasaki Heavy Industries, Inc. The HRP series also goes by the name Promet[3].

The project started with a purchase of 3 Honda P3 robots from Honda.

- ✓ The first robot in this project was HRP-1, developed in 1997. Others were HRP-2P (1998), HRP-2 Promet2 (2002), HRP-3P (2005), HRP-3 Promet MK-II2 (2007) and HRP-4C3 (2009).
- ✓ Latest robot in this project is HRP-4 (2010). HRP-4 is a 39 kg 151 cm robot which has 34 degrees of freedom.

The model **HRP-4C** was called "Cybernetic Human" that looks like a woman "HRP-4C" is a humanoid robot platform for research and development center has been developed by AIST and "HRP" the latest in the series. 158cm tall, 43kg weight (including battery). The reference to the average young Japanese women, human-like appearance was achieved. It had 42 degrees of freedom, consisted of 30 body parts (neck 3, 6 × 2 arms, 3 hips, 6 × 2 feet), 8 faces, 2 × 2 hands. The battery is mounted in the waist area in nickel metal hydride. Assuming continuous operation time of 20 minutes. Intel Pentium M 1.6GHz to generate whole-body motion.

What are Android & Gynoid Robots?

An android is a robot that looks and acts like a human. "Android" technically refers to the male form, while "Gynoid" isthe feminine form. Until recently, androids have largely remained within the domain of science fiction, frequently seen in film and television. The examples of Android is Robonaut-2 while that of a Gynoid is HRP-4C.

Some Humanoid Robots

- ✓ **SEROPI** (Service Robot Platform Initiative) is a wheel based humanoid robot developed by KITECH (Korea Institute of Industrial Technology)
- ✓ **RuBot II** is a Rubik's cube solving robot developed by Irish roboticist and inventor Pete Redmond. RuBot II is the world's fastest Rubik's cube-solving robot, and it appears in the 2010 Guinness Book of World Records as the world's fastest robot to solve a Rubik's cube.
- ✓ **Dexter:** Dexter is a compliant, dynamically balancing bipedal humanoid robot research project. It is learning to walk and can jump, with its feet clearing the ground for a third of a second. Because it uses pneumatics as actuators, its joints are compliant and provide a springy restoring force, much like a human's tendons, allowing it much greater capability to deal with obstacles
- ✓ **Monty:** Monty is a telemanipulation prototype. He picks things up with an 18 degree of freedom hand and is operated remotely through the use of a suit that includes a special glove.

2 MARKERS ON ROBOTICS

Packbot

The PackBot Tactical Robot is deployed by the US in wars. It was first used by US ground troops in Afghanistan in 2002 to help clear caves and bunkers, search buildings and cross live minefields. They were also used in 2003 in Iraq in urban warfare and to search vehicles. By 2007, more than 800 PackBot robots were in operation in Iraq, Afghanistan and around the world. PackBot, weighing 18 kg, has a unique propulsion system of road speed of up to 14 km/h, with 'flippers' with continuous 360 degrees rotation and

[3] From wikipedia

negotiation of rough terrain, stairs and rubble. It is controlled by a Pentium-based computer, is tough, can survive falls and being submerged in water.

Ibn Sina

Ibn Sina is a Arabic-speaking android developed at United Arab Emirates University and billed as the first of its kind in the world. It could enter mass production to help people at shopping malls.

The Ibn Sina robot, named after an 11th century philosopher is able to recognize faces, converse with people by speaking in classical Arabic, connect to the Internet, and retrieve information. It can also exchange kisses with people.

Software for Ibn Sina was developed by a team led by computer science assistant professor Nikolaos Mavridis, with the mechanics by Hanson Robotics. Mavridis says some companies have approached his lab and asked about using the turban-wearing, bearded bot in shopping malls or as a receptionist.

Rex Bionic legs

Two Britons, Richard Little and Robert Irving in who are living in New Zealand since 1992 have been successful in developing world's first workable pair of Bionic legs which allow the paraplegics - those with complete paralysis of the lower half of the body - to walk again. The name is given Rex which is an acronym for Robotic Exoskeleton; the legs weigh 38 kg and are operated by a small electric motor powered from a lightweight battery.

Cyborg

The term Cyborg refers to an organism that has enhanced abilities due to technology. Thus a **Cyborg means being with both biological and artificial (e.g. electronic, mechanical or robotic) parts.** The term was coined in 1960 when Manfred Clynes and Nathan Kline used it in an article about the advantages of self-regulating human-machine systems in outer space. While cyborgs are commonly thought of as mammals, they might also conceivably be any kind of organism and the term "Cybernetic organism" has been applied to networks, such as road systems, corporations and governments, which have been classed as such. The term can also apply to micro-organisms which are modified to perform at higher levels than their unmodified counterparts. Example is Cochlear implants that combine mechanical modification with any kind of feedback response.

Cybernatics

Cybernetics is a Greek word meaning steersmanship an opposite of 'dictatorship.' Borrowed from French by the US mathematician Dr. Norbert Weiner (1894-1964) and quoted in his 1948 book 'Cybernetics, Or Control and Communication in Animal and Machine' which is based on the concepts he co-developed with a Mexican physician, Dr. Arturo Rosenblueth (1900-70).

Cybernetics is the science of communications and automatic control systems in both machines and living things. It deals with mechanisms employed by natural and man-made systems to learn and evolve, and to organize, regulate, and reproduce themselves. Cybernetics is concerned with the communication and control through feedback rather than with the 'wholeness' of a system or with complex interactions within and among systems.

Electronic Spider or Web Crawler

An electronic spider, also called a web crawler or a web robot, is a programme that can visit the pages on the world wide web in a methodical automatic manner. They are most commonly employed by search engines for browsing the web and copying new pages so that the indexes of the engine are updated periodically. The

spiders are also used by some sites for maintaining their pages, to ensure that the hyperlinks are updated and the HTML code is valid. They are also said to be used by spam creators for capturing e-mail addresses contained in web pages.

OLE Robotic Beetle

These are robots that look like Volkswagen Beetle cars, only they have legs instead of wheels. They can scuttle across spaces and have the potential to help put out forest fires. They can be used in areas which can be quite dangerous for humans. These robotic Beetles were developed by the University of Magdeburg-Stendal in Germany.

Nanomites

Nanomites are nanosized particles, nanorobots or nanites, which when released into the bloodstream of a human kill infected or cancerous cells. The precision and minute size of these particles make them useful in medical science. However, it's still a concept and there's a long way to go before actual nanomites being made.

Zero Moment Point

Zero Moment Point is a concept related with dynamics and control of legged locomotion, e.g., for humanoid robots. It specifies the point with respect to which dynamic reaction force at the contact of the foot with the ground does not produce any moment, i.e. the point where total inertia force equals 0 (zero).

NANOTECHNOLOGY

A nano is 10−9. One nanometer (nm) is one billionth of the meter. Nanotechnology is the study of manipulating matter on an atomic and molecular scale. Generally, nanotechnology deals with developing materials, devices, or other structures possessing at least one dimension sized from 1 to 100 nanometers. They are also supposed to be self replicating or self assembling and this aspect gel confused with cloning.

Major benefits of Nanotechnology

Major benefits of nanotechnology include

1. Improved manufacturing methods,
2. water purification systems,
3. energy systems,
4. physical enhancement,
5. nanomedicines,
6. better food production methods and nutrition and
7. large scale infrastructure auto-fabrication.

Nanotechnology's reduced size may allow for automation of tasks which were previously inaccessible due to physical restrictions, which in turn may reduce labor, land, or maintenance requirements placed on humans.

Potential Risks

Potential risks include

1. environmental, health, and safety issues;
2. transitional effects such as displacement of traditional industries as the products of nanotechnology become dominant;
3. military applications such as biological warfare and implants for soldiers;
4. and surveillance through nano-sensors, which are of concern to privacy rights advocates.

The scope and application of nanotechnology is tremendous and mind-boggling. It has been said that 21st century would be the **nanotechnology century**. Many scientific institutions in the country have already begun R&D in this field. With the rapid strides being made in nanotechnology research it is emerging as an area of fast growth and potential employment.

Nanotechnology is very diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on the nanoscale to investigating whether we can directly control matter on the atomic scale.

Nanotechnology entails the application of fields of science as diverse as surface science, organic chemistry, molecular biology, semiconductor physics, microfabrication, etc.

According to a NASSCO, the worldwide market for nanotechnology is estimated to touch $891 billion by 2015 . This sector is also expected to create 12 million new jobs by 2015.Electronics and materials account for more than 65 per cent of the market.

India cannot afford to miss the revolution in nanotechnology and must make investments in the area carefully. As per eminent scientist and first India Science Award winner Dr. C N R Rao-"India missed the semiconductor revolution in 1950's", The transistor discovery changed the world. "We cannot do that again in the area of nanotechnology which may become big in five-six years." The scientist also said that India should be on equal footing with other countries in nanotechnology. 'we should not be at receiving end when the world is driven by nanotechnology. There is a good work going on in India on nanomaterials, but not much work has been done in the nano-electronics.

Graphene

- ✓ Graphene is the name given to a flat monolayer of carbon atoms tightly packed into a two-dimensional (2D) honeycomb lattice, and is a basic building block for graphitic materials of all other dimensionalities. The material has enormous potential particularly in the high-speed electronic devices.
- ✓ Graphene is closely related to graphite. Each time a pencil is drawn across a page; tiny fragments of Graphene are shed. When properly magnified, the substance resembles an atomic-scale chicken wire. Sheets of the material possess exceptional electronic and optical properties, making it highly attractive for varied applications.

Limitations of Graphene production:

- ✓ Graphene is a mere one atom thick– perhaps the thinnest material in the universe–and forms a high-quality crystal lattice, **with no vacancies or dislocations in the structure**. This structure gives it intriguing properties, and yielded surprising new physics.
- ✓ Graphene's huge electrical mobility -- the ease with which electrons can flow through the material. Such high mobility is a critical parameter in determining the speed of components like transistors. However, at present producing usable amount of Graphene has been very tricky.
- ✓ There are only two methods of producing graphics and the popular method is a peel a single layer from the sheet of graphite.
- ✓ Graphene's limitation is using it in transistors is that it has intrinsic property. This property must be overcome. Intrinsic property means that it should be able to turn off and on.
- ✓ A Graphene transistor is very fast , but it's on off ratio is very low. This is because; band gap (the space between the valence and conduction bands) is zero in Graphene. The process of enlarging the band gap of Graphene is laborious and involves high cost, so there are no viable sources of commercial mass production of Graphene.

Is Graphene usable as transistors?

Graphene is a one-atom-thick layer of carbon that conducts electricity with little resistance or heat generation. After its discovery in 2004 -- which earned a Nobel Prize in physics -- it was touted as a potential replacement for silicon, possibly leading to ultrafast devices with simplified circuits that might be less expensive to manufacture. However, Graphene's luster has dulled in recent years for digital applications as researchers have discovered that it has no "band gap," a trait that is needed to switch on and off, which is critical for digital transistors. The fact that graphene is a zero-band-gap material by nature has raised many questions in terms of its usefulness for digital applications.

What is Gap?

Electrons in semiconductors like silicon exist at two energy levels, known as the valence and conduction bands. The energy gap between these two levels is called the band gap. Having the proper band gap enables transistors to turn on and off, which allows digital circuits to store information in binary code consisting of sequences of ones and zeroes. Researchers are making progress in creating digital transistors using a material called graphene, potentially sidestepping an obstacle thought to dramatically limit the material's use in computers and consumer electronics.

Caronene

The scientists at the Germany's Max Planck Institute, the Department of Materials Science and Engineering, University of Utah, and Tsinghua University, Beijing have in 2010 created a **Graphene transistor composed of 13 benzene rings.** It has been named as Caronene. Caronene is special because it shows an improved electronic band gap, a property which may help to overcome one of the central obstacles to applying Graphene technology for electronics.

To overcome the above difficulties, the group used benzene. Benzene has an hexagonal structure comprising 6 carbon atoms. But it is an insulating material. The newly developed Caronene has 13 benzene rings arranged in a well defined shape. When these rings are joined together, the material behaves like a semiconductor and displays well defined on off properties of a transistor.

2010 Nobel Prize for Graphene

Andre Geim (Russia) and Konstantin Novoselov (Russia and UK) have won the Nobel Prize 2010 (Physics) for "for groundbreaking experiments regarding the two-dimensional material Graphene'. Andre Geim and Konstantin Novoselov had peeled off the Graphite to get the ultrathin layers of the Graphene and started studding its properties in 2003. In October 2004, he published a paper announcing the achievement of Graphene sheets. The paper published in Science magazine, entitled "Electric field effect in atomically thin carbon film', became the most cited paper in materials physics. The researchers were able in isolating Graphene sheets. Andre Geim has become the first person to win both a IgNobel Prize and a real Nobel Prize.

Fullerene

- ✓ A fullerene is any molecule composed **entirely of carbon**, in the form of a hollow, sphere, ellipsoid, or tube.
- ✓ Spherical fullerenes are also called buckyballs, other shapes being nanotubes or Bucky tubes.
- ✓ Fullerenes are similar in structure to graphite, which is composed of stacked Graphene sheets of linked hexagonal rings; but they also contain pentagonal (or sometimes heptagonal rings).
- ✓ Fullerenes are one of the allotropes (same element in two or more forms) of carbon. The other two are **diamond and graphite**.

- ✓ The first fullerene discovered was C60 in 1985 and it was called buckminsterfullerene.
- ✓ Scientists Kroto, Smalley and Curl discovered fullerenes in Rice University in September 1985. One of the fullerenes — **Buckminsterfullerene** — consists of 60 carbon atoms linked together to form an almost spherical C60 molecule of joined hexagons (20) and pentagons (12).
- ✓ The bonds have the same arrangement as the panels on a football.
- ✓ Fullerenes can be prepared by passing an electric discharge through graphite rods in an atmosphere of helium. It is now known that a buckminsterfullerene is likely to be formed in sooty flames.
- ✓ **Carbon nanotubes** display extraordinary properties that make them potentially useful in many applications including in nanotechnology, electronics, optics and other fields of materials science. They exhibit extraordinary strength and unique electrical properties, and are efficient thermal conductors. They are either single-walled nanotubes (SWNTs) or multi-walled nanotubes (MWNTs).

New material: Nanoribbons[4]

Graphene, a one atom thin flake of plain carbon, has a wide range of unusual and highly interesting properties. As a conductor of electricity it performs as good as copper. As a conductor of heat it outperforms all other known materials. There are possibilities to achieve strong variations of the Graphene properties by making Graphene in the form of belts with various widths, so called Nanoribbons. These Nanoribbons are now the real focus of attention in physics and an extremely promising material for electronics, solar cells and many other things. However, it is has not been easy to make such ribbons.

Recently (September 2011), the scientists at Umeå University have discovered a way to use the hollow space inside carbon nanotubes as a one-dimensional chemical reactor to make encapsulated graphene. An intriguing property of this space is that chemical reactions occur differently here compared to under bulk three-dimensional conditions.

As per the magazine *Nanoletters,* the scientists used caronene and perylene, which are large organic molecules, as building blocks to produce long and narrow graphene nanoribbons inside the tubes. The idea of using these molecules as building blocks for graphene synthesis was based on thier previous study. This study revealed that coronene molecules can react with each other at certain conditions to form dimers, trimers and longer molecules in a bulk powder form. The result suggested that coronene molecules can possibly be used for synthesis of graphene but need to be somehow aligned in one plane for the required reaction. The inner space of single-walled carbon nanotubes seemed to be an ideal place to force molecules into the edge-to-edge geometry required for the polymerization reaction.

Applications of Nanoribbons:

- ✓ Nanoribbons have an enormous potential for a wide range of applications. We can prepare hybrids that combine graphene and nanotubes in all possible combinations in the future.
- ✓ For example, metallic Nanoribbons inside insulating nanotubes are very thin insulated wires. They might be used directly inside carbon nanotubes to produce light thus making nano-lamps. Semiconducting Nanoribbons can possibly be used for transistors or solar cell applications and

[4] **Science Daily, 16.9.2011**

metallic-metallic combination is in fact a new kind of coaxial nano-cable, macroscopic cables of this kind are used e.g. for transmitting radio signals.

Nano Mission

The Mission on Nano Science and Technology (Nano Mission) - an umbrella programme was launched in May 2007 to promote R&D in this emerging and highly competitive area of research in a comprehensive fashion. The main objectives of the Nano Mission are - basic research promotion, infrastructure development for carrying out front-ranking research, development of nano technologies and their applications, human resource development and international collaborations. Some achievements during the period 2010-11 are summarized as follows:

1. Development of innovative peptide and peptide hybrid material based multifunctional nanostructures for cancer imaging and targeted drug delivery
2. Nanoscale fabrication with metal phosphides as anode for next generation lithium-ion battery applications
3. Nanosensor array for real time monitoring of toxic volatile organic compounds
4. Computational study of functionalized nanoparticles
5. Characterization of composite materials and application of nanomaterials for sustainable energy
6. Development of polymer nanocomposites for nanocoating and nanostructured magnets.

Some previous and ongoing projects

1. Chitosan nanoparticles and chitosan tripolyphosphate were used to deliver DNA vaccine in aquatic animals.
2. A CD-14 co-receptor nanopeptide agonist was successfully designed and bioproduced which can be used for targeted delivery of drugs to monocytes, dendritic cells and macrophages.
3. Different types of glass matrices have been prepared and processing procedure for quantum dot growth was optimized.
4. Gold and ZnO nanoparticles were prepared by liquid phase pulsed laser ablation and wet-chemical route respectively and were embedded in polymer matrix for non-liner optical applications.
5. Rheological properties of many soft materials at micro and nano scale are helpful for manufacture of better paints, gels, toothpaste and many other commercial products. Stable ferro fluid of different capabilities has been developed.
6. New magnetic resonance active colloidal amine-functionalized Fe3O4 nanoassembly with enhanced T2 contrast properties has been fabricated which can be used as an effective carrier for drug molecules and a source of hyperthermia treatment for cancer.
7. Studies using low concentration of TiO2 nanoparticles were carried on human skin cell line demonstrating the cytotoxic and genotoxic effect of TiO2 nanoparticles.
8. Sulfur nanoparticles were prepared using an effective and easy route. Also, the mechanism of formation of AgBr nanoparticles in aqueous surfactant solutions was developed.
9. Cellulose microfibrils extracted from four different sources were studied by different methods of analysis. It was found out that using nanoparticles with biodegradable polymer matrix such as cellulose microfibrils can lead to biodegradable nanocomposites.

10. India's indigenous. 'psoriasis' drug had entered phase II trials in 2006 but has not been able to come to the market as of now.
11. The scientists had also produced an anti-TB molecule which had enetered phase I clinical trials which would be complete in three months.

Applications of Nanotechnology

With nanotechnology, a huge set of materials with distinct properties such as optical, electrical, magnetic, biological, chemical or physical can be fabricated. The materials which are nanotechnologically improved can strongly influence the mechanical properties such as the stiffness or elasticity. One example is that the traditional polymers, when reinforced with nanoparticles can result in some novel materials.

Health & Medicare:

- ✓ Functionalities can be added to nanomaterials by interfacing them with biological molecules or structures. The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nanomaterials can be useful for both in vivo and in vitro biomedical research and applications.
- ✓ Magnetic nanoparticles, bound to a suitable antibody, are used to label specific molecules, structures or microorganisms.
- ✓ Gold nanoparticles tagged with short segments of DNA can be used for detection of genetic sequence in a sample.
- ✓ Multicolor optical coding for biological assays has been achieved by embedding different-sized quantum dots into polymeric microbeads.
- ✓ Nanopore technology for analysis of nucleic acids converts strings of nucleotides directly into electronic signatures.

Smart Drug Delivery:

- ✓ Nanotechnology has been a boon for the medical field by delivering drugs to specific cells using nanoparticles. The overall drug consumption and side-effects can be lowered significantly by depositing the active agent in the morbid region only and in no higher dose than needed. This is known as Smart Drug Delivery.
- ✓ This highly selective approach reduces costs and human suffering. An example can be found in dendrimers and nanoporous materials.
- ✓ Another example is to use block co-polymers, which form micelles for drug encapsulation.They could hold small drug molecules transporting them to the desired location.
- ✓ A targeted or personalized medicine reduces the drug consumption and treatment expenses resulting in an overall societal benefit by reducing the costs to the public health system.
- ✓ Nanotechnology is also opening up new opportunities in implantable delivery systems, which are often preferable to the use of injectable drugs, because the latter frequently display first-order kinetics (the blood concentration goes up rapidly, but drops exponentially over time). This rapid rise may cause difficulties with toxicity, and drug efficacy can diminish as the drug concentration falls below the targeted range.
- ✓ Buckyballs can "interrupt" the allergy/immune response by preventing mast cells (which cause allergic response) from releasing histamine into the blood and tissues, by binding to free radicals "dramatically better than any anti-oxidant currently available, such as vitamin E".

Tissue Engineering

- ✓ Nanotechnology can help reproduce or repair damaged tissue. "Tissue engineering" makes use of artificially stimulated cell proliferation by using suitable nanomaterial-based scaffolds and growth factors. Bones can be regrown on carbon nanotube scaffolds.
- ✓ Tissue engineering might replace today's conventional treatments like organ transplants or artificial implants. Advanced forms of tissue engineering may lead to life extension.

Environment Sciences:

- ✓ A strong influence of photochemistry on waste-water treatment, air purification and energy storage devices is to be expected from nanotechnology.
- ✓ Mechanical or chemical methods can be used for effective filtration techniques. One class of filtration techniques is based on the use of membranes with suitable hole sizes, whereby the liquid is pressed through the membrane.
- ✓ Nanoporous membranes are suitable for a mechanical filtration with extremely small pores smaller than 10 nm ("nanofiltration") and may be composed of nanotubes.
- ✓ Nanofiltration is mainly used for the removal of ions or the separation of different fluids.

Energy:

- ✓ Nanotechnology projects can help in storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving (by better thermal insulation for example), and enhanced renewable energy sources.
- ✓ The better insulation systems can result in better insulation systems, by the use of more efficient lighting or combustion systems, and by use of lighter and stronger materials in the transportation sector.
- ✓ Use of Nanotechnology in energy conservation techniques such as light-emitting diodes (LEDs) or quantum caged atoms (QCAs) could lead to a strong reduction of energy consumption for illumination.
- ✓ Nanotechnology could help increase the efficiency of light conversion from Solar energy by using nanostructures with a continuum of bandgaps. This is because at present the best solar cells have layers of several different semiconductors stacked together to absorb light at different energies but they still only manage to use 40 percent of the Sun's energy.
- ✓ Nanotechnology could improve efficiency of combustion engines by designing specific catalysts with maximized surface area. The degree of efficiency of the internal combustion engine is about 30-40% at the moment.

Memory:

- ✓ A company Nantero has developed a carbon nanotube based crossbar memory called Nano-RAM and Hewlett-Packard has proposed the use of memristor material as a future replacement of Flash memory.

Spintronics

- ✓ Spintronics or magnetoelectronics, is an emerging technology that exploits both the intrinsic spin of the electron and its associated magnetic moment, in addition to its fundamental electronic charge, in solid-state devices.

- ✓ The dependence of the resistance of a material (due to the spin of the electrons) on an external field is called magnetoresistance. This effect can be significantly amplified (GMR - Giant Magneto-Resistance) for nanosized objects, for example when two ferromagnetic layers are separated by a nonmagnetic layer, which is several nanometers thick (e.g. Co-Cu-Co).
- ✓ The GMR effect has led to a strong increase in the data storage density of hard disks and made the gigabyte range possible.
- ✓ The so called tunneling magnetoresistance (TMR) is very similar to GMR and based on the spin dependent tunneling of electrons through adjacent ferromagnetic layers. Both GMR and TMR effects can be used to create a non-volatile main memory for computers, such as the so called magnetic random access memory or MRAM.

Display techniques:

- ✓ The production of displays with low energy consumption could be accomplished using carbon nanotubes (CNT).
- ✓ Carbon nanotubes are electrically conductive and due to their small diameter of several nanometers, they can be used as field emitters with extremely high efficiency for field emission displays (FED). The principle of operation resembles that of the cathode ray tube, but on a much smaller length scale.

Quantum Computers:

- ✓ Entirely new approaches for computing exploit the laws of quantum mechanics for novel quantum computers, which enable the use of fast quantum algorithms.
- ✓ The Quantum computer has quantum bit memory space termed "Qubit" for several computations at the same time. This facility may improve the performance of the older systems.

Aerodynamics and Aeroengineering

- ✓ Lighter and stronger materials will be of immense use to aircraft manufacturers, leading to increased performance.
- ✓ Spacecraft will also benefit, where weight is a major factor. Nanotechnology would help to reduce the size of equipment and there by decrease fuel-consumption required to get it airborne.

Chemical Catalysis

- ✓ Chemical catalysis benefits especially from nanoparticles, due to the extremely large surface to volume ratio.
- ✓ The application potential of nanoparticles in catalysis ranges from fuel cell to catalytic converters and photocatalytic devices.
- ✓ Catalysis is also important for the production of chemicals. Platinum nanoparticles are now being considered in the next generation of automotive catalytic converters because the very high surface area of nanoparticles could reduce the amount of platinum required.
- ✓ However, some concerns have been raised due to experiments demonstrating that they will spontaneously combust if methane is mixed with the ambient air. Ongoing researches may resolve their true usefulness for catalytic applications.

Construction

- ✓ Nanotechnology in construction involves the development of new concept and understanding of the **hydration of cement particles and the use of nano-size ingredients such as alumina and silica** and other nanoparticles.
- ✓ Nanotechnology is one of the most active research areas that encompass a number of disciplines Such as electronics, bio-mechanics and coatings including civil engineering and construction materials.

Metallurgy

- ✓ The use of nanotechnology in steel helps to improve the properties of steel. It may help in overcoming the fatigue, which led to the structural failure of steel due to cyclic loading, such as in bridges or towers.
- ✓ The addition of copper nanoparticles reduces the surface un-evenness of steel which then limits the number of stress risers and hence fatigue cracking.
- ✓ The use of vanadium and molybdenum nanoparticles improves the delayed fracture problems associated with high strength bolts reducing the effects of hydrogen embrittlement and improving the steel micro-structure through reducing the effects of the inter-granular cementite phase.

Glass Industry:

- ✓ Titanium dioxide (TiO2) nanoparticles are used to coat glazing since it has sterilizing and anti-fouling properties. The particles catalyze powerful reactions which breakdown organic pollutants, volatile organic compounds and bacterial membranes.
- ✓ The TiO2 is hydrophilic (attraction to water) which can attract rain drops which then wash off the dirt particles.
- ✓ Thus the introduction of nanotechnology in the Glass industry, incorporates the self cleaning property of glass.
- ✓ Fire-protective glass is another application of nanotechnology.

Consumer Products:

- ✓ Nanotechnology is already impacting the field of consumer goods, providing products with novel functions ranging from easy-to-clean to scratch-resistant.
- ✓ Modern textiles are wrinkle-resistant and stain-repellent; in the mid-term clothes will become “smart”, through embedded “wearable electronics”.
- ✓ Already in use are different nanoparticle improved products. Especially in the field of cosmetics, such novel products have a promising potential.

Food and Bioprocessing Industry:

- ✓ Complex set of engineering and scientific challenges in the food and bioprocessing industry for manufacturing high quality and safe food through efficient and sustainable means can be solved through nanotechnology.
- ✓ Bacteria identification and food quality monitoring using biosensors; intelligent, active, and smart food packaging systems; nanoencapsulation of bioactive food compounds are few examples of emerging applications of nanotechnology for the food industry.
- ✓ Nanotechnology can be applied in the production, processing, safety and packaging of food.

- ✓ A nanocomposite coating process could improve food packaging by placing anti-microbial agents directly on the surface of the coated film.
- ✓ Nanocomposites could increase or decrease gas permeability of different fillers as is needed for different products. They can also improve the mechanical and heat-resistance properties and lower the oxygen transmission rate.
- ✓ Research is being performed to apply nanotechnology to the detection of chemical and biological substances for sensanges in foods.

Nano Foods

- ✓ Examples of coming up food are a brand of canola cooking oil called Canola Active Oil, a tea called Nanotea and a chocolate diet shake called Nanoceuticals Slim Shake Chocolate.

Optics

- ✓ The first sunglasses using protective and anti-reflective ultrathin polymer coatings are on the market. For optics, nanotechnology also offers scratch resistant surface coatings based on nanocomposites.
- ✓ Nano-optics could allow for an increase in precision of pupil repair and other types of laser eye surgery.

Textiles:

- ✓ Engineered nanofibers already makes clothes water- and stain-repellent or wrinkle-free.
- ✓ Textiles with a nanotechnological finish can be washed less frequently and at lower temperatures.
- ✓ Nanotechnology has been used to integrate tiny carbon particles membrane and guarantee full-surface protection from electrostatic charges for the wearer.

Cosmetics:

- ✓ One field of application is in sunscreens. The traditional chemical UV protection approach suffers from its poor long-term stability.
- ✓ A sunscreen based on mineral nanoparticles such as titanium dioxide offer several advantages. Titanium oxide nanoparticles have a comparable UV protection property as the bulk material, but lose the cosmetically undesirable whitening as the particle size is decreased.

Agriculture:

- ✓ Major challenges related to agriculture like low productivity in cultivable areas, large uncultivable areas, shrinkage of cultivable lands, wastage of inputs like water, fertilizers, pesticides, wastage of products and of course Food security for growing numbers can be addressed through various applications of nanotechnology.

Sports:

- ✓ Materials for new athletic shoes may be made in order to make the shoe lighter (and the athlete faster).
- ✓ Baseball bats already on the market are made with carbon nanotubes which reinforce the resin, which is said to improve its performance by making it lighter.
- ✓ Other items such as sport towels, yoga mats, exercise mats are on the market and used by players in the National Football League, which use antimicrobial nanotechnology to prevent illnesses caused by bacteria such as Methicillin-resistant Staphylococcus aureus (commonly known as MRSA). (Inputs wikipedia)

SPINTRONICS

Spintronics (short for spin-based electronics), sometimes called magnetoelectronics, is the term given to microelectronic devices that function by *exploiting the spin of electrons*.

- ✓ The term "spintronics" usually refers to the branch of physics concerned with the manipulation, storage, and transfer of information by means of electron spins **in addition to or in place of** the electron charge as in conventional electronics.
- ✓ Introduced in 1996, spintronics (the word coined by S. Wolf) was originally the name for a Defense Advanced Research Projects Agency (DARPA) program managed by Wolf.

In conventional electronics, only the charge of the electrons is of consequence for device operation, but using the electron's other fundamental property, its spin, has opened up the new field of spintronics. Major advances in electron spin transport started in 1979–1980 with the discovery of large low-temperature magnetoresistance in metallic superlattices. Later demonstrations of the "giant" effect at room temperature evolved toward application in practical devices.

- ✓ Spintronics promises the possibility of integrating memory and logic into a single device.
- ✓ In certain cases, switching times approaching a picosecond are possible, which can greatly increase the efficiency of optical devices such as light-emitting diodes (LEDs) and lasers.
- ✓ The control of spin is central as well to efforts to create entirely new ways of computing, such as quantum computing, or analog computing that uses the phases of signals for computations.
- ✓ Spin is a fundamental quantum-mechanical property. It is the intrinsic angular momentum of an elementary particle, such as the electron. Of course, any charged object possessing spin also possesses an intrinsic magnetic moment. It has been known for decades that in ferromagnetism the spins of electrons are preferentially aligned in one direction.
- ✓ In 1988, it was demonstrated that currents flowing from a ferromagnet into an ordinary metal retain their spin alignment for distances longer than interatomic spaces, so that spin and its associated magnetic moment can be transported just as charge. This means that magnetization as well can be transferred from one place to another.

Applications of Spintronics:

- ✓ The most common use of spintronics today is in computer hard drives.
- ✓ In Hard Drives, the memory storage is based on **giant magnetoresistance (GMR)** a spintronics effect.
- ✓ Giant magnetoresistance (GMR) is a quantum mechanical magnetoresistance effect observed in thin film structures composed of alternating ferromagnetic and non magnetic layers. The 2007 Nobel Prize in physics was awarded to Albert Fert and Peter Grünberg for the discovery of GMR
- ✓ There is current research focusing on bringing **magnetic random-access memory (MRAM)** to market. Spintronic based MRAMs should rival the speed and rewritability of conventional RAM and retain their state (and thus memory) even when the power is turned off.
- ✓ Motorola has recently developed a 256-kb MRAM (see Figure 7) based on a single magnetic tunnel junction and a single transistor. This MRAM has read/write cycles of less than 50 nanoseconds.
- ✓ Spintronics focuses on two types of materials. Ferromagnetic metallic alloys are currently used for magnetoelectronic devices. Ferromagnetic semiconductors, however, are attracting greater attention. If the manufacture of ferromagnetic semiconductors becomes practical, the current

microchip industry could switch over to these types of spintronic devices with relatively little change in their infrastructure. The primary barrier to the synthesis of ferromagnetic semiconductors is finding a way to inject spin-polarized currents (spin currents) into a semiconductor.

As new and better techniques for synthesizing ferromagnetics are developed, their prospects for revolutionizing the microelectronic industry increases. Spintronics will sure play a major role in the next generation of information storage devices.

2& 5 Markers on Concepts related to Physics

Magnetic Leviation Technology

- ✓ Magnetic levitation is the use of the repulsion and attraction force of magnets to levitate things. The most commonly known use of the technology is the magnetic levitated (maglev) trains.
- ✓ Maglev trains can attain high speeds because they travel without friction and unlike trains with wheels, don't have to be aligned with a track.
- ✓ They operate over a guide way. In one design, known as electrodynamic suspension, super conducting magnets on the train and electrically-conductive strips or coils in the guide way set up a magnetic field that lifts the train above the guide way and keeps it stable. Maglev trains can sustain speeds 500 km/h (300 mph).
- ✓ Thus, Magnetic levitation uses the manipulation of the magnetic fields to levitate a metallic object. In this process an object is suspended above another with no other support but magnetic fields. In Magnetic leviation, the electromagnetic force is used to counteract the effects of gravitation.
- ✓ A maglev is a train, which is suspended in air above the track, and propelled forward using magnetism. Because of the lack of physical contact between the track and vehicle, the only friction is that between the carriages and air. So maglev trains can travel at very high speeds (650 km/h) with reasonable energy consumption and noise levels.

String Theory

String Theory provides a unified description of the fundamental particles and forces in nature including gravity. This quantum gravity theory is at present the best hope for concrete computable answers to fundamental questions such as the underlying symmetries of nature, the quantum behavior of black holes, the existence and breaking of supersymmetry, and the quantum treatment of singularities. It might also shed light on larger issues such as the nature of quantum mechanics and space and time. In String Theory, all forces and particles emerge in an elegant geometrical way, realizing Einstein's dream of building everything from the geometry of space-time.

Superstring Theory

It is a model of fundamental physics whose building blocks are one-dimensional extended objects called strings, rather than the zerodimensional point particles which form the basis for the standard model of particle physics. By replacing point-like particles with strings, an apparently consistent quantum theory of gravity emerges. Also, it may be possible to unify the known natural forces (gravitational, electromagnetic, weak nuclear and strong nuclear forces) by describing them with the same set of equations as described in the theory of everything called the Grand Unified Theory (GUT).

Chandrashekar Limit

In the 1930s, Subramanya Chandrasekhar, now recognised as the founder of **relativistic astrophysics**, address the important question: What happens to a star once it has burnt all its nuclear fuel? Chadrasekhar's

answer was that it depends on the mass of the burnt core left behind. If the mass of this core (not the mass of the shining star) is less than 1.44 times the mass of the sun, the core will retire as a white dwarf star. Immediately above this limit, say up to three times the solar mass, the core will become a neutron star. If the mass of the core is still higher, a black hole will be formed. In an ordinary shining star, the force of gravitation is balanced by nuclear reactions. In white dwarf and neutron stars, by complex quantum forces. In a black hole, gravitation dominates. For this pioneering work Chandrasekhar belatedly received the Nobel Prize for Physics in 1983.

The maximum limit of 1.44 times the solar mass (or sun's mass) of a star, to end its life as a white dwarf star, is known as the **Chandrashekar Limit**. This is the basic principle to determine the future of a star after the **red giant phase.** The stars with a mass more than 1.44 times the solar mass go through supernova explosions and end their lives as neutron stars or black holes.

Fifth State of Matter

The fifth state of matter is the Bose-Einstein condensate. This state of matter was first predicted by Satyendra Nath Bose and Albert Einstein in 1924–25. Albert Einstein predicted a new state of matter — the Bose-Einstein condensate (BEC). A Bose–Einstein condensate (BEC) is a state of matter of a dilute gas of weakly interacting bosons confined in an external potential and cooled to temperatures very near absolute zero (0 K or −273.15 °C). Under such conditions, a large fraction of the bosons occupy the lowest quantum state of the external potential, at which point quantum effects become apparent on a macroscopic scale. Bose first sent a paper to Einstein on the quantum statistics of light quanta (now called photons). Einstein was impressed, translated the paper himself from English to German and submitted it for Bose to the Zeitschrift für Physik, which published it. Einstein then extended Bose's ideas to material particles (or matter) in two other papers. In 2001, Eric A Carnell, Wolfgang Ketterle and Carl E Williams of the US received the Nobel Prize in Physics for achieving the Bose-Einstein condensation which is formed by cooling a gas of extremely low density to super low temperatures.

Vaccum Bomb

The vacuum bomb, also known as thermobaric bomb, is different from conventional explosive weapons in that it uses atmospheric oxygen instead of carrying an oxidiser in the explosive. They produce more energy for a given size than conventional bombs. A vacuum bomb works by first dispersing a cloud of powder or liquid explosive using a small charge, then igniting it with a second charge. The effect produced is often likened to that of a low-yield nuclear weapon, but without radiation. The significant injury dealt by either weapon on a targeted population is great. Russia tested the vacuum bomb recently. Its military dubbed it the 'father of all bombs'.

Warm holes

There are warm holes in semiconductor physics. The absence of an outer shell electron in a semiconductor lattice, formed as a result of covalent bonding of semiconductor atoms with an introduced trivalent impurity, is called a hole. A warm hole is supposed to exist at some stage.

SQUIDS

The Superconducting Quantum Interference Device, or SQUID, is a sensitive magnetic flux-to-voltage transducer. It may be the most sensitive detector of any physical quantity, with an energy resolution that approaches the quantum limit. The sensitivity of the SQUID has caused it to be incorporated into a variety of

systems. SQUIDs have been used to measure cortical activity in the human brain and to search for gravity waves.

Schwarzschild Radius

It is a characteristic radius associated with every quantity of mass. This term is used in physics and astronomy, especially in the theory of gravitation and general relativity. In 1916, Karl Schwarzschild obtained an exact solution to Einstein's field equations for gravitational field outside a nonrating, spherically symmetric body. The solution contained a formula, where one of the values came to be known as Schwarzschild Radius.

Superpartners of particles

In particle physics, a superpartner is a hypothetical elementary particle. Supersymmetery is one of the synergistic bleeding-edge theories in current high energy physics which predicts these shadow particles. The word superpartner is a portmanteau of the words supersymmetry and partner (sparticle). According to the supersymmetry theory, each fermion should have a partner boson, the fermion's superpartner and each boson should have a partner fermion. Exact unbroken supersymmetry would predict that a particle and its superpartners would have the same mass. No superpartners of the standard mode particles have yet been found and if these are found, its mass would determine the scale of which supersymmetry is broken.

Cosmic Rays

- ✓ Cosmic rays are high energy light particles that bombard the earth from anywhere beyond the atmosphere.
- ✓ The velocity of cosmic rays can go from a small fraction of the speed of light up to about 999999999999 times the speed of light.
- ✓ Since cosmic rays are matter (typically the bare nuclei of atoms), they cannot exceed the speed of light. They also cannot escape from the event horizon of black holes. The cosmic ray particles can produce light by colliding with molecules in the atmosphere and exciting them.
- ✓ Very sensitive photo detectors (called photomultipliers) are used to measure these types of light levels from cosmic rays, and they need large area mirrors to focus the light onto them.
- ✓ To a great extent, the abundance of cosmic rays is the same as the abundance in the universe as a whole. So the 10 most abundant elements (in order from most abundant down) are hydrogen, helium, oxygen, carbon, neon, nitrogen, magnesium, silicon, iron, and sulphur.
- ✓ Cosmic rays include:
  - o Galactic cosmic rays coming from outside the solar system.
  - o Anomalous Cosmic rays coming from the interstellar space at the edge of the heliopause.
  - o Solar energetic particles associated with solar flares and other energetic solar events.

OLED

- ✓ OLED refers to Organic Light Emitting Diode.
- ✓ It is a light-emitting diode (LED) in which the emissive **electroluminescent layer is a film of organic compounds which emit light** in response to an electric current.
- ✓ This layer of organic semiconductor material is situated between two electrodes. Generally, at least one of these electrodes is transparent.
- ✓ OLEDs are used in television set screens, computer monitors, small, portable system screens such as mobile phones and PDAs, watches, advertising, information, and indication. OLEDs are also used in

large-area light-emitting elements for general illumination. Due to their low thermal conductivity, they typically emit less light per area than inorganic LEDs.

- ✓ An OLED display works without a backlight. Thus, it can display deep black levels and can be thinner and lighter than liquid crystal displays. In low ambient light conditions such as dark rooms, an OLED screen can achieve a higher contrast ratio than an LCD—whether the LCD uses either cold cathode fluorescent lamps or the more recently developed LED backlight.
- ✓ There are two main families of OLEDs: those based on small molecules and those employing polymers. Adding mobile ions to an OLED creates a Light-emitting Electrochemical Cell or LEC, which has a slightly different mode of operation.

OLED displays can use either passive-matrix (PMOLED) or active-matrix addressing schemes. Active-matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch each individual pixel on or off, but allow for higher resolution and larger display sizes. (wikipedia)
