

Modern Medicine

Part 2

Prof (Col) Dr RN Basu

Contents

1. Introduction	2
2. Evidence-Based Medicine	4
3. Technology and Innovation	
▪ Vaccine	11
▪ Surgical Anaesthesia and Antisepsis	12
▪ Blood Transfusion	14
▪ Antibiotics and Antivirals	15
▪ Imaging Technology	16
▪ Endoscopy	18
▪ Organ Transplantation	21
▪ Laboratory Medicine	22

Contents

▪ Personalised Medicine	27
▪ Regenerative Medicine	38
▪ Predictive Medicine	44
▪ Nanotechnology and Nanomedicine	45
▪ Pharmaceuticals and Medical Devices	58
▪ Information Technology in Modern Medicine	80
▪ Medical Robotics	98
▪ Assisted Reproductive Technology	105
4. Modern Medicine: Environment of Care	
▪ Fragmentation of Care	110
▪ Demographic Changes	115

Contents

▪ Regulatory Environment	117
▪ Ethics and Quality	127
▪ Law and Medical Ethics	128
▪ Political Environment Influencing Healthcare	129
❖ Health Expenditure	110
❖ Recent Public Sector Health Initiative	
○ Ayushman Bharat	134
○ Health and Wellness Centre	139
• Social and Economic Mobility	143
• Defensive Medicine	146
5. Privatisation of Medicine	
▪ Private Healthcare in India	150

Contents

▪ Corporate Hospital	154
▪ Corruption in Healthcare	162
▪ Medical Education	166
▪ Violence in Healthcare	170
6. Conclusion	174
7. Bibliography	175

Regenerative Medicine⁷

- Regenerative medicine is devoted to
 - The replacement of diseased cells, tissues, or organs
 - This can be either in congenital or acquired disease,
 - Or the repair of tissues in vivo,
 - This is by augmentation of natural or induction of latent regenerative processes.
- Regenerative medicine focus on stem cells
 - Regenerative biology is just beginning at the dawn of the twenty-first century.

Regenerative Medicine

- Stem cells are cells with the ability to divide indefinitely
 - They can both replenish and renew themselves.
- They can give rise to specialized or differentiated cells
 - These cells are assigned a specific job depending on the tissue in which the cells are located.
- Stem cells contribute to the body's ability to renew and repair its tissues.
 - Out of the more than 100 trillion cells in the human body less than one percent are stem cells.

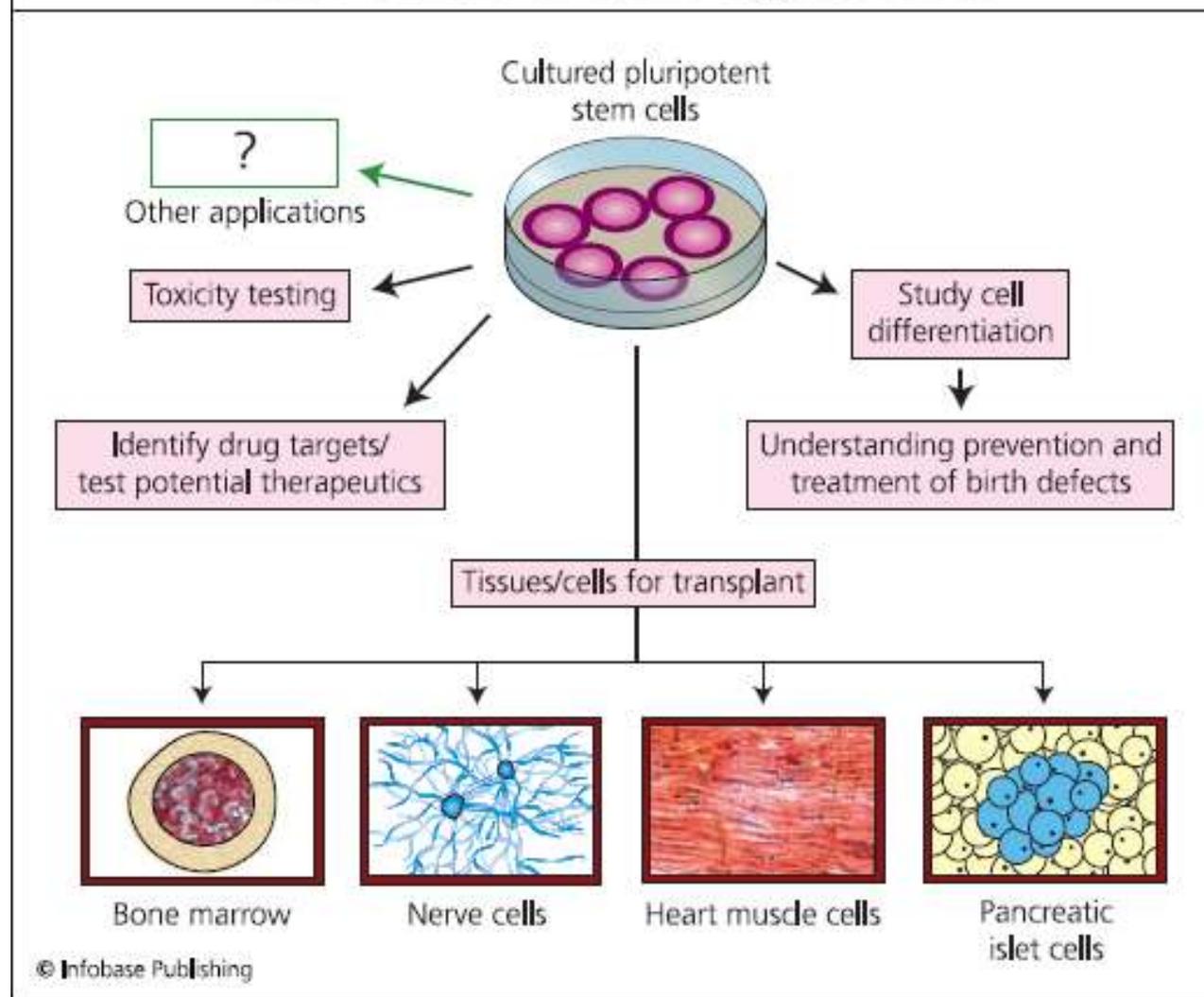
Regenerative Medicine

- Besides bone marrow, placenta and umbilical cord in some other parts of the body abound in stem cells
 - Human brain contains progenitor stem cells that can differentiate into the various types of nerve cells
 - Most success has been obtained in haemopoetic stem cell therapy particularly in leukaemia
- Besides, this there are three other areas where notable success has been obtained

Regenerative Medicine

- In Spain, keratinocytes graft in case of major burns is done
 - Also Chondrocytes are transplanted for cartilage producing cells for articular lesion
- Cornea resurfacing is done with limbal cells, amniotic membrane or epithelial cells of various mucous membrane in ocular lesions
 - Results are fairly satisfactory
- Embryonic stem cells have become a source of hope for many patients across the world
 - There is not much of justification as yet for this hope

The Promise of Stem Cell Research



Scientists continue to hold great hope for the promise of how stem cells can be used to rebuild or treat parts of the body.⁸

Regenerative Medicine

- Many scientific research findings arouse hopes that stem cells one day shall be the answer of many maladies that humans are suffering from today
 - If that happens, today's medicine will look like antiquity
- Parents are encouraged to preserve umbilical cord blood of the new born in a frozen state
 - This is again with the hope that one day there may be a breakthrough and the preserved stem cells could be used if the need arise.⁹

Predictive Medicine

- Predictive medicine is a fast emerging specialty of medicine
- The goal of predictive medicine is:
 - To evaluate a patient's genetic profile in order to predict future disease
- Based on this information the physician or the patient can make modifications in lifestyle to avoid a specific health problem
 - Example:
 - If family history of high cholesterolaemia is present and there is a biomarker present in the patient then the patient can change food habits
 - The physician can prescribe cholesterol lowering drug much earlier than he would have done in other patients

Nanotechnology and Nanomedicine

- There is no standard definition for nanomedicine.
 - Nanomedicine is defined as the application of nanobiotechnology to medicine.¹⁰
 - It is a discipline at the interface of medicine and nanobiotechnology but is not a subspecialty of either of these.
 - Its broad scope covers the use of nanoparticles and nanodevices in healthcare for diagnosis as well as therapeutics.
 - Safety, ethical and regulatory issues are also included.

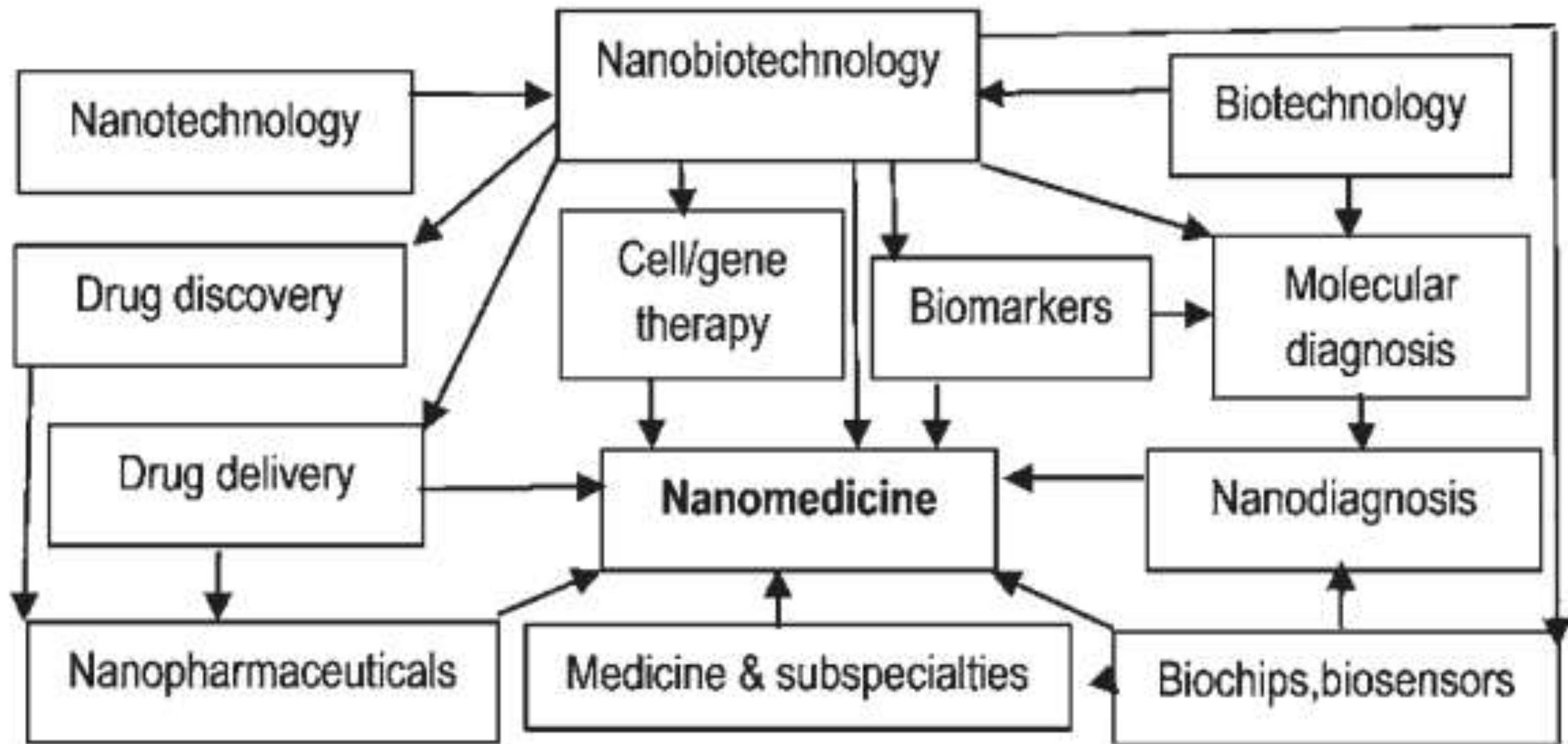


Fig. 1.1 Relationship of various biotechnologies to nanomedicine (© Jain PharmaBiotech)

Nanotechnology and Nanomedicine

- Basics of Nanobiotechnology
 - Nano is a Greek word which means dwarf
 - Nanotechnology is the creation and utilisation of materials, devices, and systems through the control of matter on the nanometer length scale
 - Nano scale means at the level of atoms, molecules, and supramolecular structures

Visualising Nano

- Just how small is “nano?”¹¹
 - In the International System of Units, the prefix “nano” means one-billionth, or 10^9
 - So one nanometer is one-billionth of a meter.
 - It’s difficult to imagine just how small that is
 - So here are some examples:
 - A sheet of paper is about 100,000 nanometers thick.
 - A strand of hair is 80,000 –100,000 nanometers in diameter.
 - There are 25,400,000 nanometers per inch.
 - Your fingernails grow about one nanometer per second!

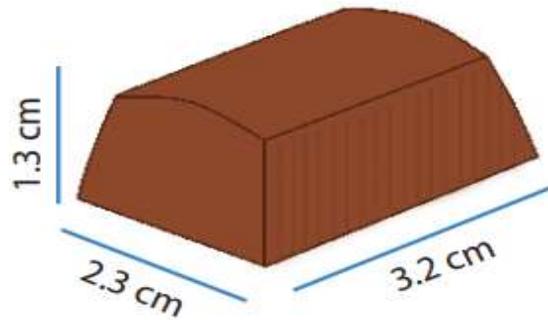
Nanotechnology and Nanomedicine

- What's so special about the nanoscale?
 - The short answer is that materials can have different properties at the nanoscale
 - some are better at conducting electricity or heat,
 - some are stronger, some have different magnetic properties, and
 - some reflect light better or change colors depending on their size.

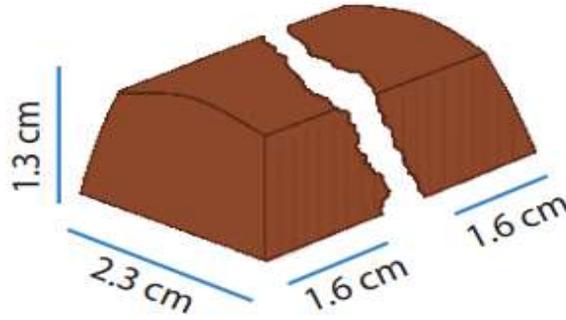
Nanotechnology and Nanomedicine

- Nanoscale materials also have far larger surface areas than similar volumes of larger-scale materials,
 - meaning that more surface is available for interactions with other materials around them,
 - making nanomaterials ideal for many applications that require high surface area, such as batteries
 - If you have block of a material, only its surface will interact with its surroundings.
 - If more surface is exposed, then more of the material is available for a reaction.

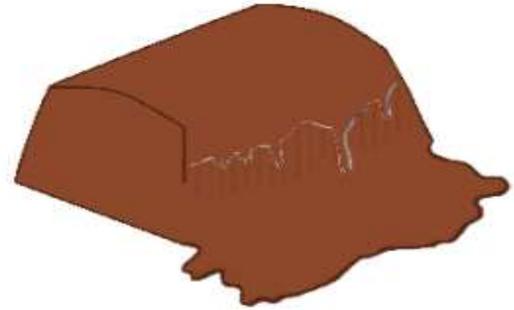
Nanoscale materials also have far larger surface areas



One piece of chocolate:
25.7 cm² of surface area
50 calories



Bite it in half:
30.8 cm² of surface area,
about half a Post-it™
50 calories



Break it down to 1 nm cubes:
510,000,000 cm² of surface area,
about 10 football fields
50 calories

- Imagine putting a block of chocolate in your mouth.
 - It has a surface area of about 25.7 cm².
 - If you bite it in half, you increase the amount of chocolate you can taste to 30.8 cm², about half the area of a Post-it™ note.
 - Bite each of those pieces in half and now you've got 41.5 cm² of chocolate to enjoy.
- If you keep chewing until you have 1 nanometer sized cubes of chocolate, you'd have a surface area equal to almost 10 football fields (but still just the calories from one piece!).

Nanotechnology and Nanomedicine

- Nanomedicine

- Nanomedicine, the application of nanotechnology in medicine, enables precise solutions for disease prevention, diagnosis, and treatment.
- This includes
 - New imaging tools like improved mris;
 - Lab-on-a-chip technologies for rapid testing in a doctor's office;
 - Novel gene sequencing technologies;
 - Nanoparticles that can help deliver medication directly to cancer cells, minimizing damage to healthy tissue; and
 - Graphene nanoribbons to help repair spinal cord injuries.

Nanotechnology and Nanomedicine

- **Wearable Sensors**

- **Scientists are developing smaller and more affordable sensors**

- These sensors can be worn on the body to detect disease or to monitor physiological functions such as temperature or heartbeat.

- For example:

- Nanomaterials are being used to make flexible, stretchable substrates that conform to the body, allowing doctors to remotely monitor your health and vital signs.

- **Coaches and trainers could use these sensors to monitor athletes to help them reach their peak performance.**

Nanotechnology and Nanomedicine

- Environmental Monitoring and Clean up
 - Nanotechnology-enabled sensors and solutions are now able to detect and identify chemical or biological agents in the air, water, and soil with much higher sensitivity than ever before.
 - A smartphone extension has been developed to help firefighters monitor air quality around fires.
 - Researchers have also tested a reusable carbon nanotube sponge for cleaning up oil that can absorb up to 100 times its weight.

Nanotechnology and Nanomedicine

- Clean Drinking Water

- Nanotechnology is providing solutions to help meet the need for clean, affordable drinking water.
- Nanotechnology-enabled filters provide rapid, low-cost removal of impurities in water.
- Engineers have developed a thin-film membrane with nanopores for energy efficient desalination, turning salt water into drinkable water.
- Nanocoatings that can be used to prevent organisms from growing on membranes and other surfaces are also being used.

Nanotechnology and Nanomedicine

- Flexible Electronics

- Flexible, bendable, foldable, rollable, and stretchable electronics are being integrated into a variety of applications in medicine, athletics, aerospace, and the Internet of Things.
- Future potential uses include tablet computers that can roll up to fit in your pocket or clothing and appliances with built-in, flexible displays.

Nanotechnology and Nanomedicine

- Energy Operations

- Oil companies have developed novel methods for using nanomaterials to refine crude oil into high-value products.
- Nanomaterials are also reducing cost and improving production levels.
- Scientists have developed sensors that can quickly detect pipeline leaks for faster repairs and less waste.

Pharmaceuticals and Medical devices

- Along with the development in science and technology pharmaceuticals (known as medications) has also grown tremendously
- The use of medications in modern medicine is ubiquitous
- In any given week, more than four of five U.S. adults take at least one medication
 - These are either prescription or over the counter drug, vitamin / mineral, or herbal supplement
- Almost a third take at least five different medications¹²

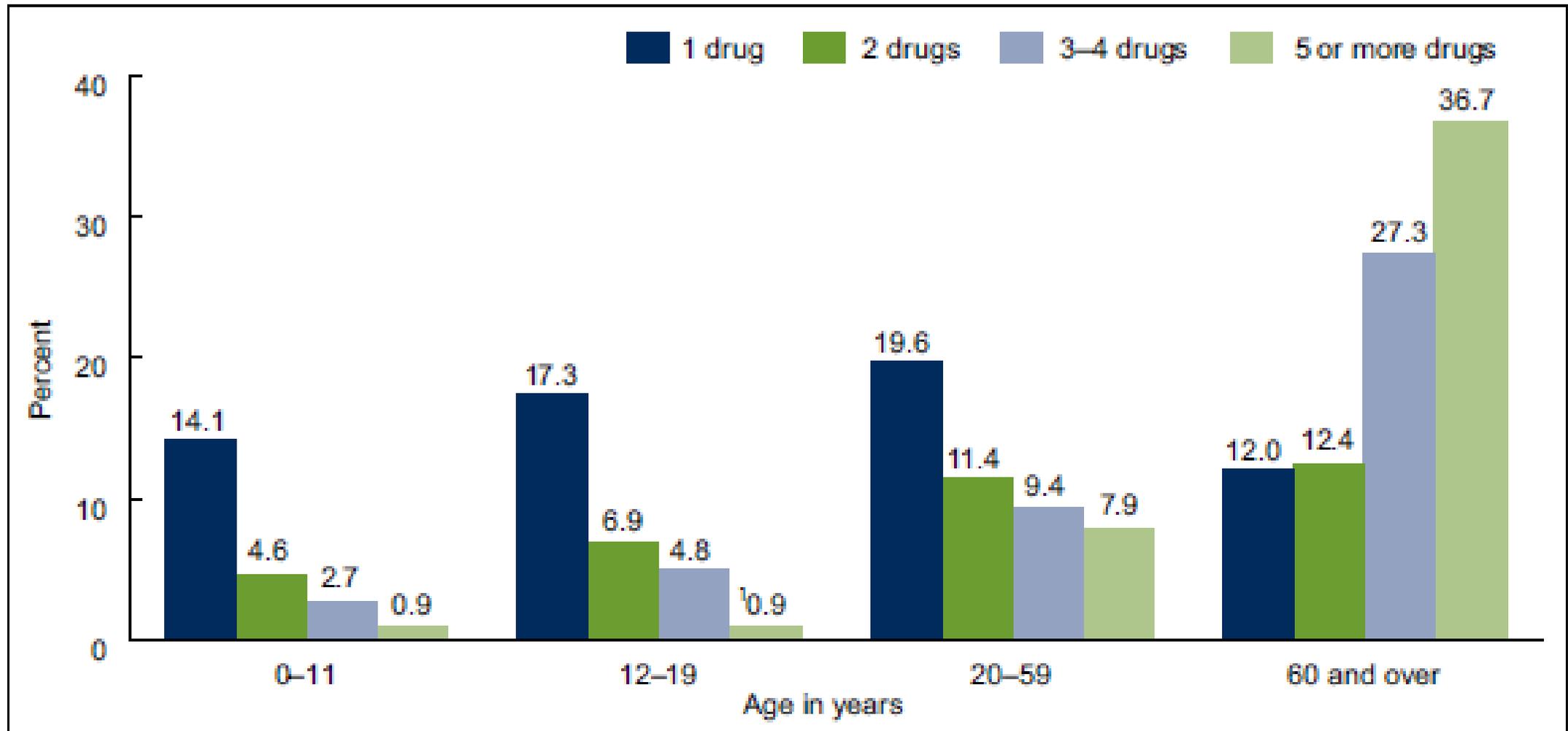
Pharmaceuticals and Medical devices

- As per the WHO, in the International Non Proprietary Name there are over 8000 generic medicine listed
- Medications are used for prevention of diseases as well as for treating them
- A survey revealed that between 1999 and 2009, the number of prescriptions dispensed in the US increased by 39%, from 2.8 billion to 3.9 billion.¹³
- A Survey by CDC revealed 48% of people have used at least one prescription drug in the past 30 days¹⁴

13. (<https://www.medicalnewstoday.com/articles/288721.php>)

14. Q Gui, CF Dilon, VL Burt. Prescription Drug Use Continues to increase (<https://www.cdc.gov/nchs/data/databriefs/db42.pdf>)

Figure 2. Percentage of prescription drugs used in the past month, by age: United States, 2007–2008



¹Estimate is unstable; the relative standard error is greater than 30%.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Survey.

15. Q Gui, CF Dilon, VL Burt. Prescription Drug Use Continues to increase (<https://www.cdc.gov/nchs/data/databriefs/db42.pdf>)

Pharmaceuticals and Medical Devices

- **Pharmaceutical Industry in India**

- The pharmaceutical sector was valued at US\$ 33 billion in 2017.
- The country's pharmaceutical industry is expected to expand at a CAGR of 22.4 per cent over 2015–20 to reach US\$ 55 billion.
- India's pharmaceutical exports stood at US\$ 17.27 billion in 2017-18.
- In 2018-19 these exports are expected to cross US\$ 19 billion.
- Indian companies received 304 Abbreviated New Drug Application (ANDA) approvals from the US Food and Drug Administration (USFDA) in 2017.
- The country accounts for around 30 per cent (by volume) and about 10 per cent (value) in the US\$ 70-80 billion US generics market.

Pharmaceuticals and Medical Devices

- India's biotechnology industry comprises bio-pharmaceuticals, bio-services, bio-agriculture, bio-industry and bioinformatics
 - This industry is expected to grow at an average growth rate of around 30 per cent a year and reach US\$ 100 billion by 2025
- Obviously such continuing growth of the pharmaceutical industry shows that modern medical practices are heavily dependent on the pharmaceuticals

Pharmaceuticals and Medical Devices

- The rapid growth of pharmaceuticals has its negative side as well
 - It becomes difficult for the medical practitioners to remain abreast with the scientific information pertaining to new drugs
 - As a result the physicians heavily depend on the information provided by the Pharmaceutical Sales Representatives (PSR)
- Physician-PSR Interactions are in the form of personal communications, free gifts such as drug samples, sponsored meals, sponsored conference travel, funding for research and CMEs and honoraria
- Such interactions have been found to affect physicians' prescribing behaviour and are likely to contribute to irrational prescribing of the company's drug.⁸
- Relationship of patients with physicians is fiduciary in nature.
 - Such physician-PSR interactions breaches that relationship

Medical Devices

- Medical devices are an important part of health care, yet they are an extraordinarily heterogeneous class of products.
- The term —medical device continuum- includes :
 - At one end technologically simple items as ice bags and tongue depressors
 - On the other end very sophisticated items such as cardiac pacemakers and proton therapy devices.
- Broadly based on the function of medical device they may be classified as preventive care device, assistive care device, diagnostic device and therapeutic device.

Pharmaceuticals and Medical Devices

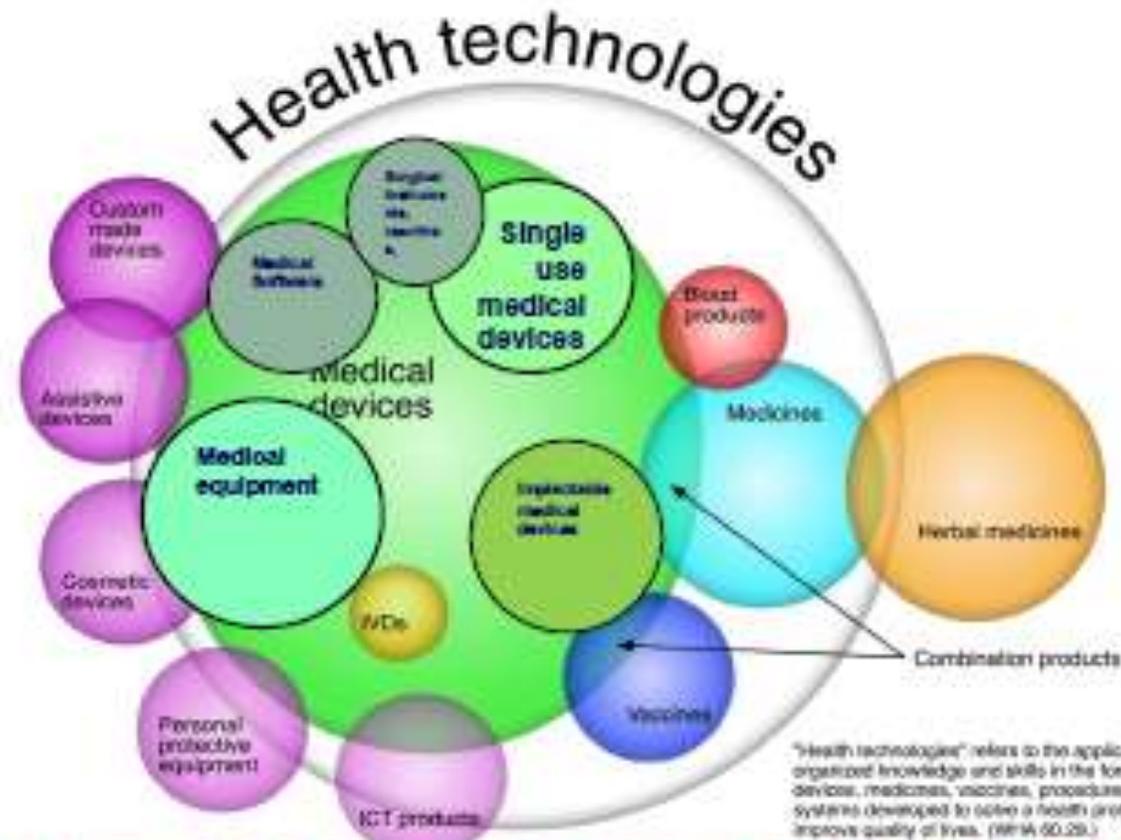
- Medical device:

- Definition

- An article, instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or
 - for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health purpose.

- Typically, the purpose of a medical device is not achieved by pharmacological, immunological or metabolic means.

Definitions: Medical devices are health technologies that include: in vitro diagnostics, implantables, medical equipment, software, surgical instruments, ...



Nanotechnology and Nanomedicine

- Energy Operations

- Oil companies have developed novel methods for using nanomaterials to refine crude oil into high-value products.
- Nanomaterials are also reducing cost and improving production levels.
- Scientists have developed sensors that can quickly detect pipeline leaks for faster repairs and less waste.

Pharmaceuticals and Medical devices

- Along with the development in science and technology pharmaceuticals (known as medications) has also grown tremendously
- The use of medications in modern medicine is ubiquitous
- In any given week, more than four of five U.S. adults take at least one medication
 - These are either prescription or over the counter drug, vitamin / mineral, or herbal supplement
- Almost a third take at least five different medications¹²

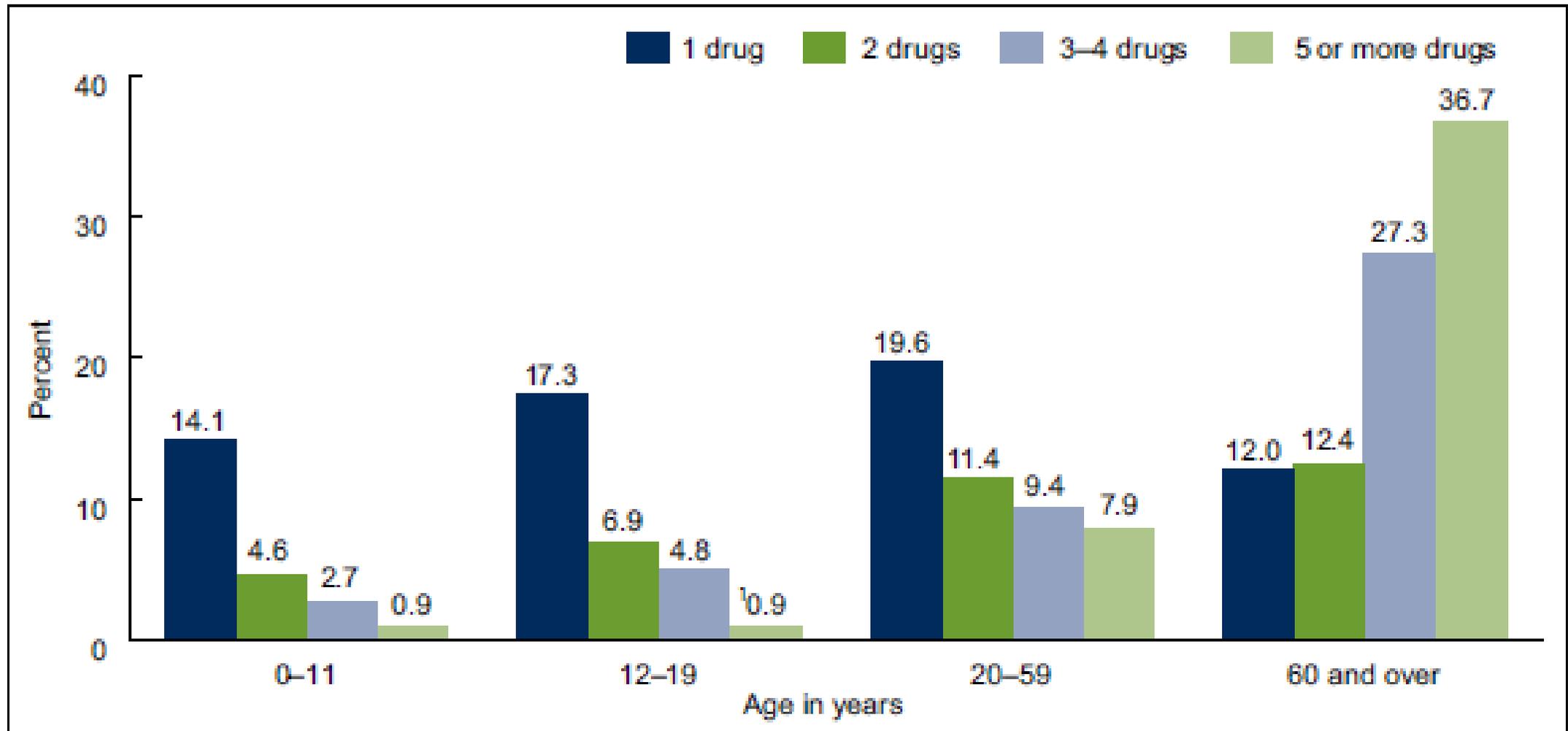
Pharmaceuticals and Medical devices

- As per the WHO, in the International Non Proprietary Name there are over 8000 generic medicine listed
- Medications are used for prevention of diseases as well as for treating them
- A survey revealed that between 1999 and 2009, the number of prescriptions dispensed in the US increased by 39%, from 2.8 billion to 3.9 billion.¹³
- A Survey by CDC revealed 48% of people have used at least one prescription drug in the past 30 days¹⁴

13. (<https://www.medicalnewstoday.com/articles/288721.php>)

14. Q Gui, CF Dilon, VL Burt. Prescription Drug Use Continues to increase (<https://www.cdc.gov/nchs/data/databriefs/db42.pdf>)

Figure 2. Percentage of prescription drugs used in the past month, by age: United States, 2007–2008



¹Estimate is unstable; the relative standard error is greater than 30%.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Survey.

15. Q Gui, CF Dillon, VL Burt. Prescription Drug Use Continues to increase (<https://www.cdc.gov/nchs/data/databriefs/db42.pdf>)

Pharmaceuticals and Medical Devices

- **Pharmaceutical Industry in India**

- The pharmaceutical sector was valued at US\$ 33 billion in 2017.
- The country's pharmaceutical industry is expected to expand at a CAGR of 22.4 per cent over 2015–20 to reach US\$ 55 billion.
- India's pharmaceutical exports stood at US\$ 17.27 billion in 2017-18.
- In 2018-19 these exports are expected to cross US\$ 19 billion.
- Indian companies received 304 Abbreviated New Drug Application (ANDA) approvals from the US Food and Drug Administration (USFDA) in 2017.
- The country accounts for around 30 per cent (by volume) and about 10 per cent (value) in the US\$ 70-80 billion US generics market.

Pharmaceuticals and Medical Devices

- India's biotechnology industry comprises bio-pharmaceuticals, bio-services, bio-agriculture, bio-industry and bioinformatics
 - This industry is expected to grow at an average growth rate of around 30 per cent a year and reach US\$ 100 billion by 2025
- Obviously such continuing growth of the pharmaceutical industry shows that modern medical practices are heavily dependent on the pharmaceuticals

Pharmaceuticals and Medical Devices

- The rapid growth of pharmaceuticals has its negative side as well
 - It becomes difficult for the medical practitioners to remain abreast with the scientific information pertaining to new drugs
 - As a result the physicians heavily depend on the information provided by the Pharmaceutical Sales Representatives (PSR)
- Physician-PSR Interactions are in the form of personal communications, free gifts such as drug samples, sponsored meals, sponsored conference travel, funding for research and CMEs and honoraria
- Such interactions have been found to affect physicians' prescribing behaviour and are likely to contribute to irrational prescribing of the company's drug.⁸
- Relationship of patients with physicians is fiduciary in nature.
 - Such physician-PSR interactions breaches that relationship

Medical Devices

- Medical devices are an important part of health care, yet they are an extraordinarily heterogeneous class of products.
- The term —medical device continuum- includes :
 - At one end technologically simple items as ice bags and tongue depressors
 - On the other end very sophisticated items such as cardiac pacemakers and proton therapy devices.
- Broadly based on the function of medical device they may be classified as preventive care device, assistive care device, diagnostic device and therapeutic device.

Pharmaceuticals and Medical Devices

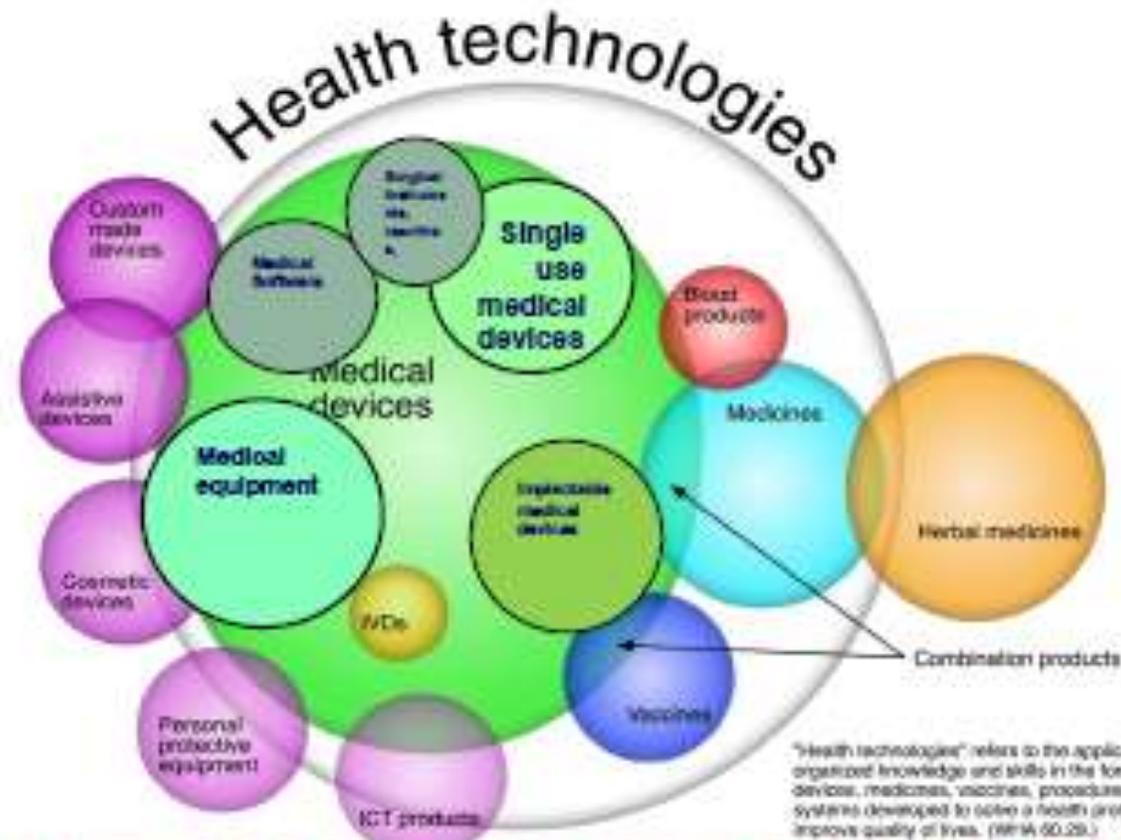
- Medical device:

- Definition

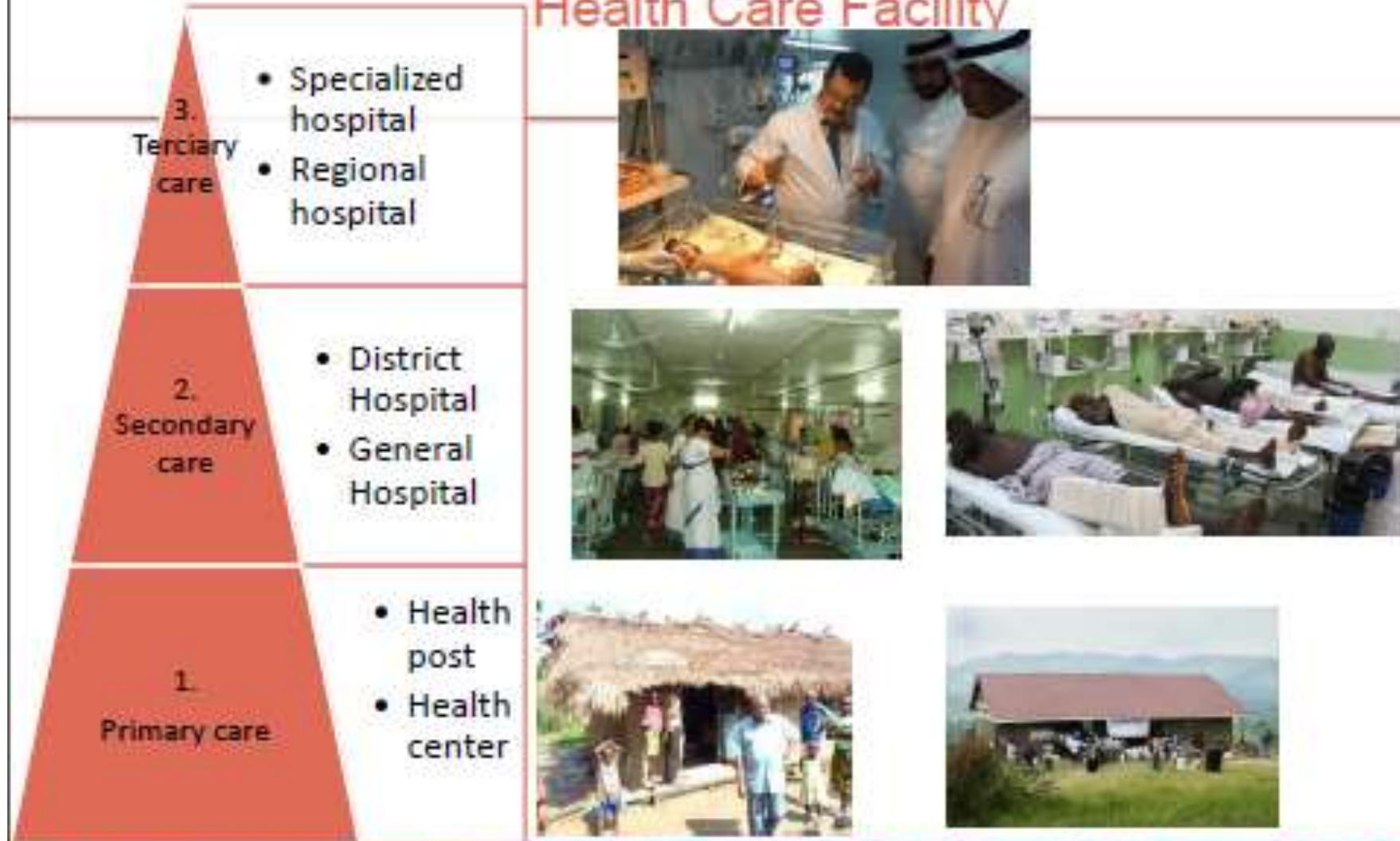
- An article, instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or
 - for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health purpose.

- Typically, the purpose of a medical device is not achieved by pharmacological, immunological or metabolic means.

Definitions: Medical devices are health technologies that include: in vitro diagnostics, implantables, medical equipment, software, surgical instruments, ...



Medical devices need to be appropriate for each Health Care Facility



End of Part 2