Yildiz Technical University

Department of Bioengineering

BIOENGINEERING AND MEDICINE

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2019

Cell Culture and Tissue Engineering Laboratory

Recent studies

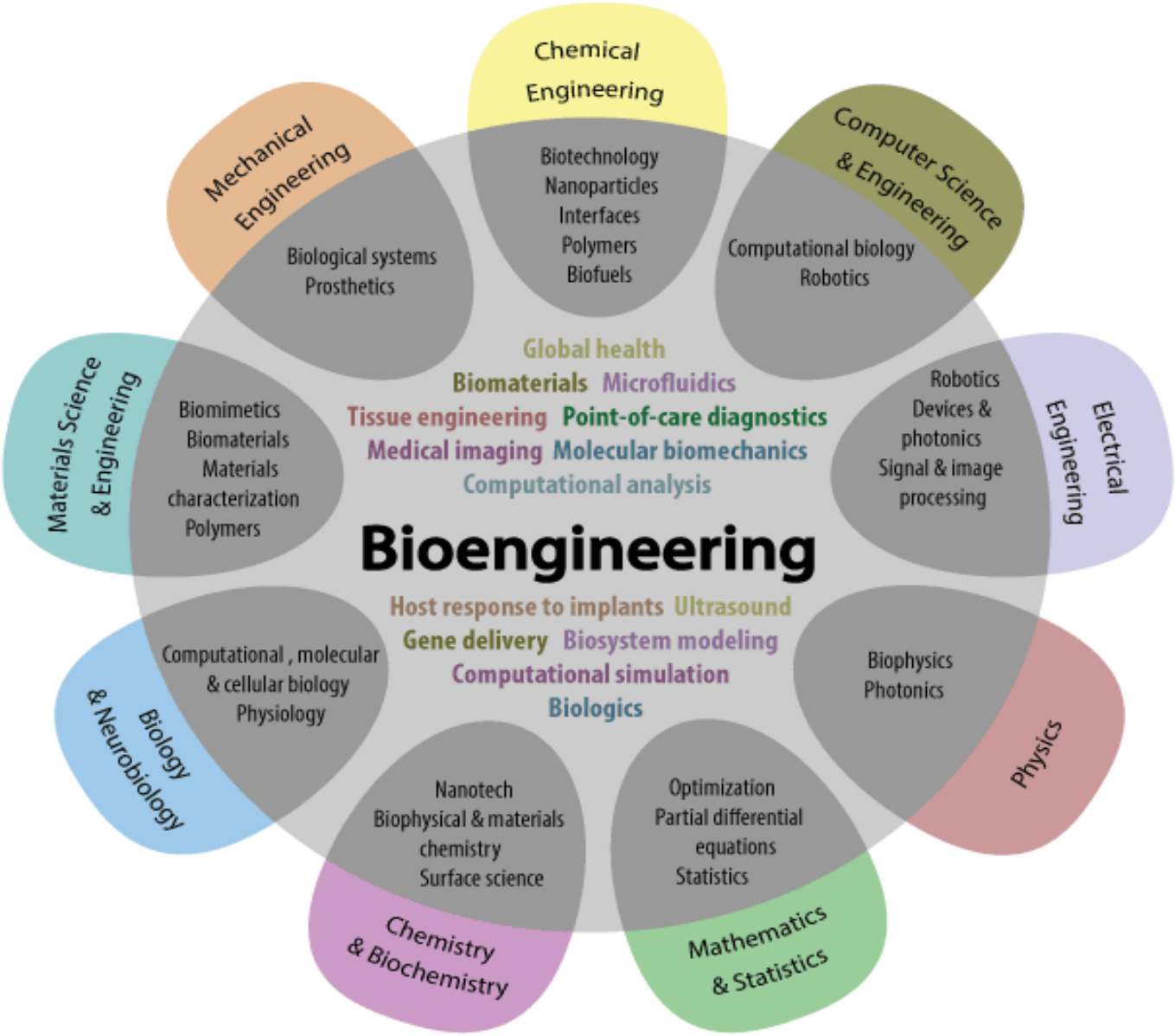
Vaccine Development

Stem Cell and Tissue Engineering

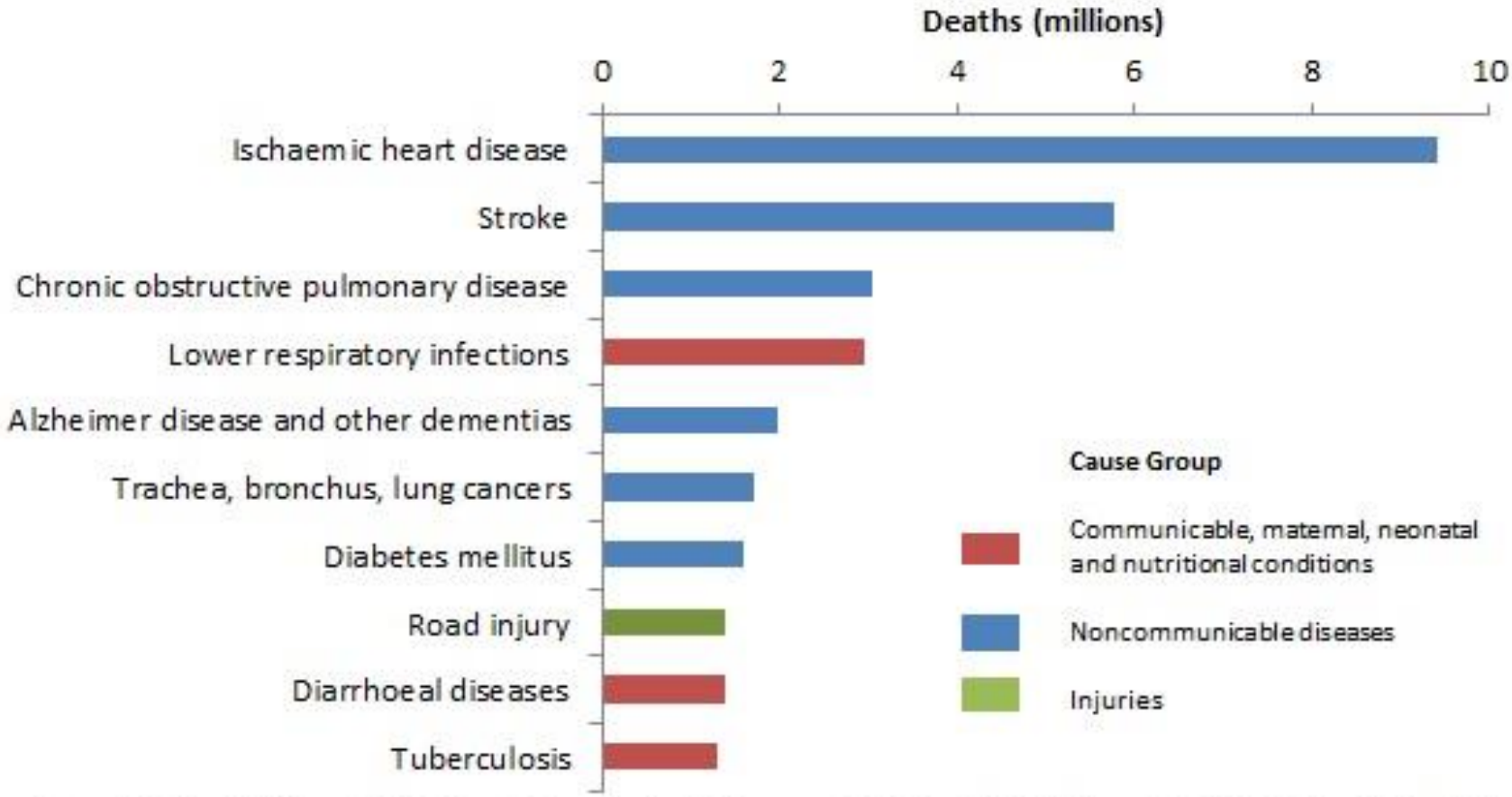
Nanobiotechnology

Development of Diagnostic Methods

Chemotherapy

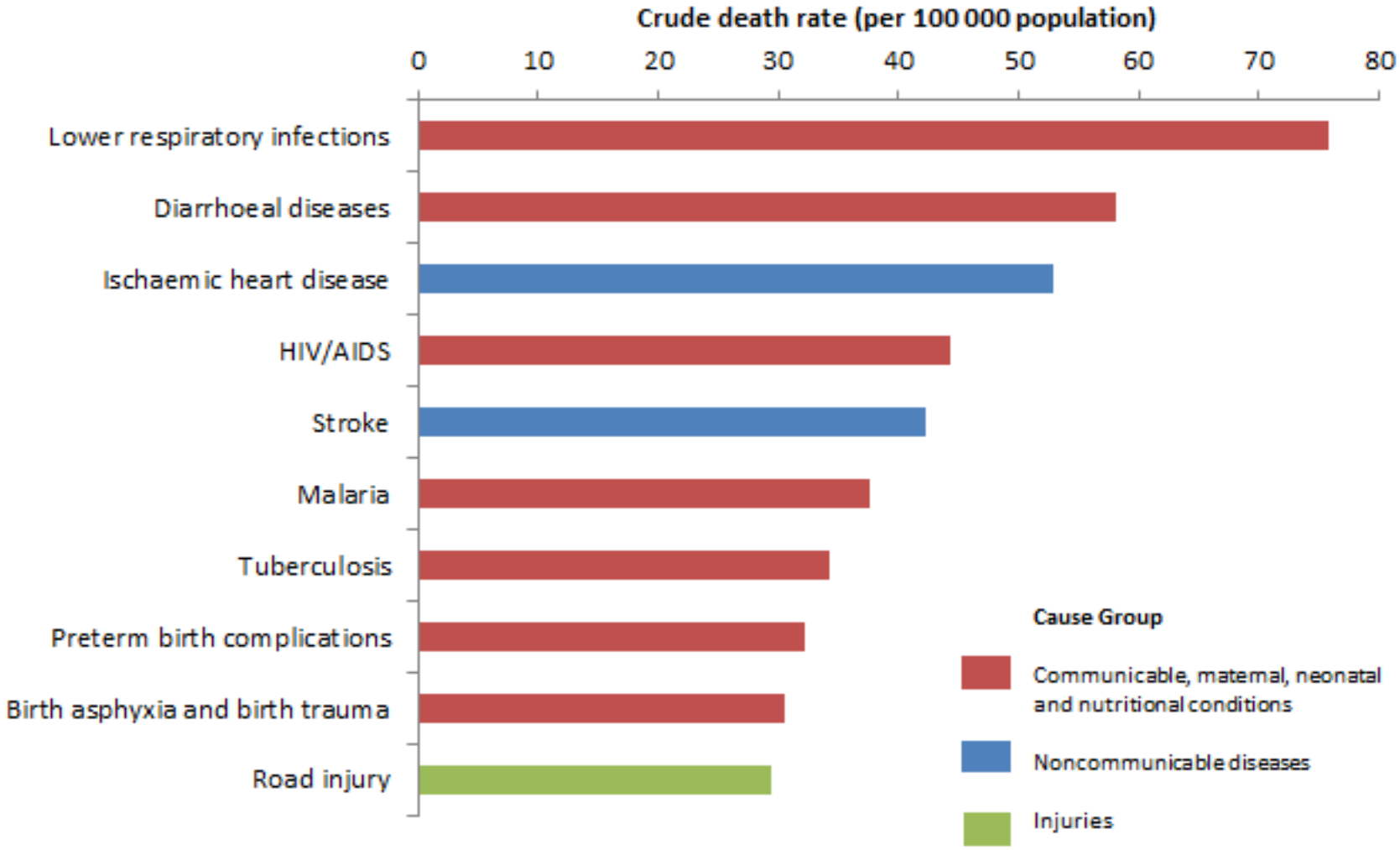

Chemical Engineering
Biotechnology
Nanoparticles
Interfaces
Polymers
Biofuels
Mechanical Engineering
Biological systems
Prosthetics
Computer Science & Engineering
Computational biology
Robotics
Materials Science & Engineering
Biomimetics
Biomaterials
Materials characterization
Polymers
Electrical Engineering
Robotics
Devices & photonics
Signal & image processing
Global health
Biomaterials Microfluidics
Tissue engineering Point-of-care diagnostics
Medical imaging Molecular biomechanics
Computational analysis
Bioengineering
Host response to implants Ultrasound
Gene delivery Biosystem modeling
Computational simulation
Biologics
Biology & Neurobiology
Computational , molecular & cellular biology
Physiology
Physics
Biophysics
Photonics
Chemistry & Biochemistry
Nanotech
Biophysical & materials chemistry
Surface science
Mathematics & Statistics
Optimization
Partial differential equations
Statistics

Top 10 global causes of deaths, 2016



Source: Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018.

Top 10 causes of deaths in low-income countries in 2016



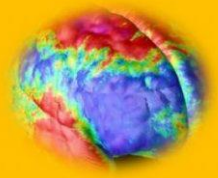
Source: Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization; 2018.
World Bank list of economies (June 2017). Washington, DC: The World Bank Group; 2017 (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups).

Diagnostics

In vitro
& In vivo

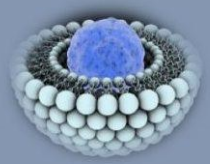
Medical Imaging

In vivo



Nano-therapeutics

Systems &
Devices



Vaccines

Regenerative Medicine

Biomaterials
Functionalisation

What is Diagnosis?

- **Determination of the nature of a diseased condition; identification of a disease by careful investigation of its symptoms and history; also, the opinion (formally stated) resulting from such investigation**

What is Medical Treatment ?

- **Medical treatment** means the management and care of a patient for the purpose of combating disease, injury, or disorder.

Antibiotics

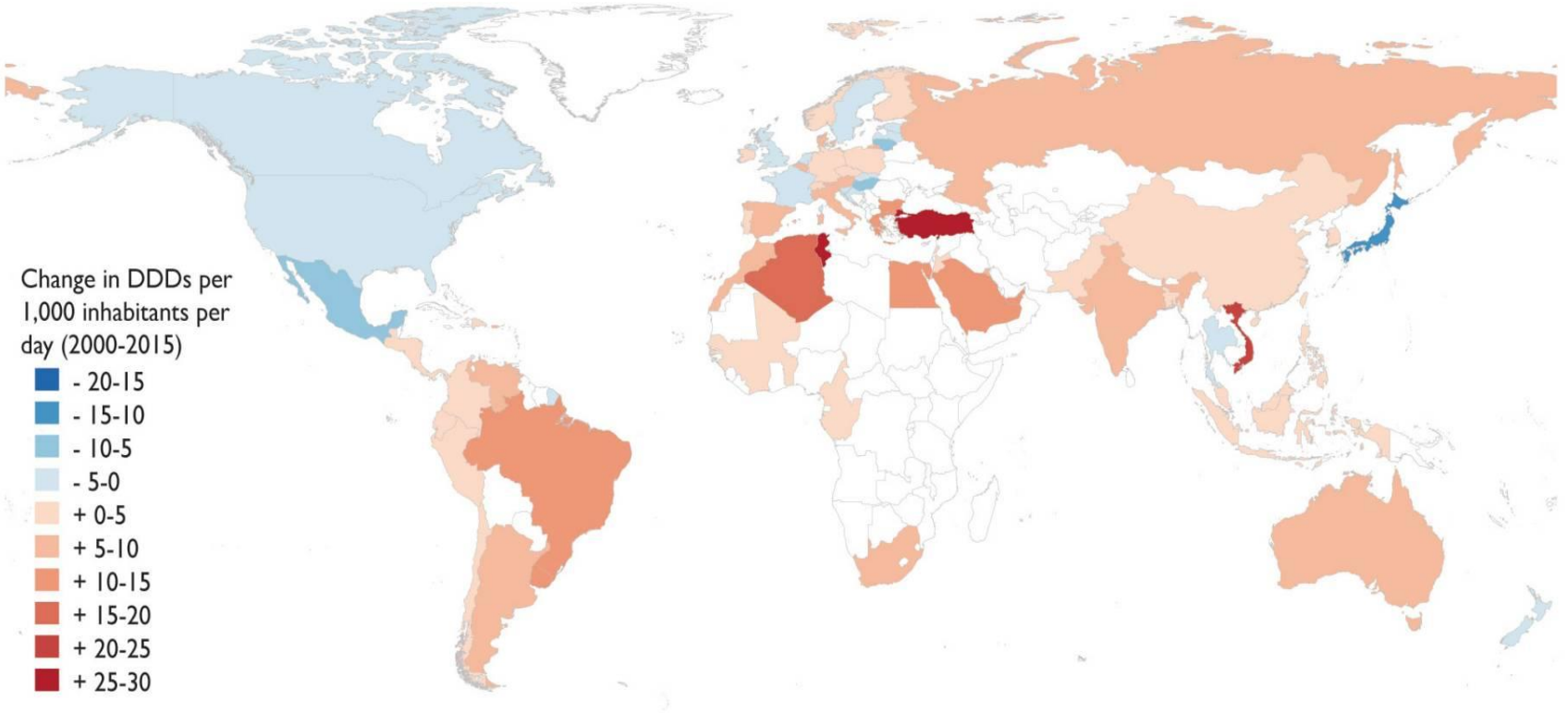
Antibiotics, also known as antibacterials, are medications that destroy or slow down the growth of bacteria. They include a range of powerful drugs and are used to treat diseases caused by bacteria.

Antibiotics cannot treat viral infections, such as cold, flu, and most coughs.

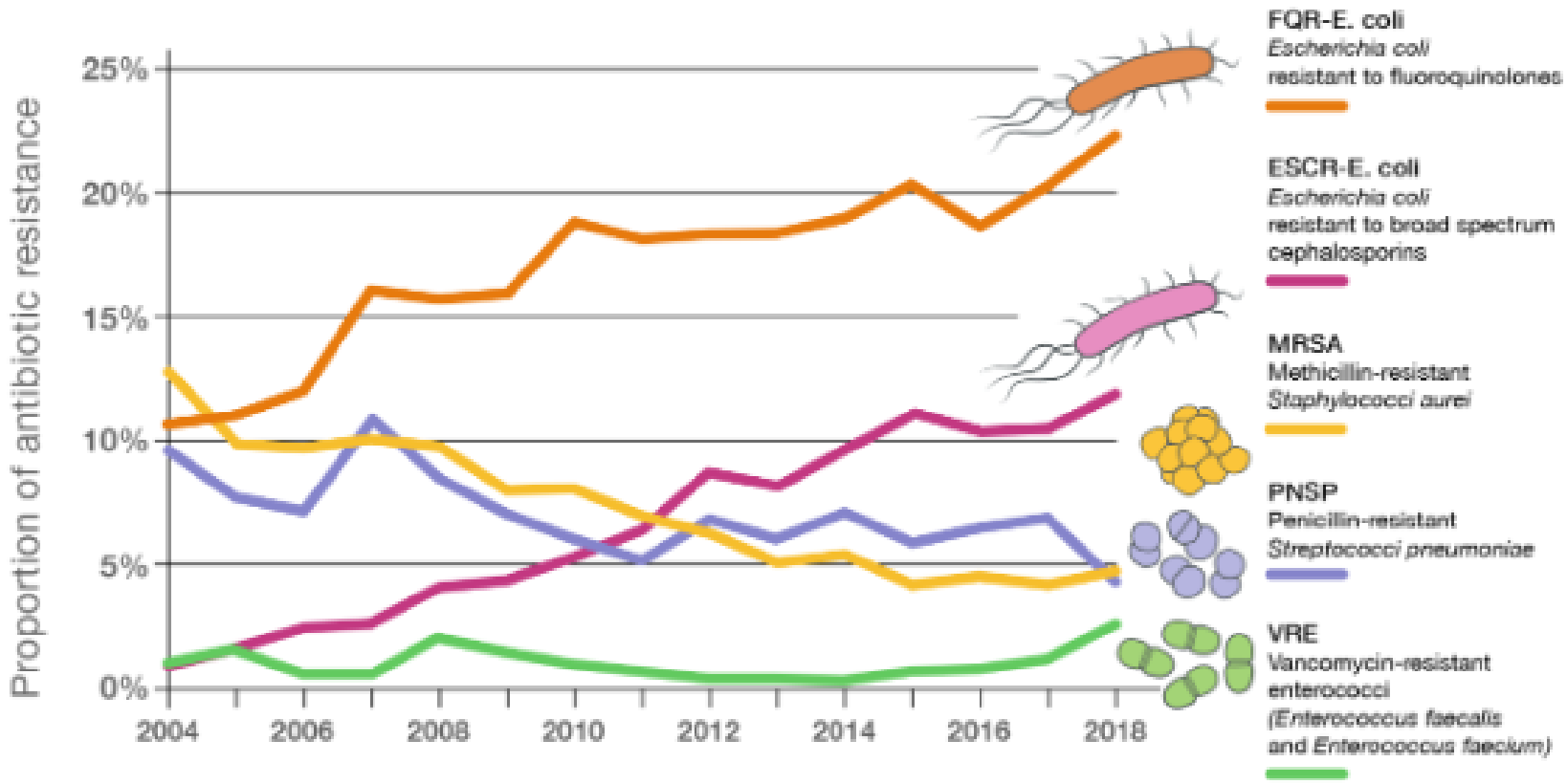
Antibiotic Resistance

- **Antibiotic resistance**: The ability of bacteria and other microorganisms to resist the effects of an **antibiotic** to which they were once sensitive.
- **Antibiotic resistance** is **a major concern of overuse of antibiotics.** Also known as drug resistance.

As antibiotics fail, global consumption of antibiotics skyrockets, further driving drug resistance



Increase in Antibiotic Resistance



Chemotherapy

- Chemotherapy means **the therapeutic use of chemical agents to treat disease especially cancer** : the administration of one or more cytotoxic drugs to destroy or inhibit the growth and division of malignant cells in the treatment of cancer.

Drugs used in cancer chemotherapy

Cytotoxic druges

- Alkylating agents and related drugs
- Antimetabolites
- Antitumor antibiotics
- Antimicrotubule agents
- Miscellaneous agents

Hormones

Others

characteristics of cytotoxic drugs

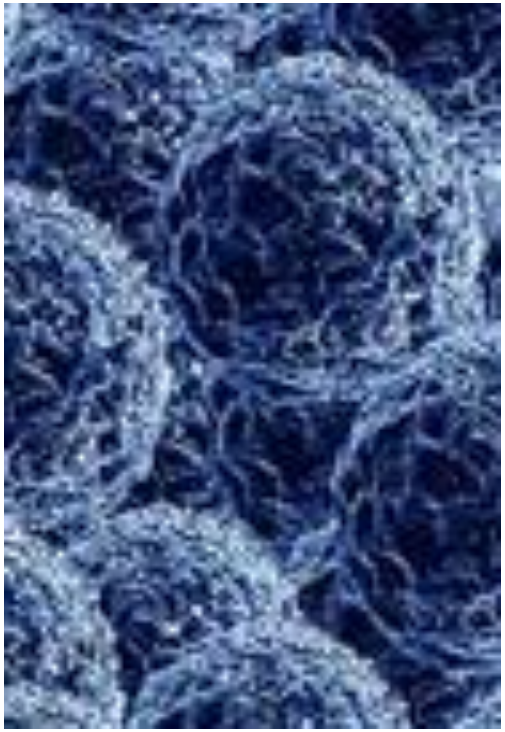
- Mostly antiproliferative
- Action during the S phase of the cell cycle
- No specific inhibitory effect on invasiveness, loss of differentiation

Side toxic effects

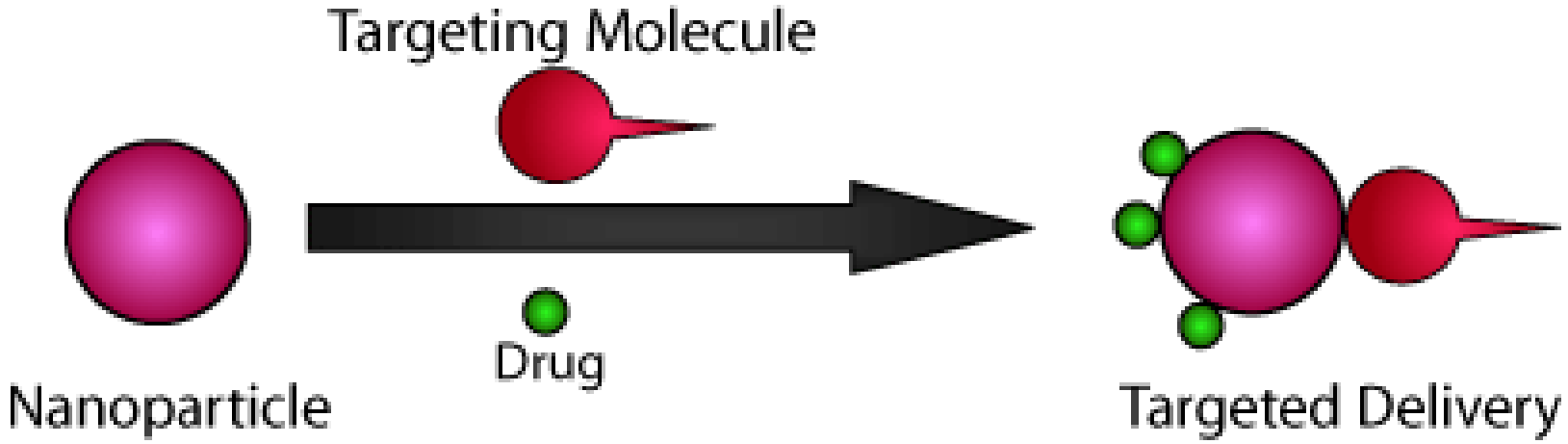
- Cytotoxic drugs act on dividing cells (both cancer and normal cells)
- They will affect all rapidly dividing normal tissues

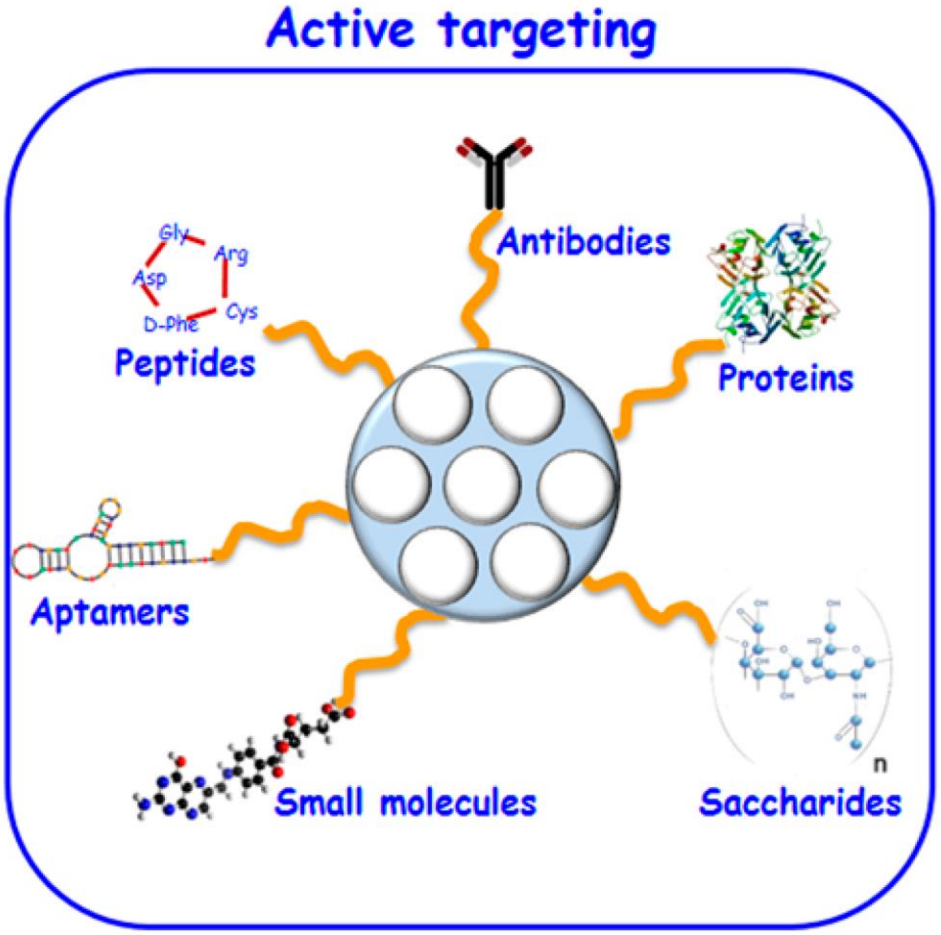
Nanotechnology and Nanoparticles

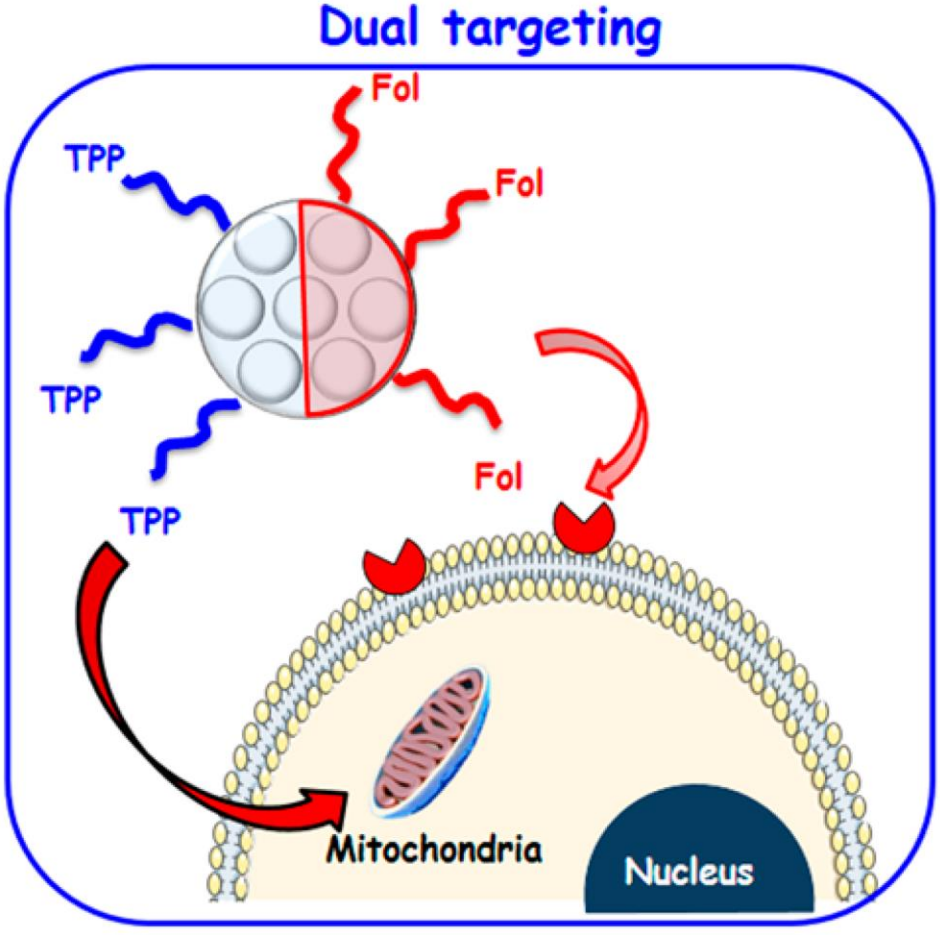
- Nanoparticles often have unique physical and chemical properties. For example, the electronic, optical, and chemical properties of nanoparticles may be very different from those of each component in the bulk.
- At the nanoscale, materials behave very differently compared to larger scales and it is still very difficult to predict the physical and chemical properties of particles of such a very small size.



Targeted Delivery




Active targeting
Antibodies
Gly
Arg
Asp
D-Phe
Cys
Peptides
Proteins
Aptamers
Small molecules
n
Saccharides


Dual targeting
Fol
TPP
Fol
TPP
Fol
TPP
Mitochondria
Nucleus

What is a Vaccine?

- A **vaccine** is a biological preparation that improves immunity to a particular disease.
- A vaccine typically contains an agent that resembles a disease-causing microorganism and is often made from weakened or killed forms of the microbe.

- The agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and keep a record of it.
- So that the immune system can more easily recognize and destroy any of these microorganisms that it later encounters.
- The terms *vaccine* and *vaccination* are derived from *Variolae vaccinae* (smallpox of the cow), the term devised by Edward Jenner to denote cowpox.

History:

- During the late 1760s whilst serving his apprenticeship as a surgeon Edward Jenner learned of the story, common in rural areas, that dairy workers would never have the often-fatal or disfiguring disease smallpox
- Because they had already had cowpox, which has a very mild effect in humans.

Edward Jenner

- In 1796, Jenner took pus from the hand of a milkmaid with cowpox, scratched it into the arm of an 8-year-old boy.
- Six weeks later inoculated the boy with smallpox, afterwards observing that he did not catch smallpox.
- Jenner extended his studies and in 1798 reported that his vaccine was safe in children and adults.

- The second generation of vaccines was introduced in the 1880s by Louis Pasteur who developed vaccines for chicken cholera and anthrax.
- From the late nineteenth century vaccines were considered a matter of national prestige, and compulsory vaccination laws were passed.

Types:

1. Live, attenuated vaccines
2. Inactivated vaccines
3. Subunit vaccines
4. Toxoid vaccines
5. Conjugate vaccines
6. DNA vaccines
7. Recombinant vector vaccines

1. Live and Attenuated Vaccines

- Live, attenuated vaccines contain a version of the living microbe that has been weakened in the lab so it can't cause disease.
- Because a live, attenuated vaccine is the closest thing to a natural infection, these vaccines are good "teachers" of the immune system.
- Example: Vaccines against measles, mumps, and chickenpox

2. Inactivated Vaccines

- Scientists produce inactivated vaccines by killing the disease-causing microbe with chemicals, heat, or radiation. Such vaccines are more stable and safer than live vaccines.
- Because dead microbes can't mutate back to their disease-causing state.
- Example: Vaccines against influenza, polio, hepatitis A, and rabies.

3.Subunit Vaccines

- Instead of the entire microbe, subunit vaccines include only the antigens that best stimulate the immune system.
- In some cases, these vaccines use epitopes the very specific parts of the antigen that antibodies or T cells recognize and bind to.
- Because subunit vaccines contain only the essential antigens and not all the other molecules that make up the microbe.
- Example: Plague immunization.

4. Toxoid Vaccines

- For bacteria that secrete toxins, or harmful chemicals, a toxoid vaccine might be the answer.
- These vaccines are used when a bacterial toxin is the main cause of illness.
- Scientists have found that they can inactivate toxins by treating them with formalin. Such "detoxified" toxins, called toxoids, are safe for use in vaccines.
- Example: *Crotalus atrox toxoid* is used to vaccinate dogs against rattlesnake bites.

5. Conjugate Vaccines

- If a bacterium possesses an outer coating of sugar molecules called polysaccharides, as many harmful bacteria do, researchers may try making a conjugate vaccine for it.
- Polysaccharide coatings disguise a bacterium's antigens so that the immature immune systems of infants and younger children can't recognize or respond to them.
- Example : *Haemophilus influenzae* type B vaccine.

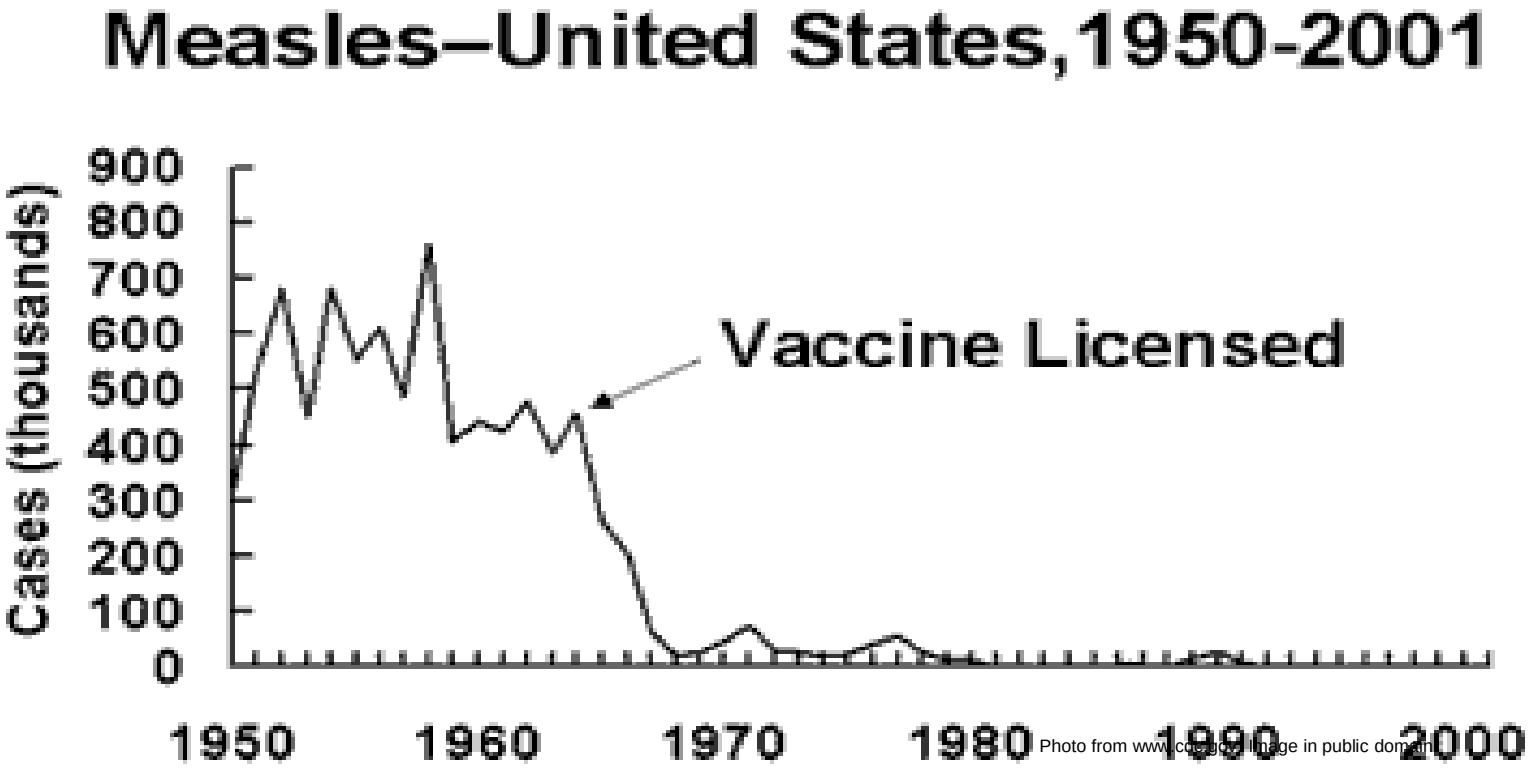
6. DNA Vaccines

- Still in the experimental stages, these vaccines show great promise, and several types are being tested in humans.
- DNA vaccines take immunization to a new technological level.
- These vaccines dispense with both the whole organism and its parts and get right down to the essentials: the microbe's genetic material.
- Example: Influenza vaccine.

7. Recombinant Vector Vaccines

- Recombinant vector vaccines are experimental vaccines similar to DNA vaccines
- But they use an attenuated virus or bacterium to introduce microbial DNA to cells of the body.
- “Vector” refers to the virus or bacterium used as the carrier.
- Example : DPT

Do Vaccines Work?
Measles Example



Hemophilus influenza type b

- **Vaccine introduced 1988**
    - **85-92% reduction in Hib invasive disease**
  - **Dramatic reduction**
    - **1987 – Incidence 41/100,000**
    - **2000 – Incidence 1.6/100,000**
    - **2004 – Incidence 0.14/100,000**

Vaccination is the most effective method for disease prevention

TABLE 2. VACCINE-PREVENTABLE DISEASE TRENDS[9]

Disease	Max Cases	Year	Cases 2012	Cases 2013	Cases 2014	Cases 2015	Cases 2016
Diphtheria	206,939	1921	1	0	1	0	0
Hib	~20,000	1980s	30	18	27	16	22
Measles	894,134	1941	55	184	628	188	72
Mumps	152,209	1968	229	438	1151	422	5311
Pertussis	265,209	1934	48,277	24,231	28,660	13,004	1634
Rubella	2.5 million	1964-1965	9	9	8	4	2
CRS	~30,000		3	0	1	1	0
Tetanus	601	1948	37	19	21	17	2
Varicella	221,983	1984	13,447	9987	9058	5373	815

CRS = congenital rubella syndrome; Hib = *Haemophilus influenzae* type b.

What Vaccines Don't We Have?

Viral Diseases

- HIV - Presence of variants and Immunosuppression
  Ignorance of immunogenic antigens to use
- Herpes Viruses (Papilloma virus vaccine announced Fall, 2002)
- Adenoviruses, Rhinoviruses - Multiple types

Bacterial Diseases

- Staphylococci
- Group A Streptococci
- Mycobacterium leprae (Some benefit from BCG)
- Treponema pallidum (syphilis)
- Non-Hemophilus and Non-Neisseria Bacterial Menigitis

Fungal Pathogens

- Candida
- Pneumocystis

More Vaccines That We Don't Have

Protozoa

- Malaria
- Trypanosomiasis

  Sleeping Sickness

  Chagas Disease - Autoimmunity and Immunosupression
- Leishmaniasis

Multicellular Parasites - Worms

- Schistosomiasis

Prophylactic and Therapeutic Cancer Vaccines