Introduction and Overview of Immunology
Immunology is the study of mechanisms that humans and other animals use to defend their bodies from invading organisms or foreign macromolecules and their responses to them.

- Host – e.g. me or any one among you !!!!

- Foreign macromolecule, antigen – e.g. viral protein, bacteria, parasite (Anything that should not be in our body)
Brief History & Prospect of Immunology

- Latin term ‘immunis’ meaning “exempt” – State of Protection from disease
- Earliest written evidence traced back to 430 BC, by Tucydides, the great historian of Peloponnesian war-described a plague epidemic in Athens
- Earliest Milestone in Immunology : First recorded attempts to induce immunity- By Chinese and Turks – Variolation against Small pox
- Modern day immunology begins with Edward Jenner and his Cowpox vaccination in 1798
- Most successful event in Immunology : Eradication of small pox from our planet in 1979 – WHO Program
Development of Immunology

- Empirical Immunology
- Scientific Immunology
- Modern Immunology
EMPIRICAL IMMUNOLOGY

- Ancient Chinese practice of immunization by inhaling powders derived from crusts of small pox lesions
- Edward Jenner in 1798: Inoculating fluid from cowpox pustule to protect against Smallpox
- Succeeded in preventing the disease in a boy named James Phipps and published a booklet on the nature of Cowpox and how it prevented Variola
- The knowledge of these was obtained from experiences and lacked for systematically scientific experimental supports
Observation:

Milkmaids who contracted cowpox (a mild disease) were subsequently immune to small pox
Jenner - Smallpox vaccine

- Noticed that milkmaids that had contracted cowpox did NOT get smallpox
- Test on an 8 year old boy, injected cowpox into him (NOT very nice......)
- Followed by exposure to smallpox
- Vaccine was invented (Latin vacca means "cow")
Smallpox

Caused by the variola virus. It enters the body through the lungs and is carried in the blood to the internal organs and skin where it multiplies. It can kill 10 to 30% of the total population, the most feared and greatest killer in human history. The first recorded infection was in Egypt in 1350.

There was no treatment. It affected societies dramatically. Prince William died at 11. Mozart, George Washington and Abraham Lincoln were all infected.

Smallpox is the earliest disease found to induce lifelong immunity. Variolation is the form of vaccination. Stopped in 1972.

Smallpox vaccine is the first vaccine to be used and the first vaccine to be discontinued.

President Bush was immunized with smallpox vaccine on Dec. 21, 2002.
Song dynasty (960-1279), Chinese used "Yi Miao": wearing an infected person’s clothes who had just recently died.

Inoculation against smallpox in China did not become widely known and practiced until the period 1567-72. Vivid descriptions of the practice are recorded by Yu Chang in his book *Miscellaneous Ideas in Medicine*, of 1643.”

Ming dynasty (1368-1644), Variolation: inserting scabs from patients under the skin of healthy individuals or blowing dried scab material up the noses of the individuals with a silver tube ("Gan Miao": dry vaccine) or using water to make a paste from scabs to insert into the nostrils ("Shi Miao": wet vaccine).

A more systemic summary of the Chinese smallpox vaccination was done by Chang Yen in 1741 in his "Zhong Miao Xin Shu" (a new book about vaccination).
Edward Jenner

- Born on May 17, 1749, in Berkeley, Gloucestershire, England,
  Died Jan. 26, 1823.
- As a teenager, while learning to be a physician, he heard a young farm girl
tell a doctor that she could not contract smallpox because she had
once had cowpox (a very mild disease). This started him thinking
about a vaccine.
- After years of experimenting, on May 14, 1796, Edward Jenner carried out
a famous experiment on a healthy 8-year-old boy, James Phipps,
with cowpox. He took material from a burst pustule on the arm of
Sarah Nelmes who had apparently contracted cowpox. He then
deliberately exposed the boy to virulent variola virus two months
later and found that the child was protected, showing only a mild
inflammation around the site where the variola was injected.
- Some record shows that in 1789 he had already experimented vaccination
on his own son, then aged one-and-a-half, with the swine pox,
followed by conventional smallpox inoculation.

A CRIME??
Jenner wrote a paper in 1798 explaining his experiments, and wanted to report his first case study in the “Transactions of the Royal Society of London” His study was rejected. He then went to London to demonstrate his theory. No one would submit to his vaccination. Discouraged, Jenner returned to Berkeley.

In 1801, Jenner published “The Origin of the Vaccine Inoculation” describing how cowpox virus was prepared and used to protect ("vaccinate") healthy persons against smallpox. Material used as the vaccine was prepared from the arm of a vaccinated child, thus the distribution of vaccine involved the transportation of vaccinated children all over Europe. Orphans were often used for this purpose. Eventually, material from infected cows was used directly as vaccine. By 1840, the British government had banned other preventive treatments against smallpox.
1798 Edward Jenner

Profound results:

(1) Jenner’s technique of inoculating with cowpox to protect against small pox spread quickly throughout Europe.

(2) Began the science of Immunology, the study of the body’s response to foreign substances.
Aging had weakened the virulence of the pathogen and that such an attenuated strain (called vaccine) might be administered to protect against disease.

Profound result:
Began the discipline of Immunology...

Immunology:
began as a branch of microbiology...
Observation:

Chicken cholera
Development of **Germ theory of disease**

Discovery of Pathogens and Application of Vaccines

**Antony van Leeuwenhoek** – Microscope

**Louis Pasteur** : First Experimental Immunologist
- Fermentation process
- Pasteurization
- Anthrax vaccine -1881
- Rabies vaccine – 1885

**Robert Koch** : Founder (Father) of Modern Bacteriology
- Pure culture techniques for bacteria
- Tubercle bacillus, Cholera bacillus
- Defined micro organisms as etiological agents of large number of diseases
FIGURE 1-1 Wood engraving of Louis Pasteur watching Joseph Meister receive the rabies vaccine. [From Harper’s Weekly 29:836 courtesy of the National Library of Medicine.]
• Stereochemist: molecular asymmetry  
• Fermentation and Pasteurisation  
• Germ Theory of disease

Attenuated vaccines for cholera, anthrax, and rabies
On July 4, 1886, 9-year-old Joseph Meister was bitten repeatedly by a rabid dog. Pasteur treated him with his attenuated rabies vaccine two days later. Meister survived.
Joseph Meister later become a gatekeeper for the Pasteur Institute. In 1940, when he was ordered by the German occupiers to open Pasteur's crypt, Joseph Meister refused and committed suicide!

• Another way to look at Louis Pasteur:
  THE DREAM AND LIFE OF LOUIS PASTEUR by R. B. Pearson
Pasteur’s contributions...

- First, championed changes in hospital practices to minimize the spread of disease by microbes.
- Second, discovered that weakened forms of a microbe could be used to immunize against more virulent forms of the microbe.
- Third, found that rabies was transmitted by agents so small they could not be seen under a microscope, thus revealing the world of viruses. As a result he developed techniques to vaccinate dogs against rabies, and to treat humans bitten by rabid dogs.
- And fourth, developed "pasteurization," a process by which harmful microbes in perishable food products are destroyed by heat, without destroying the food.
Robert Koch (1843-1910)

- German physician; also started to work on Anthrax in 1870's. Identified the spore stage. First time the causative agent of an infectious disease was identified.

- Koch's postulates: conditions that must be satisfied before accepting that particular bacteria cause particular diseases.

- Discovered the tubercle bacillus and tuberculin. Detailed tuberculin skin test (DTH).

Awarded Nobel Prize (1905).
• A Student of Koch

• With Kitasato and Wernike, discovered anti-toxin for Diphtheria and Tetanus and applied as “serotherapy”.

• Awarded first Nobel Prize in Physiology, 1901
Discovery and Application of Antibodies:

- **Mechanism of Immunity**: Emil von Behring & Kitasato
  - Immunised against Diphtheria, Demonstrated diphtheria anti-toxin in blood, Passive immunization - infectious diseases
  - Serum therapy – Nobel Prize in 1901

- **Humoral Immunity**
  - Tiselius & Kabat, 1938 demonstrated antibody activity of serum

- **Cellular immunity**
  - Elie Metchnikoff, 1883 - Cellular immunity
    - Phagocytosis
  - Emergence of improved cell culture techniques, 1950
    - Lymphocytes responsible for
      - Cellular immunity
      - Humoral immunity
Paul Ehrlich (1854 – 1915)

- Developed a series of tissue-staining dyes including that for tubercle bacillus.
- Worked with Koch. Developed anti-toxin (Diphtheria) and hemolysis.
- Side-chain theory of antibody formation: "surface receptors bound by lock & key; Ag stimulated receptors"
- Shared 1908 Nobel Prize with Metchnikoff.
Elie Metchnikoff (1845-1916)

• Embryologist studying starfish development.

• Found phagocytosis. Phagocytes from larva stuck on thorn from a tangerine tree. Later he found a fungal spore attached to a phagocyte of Daphnia. Formed the basis of leukocyte phagocytosis.

• Birth of Cellular immunology
• Shared Nobel Prize with Ehrlich in 1908
FIGURE: Electronmicrograph of macrophage (pink) attacking *Escherichia coli* (green). The bacteria are phagocytized. The monocyte (purple) has been recruited to the vicinity of the encounter by soluble factors secreted by the macrophage. The red sphere is an erythrocyte.
• Important work on influenza. Discovery of an influenza viral enzyme with the specificity for particular forms of neuramic acid. Used today for detection.

• Clonal selection theory to explain tolerance

• 1960 Nobel Prize for the discovery of acquired immunological tolerance. Rejection of donor grafts was due to an immunological reaction and that tolerance can be built up by injections into embryos.
<table>
<thead>
<tr>
<th>Year</th>
<th>Recipient</th>
<th>Country</th>
<th>Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>1901</td>
<td>Emil von Behring</td>
<td>Germany</td>
<td>Serum antitoxins</td>
</tr>
<tr>
<td>1905</td>
<td>Robert Koch</td>
<td>Germany</td>
<td>Cellular immunity to tuberculosis</td>
</tr>
<tr>
<td>1908</td>
<td>Elie Metchnikoff</td>
<td>Russia</td>
<td>Role of phagocytosis (Metchnikoff) and antitoxins (Ehrlich) in immunity</td>
</tr>
<tr>
<td></td>
<td>Paul Ehrlich</td>
<td>Germany</td>
<td></td>
</tr>
<tr>
<td>1913</td>
<td>Charles Richet</td>
<td>France</td>
<td>Anaphylaxis</td>
</tr>
<tr>
<td>1919</td>
<td>Jules Bordet</td>
<td>Belgium</td>
<td>Complement-mediated bacteriolysis</td>
</tr>
<tr>
<td>1930</td>
<td>Karl Landsteiner</td>
<td>United States</td>
<td>Discovery of human blood groups</td>
</tr>
<tr>
<td>1951</td>
<td>Max Theiler</td>
<td>South Africa</td>
<td>Development of yellow fever vaccine</td>
</tr>
<tr>
<td>1957</td>
<td>Daniel Bovet</td>
<td>Switzerland</td>
<td>Antihistamines</td>
</tr>
<tr>
<td>1960</td>
<td>F. Macfarlane Burnet</td>
<td>Australia</td>
<td>Discovery of acquired immunological tolerance</td>
</tr>
<tr>
<td></td>
<td>Peter Medawar</td>
<td>Great Britain</td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>Rodney R. Porter</td>
<td>Great Britain</td>
<td>Chemical structure of antibodies</td>
</tr>
<tr>
<td></td>
<td>Gerald M. Edelman</td>
<td>United States</td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td>Rosalyn R. Yalow</td>
<td>United States</td>
<td>Development of radioimmunoassay</td>
</tr>
<tr>
<td>1980</td>
<td>George Snell</td>
<td>United States</td>
<td>Major histocompatibility complex</td>
</tr>
<tr>
<td></td>
<td>Jean Daussct</td>
<td>France</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baruj Benacerraf</td>
<td>United States</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>Cesar Milstein</td>
<td>Great Britain</td>
<td>Monoclonal antibody</td>
</tr>
<tr>
<td></td>
<td>Georges E. Köhler</td>
<td>Germany</td>
<td></td>
</tr>
</tbody>
</table>
- **Immunological Tolerance:**
  - Owen, 1945 – Tolerance to self antigens occur because it was exposed to immune system during early development
  - Tolerent to blood cell antigens in dizygotic twin cows
  - Medawar, 1953 – First lab exp in Cellular basis of Immunological tolerance
  - Injection of allogenic tissues in fetal mice and ability to reject skin grafts from same allogenic mouse

- **Burnet’s Clonal Selection Theory:**
  - 1957, Land mark in history of Immunology and of Modern Immunology
  - Explained specificity and diversity of Clonal proliferation of Lymphocytes
  - Role of Thymus (T cells) and Bursa of Fabricius (B cells) in Immune Response – Bruce Glick & Jacqes Miller
MODERN IMMUNOLOGY

- Molecular Mechanisms of Immune phenomena
- Advanced Immunological methods in diagnosis
- Diversity of Antigen receptors
- Discovery of Signal transduction pathway
- Discovery of Apoptosis
- Hematogenesis and development of Immune cells
1972 Nobel Prize for their discoveries concerning the chemical structure of antibodies.

Gerald M. Edelman 1929-

Rodney R. Porter 1917-1985
BARUJ BENACERRAF  
JEAN DAUSSET  
GEORGE D. SNELL

**Discovered genes that regulate immune responses**
- (Ir gene)
**Now known as the major histocompatibility antigens**

1980 Noble Prize
• Antibody avidity maturation
• Plaque forming assay
• Pre-existing repertoire (in host DNA) theory helped the formation of clonal selection theory.
• Host MHC is the driving force for the maturation and selection of T cells in the thymus.
• **Idiotype network

Nobel Prize, 1984, for theories concerning "the specificity in development and control of the immune system" and the discovery of "the principle for production of monoclonal antibodies."
Milstein (b. 1927) and Köhler (1946-1995)

- Monoclonal antibody
Susumu Tonegawa (b. 1939)

- Cloning of the Immunoglobulin gene

- 1987 Nobel prize for his discovery of "the genetic principle for generation of antibody diversity".
Peter C. Doherty and Rolf M. Zinkernagel

- 1996 Nobel Prize for their discoveries concerning "the specificity of the cell-mediated immune defence".
Historical Events in Immunology

- 1796 - Edward Jenner (smallpox)
- 1881 - Louis Pasteur (vaccines)
- 1884 - Elie Metchnikoff (phagocytes)
- 1890 - Emil von Behring* (antibodies)
- 1895 - Jules Bordet* (complement)
- 1906 - August Wasserman (syphilis)
- 1959 - Rodney Porter Gerald Edelman* (antibodies)
- 1960 - F McFarlane Burnet* (tolerance)
- 1975 - Cesar Milstein* (monoclonal Ab)
- 1987 - Susumu Tonegawa* (genetics)
- 1996 - Peter Doherty Rolf Zinkernagel* (MHC)
Timeline of immunology

- **1718** - **Lady Mary Wortley Montagu**, the wife of the British ambassador to Constantinople, observed the positive effects of variolation on the native population and had the technique performed on her own children.
- **1798** - First demonstration of vaccination smallpox vaccination (**Edward Jenner**)
- **1837** - First description of the role of microbes in putrefaction and fermentation (**Theodore Schwann**)
- **1838** - Confirmation of the role of yeast in fermentation of sugar to alcohol (**Charles Cagniard-Latour**)
- **1840** - First "modern" proposal of the germ theory of disease (**Jakob Henle**)
- **1850** - Demonstration of the contagious nature of puerperal fever (childbed fever) (**Ignaz Semmelweis**)
- **1857-1870** - Confirmation of the role of microbes in fermentation (**Louis Pasteur**)
- **1862** - phagocytosis (**Ernst Haeckel**)
- **1867** - First aseptic practice in surgery using carbolic acid (**Joseph Lister**)
- **1876** - First demonstration that microbes can cause disease-anthrax (**Robert Koch**)
- **1877** - Mast cells (**Paul Ehrlich**)
- **1878** - Confirmation and popularization of the germ theory of disease (**Louis Pasteur**)
- **1880 - 1881** - Theory that bacterial virulence could be attenuated by culture in vitro and used as vaccines. Proposed that live attenuated microbes produced immunity by depleting host of vital trace nutrients. Used to make chicken cholera and anthrax "vaccines" (Louis Pasteur).
- **1883 - 1905** - Cellular theory of immunity via phagocytosis by macrophages and microphages (polymorphonuclear leukocytes) (Elie Metchnikoff).
- **1885** - Introduction of concept of a "therapeutic vaccination". First report of a live "attenuated" vaccine for rabies (Louis Pasteur).
- **1888** - Bactericidal action of blood (George Nuttall).
- **1890** - Demonstration of antibody activity against diphtheria and tetanus toxins. Beginning of humoral theory of immunity. (Emil von Behring) and (Shibasaburo Kitasato).
- **1891** - Demonstration of cutaneous (delayed type) hypersensitivity (Robert Koch).
- **1893** - Use of live bacteria and bacterial lysates to treat tumors - "Coley's Toxins" (William B. Coley).
- **1894** - Bacteriolysis (Richard Pfeiffer).
- **1896** - An antibacterial, heat-labile serum component (complement) is described (Jules Bordet).
1900 - Antibody formation theory (Paul Ehrlich)
1901 - blood groups (Karl Landsteiner)
1902 - Immediate hypersensitivity anaphylaxis (Paul Portier) and (Charles Richet)
1903 - Intermediate hypersensitivity, the "Arthus reaction" (Maurice Arthus)
1903 - Opsonization
1905 - "Serum sickness" allergy (Clemens von Pirquet and (Bela Schick)
1911 - 2nd demonstration of filterable agent that caused tumors (Peyton Rous)
1917 - hapten (Karl Landsteiner)
1921 - Cutaneous allergic reactions (Carl Prausnitz and Heinz Küstner)
1924 - Reticuloendothelial system
1938 - Antigen-Antibody binding hypothesis (John Marrack)
1940 - Identification of the Rh antigens (Karl Landsteiner and Alexander Weiner)
1942 - Anaphylaxis (Karl Landsteiner and Merill Chase)
1942 - Adjuvants (Jules Freund and Katherine McDermott)
1944 - hypothesis of allograft rejection
- 1946 - identification of mouse MHC (H2) by George Snell and Peter A. Gorer
- 1948 - antibody production in plasma B cells
- 1949 - growth of polio virus in tissue culture, neutralization with immune sera, and demonstration of attenuation of neurovirulence with repetitive passage (John Enders) and (Thomas Weller) and (Frederick Robbins)
- 1949 - immunological tolerance hypothesis
- 1951 - vaccine against yellow fever
- 1953 - Graft-versus-host disease
- 1953 - immunological tolerance hypothesis
- 1957 - Clonal selection theory (Frank Macfarlane Burnet)
- 1957 - Discovery of interferon
- 1958-1962 - Discovery of human leukocyte antigens (Jean Dausset and others)
- 1959-1962 - Discovery of antibody structure (independently elucidated by Gerald Edelman and Rodney Porter)
- 1959 - Discovery of lymphocyte circulation (James Gowans)
- 1960 - Discovery of lymphocyte "blastogenic transformation" and proliferation in response to mitogenic lectins-phytohemagglutinin (PHA) (Peter Nowell)
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961-1962</td>
<td>Discovery of thymus involvement in cellular immunity (Jacques Miller)</td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>Demonstration that glucocorticoids inhibit PHA-induced lymphocyte proliferation (Peter Nowell)</td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>Development of the plaque assay for the enumeration of antibody-forming cells in vitro (Niels Jerne) (Albert Nordin)</td>
<td></td>
</tr>
<tr>
<td>1964-1968</td>
<td>T and B cell cooperation in immune response</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>Discovery of the first lymphocyte mitogenic activity, &quot;blastogenic factor&quot; (Shinpei Kamakura) (Louis Lowenstein) (J. Gordon) and (L.D. MacLean)</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>Discovery of &quot;immune interferon&quot; (gamma interferon) (E.F. Wheelock)</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>Secretory immunoglobulins</td>
<td></td>
</tr>
<tr>
<td>1967</td>
<td>Identification of IgE as the reaginic antibody (Kimishige Ishizaka)</td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td>Passenger leukocytes identified as significant immunogens in allograft rejection (William L. Elkins and Ronald D. Guttmann)</td>
<td></td>
</tr>
<tr>
<td>1969</td>
<td>The lymphocyte cytolyis Cr51 release assay (Theodore Brunner) and (Jean-Charles Cerottini)</td>
<td></td>
</tr>
<tr>
<td>1971</td>
<td>Peter Perlmann and Eva Engvall at Stockholm University invented ELISA</td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>Structure of the antibody molecule</td>
<td></td>
</tr>
<tr>
<td>1974</td>
<td>T-cell restriction to major histocompatibility complex (Rolf Zinkernagel and Peter Doherty)</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>Generation of the first monoclonal antibodies (Georges Köhler) and (César Milstein)</td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>Identification of somatic recombination of immunoglobulin genes (Susumu Tonegawa)</td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>Generation of the first monoclonal T cells (Kendall A. Smith)</td>
<td></td>
</tr>
<tr>
<td>1980-1983</td>
<td>Discovery and characterization of the first interleukins, 1 and 2 (Kendall A. Smith)</td>
<td></td>
</tr>
</tbody>
</table>
- **1981** - Discovery of the IL-2 receptor IL2R (Kendall A. Smith)
- **1983** - Discovery of the T cell antigen receptor TCR (Ellis Reinherz) (Philippa Marrack) and (John Kappler) (James Allison)
- **1983** - Discovery of HIV (Luc Montagnier)
- **1983** - Discovery of HIV (Luc Montagnier)
- **1984** - The first single cell analysis of lymphocyte proliferation (Doreen Cantrell) and (Kendall A. Smith)
- **1985**-1987 - Identification of genes for the T cell receptor
- **1986** - Hepatitis B vaccine produced by genetic engineering
- **1986** - Th1 vs Th2 model of T helper cell function (Timothy Mosmann)
- **1988** - Discovery of biochemical initiators of T-cell activation: CD4- and CD8-p56lck complexes (Christopher E. Rudd)
- **1990** - Gene therapy for SCID
- **1994** - 'Danger' model of immunological tolerance (Polly Matzinger)
- **1995** - Regulatory T cells (Shimon Sakaguchi)
- **1996**-1998 - Identification of Toll-like receptors
- **2001** - Discovery of FOXP3 - the gene directing regulatory T cell development
- **2005** - Development of human papillomavirus vaccine (Ian Frazer)
Application of Antigen-antibody interactions:

- Techniques in Biomedical research
  eg: ELISPOT
- Immunofluorescence – Albert Coons, 1944
- Flow Cytometry (FCM)
- Western Blotting: Separation & analysis of specific proteins
- Immunoprecipitation: Sensitive assay for particular Antigen
■ **New Vaccines**:
  - Synthetic peptide vaccines
  - Multivalent subunit vaccine
  - Plasmid and DNA vaccines: Clinical trials for diseases such as HBV, HIV, Influenza, Malaria & Cancer

■ **Recombinant Cytokines**:
  - Advances in recombinant DNA technology
  - Interferon, Interleukin, Colony stimulating factor
  - Adjuvant therapy of Infectious diseases, Cancer, Immunodeficiency, Anaemia and Leukemia
  - Genetic engineering – High yielding low-cost cytokines
  - Help to investigate the differentiation of hematopoietic stem cells in vitro
  - Immune Cell Therapy: Promotes studies of immune cells, Dendritic cells
Immune cells therapy

- Bone marrow Transplantation – Therapy for a number of hematologic diseases: Leukemia, Lymphoma, Aplastic anaemia, Thalassemia and Immunodeficiency diseases

- Stem cell transplantation for Gene therapy of cancer: Genetic engineering- Introduction of normal gene to correct a defective gene

- Dendritic cells in Immunotherapy of many tumors
Prospect of Immunology

- Completion of Human Genome project
- Immunology deals with Acute infectious diseases – Vaccine
- Future of Immunology in understanding more about the debilitating diseases like
  - Autoimmune diseases
  - Tumors
  - Hypersensitivity
  - Graft rejections
- Recent developments in Immunology are opening up potential new approaches of prevention and therapy of disease.
“Looking back makes one know the path that leads to the future...

A path is the footprints of many, though only those walk in front are said ‘Heroes’.

When many walk together, a path comes into being.”