

IMMUNITY & PRINCIPLES OF VACCINATION



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

Suman Kumar Meikap
Assistant Professor (Pharmacology)
CUTM, Bhubaneswar

Edward Jenner

The Father of Immunization



Plate 4.4. Edward Jenner. (1749-1823). Pastel portrait by J. R. Smith in 1805.

Types of immunity

Innate

(Non specific , Natural)

- **General Barriers**
- **Physical barriers**

Adaptive

(Specific, Acquired)

- **Active**
- **Passive**
- **Adoptive**

Innate Immunity

- Present from birth in all individuals.
- Once activated the same mechanism occurs regardless of which challenge is encountered or previous exposure.
- Immediate response.



Innate Immunity - General Barriers

- **Direct Factors**

- Nutrition.
- Acute phase reactants.
- Fever.
- Age.
- Genetics.
- Race.

- **Indirect Factors**

- Personal hygiene.
- Socioeconomic status.
- Living conditions.

Innate Immunity - Physical Barriers

- **Skin & Mucous Membrane**
- **Respiratory System**
- **Gastrointestinal Tract**
- **Genitourinary Tract**
- **Eye**

Adaptive Immunity

- Immunity which is acquired or developed by an individual only after a specific challenge is encountered.
- The resulting adaptive immune products are effective only against the specific challenge.
- Immunologic memory in adaptive immunity provides greater efficiency should there be subsequent exposure to the same challenge.
- There is a time lag for development of adaptive immunity but secondary response is almost immediate.



Characteristics of Adaptive Immunity

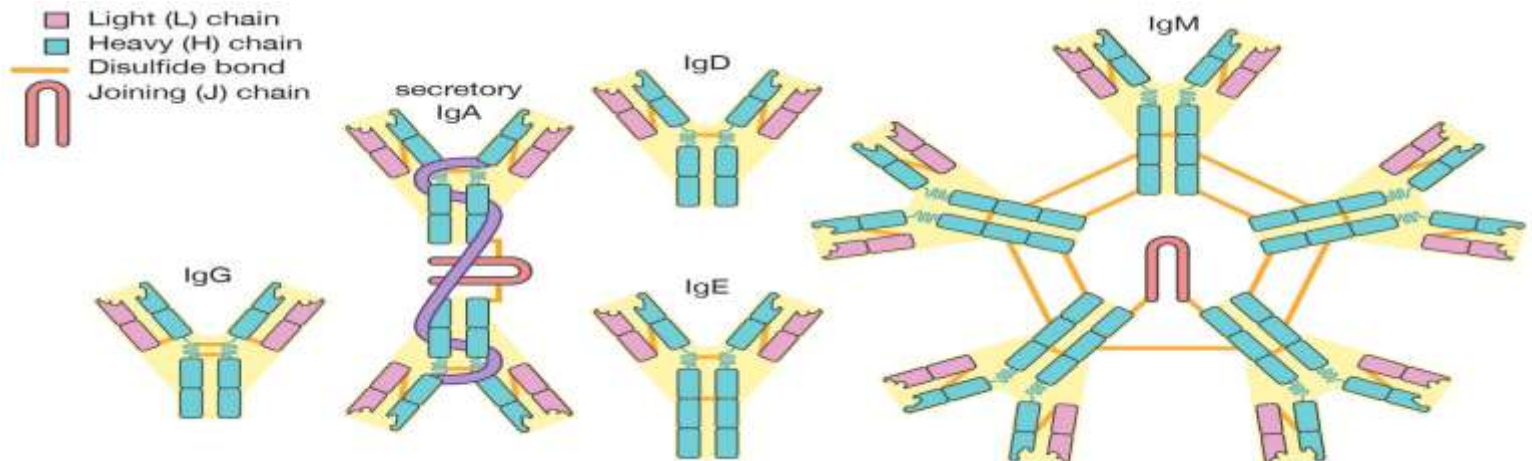
- In recent years, with increased knowledge of the molecular processes underlying the function of cells, it has become possible to explain at a cellular and molecular level the features that are the hallmark of acquired immune responses.
 - **Specificity and diversity.**
 - **Memory.**
 - **Regulation.**
 - **Self / non-self discrimination.**
- The acquire immune processes that lead to the elimination of foreign material involve the concerted efforts of a number of different cells and molecules and can be divided into three stages.
 - **Recognition stage.**
 - **Activation stage.**
 - **Effector stage.**

Classification of Adaptive Immunity

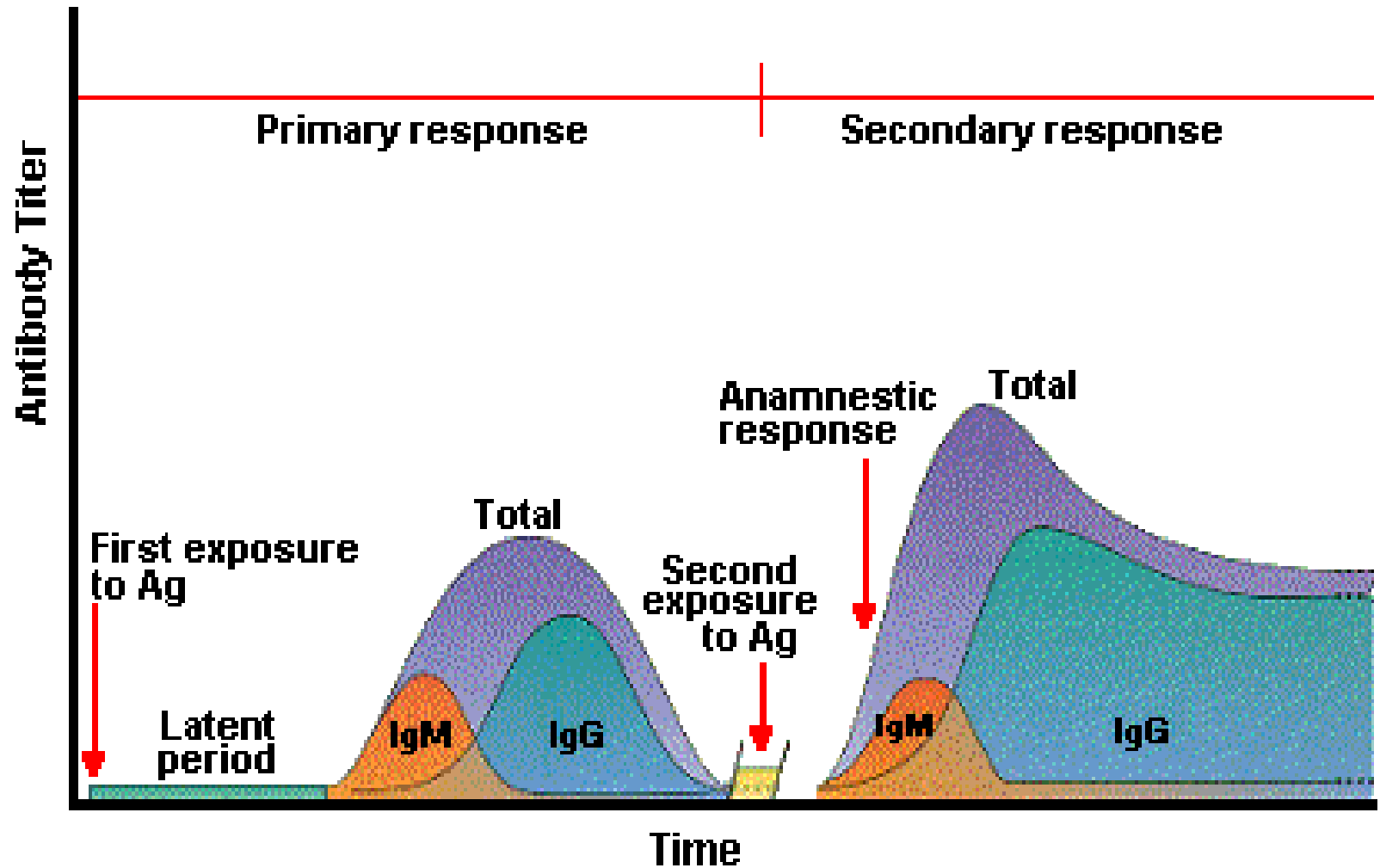
- The two major arms of effective specific immunity are humoral immunity and cell mediated immunity. While historically these are quite distinct, current knowledge suggests that each time adaptive immunity is activated, both arms are activated. It becomes a matter of the degree to which each arm is activated.
- Adaptive immunity may be classified based on the host's role in developing the adaptive specific immunity.
 - Active immunity is generated when an immuno competent host is exposed to the foreign challenge and the host's native immune cells respond by generating specific immune products.
 - Passive immunity is bestowed to the host when preformed immune products are administered to the host.
 - In adoptive immunity, immunocompetent cells are transplanted to an immunoincompetent host to restore the immune system.

Antibody

- An antibody is a protein that is produced by lymphocytes (type of white blood cell) in response to the presence of a specific antigen.
- Specific antibodies bind to specific antigens and cause their destruction.



Primary and Secondary Responses to Antigen



Vaccination

- You can become immune to a disease through vaccination.
- Immunization programmes and the development of new vaccines play an important role in protecting individuals against illness.
- Vaccination works by safely exposing individuals to a specific pathogenic microbe, artificially increasing their immunity to it.



Vaccination

Vaccination



Vaccine production.

Vaccines are made from:

- Live micro-organisms that have been 'treated' so that they are weakened (attenuated) and are unable to cause disease.
- Dead micro-organisms.
- Some part or product of the micro-organism that can produce an immune response.

Principles of Vaccination

- The primary goal in vaccination is to provide protective immunity by inducing a memory response to an infectious microorganism using a non-toxic antigen preparation. It is important to produce immunity of the appropriate kind: antibody / or cellular immunity.
- Antibodies produced as a result of immunization are effective primarily against extracellular organisms and their products e.g., toxins. Passively administered antibodies have the same effect as induced antibodies.
- Cell-mediated immunity (T cells, macrophages) induced by vaccination is important particularly in preventing intracellular bacterial and viral infections and fungal infections.
- The ultimate goal of any immunization program is the eradication of the disease.
- This requires that the infection is limited only to humans, with no animal or environmental reservoir, and the absence of any subclinical or carrier state in humans.

Principles of Vaccination

- Achieving elimination requires a high level of herd immunity to prevent person to person spread.
- This requires considerable infrastructure support to ensure that all at-risk populations are targeted for immunization.
- This has been achieved for small pox, although we are close to the elimination of polio.

A depiction of Edward Jenner vaccinating James Phipps, a boy of eight, on May 14, 1796.



Smallpox vaccination site Days 4 through 21



Day 4



Day 7



Day 14



Day 21

Passive Immunization

- Passive immunization is the administration of preformed antibodies either intravenously or intramuscularly.
- It is used to provide rapid protection in certain infections such as diphtheria or tetanus or in the event of accidental exposure to certain pathogens such as hepatitis B.
- It is also used to provide protection in immune compromised individuals.

Passive Immunization

Infection	Source of Antiserum	Indications
Tetanus	Immune human; horse	Post exposure (plus vaccine)
Diphtheria	Horse	Post-exposure
Gas gangrene	Horse	Post-exposure
Botulism	Horse	Post-exposure
Varicella-Zoster	Immune human	Post-exposure in immunodeficiency
Rabies	Immune human	Post exposure (plus vaccine)
Hepatitis B	Immune human	Post-exposure prophylaxis
Hepatitis A	Pooled human Ig	Prophylaxis
Measles	Immune human	Prophylaxis
Snakebite	Horse	Post-bite
Some autoimmune disease	Pooled human ig	Acute thrombocytopenia and neutropenia

Active Immunization

- Active immunization is the administration of vaccines containing microbial products with or without adjuvants in order to obtain long term immunological protection against the offending microbe.
- At present the normal route of vaccination in most instances is either intramuscularly or subcutaneously.
- Oral immunization is the method of choice for polio and *Salmonella typhi* vaccines. However, there is an increasing awareness that this route of immunization may be the best for most immunizations since nearly all infectious agents gain entrance through the mucosal surfaces.

Antigen Preparations

- Protection against pathogenic microorganisms require the generation of effective immune mechanisms.
- Thus, vaccines must be capable of targeting the immune system appropriately i.e. cellular / or humoral mechanisms.
- Most vaccines consist of either attenuated organisms, killed organisms, inactivated toxins, or subcellular fragments and more recently genes for antigens in viral 'vectors', and DNA itself.

Antigen Preparations Used in Vaccines

Type of antigen	Examples	
	Viruses	Bacteria
Normal heterologous organism	Vaccinia (Cowpox)	
Living attenuated organism	Measles	BCG
	Mumps	Typhoid (New)
	Rubella	
	Polio (Sabin)	
	Yellow fever	
	Varicella-Zoster	
	Whole killed organism	Rabies
	Poli (Salk)	Typhoid
	Influenza	Cholera
Subcellular fragment		
Inactivated toxin (toxoid)		Diphtheria
		Tetanus
		Cholera (New)
		<i>Meningococcus</i>
Capsular polysaccharide		<i>Pneumococcus</i>
		<i>Haemophilus</i>
		Typhoid (New)
Surface antigen	Hepatitis B	

Adjuvants

- Nonliving vaccines, especially those consisting of small molecules require the inclusion of agents to enhance their effectiveness.
- These adjuvants include microbial, synthetic and endogenous preparations having adjuvant activity, but at present only aluminium or calcium salts are generally used in humans.
- Adjuvants should enable antigens to be slowly released, preserve antigen integrity, target antigen presenting cells and induce cytotoxic lymphocytes.

Tumor Vaccines

- Vaccination strategies against cancer are currently being investigated.
- Vaccines containing tumor antigens such as those associated with prostate cancer (prostate specific antigens) as well as those associated with the breast, colon, and ovarian cancers such as HER2 / neu offer hope for the future.

Acquired Immuno Deficiency Syndrome

No cure

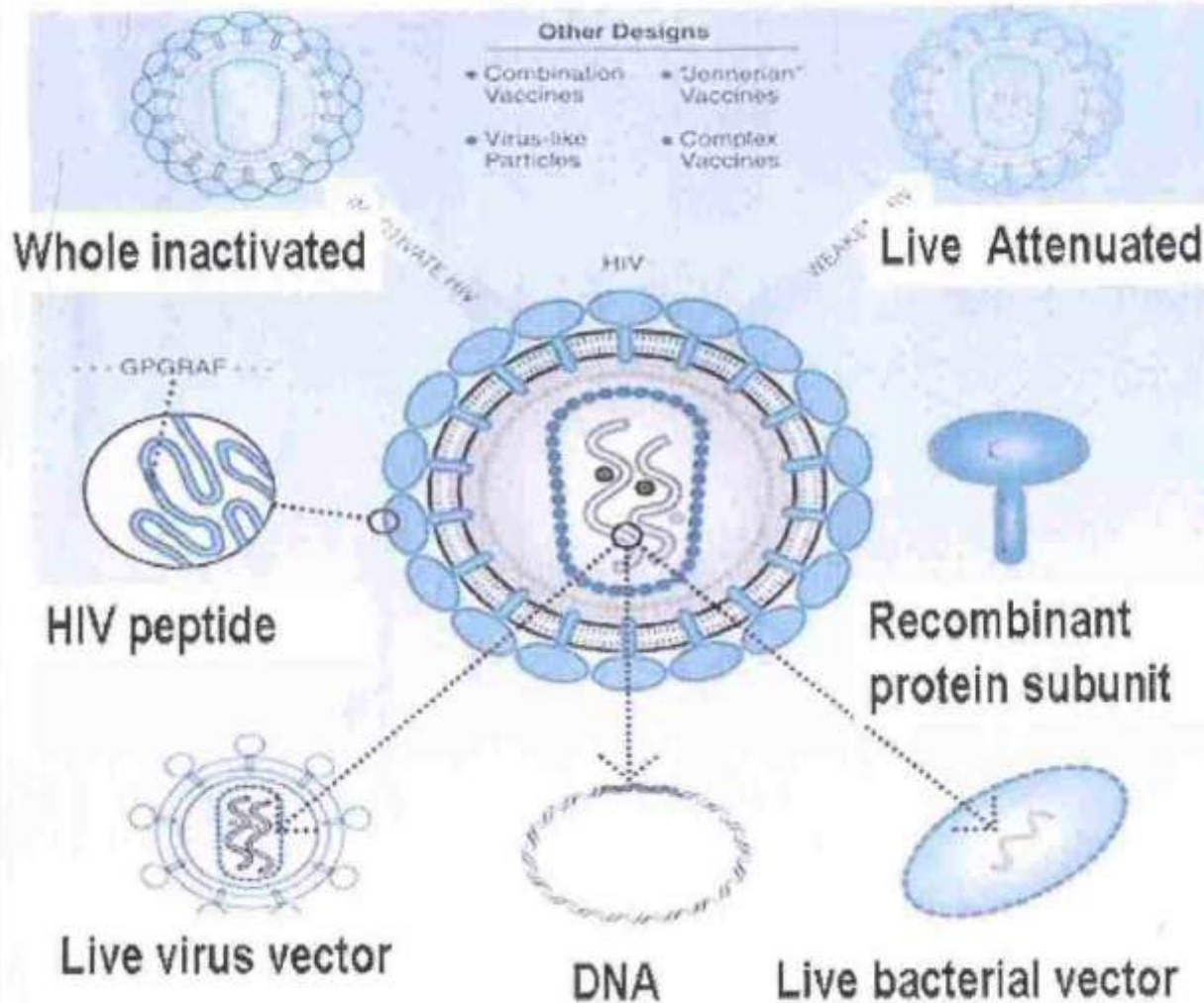
No vaccine

Obstacles to Development of HIV Vaccine

- Genomic diversity of HIV strains.
- Progression of infection despite vigorous immune response.
 - Transmission of HIV in vivo by cell fusion as well as by cell-free virus.
- Lack of good animal model.
- Potential enhancement of HIV replication by neutralizing antibody.

Vaccine Strategies

Overview of AIDS Vaccine Designs



THANK YOU