2-Adaptive immunity (Acquired immunity)

Adaptive immunity refers to antigen-specific immune response. The adaptive

immune response is more complex than the innate. The antigen first must be

processed and **recognized**.

Once an antigen has been recognized, the adaptiv immune system creates an army of immune cells specifically designed to attack that antigen.

Adaptive immunity also includes a **"memory"** that makes future responses

against a specific antigen more efficient.

Adaptive immunity -divided into two major types depending on how the immunity was introduced.

1- 'Naturally acquired immunity' occurs through contact with a disease causing agent, when the contact was not deliberate,

2- 'artificially acquired immunity' develops only through actions such as vaccination.

Both naturally and artificially acquired immunity can be further subdivided depending on

whether immunity **is induced** in the host or **passively** transferred from an immune host.

1- **active immunity**, the host undergoes an immunological response and produces its own antibodies and/or immuno-reactive lymphocytes.

Active immunity can persist a long time in the host, up to many years in humans.

2-Passive immunity is acquisition by a host of immune factors which were produced in another animal, i.e., the host receives antibodies and/or immuno-reactive lymphocytes

originally produced during an active response in another animal.

Passive immunity is typically short-lived and usually persists only a few weeks or months.

Table 1. Examples of Active and Passive Immunity

Type of Immunity	How Acquired by Host	Examples
Active Immunity	As a result of exposure to an infectious agent or one of its products (antigens)	Antibodies are produced by the host in response to the infectious agent itself (e.g. recovery from the disease), or in response to artificial immunization (vaccination) with some product derived from the infectious agent (e.g. toxoid, killed cells, structural components of cells, inactivated virus, etc.).
Passive Immunity	As a result of the acquisition of antibodies which have been produced in another animal (by active means) or derived from cells grown in tissue culture (monoclonal antibodies)	-Injection of immune serum from an individual previously immunized or recovered from disease, e.g. hepatitis; ---- Injection of serum from an animal hyperimmunized with tetanus toxoid; -- Placental transfer of antibodies from mother to fetus; Transfer of antibodies from mother to infant in milk by nursing.

Key to the adaptive immune response is the lymphocyte. There are several subtypes,

, however these fall under two broad designations:

T lymphocytes and B lymphocytes (commonly known as T cells and B cells).

Although both originate in the bone marrow, T cells mature in the **thymus,** whilst B cells mature **in the bone marrow.**

An additional aspect of the maturation process for T cells is that further distinct subsets

are produced – **helper T cells (also called CD4+ T cells)** and **cytotoxic T cells (also called CD8+ T cells).**

Adaptive immunity utilises many kinds of receptor to coordinate its activities:.

T cells carry T-cell receptors (TCR), whilst B cells carry B-cell receptors (BCR),

and variations in the fine structure of these receptors account for the individual specificity described above.

In addition, another set of receptors, encoded by the major histocompatibility complex **(MHC),** play an important role in adaptive immunity.

MHC class I receptors are displayed on a majority of body cells, whilst **MHC class II**

Receptors are restricted to **antigen-presenting cells (APCs)**

Both of these receptor types interact with **TCRs.**

The adaptive immune response consists of two branches,

1- a cellular adaptive response

(effected by cytotoxic T cells) and

2-a humoral adaptive response (effected by B cells)

Two subtypes **of helper T cells (Th1 and Th2)** have been identified as being responsible for guiding adaptive responses towards either a **cellular profile (Th1) or a humoral profile (Th2)**

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Initiation of adaptive immunity

Antigen-presenting cells able too initiate adaptive immune responses by **presenting antigen to T cells**. Major APCs are **dendritic cells (DCs),** which are found throughout the body – however **macrophages and B cells** may also **serve as APCs**, with the former providing an important link from innate immunity.

Dendritic cells monitor the bodily environment by absorbing protein fragments that they acquire from their surroundings, and presenting them on the their cell surface in association with **MHC receptors.**

DCs may be activated by local innate immune signals (induced by infection) causing them to migrate through the lymph (or blood) to lymph nodes where they present antigen to T cells.

- If a protein fragment is recognised by **cytotoxic T cell** this will suggest that it is of (foreign origin) leading to **a cellular adaptive response**

-Similarly, B cells in the lymph node may encounter free antigen carried in the lymph, leading to **a humoral adaptive response**.

In both cases, concurrent **activation of helper T** cells is usually necessary to ensure an effective overall response.

The cellular adaptive response

Body cells are continuously processing protein derived from the internal cellular environment and presenting it in association with **MHC class I receptors.**

This will typically 'self' antigen (that is ignored by the immune system), but can also be peptides derived from infecting viruses or bacteria, or aberrant cancer peptides. Activated **cytotoxic T cells** of a given specificity

proliferate in the lymph and then migrate to sites of infection where they monitor body cells for signs of intracellular infection or aberrant self proteins associated with cancer – presented **on MHC class I molecules** – using **their TCRs**. If they encounter antigen that they recognise, this indicates infection or malignancy, and they are then able to induce apoptosis (autodestruction) of targeted body cells. This constitutes the **cellular adaptive response.**

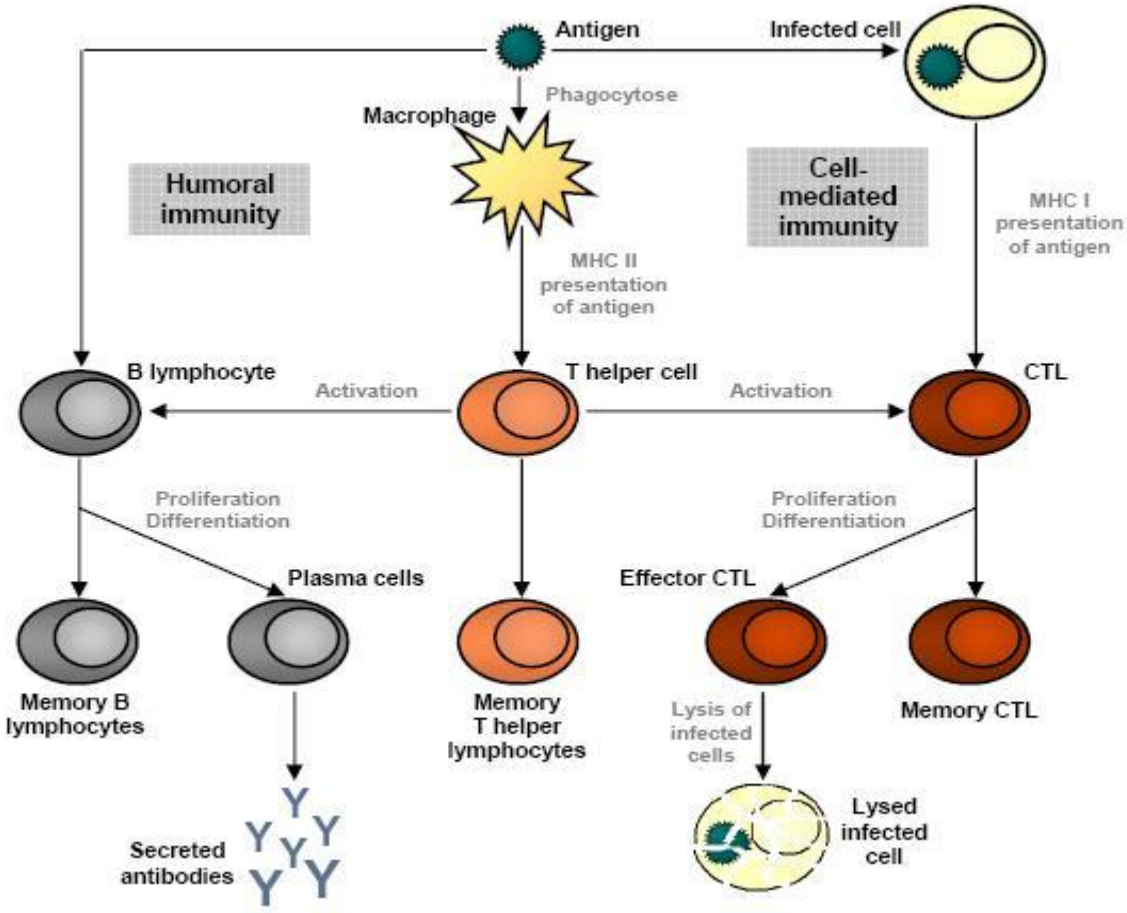
The humoral adaptive response

B cells can recognise antigen via their **BCRs,** without the need for prior processing or presentation via a receptor – so they are key to identifying extracellular pathogens (e.g. bacteria in the lymph). Once activated, B cells differentiate into **plasma cells** that are capable of secreting antibody molecules

Once bound to a target, antibody **molecules can activate the classical pathway of the complement system,** thereby directing it to neutralise its targets with great specificity. Binding of antibody also enhances phagocytosis.

Immune memory

It is important to note that an effective primary **adaptive**) takes some time to develop, since only small numbers of target-specific B- and T cells are present initially and, once activated, they must first proliferate through a process known as **clonal selection** to form **effector cells.** A proportion of these effector cells go on to form a stock of **long-lived memory cells** ensuring that if a particular pathogen is encountered again, any subsequent develops more quickly and is thus **secondary adaptive response (or 'memory response')**more effective

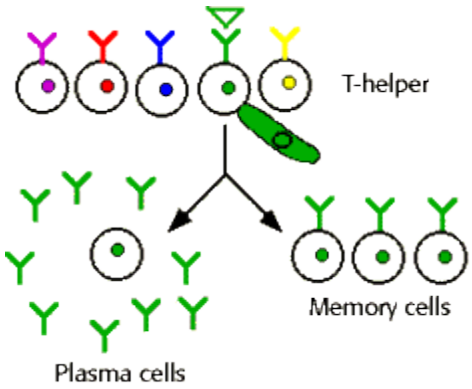


The Clonal Selection Theory

- The immune systems produces Billions of kinds of B-cells each making one kind of antibody receptor.
- The presence of antigen leads to the proliferation and differentiation of clones that have antibody capable of binding the antigen. In the diagram the "green" antigen binds to the green antibody on a B-cell. The color code means that only this antibody receptor on the cell binds free antigen.
- The "green" helper T-cell must give a stimulatory signal to allow a particular B-cell to

be selected. This step allows a regulation or control of the process.

- The antigen driven selection produces memory cells and plasma cells secreting antibody capable of binding the original selecting antigen with high affinity..
- If antigen appears in the organism a second time, then the memory cells are already present at high levels, and produce a more rapid and much stronger immune response.



We will discuss the Humoral System, and in particular how we can produce so many kinds of antibody, and the differences between a primary and secondary immune response. Regulation of the immune response requires the participation of a set of cell surface glycoproteins called the MHC or Major Histocompatibility Complex. The Cellular System recognizes the MHC to regulate both B-cell and T-cell responses.