

OCR (B) Biology A-level

Topic 3.2 - Pathogens, Immunity and Disease Control

Definitions and Concepts

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3.2.1 Pathogenic microorganisms

Acquired Immunodeficiency Syndrome (AIDS) - A disease which occurs when HIV destroys a given proportion of T helper cells and the immune system is no longer functional.

Bacteria - Prokaryotic cells that have cell walls but lack organelles. Some bacteria are pathogenic, producing toxins that damage host cells.

Chickenpox - A communicable disease caused by varicella-zoster virus (VSV). It causes an itchy skin rash.

Communicable disease - A disease that is caused by a pathogen and transmitted directly between organisms.

Droplet infection - When a disease is transmitted by airborne respiratory droplets.

Endemic disease - A disease which is common in a certain local geographic area or population.

Epidemic - An infectious disease which has spread to many individuals within a community or region concurrently.

Epidemiology - Analysis of patterns of disease in defined populations and why they occur. The World Bank publishes much of the data, e.g. related to HIV & tuberculosis.

Fungus - A type of non-photosynthetic eukaryote with a chitin cell wall that can act as a pathogen.

Gram negative bacteria - A type of bacteria with an outer membrane and a thin inner peptidoglycan cell wall which does not retain the crystal violet stain during gram staining.

Gram positive bacteria - A type of bacteria with thick outer peptidoglycan cell walls which retain the crystal violet stain during gram staining.

Gram stain - The culture is stained with crystal violet and then with Gram's iodine solution.

Human Immunodeficiency Virus (HIV) - An infectious virus that destroys T helper cells, weakening the immune system of the body. HIV makes an individual more susceptible to opportunistic infections and can lead to AIDS (Acquired Immunodeficiency Syndrome).

Incidence rate - Indicates the probability that a medical condition will occur in members of a population in a given time. Calculated using:

$$\frac{\text{number of new cases}}{\text{duration of time period} \times \text{total susceptible population}}$$

Mortality rate - Calculated using the following formula, where 10^n is a scale factor:

$$\frac{\text{number of deaths in a given time period} \times 10^n}{\text{population size}}$$



Non-communicable disease - A disease that cannot be transmitted by direct contact between individuals e.g. sickle cell anaemia or lung cancer.

Notifiable disease - Medical practitioners & laboratories have a legal duty to report symptoms of these conditions (e.g. cholera, anthrax, malaria) within 3 days by submitting a form to Public Health England.

Opportunistic infection - When T_H count is too low to stimulate an immune response against pathogens as a result of HIV, patients experience secondary infections.

Pandemic - An epidemic in several different geographical locations.

Pathogen - A disease-causing microorganism. Includes bacteria, viruses, fungi and protoctista.

Prevalence rate - Represents the proportion of a population affected by a disease in a given time. Calculated using the following formula, where 10^n is a scale factor:

$$\frac{\text{number of new and pre-existing cases in a given time} \times 10^n}{\text{total population size}}$$

Primary TB - *Mycobacterium Tuberculosis* trigger an inflammatory response by infecting phagocytes in the lungs. Infected phagocytes are sealed in waxy-coated tubercles so bacteria remain dormant. Primary TB has no symptoms.

Public Health England (PHE) - An organisation which aims to prevent epidemics by detecting highly contagious 'notifiable diseases' as early as possible. It was previously called the Health Protection Agency (HPA).

Secondary TB - If another factor weakens the immune system, dormant bacteria in tubercles become active and destroy lung tissue.

Severe Acute Respiratory Syndrome (SARS) - A viral respiratory disease transmitted from humans to animals which caused an epidemic in China in 2002.

Toxin - A chemical secreted by some bacteria which damages cells.

Tuberculosis (TB) - A bacterial disease caused by *Mycobacterium tuberculosis* which results in a persistent cough, worsening breathlessness, extreme fatigue, fever and weight loss.

Viruses - Non-living infectious agents that invade host cells and take over cell metabolism, replicating within them.



3.2.2 The immune system

Active immunity - Resistance in an organism that has developed through the production of specific antibodies in response to a pathogen. It provides long-lasting immunity as memory cells are produced.

Agglutinins - Chemicals that cause pathogens to aggregate together, aiding phagocytosis. Antibodies can act as agglutinins.

Allergen - Substance that triggers an allergic response.

Allergic response - An allergen triggers production of a specific form of Immunoglobulin E, which attaches to mast cells, so that individuals become sensitized.

Antibody - Immunoglobulin produced by B-lymphocytes in response to a specific antigen, triggering an immune response.

Antigen - A chemical present on the surface of a cell that induces an immune response.

Antigen-presenting cell - A macrophage that displays foreign antigens.

Antitoxins - Chemicals produced by white blood cells that neutralise toxins released by pathogens.

Artificial active immunity - The production of antibodies by the immune system following the exposure to a weakened, attenuated or dead pathogen, e.g. by vaccination.

Artificial passive immunity - The immunity acquired from the administration of specific antibodies from another organism, e.g. by vaccination.

B effector cells - A type of B lymphocyte that divides to form plasma cells.

B lymphocytes - Lymphocytes that mature in the bone marrow. There are three main types: plasma cells, B effector cells and B memory cells.

B memory cells - B lymphocytes that provide immunological memory.

Cilia - Small hair-like structures that project from the surface of cells.

Ciliated epithelial cells - Specialised cells with tiny hair-like cilia found lining the trachea that waft bacteria-containing mucus up to the back of the throat, where it is swallowed.

Clonal expansion - The mass proliferation of specific antibody-producing cells.

Clonal selection - The identification of an antibody-producing cell with complementary receptors to the shape of a specific antigen.

Cytokines - Cell-signalling molecules produced by mast cells in damaged tissue. They attract white blood cells to the site of damage.



Direct ELISA test - Antigen molecules bind to monoclonal antibodies on the bottom of the test plate. Mobile antibodies with a 'reporter enzyme' attached bind to the antigens that are 'fixed' on the monoclonal antibodies. When a substrate for the reporter enzyme is added, there is a colour change. Used for HIV and TB testing.

Expulsive reflexes - Coughs or sneezes initiated upon irritation of the respiratory tract. They remove microorganism-containing mucus from the gaseous exchange system.

Goblet cells - Specialised cells that secrete mucus onto the trachea lining. The mucus traps harmful substances and microorganisms, preventing their entry into the lungs.

Hay fever - Hypersensitivity of the immune system to the allergen pollen, causing rhinitis and itchy, watery eyes.

Hydrochloric acid - The primary constituent of stomach acid.

Immunity - Rapid mitosis of memory cells means that the secondary immune response is much faster and the pathogen does not cause symptoms.

Indirect ELISA test - Antibodies in a sample bind to antigens on the bottom of the test plate. A secondary antibody with a 'reporter enzyme' attached binds to primary antibodies from the sample. When a substrate for the reporter enzyme is added, there is a colour change.

Inflammation - A localised response of vascular tissue to pathogens, damage or irritants. It is characterised by pain, redness, heat and swelling.

Lysosomes - Membrane-bound vesicles found in the cytoplasm that contain a hydrolytic enzyme called lysozyme.

Lysozyme - A hydrolytic enzyme found in lysosomes and tears.

Mantoux test - PPD tuberculin is injected into the forearm. Individuals with latent TB are sensitive to PPD tuberculin. A hard red bump forms on the skin and its size is measured.

Mast cells - Cells which produce cytokines to attract white blood cells to the site of tissue damage.

Memory cells - Specialised T or B lymphocytes produced from the primary immune response which remain in low levels in the blood and can divide very rapidly by mitosis if the organism encounters the same pathogen again.

Mucus - A viscous, slimy mixture of mucins, water, electrolytes, epithelial cells, and leukocytes that is secreted by glands lining the nasal, esophageal, and other body cavities and serves primarily to protect and lubricate surfaces.

Natural active immunity - The production of antibodies by the immune system following infection.

Natural passive immunity - The immunity acquired by an infant mammal when antibodies are transferred through the placenta and the colostrum from the mother.



Non-specific defences - Defenses that are always present and are the same for all organisms, e.g: skin, blood clotting, inflammation, mucous membranes and expulsive reflexes.

Opsonins - Chemicals that bind to and tag foreign cells, making them easily recognisable to phagocytes.

Pathogen - A disease-causing microorganism. Includes bacteria, viruses, fungi and protoctista.

Phagocytes - Specialised white blood cells that engulf and destroy pathogens. There are two types: neutrophils and macrophages.

Phagocytosis - The process by which phagocytes engulf and destroy pathogens.

Phagolysosome - A vesicle within a phagocyte formed by the fusion of a phagosome and lysosome.

Phagosome - The vacuole inside a phagocyte in which a foreign particle is engulfed.

Plasma cells - B lymphocytes that produce antibodies specific to a particular antigen.

Secondary immune response - The response of the immune system to a pathogen when it is encountered for a second (third, fourth...etc.) time. Immunological memory gives a rapid production of a large number of antibodies.

T helper cells - T lymphocytes with CD4 receptors on the cell surface membrane. These bind to antigens on antigen-presenting cells and secrete interleukins.

T killer cells - T lymphocytes that produce perforin, destroying pathogens with a specific antigen.

T lymphocytes - Lymphocytes that mature in the thymus gland. There are four main types: T helper cells, T killer cells, T memory cells and T regulatory cells.

T memory cells - T lymphocytes that provide immunological memory

T regulatory cells - T lymphocytes that regulate the immune response by suppressing other T cells and maintaining tolerance to self-antigens.

Tuberculosis (TB) - A bacterial disease, caused by *Mycobacterium tuberculosis* and *M. bovis*, that damages lung tissue and weakens the immune system.

3.2.3 Controlling communicable diseases

Antibiotic - A chemical or compound produced by a living organism that kills or prevents the growth of bacteria.



Antibiotic resistance - Some bacteria have favourable mutations which allow them to survive in the presence of an antibiotic. These bacteria reproduce rapidly to form resistant strains.

Antigen - A chemical present on the surface of a cell that induces an immune response.

Antigen variability - Random DNA mutations result in new antigen shapes for a given species of bacteria.

Bactericidal antibiotics - A class of antibiotics which kill bacteria.

Bacteriostatic antibiotics - A class of antibiotics which inhibit or hinder the growth and replication of bacteria.

Booster vaccination - Re-exposure to the antigen in a vaccine increases the level of memory cells.

Disinfectant - A chemical that destroys or inactivates microorganisms on a non-living surface.

Gram-negative bacteria - A type of bacteria with an outer membrane and a thin inner peptidoglycan cell wall which does not retain the crystal violet stain during gram staining.

Gram-positive bacteria - A type of bacteria with thick outer peptidoglycan cell walls which retain the crystal violet stain during gram staining.

Herd immunity - A type of disease immunity that occurs when a large proportion of a population are vaccinated against a disease which prevents the spread of the disease to unvaccinated individuals.

Human Papillomavirus (HPV) - A group of DNA viruses which usually cause no symptoms but may sometimes cause precancerous lesions or genital warts.

MRSA - A type of bacteria that is resistant to the antibiotic methicillin.

Vaccination - The deliberate exposure of an individual to antigens from a pathogen to provide artificial active immunity.

