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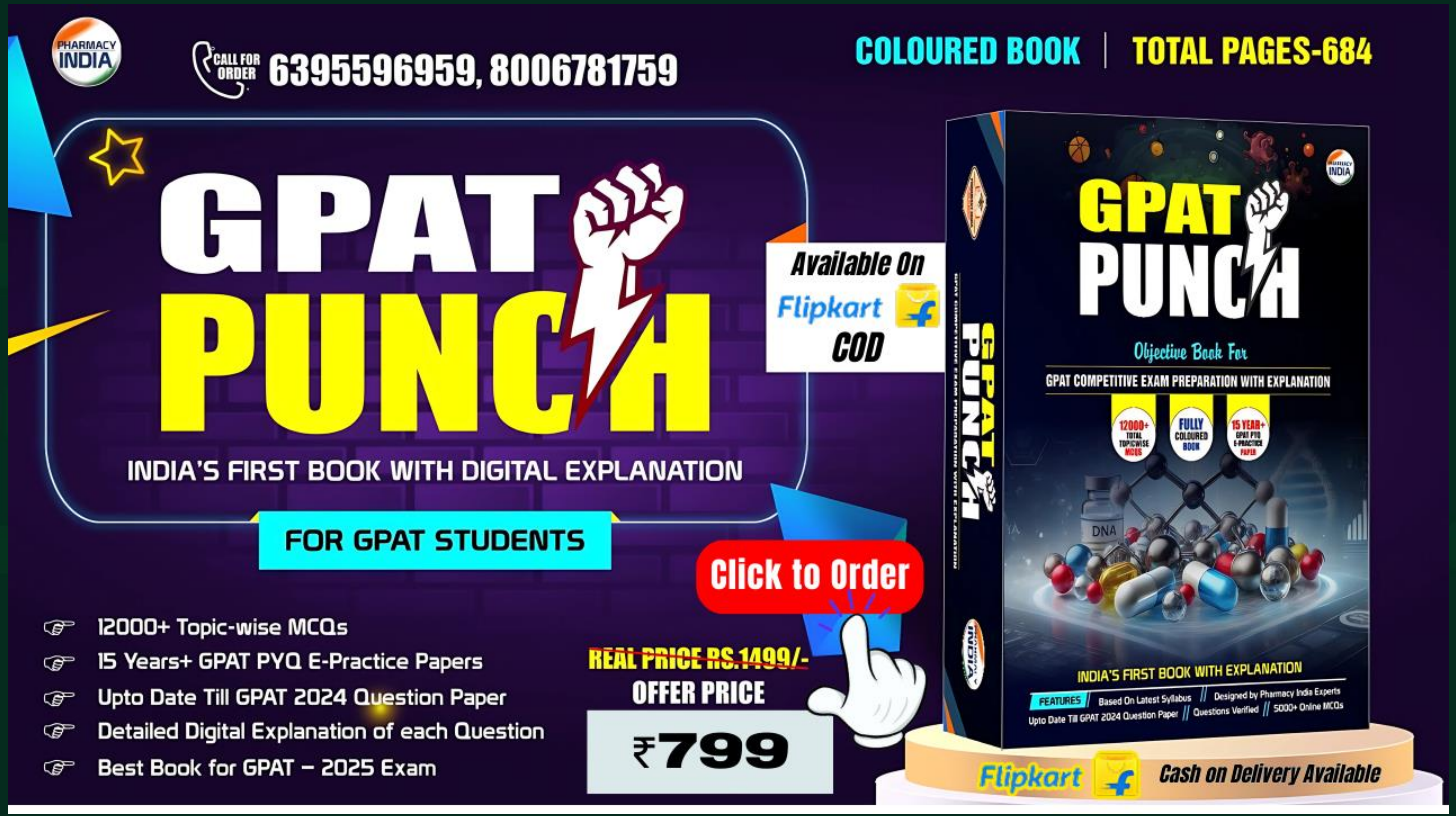

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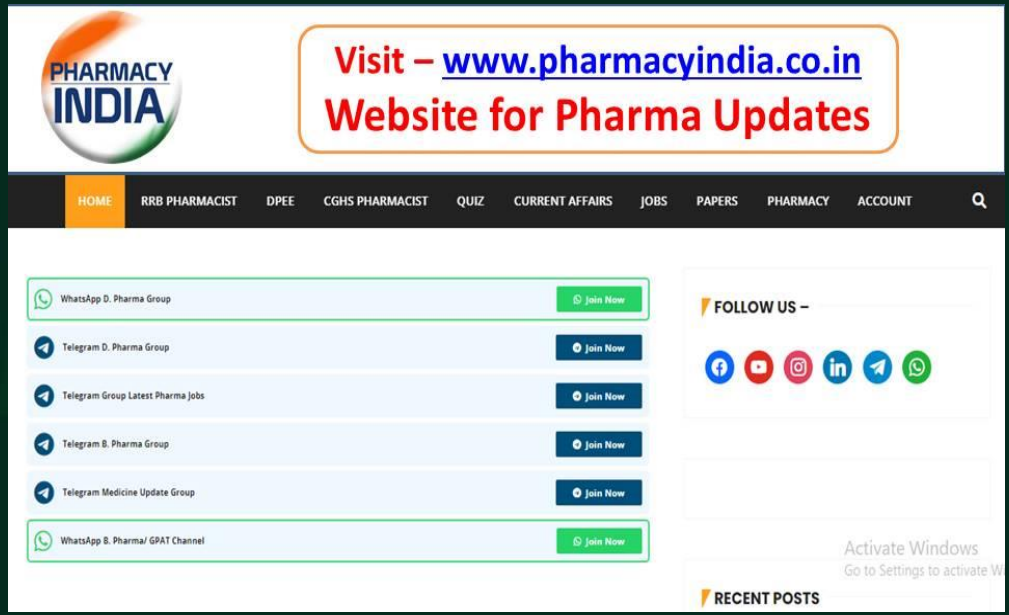

1. **Match the following antibodies with their correct description**

Antibody	Description
P. IgE	(i) Cross the placenta
Q. IgG	(ii) Dominant antibody produced in immune responses
R. IgM	(iii) It is found in the mother's milk
S. IgA	(iv) Responsible for autoimmune responses including allergies

(a) P-(i), Q-(ii), R-(iii), S-(iv)
(b) P-(iv), Q-(i), R-(iii), S-(ii)
(c) P-(ii), Q-(iii), R-(iv), S-(i)
(d) P-(iv), Q-(ii), R-(i), S-(iii)

1. **Match the following antibodies with their correct description**

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(b) P-(iv), Q-(i), R-(iii), S-(ii)

(c) P-(ii), Q-(iii), R-(iv), S-(i)

(d) P-(iv), Q-(ii), R-(i), S-(iii)

Explanation:

Antibody	Function	Matching Description
IgE (P)	Causes allergic reactions and mediates autoimmune responses	Responsible for autoimmune responses (iv)
IgG (Q)	Passes through the placenta to provide passive immunity to the fetus	Cross the placenta (i)
IgM (R)	Found in mother's milk, plays a key role in early immune response	It is found in the mother’s milk (iii)
IgA (S)	Found in mucosal areas, protects against pathogens in secretions	Dominant antibody produced in immune responses (ii)

Key Points:

1. **IgE:** Known for triggering **hypersensitivity reactions**, such as **asthma** and **anaphylaxis**.
2. **IgG:** Most abundant antibody in serum, **crosses the placenta** to protect newborns.
3. **IgM:** First antibody produced during infection, present in **breast milk**.
4. **IgA:** Protects mucosal surfaces like **respiratory and gastrointestinal tracts**.

Reference: "Roitt's Essential Immunology," 13th Edition, Chapter 8, Page 132

2. **Autoimmunity refers to**

(a) An automatic trigger of the immune system directed against a specific pathogen

(b) Failure to distinguish between self and non-self

(c) An automatic segregation of T and B cells

(d) Failure of B-cells to interact with T-cells

2. **Autoimmunity refers to**

(a) An automatic trigger of the immune system directed against a specific pathogen

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(d) Failure of B-cells to interact with T-cells

Explanation:

Autoimmunity is like a **security system** that mistakes the **house's residents** for intruders. Instead of protecting the body, the immune system starts attacking its own cells and tissues. For example:

- In **rheumatoid arthritis**, the immune system targets **joint tissues**, causing inflammation.
- In **systemic lupus erythematosus**, it produces antibodies against the body's own **DNA**.
  This results from a failure to distinguish between **self-antigens** and foreign invaders, leading to chronic tissue damage.

Reference: "Abbas AK, Basic Immunology," 6th Edition, Chapter 12, Page 230

3. **The immunity acquired by inoculation of living organism of attenuated virulence is**

(a) Natural passive immunity

(b) Passive immunity

(c) Artificial active immunity

(d) Natural active immunity

3. **The immunity acquired by inoculation of living organism of attenuated virulence is**

(a) Natural passive immunity

(b) Passive immunity

(c) Artificial active immunity

(d) Natural active immunity

Explanation:

1. **Definition:** Artificial active immunity involves the deliberate introduction of an **attenuated (weakened) pathogen** to stimulate the immune system.
2. **Mechanism:** The immune system mounts a response against the pathogen without causing disease, producing **memory cells**.
3. **Examples:**
   - **MMR vaccine** (Measles, Mumps, Rubella).
   - **BCG vaccine** for tuberculosis.
4. **Outcome:** The body develops **long-term immunity**.

Reference: "Janeway's Immunobiology," 9th Edition, Chapter 11, Page 460

4. **In treating immunodeficiency disease, the goal is to maintain IgG levels at about**

(a) 100 mg/dL

(b) 400 mg/dL

(c) 200 mg/dL

(d) 300 mg/dL

4. In treating immunodeficiency disease, the goal is to maintain IgG levels at about

(a) 100 mg/dL

(b) 400 mg/dL

(c) 200 mg/dL

(d) 300 mg/dL

Explanation:

In patients with immunodeficiency, **IgG levels** are critical to prevent infections.

- **Normal IgG levels:** 600–1600 mg/dL.
- **Target for immunodeficiency treatment:** Maintaining IgG at **200 mg/dL** ensures adequate immunity.
- Patients with conditions like **Common Variable Immunodeficiency (CVID)** or those receiving **IVIG therapy** require this level for protection.

Reference: "Clinical Immunology: Principles and Practice," 5th Edition, Chapter 15, Page 750

5. **Cells that contribute to the immune system are**

1. T lymphocytes
2. Eosinophil
3. B lymphocytes
4. Dendritic cells
5. Erythrocytes
6. Natural killer cells

(a) 1, 3, 4, and 6
(b) 1, 2, and 6
(c) 1, 3, 5, and 6
(d) 1, 2, 5, and 6

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(a) 1, 3, 4, and 6
(b) 1, 2, and 6
(c) 1, 3, 5, and 6
(d) 1, 2, 5, and 6

Explanation:

1. **T lymphocytes (1):** Coordinate adaptive immune responses and directly kill infected cells.
2. **B lymphocytes (3):** Produce antibodies to neutralize pathogens.
3. **Dendritic cells (4):** Act as antigen-presenting cells (APCs) to activate T cells.
4. **Natural killer cells (6):** Part of the innate immune system, they kill virus-infected cells and tumor cells.

Excluded Cells:

- **Eosinophils (2):** Primarily combat parasitic infections.
- **Erythrocytes (5):** Carry oxygen but do not play a direct role in immunity.

Reference: "Kuby Immunology," 8th Edition, Chapter 2, Page 78

6. **Which is a secretory antibody**

(a) IgG

(b) IgM

(c) IgE

(d) IgA

6. Which is a secretory antibody

(a) IgG

(b) IgM

(c) IgE

(d) IgA

Explanation:

- IgA is the **primary antibody in mucosal secretions** such as saliva, tears, and breast milk.
- It prevents pathogen adherence to epithelial surfaces, offering **local immunity**.
- Found in high concentrations in the gastrointestinal and respiratory tracts.

Clinical Importance: Protects against respiratory and gastrointestinal infections.

Reference: "Abul K. Abbas, Cellular and Molecular Immunology," 9th Edition, Chapter 4, Page 120

7. **Antibody responsible for agglutination of blood**

(a) IgA

(b) IgD

(c) IgE

(d) IgM

7. **Antibody responsible for agglutination of blood**

(a) IgA

(b) IgD

(c) IgE

(d) IgM

Explanation:

1. **IgA:** Found in mucosal secretions, not involved in agglutination.
2. **IgD:** Functions as a receptor on immature B cells but does not play a role in agglutination.
3. **IgE:** Involved in allergic reactions, not agglutination.

Why IgM is correct:

- IgM is the **largest antibody** and exists as a **pentamer**, allowing it to bind multiple antigens.
- This makes it highly effective in **agglutination** (clumping of antigens), a crucial step in immune defense and blood typing.

Reference: "Roitt's Essential Immunology," 13th Edition, Chapter 6, Page 185

8. **Which of the following cell types are responsible for initiating a secondary immune response**

(a) Memory cells

(b) Macrophages

(c) Stem cells

(d) B cells

8. **Which of the following cell types are responsible for initiating a secondary immune response**

(a) Memory cells

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(d) B cells

Explanation:

1. **Primary Immune Response:**
   - During the first exposure to a pathogen, naïve B and T cells are activated to combat the infection.
   - Some of these cells differentiate into **memory cells**.
2. **Secondary Immune Response:**
   - Upon re-exposure to the same pathogen, **memory cells** recognize the antigen quickly.
   - They initiate a faster and stronger response by producing large quantities of antibodies (B cells) or activating cytotoxic T cells.

3. Role of Memory Cells:

- Enable long-term immunity (e.g., from vaccines or past infections).

Reference: "Janeway's Immunobiology," 9th Edition, Chapter 11, Page 482

9. **Quantification of minute quantity of a drug from a complex matrix is done using one of the following techniques. Identify that**

(a) Coulometry

(b) Potentiometry

(c) Fluorescence spectroscopy

(d) Radioimmunoassay

9. **Quantification of minute quantity of a drug from a complex matrix is done using one of the following techniques. Identify that**

(a) Coulometry

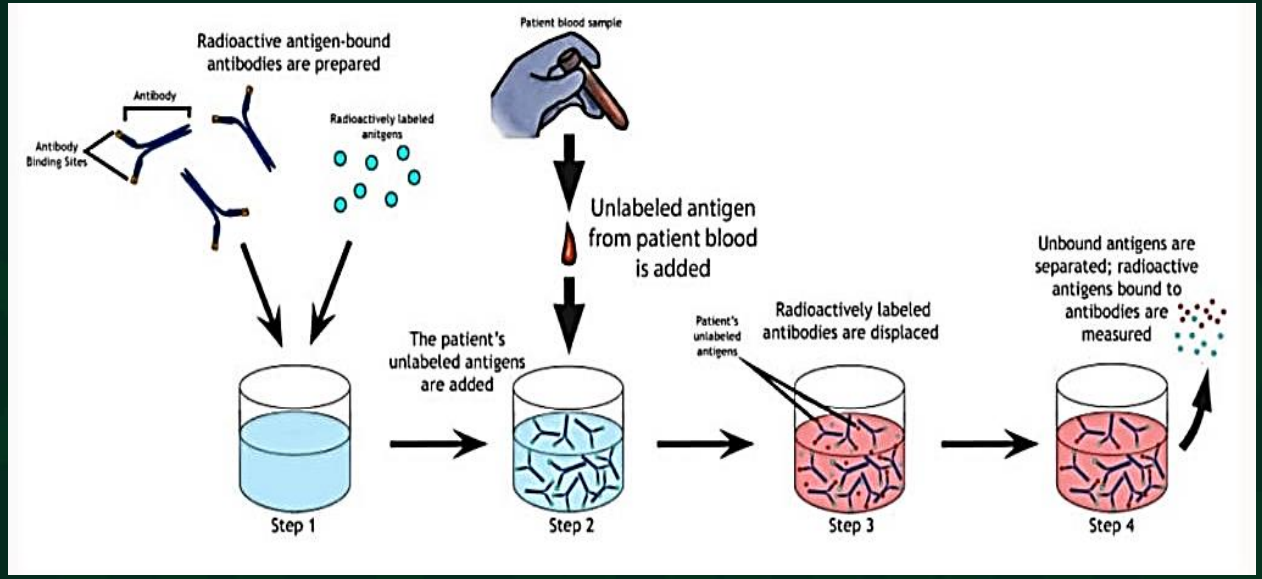
(b) Potentiometry

(c) Fluorescence spectroscopy

(d) Radioimmunoassay

Explanation:

- **Radioimmunoassay (RIA):**
  - Highly sensitive technique to measure **minute quantities** of substances, including drugs, hormones, and antigens.
  - Uses radiolabeled antigens and specific antibodies.
- **Principle:**
  - A known amount of radiolabeled antigen competes with the sample antigen for antibody binding.
  - The amount of radiolabeled antigen bound to the antibody is inversely proportional to the antigen concentration in the sample.



- **Advantages:**
  - Extremely sensitive (detects nanogram to picogram levels).
  - Widely used in pharmacokinetics and clinical diagnostics.

Reference: "Goodman & Gilman's: The Pharmacological Basis of Therapeutics," 13th Edition, Chapter 3, Page 82

10. IgG provides immunity to newborns because

[P] IgG provides immunity to newborn babies while
[Q] IgM is the first generated antibody.

(a) P is correct, and Q is incorrect

(b) P is incorrect, and Q is correct

(c) Both P and Q are correct

(d) Both P and Q are incorrect

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[P] IgG provides immunity to newborn babies while IgM is the first generated antibody.

[Q] IgG is correct, and Q is incorrect.

(a) P is correct, and Q is incorrect

(b) P is incorrect, and Q is correct

(c) Both P and Q are correct

(d) Both P and Q are incorrect

Explanation:

- **IgG:**
  - Crosses the placenta during pregnancy, providing the baby with passive immunity.
  - Protects the newborn from infections until its immune system matures.
- **IgM:**
  - The **first antibody** produced during an immune response, primarily involved in agglutination and complement activation.

Both statements are correct because IgG provides immunity to newborns, while IgM is the first antibody produced during infections.

Reference: "Kuby Immunology," 8th Edition, Chapter 6, Page 135

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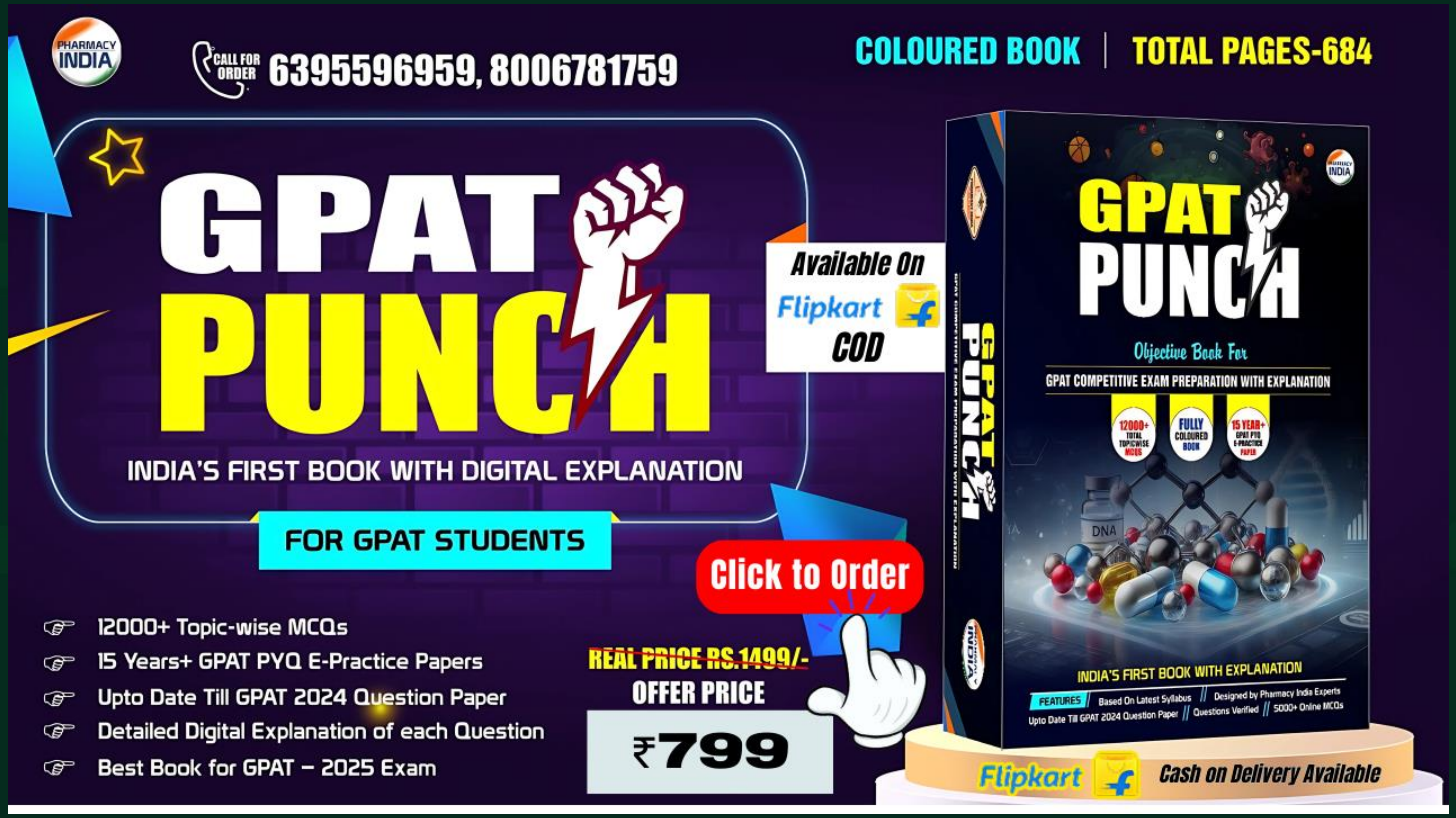

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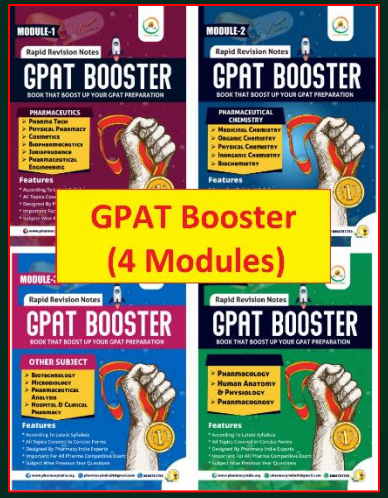

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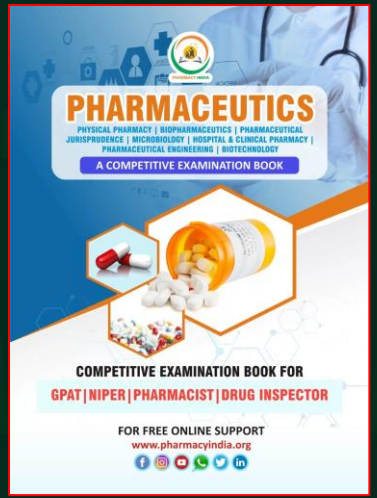

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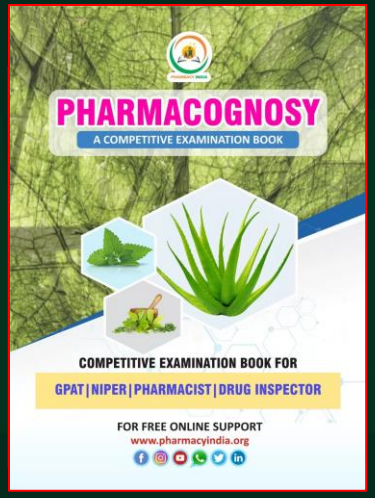

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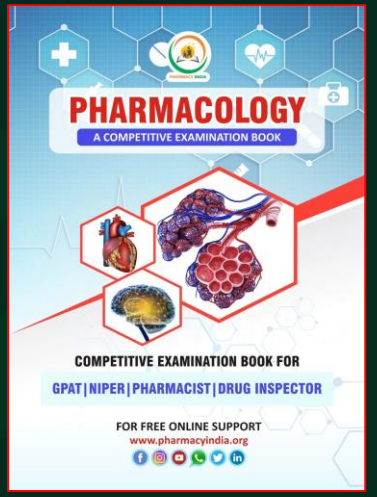

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11. Group the following immunoglobulins based on their function [GATE-2003]

Immunoglobulin	Function
1. IgG	[P] Agglutination and cytolysis
2. IgA	[Q] Antiallergic
3. IgM	[R] Neutralizes toxins
4. IgE	[S] Antimicrobial

(a) 1-[S], 2-[R], 3-[Q], 4-[P]
(b) 1-[R], 2-[S], 3-[P], 4-[Q]
(c) 1-[Q], 2-[R], 3-[S], 4-[P]
(d) 1-[Q], 2-[P], 3-[S], 4-[R]

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(a) 1-[S], 2-[R], 3-[Q], 4-[P]
(b) 1-[R], 2-[S], 3-[P], 4-[Q]
(c) 1-[Q], 2-[R], 3-[S], 4-[P]
(d) 1-[Q], 2-[P], 3-[S], 4-[R]

Explanation:

- **IgG (1-[Q]):** Neutralizes toxins and provides immune memory and long-term immunity. It is also involved in opsonization and neutralization of pathogens.
- **IgA (2-[R]):** Provides antimicrobial action in mucosal areas such as the gastrointestinal and respiratory tracts. It prevents pathogen attachment to epithelial cells.
- **IgM (3-[S]):** Plays a key role in agglutination and cytolysis during the initial immune response due to its pentameric structure.
- **IgE (4-[P]):** Involved in antiallergic responses by triggering the release of histamines and other chemicals from mast cells and basophils.

Kuby Immunology, 7th Edition, Chapter 4: Antibody Structure and Function, Page 87.

12. **What is the role of Helper T cells (CD4+ T cells)?**

(a) Directly kill infected cells

(b) Present antigens

(c) Activate other immune cells

(d) Phagocytose pathogens

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(a) Directly kill infected cells

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Explanation:

- CD4+ T cells are crucial for **orchestrating immune responses**.
- They release **cytokines** to activate B cells, macrophages, and cytotoxic T cells.
- Indispensable in fighting infections, particularly intracellular pathogens like viruses and some bacteria.

Clinical Importance: HIV targets CD4+ T cells, impairing immune coordination and leading to immunodeficiency.

Reference: "Abul K. Abbas, Cellular and Molecular Immunology," 9th Edition, Chapter 5, Page 142

13. **What type of immunity is conferred by a vaccine?**

(a) Passive innate immunity

(b) Active adaptive immunity

(c) Passive adaptive immunity

(d) Active innate immunity

13. What type of immunity is conferred by a vaccine?

(a) Passive innate immunity

(b) Active adaptive immunity

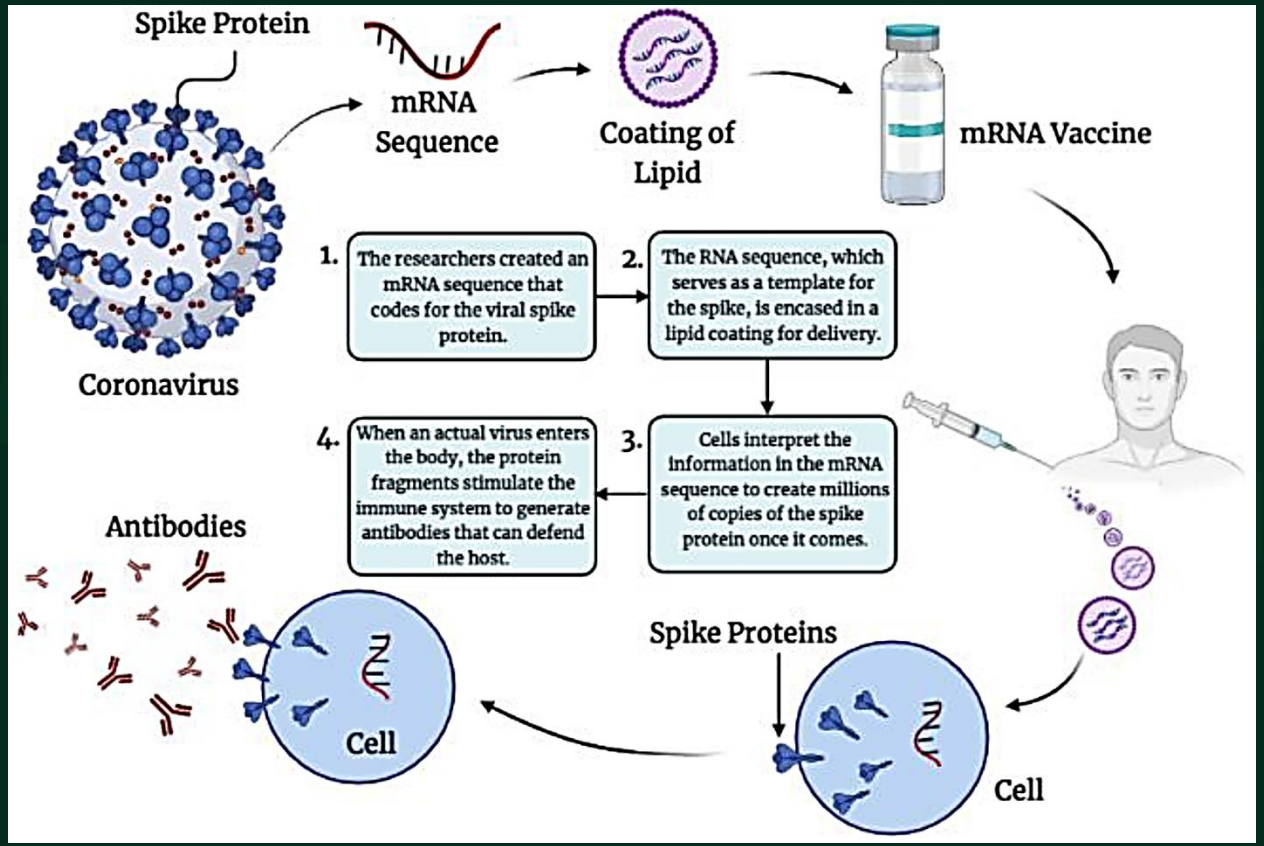
(c) Passive adaptive immunity

(d) Active innate immunity

Explanation:

1. **Definition:** Vaccines introduce antigens into the body to stimulate an immune response.
2. **Process:**
   - **Antigen recognition** by immune cells (T and B cells).
   - Formation of **memory cells** to provide long-lasting protection.
3. **Outcome:** Immunity is "active" because the body generates the response, and "adaptive" because it is specific to the introduced antigen.

Examples: Polio vaccine, influenza vaccine.



Reference: "Janeway's Immunobiology," 9th Edition, Chapter 10, Page 451

14. **What is the term for the process where neutrophils move towards the site of infection?**

(a) Apoptosis

(b) Opsonization

(c) Diapedesis

(d) Chemotaxis

14. **What is the term for the process where neutrophils move towards the site of infection?**

(a) Apoptosis

(b) Opsonization

(c) Diapedesis

(d) Chemotaxis

Explanation:

1. **Definition of Chemotaxis:**

   Chemotaxis is the directed migration of **neutrophils** or other immune cells towards a chemical signal at the site of infection or tissue damage.

2. **Process:**

   - Pathogens or damaged tissues release **chemotactic factors** (e.g., interleukin-8, bacterial peptides).
   - Neutrophils detect these signals through their **surface receptors** and move in the direction of increasing concentration of the signals.

3. Function:
This process ensures neutrophils reach the site of infection, where they perform **phagocytosis** and release antimicrobial substances to combat pathogens.

- **Apoptosis (a):** Refers to programmed cell death, not movement.
- **Opsonization (b):** Involves marking pathogens for phagocytosis.
- **Diapedesis (c):** Refers to neutrophils squeezing through blood vessel walls, which is part of their migration but not the directional movement itself.

Reference: "Kuby Immunology," 8th Edition, Chapter 2, Page 45

15. **Which cytokine is known as the “interferon”?**

(a) IL-1

(b) IFN-γ

(c) TNF-α

(d) IL-6

15. **Which cytokine is known as the “interferon”?**

(a) IL-1

(b) IFN-γ

(c) TNF-α

(d) IL-6

Explanation:

Imagine a **viral infection** spreading in a cell. The immune system produces **interferons** like **IFN-γ** to:

1. **Inhibit viral replication**: IFN-γ signals surrounding cells to increase their antiviral defenses.
2. **Activate macrophages**: Enhances their ability to destroy infected cells and pathogens.
3. **Coordinate immune response**: Helps regulate adaptive immunity by activating T cells.

Excluded Options:

- **IL-1 (a):** Involved in fever induction.
- **TNF-α (c):** Promotes inflammation.
- **IL-6 (d):** Mediates inflammation and acute-phase reactions.

Reference: "Abul K. Abbas, Cellular and Molecular Immunology," 9th Edition, Chapter 8, Page 233

16. **What is the role of major histocompatibility complex (MHC) molecules?**

(a) Produce antibodies

(b) Present antigens to T cells

(c) Kill infected cells

(d) Activate macrophages

16. What is the role of major histocompatibility complex (MHC) molecules?

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- **Explanation:**

MHC → "Major Helper for Cells"

- **Role:** MHC molecules are essential for **antigen presentation** to T cells.
  - **MHC Class I:** Presents antigens to **cytotoxic (CD8+) T cells**, primarily from intracellular pathogens (e.g., viruses).
  - **MHC Class II:** Presents antigens to **helper (CD4+) T cells**, primarily from extracellular pathogens.
- Without MHC, T cells cannot recognize antigens and initiate an immune response.

Reference: "Janeway's Immunobiology," 9th Edition, Chapter 7, Page 340

17. **What is the main role of dendritic cells in immunity?**

(a) Antibody production

(b) Killing infected cells

(c) Antigen presentation

(d) Cytokine secretion

17. What is the main role of dendritic cells in immunity?

(a) Antibody production

(b) Killing infected cells

(c) Antigen presentation

(d) Cytokine secretion

Explanation:

- **Antigen presentation (c) [Correct]:** Dendritic cells are professional **antigen-presenting cells (APCs).** They capture antigens from pathogens, process them, and present them to T cells to activate adaptive immunity.

Other Options (Incorrect):

- **Antibody production (a):** Performed by B cells, not dendritic cells.
- **Killing infected cells (b):** Performed by cytotoxic T cells and natural killer cells.
- **Cytokine secretion (d):** While dendritic cells secrete cytokines, their primary role is antigen presentation.

Reference: "Roitt's Essential Immunology," 13th Edition, Chapter 4, Page 87

18. Which immunoglobulin is most abundant in serum?

(a) IgA

(b) IgG

(c) IgM

(d) IgE

18. Which immunoglobulin is most abundant in serum?

(a) IgA

(b) IgG

(c) IgM

(d) IgE

Explanation:

- IgG accounts for **75-80% of total immunoglobulins** in serum.
- Functions:
  - **Neutralization:** Binds toxins and viruses.
  - **Opsonization:** Marks pathogens for phagocytosis.
  - **Passive immunity:** Crosses the placenta to protect newborns.
- IgG has the longest half-life (about 23 days), providing prolonged immunity.

Reference: "Kuby Immunology," 8th Edition, Chapter 6, Page 152

19. **What is the name of the process where antibodies mark pathogens for phagocytosis?**

(a) Opsonization

(b) Neutralization

(c) Agglutination

(d) Complement activation

19. **What is the name of the process where antibodies mark pathogens for phagocytosis?**

(a) Opsonization

(b) Neutralization

(c) Agglutination

(d) Complement activation

Explanation:

- **Definition:** Opsonization is the process by which antibodies (e.g., IgG) or complement proteins coat pathogens, marking them for destruction by phagocytes like macrophages and neutrophils.
- **Steps:**
  1. Pathogen is coated with **antibodies** or complement.
  2. Phagocytes recognize the pathogen through **Fc receptors** or complement receptors.
  3. The pathogen is engulfed and destroyed.

- **Importance:** Enhances efficiency of the innate immune system and bridges it with the adaptive immune system.

Excluded Options:

- **Neutralization (b):** Blocking the pathogen from binding to host cells.
- **Agglutination (c):** Clumping of antigens for easy clearance.
- **Complement activation (d):** Leads to membrane attack complex formation.

Reference: "Roitt's Essential Immunology," 13th Edition, Chapter 6, Page 180

20. **What is a characteristic of the innate immune system?**

(a) Specificity to a particular pathogen

(b) Memory response

(c) Delayed response

(d) Immediate response

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(a) Specificity to a particular pathogen

(b) Memory response

(c) Delayed response

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Explanation:

The **innate immune system** is the body's first line of defense. It:

- **Acts immediately**: Within minutes to hours after infection.
- **Lacks specificity**: Responds to broad patterns on pathogens (e.g., PAMPs—Pathogen-Associated Molecular Patterns).
- **No memory**: Does not adapt or improve with repeated exposure.

In contrast, the **adaptive immune system** is specific, has memory, and takes days to activate.

Reference: "Janeway's Immunobiology," 9th Edition, Chapter 2, Page 28.

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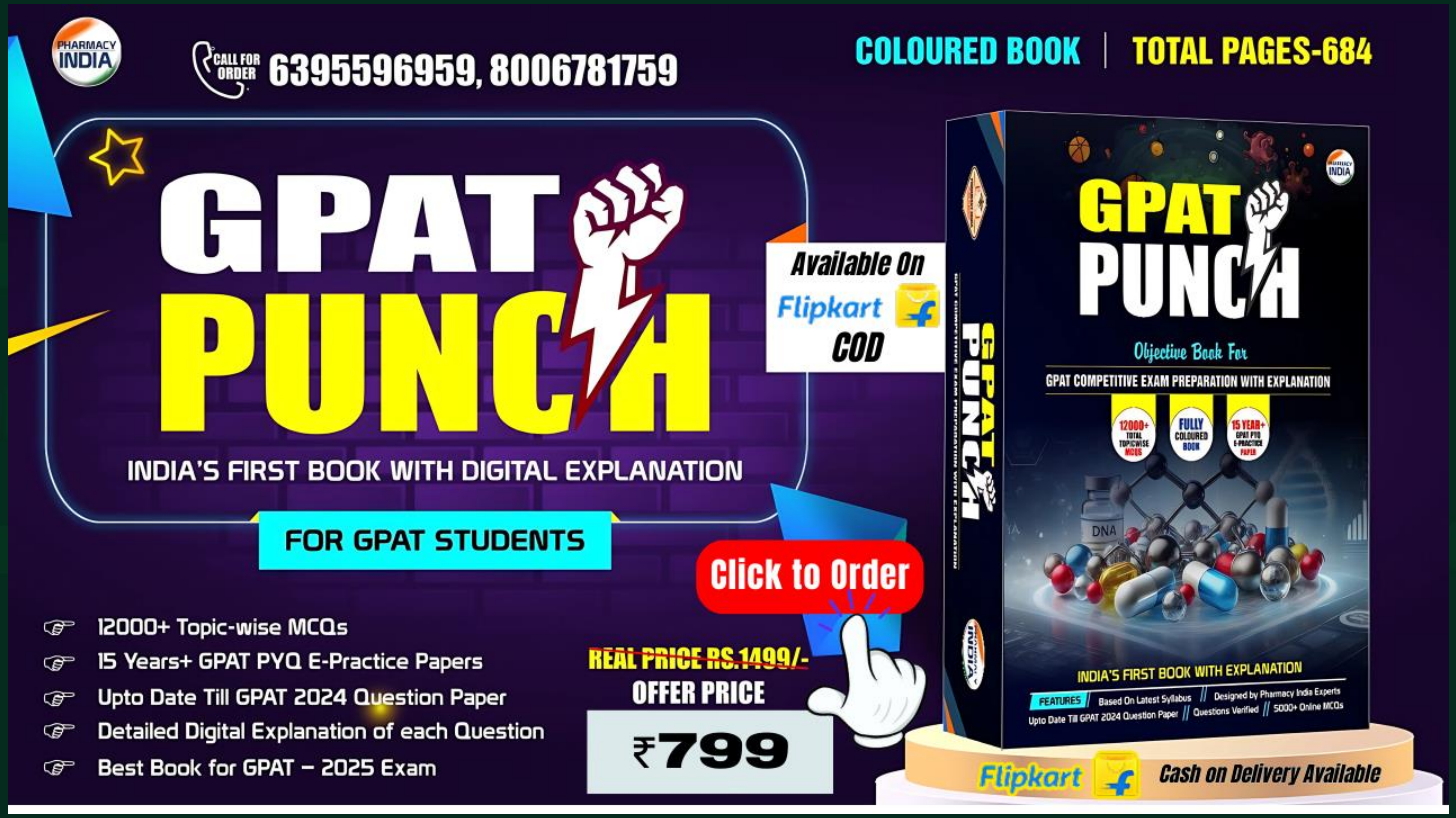

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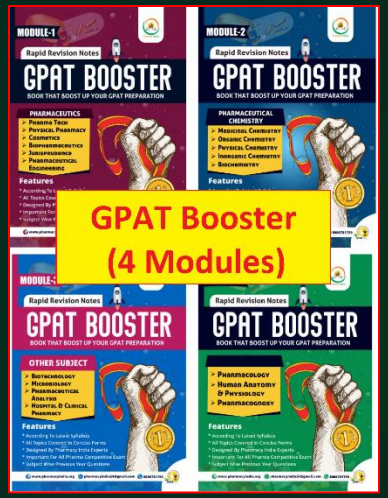

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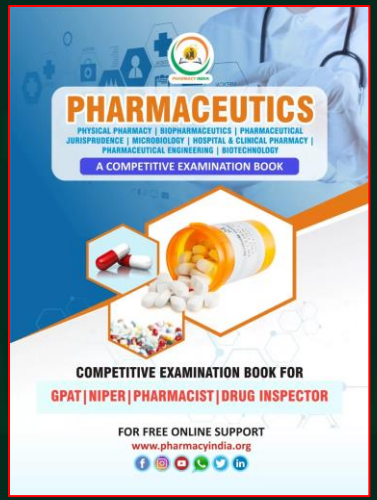

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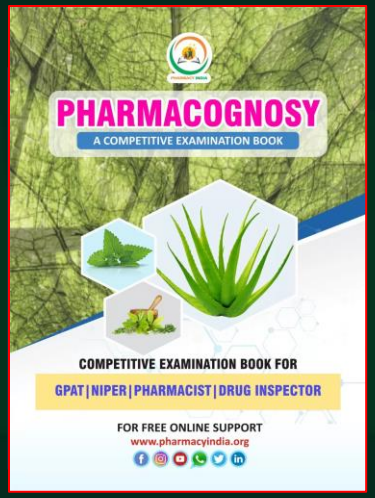

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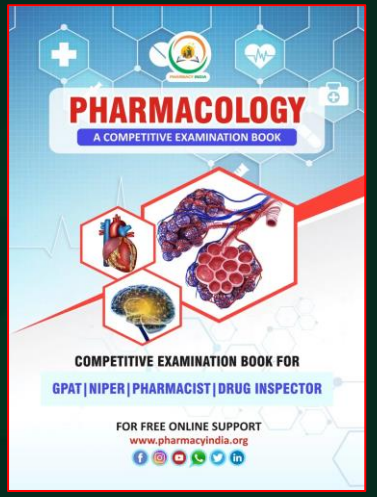

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21. **Which cytokine is primarily responsible for inducing a fever?**

(a) IL-10

(b) IL-1

(c) IL-6

(d) IFN-γ

21. **Which cytokine is primarily responsible for inducing a fever?**

(a) IL-10

(b) IL-1

(c) IL-6

(d) IFN-γ

Explanation:

1. **What is Fever?**

   Fever is a systemic response to infection or inflammation caused by **pyrogens**, which are substances that induce fever.

2. **Role of IL-1:**

   - **Interleukin-1 (IL-1)** is a key **pro-inflammatory cytokine**.
   - It acts on the **hypothalamus**, the thermoregulatory center of the brain, to increase the body temperature.
   - This process helps inhibit pathogen replication and enhances immune responses.

3. Excluded Options:

- **IL-10 (a):** Anti-inflammatory cytokine that regulates the immune response to avoid excessive inflammation.
- **IL-6 (c):** Plays a secondary role in inflammation but does not directly induce fever.
- **IFN-γ (d):** Stimulates macrophages but does not cause fever.

Reference: "Kuby Immunology," 8th Edition, Chapter 11, Page 315

22. **Which part of the antibody is responsible for antigen binding?**

(a) Constant region

(b) Hinge region

(c) Fab region

(d) Fc region

22. **Which part of the antibody is responsible for antigen binding?**

(a) Constant region

(b) Hinge region

(c) Fab region

(d) Fc region

Explanation:

1. **Structure of Antibody:**
   - Antibodies consist of two main regions:
     - **Fab region (Fragment antigen-binding):** Binds to specific antigens.
     - **Fc region (Fragment crystallizable):** Interacts with immune cells and complements.
2. **Why Fab Region?**
   - The **Fab region** contains the **variable domain**, which forms the **antigen-binding site**.

- The antigen-binding site is unique to each antibody and ensures specificity for the target antigen.

1. **Excluded Options:**
   - **Constant region (a):** Involved in effector functions, not antigen binding.
   - **Hinge region (b):** Provides flexibility to the antibody but does not bind antigens.
   - **Fc region (d):** Involved in immune effector functions like opsonization.

Reference: "Roitt's Essential Immunology," 13th Edition, Chapter 6, Page 155

23. **Which type of hypersensitivity involves immune complexes?**

(a) Type I

(b) Type II

(c) Type III

(d) Type IV

23. **Which type of hypersensitivity involves immune complexes?**

(a) Type I

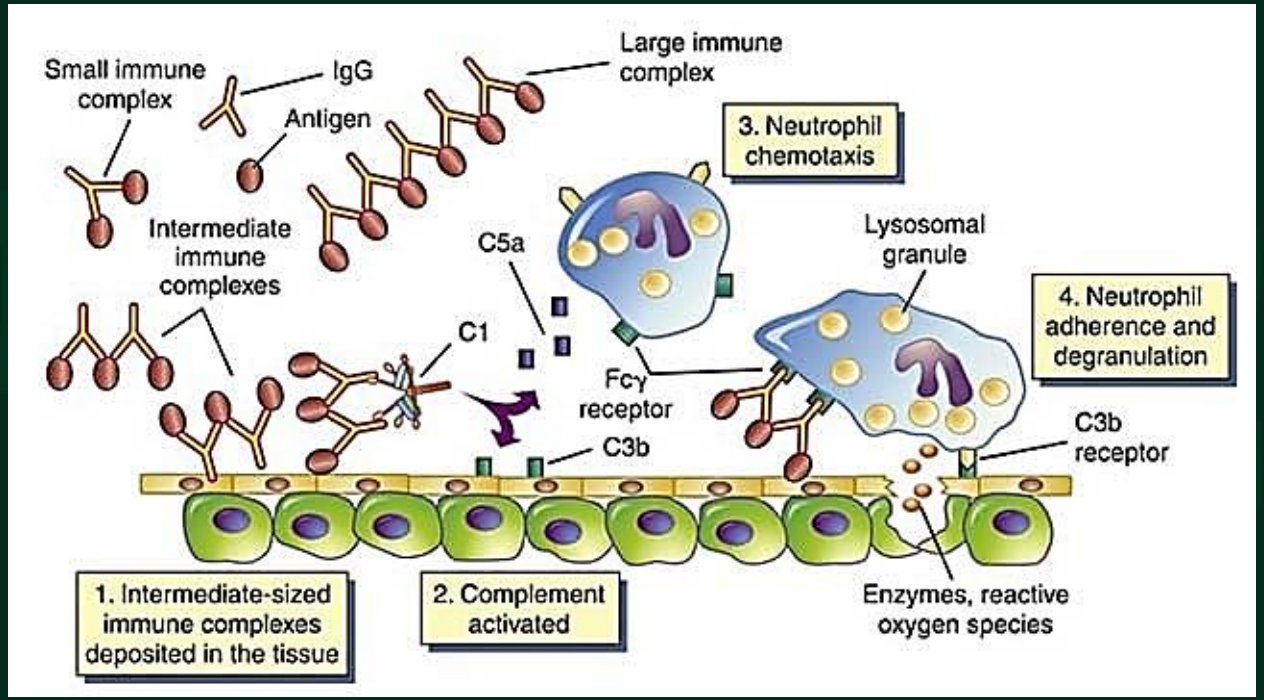
(b) Type II

(c) Type III

(d) Type IV

Explanation:

1. **Definition of Type III Hypersensitivity:**
   - This hypersensitivity occurs when **antigen-antibody complexes** are formed in excess and are not effectively cleared.
   - These immune complexes are deposited in tissues, causing inflammation and damage.
2. **Mechanism:**
   - Immune complexes activate the **complement system**, recruiting neutrophils and other inflammatory cells.
   - The resulting tissue damage leads to diseases like **systemic lupus erythematosus (SLE)** and **glomerulonephritis**.



3. Other Types of Hypersensitivity:

- **Type I (a):** Immediate hypersensitivity (e.g., allergies).
- **Type II (b):** Antibody-mediated cytotoxic reactions (e.g., hemolytic anemia).
- **Type IV (d):** Delayed-type hypersensitivity (e.g., tuberculosis).

Reference: "Abul K. Abbas, Cellular and Molecular Immunology," 9th Edition, Chapter 17, Page 295

24. **What is the role of perforin in cytotoxic T cell action?**

(a) Neutralize toxins

(b) Form pores in target cell membranes

(c) Present antigens

(d) Stimulate T cell proliferation

24. **What is the role of perforin in cytotoxic T cell action?**

(a) Neutralize toxins

(b) Form pores in target cell membranes

(c) Present antigens

(d) Stimulate T cell proliferation

Explanation:

Imagine a **cytotoxic T cell (CTL)** as a trained soldier targeting infected cells. To destroy the target:

1. **Perforin:** CTLs release **perforin**, which forms pores in the infected cell membrane.
2. **Granzyme Entry:** These pores allow **granzymes** (proteins) to enter the cell.
3. **Cell Death:** Granzymes trigger **apoptosis** (programmed cell death), effectively eliminating the infected cell.

Excluded Options:

- **Neutralize toxins (a):** Performed by antibodies, not perforin.
- **Present antigens (c):** Done by antigen-presenting cells (e.g., dendritic cells).
- **Stimulate T cell proliferation (d):** Involves cytokines like IL-2, not perforin.

Reference: "Janeway's Immunobiology," 9th Edition, Chapter 14, Page 587

25. **What is the role of IL-2 in the immune system?**

(a) Stimulates neutrophil activation

(b) Promotes T cell proliferation

(c) Enhances antibody production

(d) Induces apoptosis in B cells

25. **What is the role of IL-2 in the immune system?**

(a) Stimulates neutrophil activation

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(c) Enhances antibody production

(d) Induces apoptosis in B cells

- **Explanation:**
- IL-2 is a critical cytokine produced by activated T cells.
- It promotes the **proliferation (clonal expansion)** of T cells after activation by an antigen.
- IL-2 also enhances the activity of **natural killer (NK) cells** and supports the development of regulatory T cells.

Clinical Relevance: IL-2 is used in **immunotherapy** for cancers like renal cell carcinoma and melanoma to boost immune responses.

Excluded Options:

- **Neutrophil activation (a):** Mediated by other cytokines like IL-8.
- **Antibody production (c):** Stimulated by IL-4 and IL-6.
- **B cell apoptosis (d):** Not directly influenced by IL-2.

Reference: "Abul K. Abbas, Cellular and Molecular Immunology," 9th Edition, Chapter 8, Page 234

26. **Which component of the immune system is primarily responsible for presenting antigens to T cells?**

A. Neutrophils

B. Dendritic cells

C. Natural killer cells

D. Mast cells

26. **Which component of the immune system is primarily responsible for presenting antigens to T cells?**

A. Neutrophils

B. Dendritic cells

C. Natural killer cells

D. Mast cells

Explanation:

- **Dendritic cells (DCs)** are professional antigen-presenting cells (APCs) that play a pivotal role in bridging the innate and adaptive immune systems.
- They capture pathogens or their antigens in peripheral tissues via **phagocytosis, pinocytosis, or receptor-mediated endocytosis**. Once processed, antigens are loaded onto **major histocompatibility complex (MHC) molecules** (MHC class I for intracellular antigens and MHC class II for extracellular antigens).
- These antigen-loaded MHC molecules are then transported to the cell surface for presentation to **naive T cells**, particularly in the lymph nodes.

- Neutrophils are mainly involved in **phagocytosis and killing pathogens**, but they do not efficiently present antigens.
- Natural killer (NK) cells primarily target and destroy virally infected or cancerous cells without antigen presentation.
- Mast cells are primarily involved in **allergic responses** and inflammation via histamine release.

Reference: Kuby Immunology, 8th Edition, Chapter 4: Antigen-Presenting Cells, Page 89.

27. **What is the key feature distinguishing innate immunity from adaptive immunity?**

A. Use of memory cells

B. Rapid and nonspecific response

C. Production of antibodies

D. Dependence on T and B cells

27. **What is the key feature distinguishing innate immunity from adaptive immunity?**

A. Use of memory cells

B. Rapid and nonspecific response

C. Production of antibodies

D. Dependence on T and B cells

Explanation:

Innate immunity is the body's first line of defense, characterized by:

1. **Non-specificity:** It recognizes general patterns associated with pathogens (Pathogen-Associated Molecular Patterns, or PAMPs) rather than specific antigens.
2. **Speed:** It responds immediately upon pathogen detection, often within minutes to hours.
3. **Lack of memory:** Unlike adaptive immunity, innate immunity does not improve or adapt upon repeated exposure to the same pathogen.

4. Components: Includes **physical barriers** (skin, mucosa), **chemical defenses** (enzymes like lysozyme, acidic pH), and **cellular components** (macrophages, neutrophils, natural killer cells).

In contrast, adaptive immunity is **specific**, slower to respond (taking days), and has **memory**, allowing enhanced responses upon subsequent exposures. It involves **T and B cells**.

Reference: Janeway's Immunobiology, 9th Edition, Chapter 2: Innate Immunity, Page 31-34.

28. **Which of the following cytokines is associated with the recruitment of neutrophils during an inflammatory response?**

A. IL-2

B. IL-6

C. IL-8

D. IFN-γ

28. **Which of the following cytokines is associated with the recruitment of neutrophils during an inflammatory response?**

A. IL-2

B. IL-6

C. IL-8

D. IFN-γ

Explanation:

IL-8 (Interleukin-8) is a chemokine secreted by macrophages, endothelial cells, and epithelial cells during inflammation. Its primary function is to attract **neutrophils** to the site of infection or injury via chemotaxis. Neutrophils are the first cells to respond to acute inflammation. IL-8 also enhances neutrophil adhesion to the endothelium by upregulating adhesion molecules.

- **IL-2:** Promotes T-cell proliferation and activation.
- **IL-6:** Induces acute-phase proteins and has a broader role in inflammation.
- **IFN-γ:** Activates macrophages and promotes cell-mediated immunity but does not directly recruit neutrophils.

Reference:

Cytokine Storm Syndrome, Springer Nature, Chapter 3: Chemokines and Inflammation, Page 45.

29. **Which immunoglobulin is predominantly found in mucosal secretions?**

A. IgG

B. IgM

C. IgA

D. IgE

29. **Which immunoglobulin is predominantly found in mucosal secretions?**

A. IgG

B. IgM

C. IgA

D. IgE

- **Explanation:**

IgA (Immunoglobulin A) is the predominant antibody found in mucosal secretions, such as saliva, tears, breast milk, and secretions from the respiratory and gastrointestinal tracts. It plays a crucial role in **mucosal immunity**, where it prevents the adherence of pathogens to epithelial cells and neutralizes toxins.

- IgA exists primarily as a **dimer** in secretions, linked by a J-chain, and is stabilized by a **secretory component** that protects it from enzymatic degradation.

- Other immunoglobulins:
  - **IgG:** Abundant in serum and crosses the placenta for passive immunity.
  - **IgM:** First antibody produced during primary immune responses.
  - **IgE:** Mediates allergic reactions and immunity against helminths.

Reference: Roitt's Essential Immunology, 13th Edition, Chapter 6: Antibodies, Page 112-115.

30. What is the role of complement protein C3b?

A. Opsonization

B. Chemotaxis

C. Lysis of pathogens

D. Neutralization of viruses

30. What is the role of complement protein C3b?

A. Opsonization

B. Chemotaxis

C. Lysis of pathogens

D. Neutralization of viruses

Explanation:

C3b, a fragment of the complement protein C3, is generated during complement activation. It plays a vital role in **opsonization**, where it binds to microbial surfaces and tags them for recognition by phagocytic cells like macrophages and neutrophils. This enhances phagocytosis through interaction with **complement receptors** on these cells.

- **Chemotaxis:** Mediated by C5a, which recruits immune cells to the infection site.
- **Lysis of pathogens:** Achieved by the **Membrane Attack Complex (MAC)**, composed of C5b, C6, C7, C8, and C9.
- **Neutralization of viruses:** Typically mediated by antibodies, not C3b.

Reference: Abbas et al., Cellular and Molecular Immunology, 10th Edition, Chapter 13: Complement System, Page 230-233.

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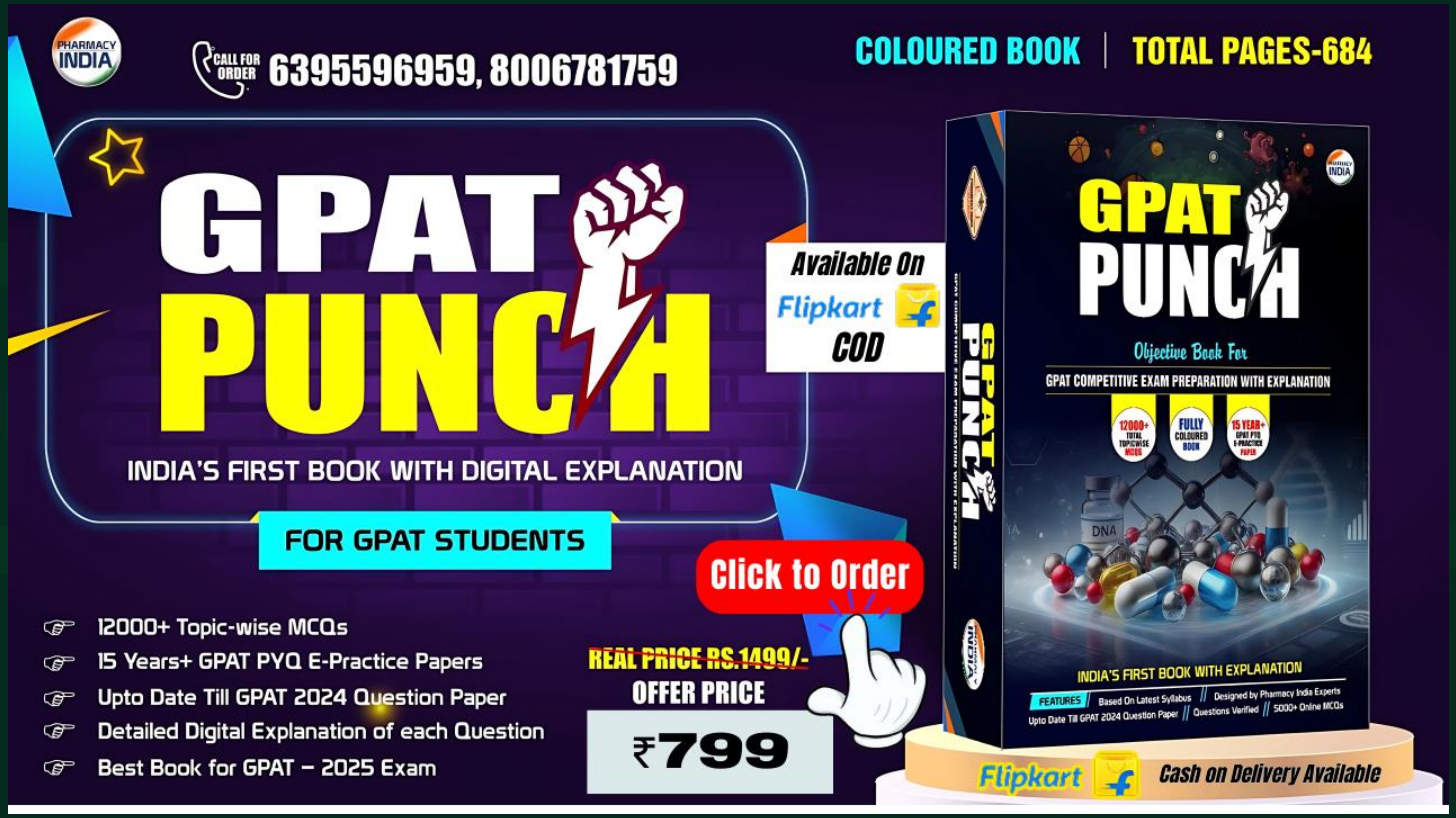

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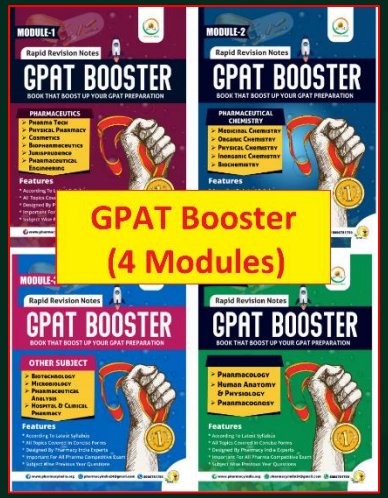

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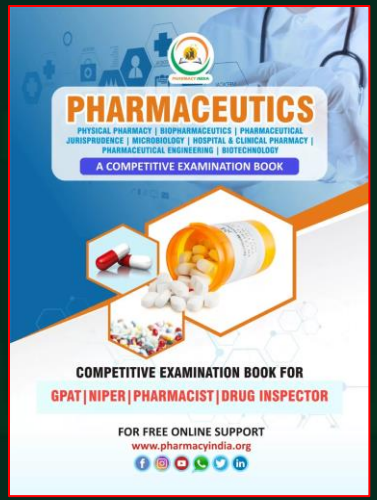

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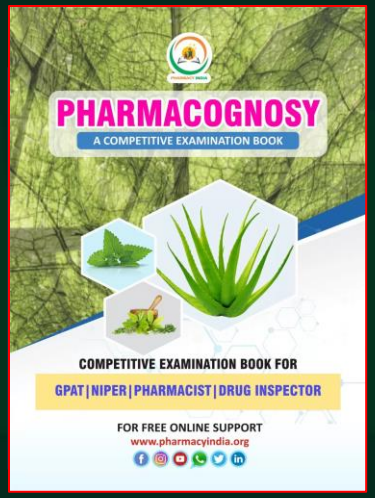

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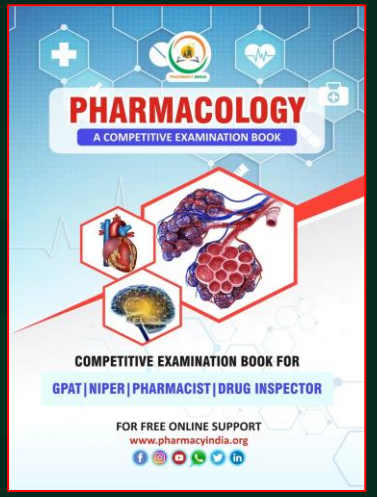

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31. **Which of the following pathways of complement activation is initiated by antigen-antibody complexes?**

A. Classical pathway

B. Alternative pathway

C. Lectin pathway

D. Terminal pathway

31. Which of the following pathways of complement activation is initiated by antigen-antibody complexes?

A. Classical pathway

B. Alternative pathway

C. Lectin pathway

D. Terminal pathway

Explanation:

The **classical pathway** of complement activation is triggered by the binding of **IgG or IgM antibodies** to antigens, forming antigen-antibody complexes. This interaction activates the **C1 complex (C1q, C1r, and C1s)**, which subsequently leads to the cleavage of C2 and C4, forming the **C3 convertase** (C4b2a). The classical pathway is part of the **adaptive immune system**, requiring specific antibodies to initiate.

32. **Which molecule is responsible for regulating self-tolerance and preventing autoimmunity?**

A. CTLA-4

B. CD28

C. IL-10

D. FOXP3

32. **Which molecule is responsible for regulating self-tolerance and preventing autoimmunity?**

A. CTLA-4

B. CD28

C. IL-10

D. FOXP3

Explanation:

FOXP3 is a transcription factor critical for the development and function of **regulatory T cells (Tregs)**. Tregs play a vital role in maintaining **self-tolerance** and suppressing excessive immune responses, thereby preventing autoimmune diseases. Mutations in the FOXP3 gene lead to **immune dysregulation, polyendocrinopathy, enteropathy, X-linked syndrome (IPEX)**, characterized by severe autoimmunity.

- **CTLA-4:** Inhibitory receptor that downregulates T-cell activation.
- **CD28:** Co-stimulatory receptor that enhances T-cell activation.
- **IL-10:** Anti-inflammatory cytokine that modulates immune responses but is not directly involved in Treg differentiation.

Reference: Janeway's Immunobiology, 9th Edition, Chapter 10: T-Cell Mediated Immunity, Page 241-244

33. Which hypersensitivity reaction involves immune complex deposition in tissues?

A. Type I

B. Type II

C. Type III

D. Type IV

33. **Which hypersensitivity reaction involves immune complex deposition in tissues?**

A. Type I

B. Type II

C. Type III

D. Type IV

Explanation:

Type III hypersensitivity reactions occur when **immune complexes** (antigen-antibody complexes) form in excess and are deposited in tissues, leading to inflammation and tissue damage. The deposited immune complexes activate the **complement system**, causing recruitment of neutrophils and subsequent tissue injury.

- Examples: **Systemic lupus erythematosus (SLE), serum sickness, and post-streptococcal glomerulonephritis**.

- **Type I:** Immediate hypersensitivity mediated by IgE (e.g., anaphylaxis).
- **Type II:** Antibody-mediated cytotoxicity (e.g., hemolytic anemia).
- **Type IV:** Delayed-type hypersensitivity mediated by T cells (e.g., tuberculosis skin test).

Reference: Roitt's Essential Immunology, 13th Edition, Chapter 13: Hypersensitivity, Page 257-260.

34. **What is the primary function of Toll-like receptors (TLRs)?**

A. Antigen presentation

B. Recognition of PAMPs

C. Antibody production

D. Complement activation

34. What is the primary function of Toll-like receptors (TLRs)?

A. Antigen presentation

B. Recognition of PAMPs

C. Antibody production

D. Complement activation

Toll-like receptors (TLRs) are pattern recognition receptors (PRRs) expressed on innate immune cells like macrophages and dendritic cells. They recognize **pathogen-associated molecular patterns (PAMPs)**, such as lipopolysaccharides (LPS) on Gram-negative bacteria and double-stranded RNA from viruses. This recognition triggers intracellular signaling cascades that activate **pro-inflammatory cytokine production**, enhancing the innate immune response.

- Antigen presentation is performed by APCs (e.g., dendritic cells).
- Antibody production is a function of plasma cells in adaptive immunity.
- Complement activation is not directly mediated by TLRs.

Reference: Janeway's Immunobiology, 9th Edition, Chapter 5: Innate Immunity, Page 107-110.

35. **Which cytokine is critical for the differentiation of naive CD4+ T cells into Th17 cells?**

A. IL-2

B. IL-4

C. IL-6

D. IL-12

35. **Which cytokine is critical for the differentiation of naive CD4+ T cells into Th17 cells?**

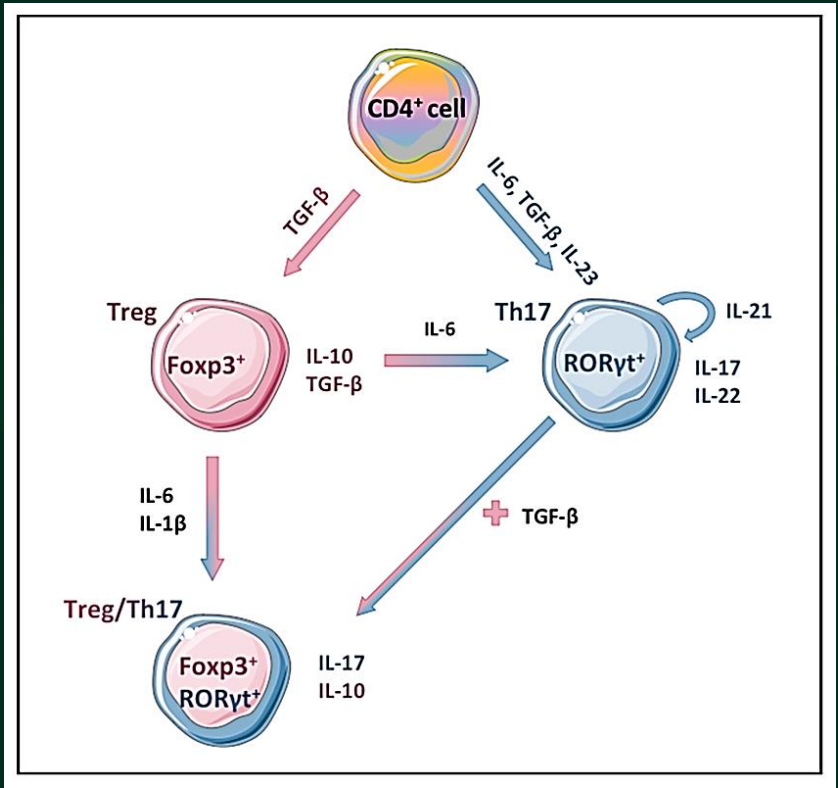
A. IL-2

B. IL-4

C. IL-6

D. IL-12

- **Explanation:**



IL-6, along with **TGF-β**, is essential for the differentiation of naive CD4+ T cells into **Th17 cells**. Th17 cells produce pro-inflammatory cytokines, such as **IL-17**, which are crucial for host defense against extracellular pathogens, particularly fungi and bacteria.

- **IL-2:** Promotes T-cell proliferation and survival.
- **IL-4:** Drives differentiation into Th2 cells, which are involved in humoral immunity and allergic responses.
- **IL-12:** Promotes differentiation into Th1 cells, which are essential for cell-mediated immunity.

Reference:

Kuby Immunology, 8th Edition, Chapter 11: T-Cell Differentiation, Page 267-269.

36. What is the role of Natural Killer (NK) cells in the immune system?

A. Phagocytosis

B. Antibody production

C. Killing infected or cancerous cells

D. Complement activation

36. **What is the role of Natural Killer (NK) cells in the immune system?**

A. Phagocytosis

B. Antibody production

C. Killing infected or cancerous cells

D. Complement activation

Explanation:

Natural Killer (NK) cells are cytotoxic lymphocytes of the innate immune system. They recognize and kill virally infected cells or tumor cells by detecting the absence of **MHC class I molecules** or through antibody-dependent cell-mediated cytotoxicity (ADCC). NK cells release **perforin and granzymes**, leading to target cell apoptosis. They do not perform phagocytosis, antibody production, or complement activation.

Reference:

Janeway's Immunobiology, 9th Edition, Chapter 3: The Induced Innate Response, Page 72-75.

37. **Which immunoglobulin is primarily involved in mediating allergic reactions?**

A. IgA

B. IgG

C. IgM

D. IgE

37. **Which immunoglobulin is primarily involved in mediating allergic reactions?**

A. IgA

B. IgG

C. IgM

D. IgE

Explanation:

IgE (Immunoglobulin E) is responsible for mediating **Type I hypersensitivity reactions**, commonly associated with allergies. It binds to Fc receptors on **mast cells** and **basophils**, sensitizing these cells to allergens. Upon subsequent exposure to the same allergen, cross-linking of IgE occurs, leading to the release of inflammatory mediators like **histamine**, **leukotrienes**, and **prostaglandins**, resulting in allergic symptoms such as bronchoconstriction, increased vascular permeability, and inflammation.

- IgA: Found in mucosal secretions, important for mucosal immunity.
- IgG: Involved in opsonization and secondary immune responses.
- IgM: First antibody produced during primary responses, forms pentamers.

Reference: Roitt's Essential Immunology, 13th Edition, Chapter 12: Hypersensitivity, Page 247-250.

38. **Which enzyme is responsible for somatic hypermutation in B cells?**

A. RAG1/RAG2

B. Activation-induced cytidine deaminase (AID)

C. TdT (Terminal deoxynucleotidyl transferase)

D. DNA ligase

38. **Which enzyme is responsible for somatic hypermutation in B cells?**

A. RAG1/RAG2

B. Activation-induced cytidine deaminase (AID)

C. TdT (Terminal deoxynucleotidyl transferase)

D. DNA ligase

Explanation:

AID (Activation-induced cytidine deaminase) is an enzyme expressed in B cells during the germinal center reaction. It introduces **point mutations in the variable regions of immunoglobulin genes**, a process known as **somatic hypermutation**, which enhances the antigen-binding affinity of antibodies.

- **RAG1/RAG2:** Involved in V(D)J recombination during early B and T cell development.
- **TdT:** Adds random nucleotides during V(D)J recombination.
- **DNA ligase:** Joins DNA fragments but does not mediate hypermutation.

Reference: Janeway's Immunobiology, 9th Edition, Chapter 6: B Cell Development, Page 162-165.

39. **Which cytokine is critical for class switching of B cells to produce IgE?**

A. IL-2

B. IL-4

C. IL-10

D. IFN-γ

39. **Which cytokine is critical for class switching of B cells to produce IgE?**

A. IL-2

B. IL-4

C. IL-10

D. IFN-γ

Explanation:

IL-4 is a cytokine produced by **Th2 cells** and is crucial for inducing class switching in B cells to produce **IgE**. This immunoglobulin is involved in allergic responses and immunity against parasites. IL-4 also promotes the differentiation of naive T cells into Th2 cells, further amplifying humoral immunity.

- IL-2: Promotes T cell proliferation.
- IL-10: Regulates inflammation by inhibiting Th1 responses.
- IFN-γ: Induces class switching to IgG and inhibits Th2 responses.

Reference: Kuby Immunology, 8th Edition, Chapter 11: Cytokines in Immunity, Page 275-277.

40. **What is the primary role of HLA (human leukocyte antigen) molecules in the immune system?**

A. Recognizing PAMPs

B. Presenting antigens to T cells

C. Activating B cells

D. Neutralizing pathogens

40. **What is the primary role of HLA (human leukocyte antigen) molecules in the immune system?**

A. Recognizing PAMPs

B. Presenting antigens to T cells

C. Activating B cells

D. Neutralizing pathogens

Explanation:

HLA (Human Leukocyte Antigen) molecules, part of the **major histocompatibility complex (MHC)**, are essential for presenting antigens to **T cells**.

- **MHC class I** molecules present endogenous antigens (e.g., viral proteins) to **CD8+ cytotoxic T cells**.
- **MHC class II** molecules present exogenous antigens (e.g., bacterial proteins) to **CD4+ helper T cells**.
  HLA polymorphism ensures diversity in antigen presentation among individuals, which is critical for immune defense.

Reference: Janeway's Immunobiology, 9th Edition, Chapter 8: Antigen Presentation, Page 203-206.

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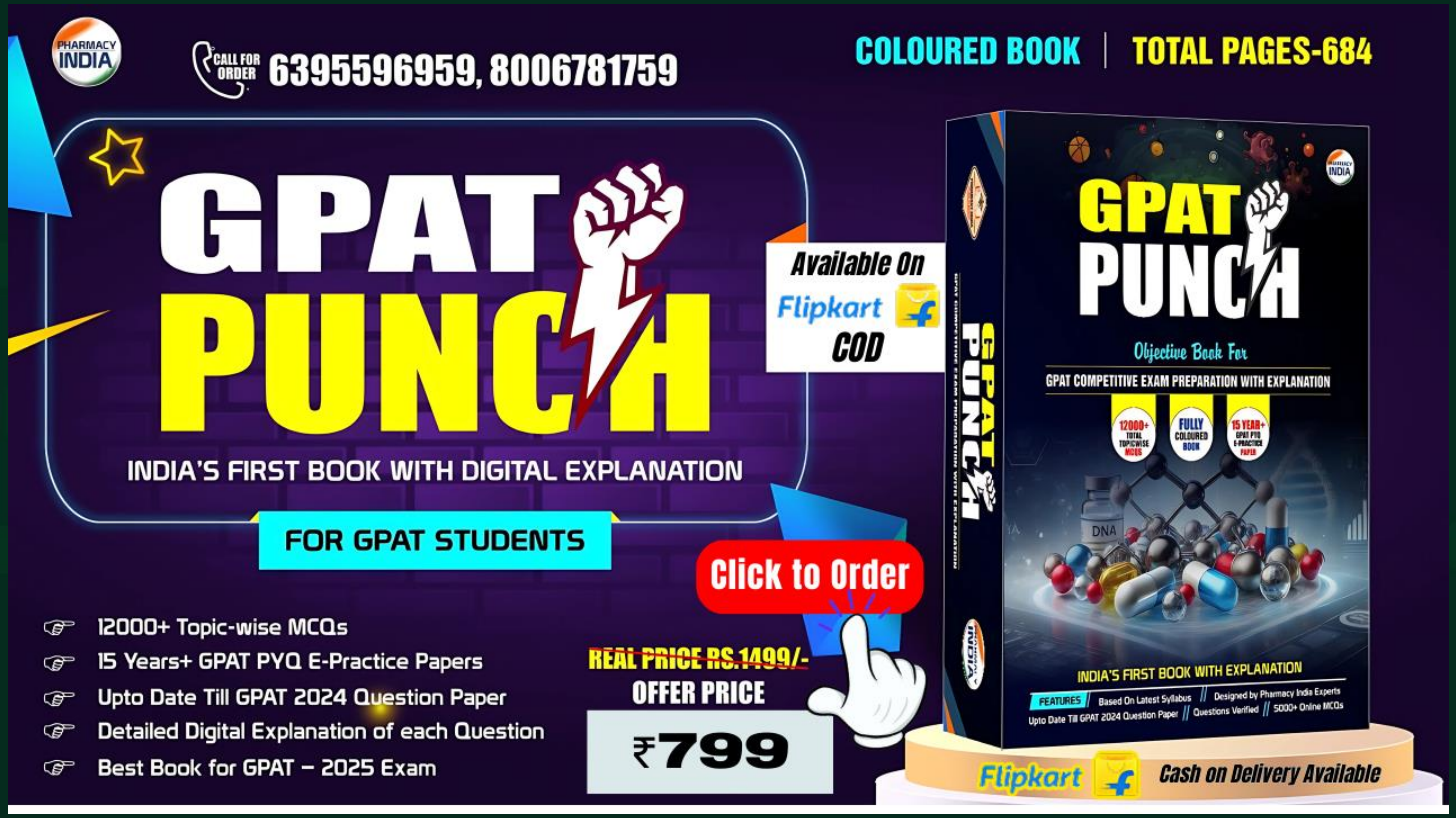

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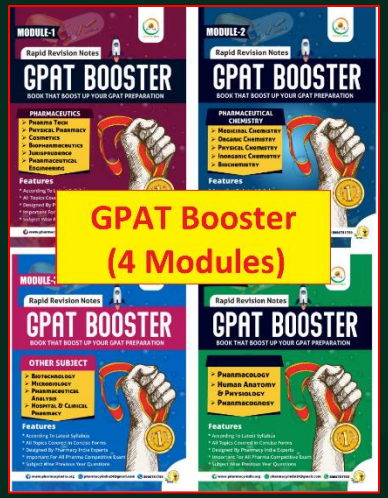

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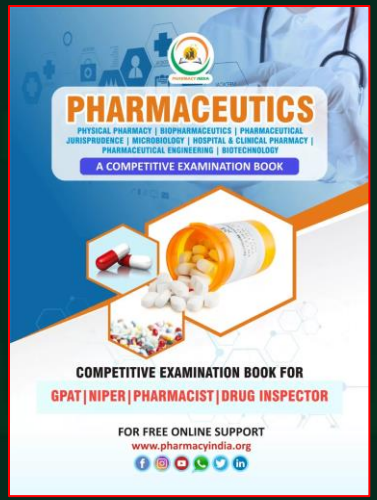

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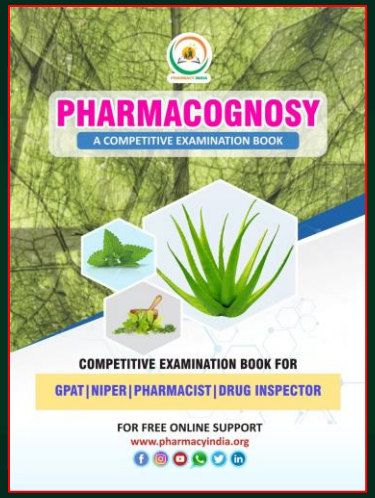

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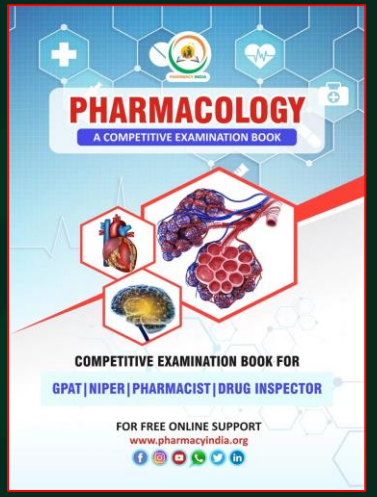

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41. **Which type of immune cells express CD4 and provide help to B cells and cytotoxic T cells?**

A. Regulatory T cells

B. Helper T cells

C. Cytotoxic T cells

D. Natural killer cells

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C. Cytotoxic T cells

D. Natural killer cells

Explanation:

Helper T cells (Th cells) express the **CD4 co-receptor**, which binds to MHC class II molecules on antigen-presenting cells. They produce cytokines that:

1. **Activate B cells** to differentiate into plasma cells and produce antibodies.
2. Enhance the activity of **cytotoxic T cells (CD8+ T cells)**.
3. Recruit macrophages for pathogen clearance.
   Helper T cells are further classified into subtypes (e.g., Th1, Th2, Th17) based on their cytokine profiles and functions.

Reference: Kuby Immunology, 8th Edition, Chapter 11: T Cell Activation, Page 251-254.

42. **Which complement protein is part of the Membrane Attack Complex (MAC)?**

A. C1

B. C3

C. C5b

D. C4

42. **Which complement protein is part of the Membrane Attack Complex (MAC)?**

A. C1

B. C3

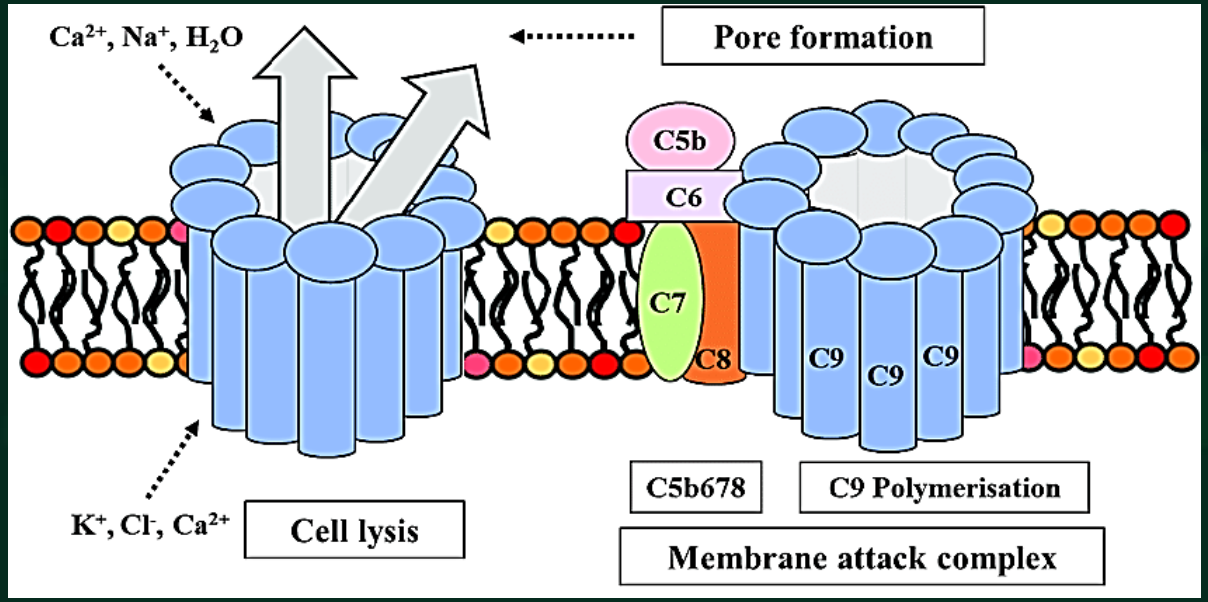
C. C5b

D. C4

Explanation:

C5b is a critical component of the **Membrane Attack Complex (MAC)**, formed during the terminal pathway of complement activation. C5b binds to C6, C7, C8, and multiple C9 molecules to create the MAC, which perforates the membrane of pathogens, leading to cell lysis.

- C1: Part of the classical pathway initiation.
- C3: Central in all complement pathways but not directly in the MAC.
- C4: Involved in classical and lectin pathways upstream of MAC formation.



Reference: Roitt's Essential Immunology, 13th Edition, Chapter 14: Complement System, Page 269-271.

43. **Which transcription factor is essential for T cell differentiation in the thymus?**

A. NF-κB

B. GATA-3

C. T-bet

D. Thymopoietin

43. **Which transcription factor is essential for T cell differentiation in the thymus?**

A. NF-κB

B. GATA-3

C. T-bet

D. Thymopoietin

Explanation:

Thymopoietin is a hormone secreted by the thymus, critical for the differentiation and maturation of T cells. It promotes the development of **T cell receptors (TCRs)** and the selection processes in the thymus, ensuring that T cells are both functional and self-tolerant.

- NF-κB: General transcription factor involved in inflammation and immune signaling.
- GATA-3: Drives Th2 differentiation.
- T-bet: Drives Th1 differentiation.

Reference: Janeway's Immunobiology, 9th Edition, Chapter 9: T Cell Development, Page 211-214.

44. **Which immune cells are primarily responsible for antibody-dependent cellular cytotoxicity (ADCC)?**

A. Natural killer cells

B. Neutrophils

C. Cytotoxic T cells

D. Macrophages

44. **Which immune cells are primarily responsible for antibody-dependent cellular cytotoxicity (ADCC)?**

A. Natural killer cells

B. Neutrophils

C. Cytotoxic T cells

D. Macrophages

Explanation:

Natural killer (NK) cells play a primary role in **antibody-dependent cellular cytotoxicity (ADCC)**. ADCC occurs when antibodies bind to antigens on the surface of a target cell. NK cells recognize the **Fc region of the bound antibodies** through their FcγRIII (CD16) receptor and release cytotoxic molecules like **perforin and granzymes**, leading to the destruction of the target cell.

- Neutrophils and macrophages contribute to phagocytosis but do not mediate ADCC.
- Cytotoxic T cells (CD8+ T cells) kill infected cells directly through antigen presentation via MHC class I.

Reference: Kuby Immunology, 8th Edition, Chapter 14: Effector Mechanisms, Page 323-325.

45. **What is the main cytokine produced by Th1 cells to activate macrophages?**

A. IL-4

B. IL-10

C. IFN-γ

D. TNF-α

45. **What is the main cytokine produced by Th1 cells to activate macrophages?**

A. IL-4

B. IL-10

C. IFN-γ

D. TNF-α

Explanation:

IFN-γ (Interferon-gamma) is the signature cytokine of **Th1 cells**. It activates macrophages, enhancing their ability to phagocytose and destroy intracellular pathogens such as bacteria, viruses, and protozoa. IFN-γ also promotes antigen presentation by increasing MHC class II expression on macrophages and other antigen-presenting cells.

- IL-4: Promotes Th2 responses and antibody production.
- IL-10: Suppresses inflammatory responses.
- TNF-α: Contributes to inflammation but is not the primary cytokine for macrophage activation.

Reference:

Janeway's Immunobiology, 9th Edition, Chapter 10: T Cell Subsets, Page 259-261.

46. **Which molecule facilitates the migration of leukocytes to sites of inflammation by binding to integrins?**

A. Selectins

B. Chemokines

C. ICAM-1

D. MHC class I

46. **Which molecule facilitates the migration of leukocytes to sites of inflammation by binding to integrins?**

A. Selectins

B. Chemokines

C. ICAM-1

D. MHC class I

Explanation:

ICAM-1 (Intercellular Adhesion Molecule-1) is an adhesion molecule expressed on endothelial cells during inflammation. It binds to **LFA-1 (an integrin)** on leukocytes, facilitating **firm adhesion** and **extravasation** of leukocytes from blood vessels to the site of inflammation.

- **Selectins** mediate the initial rolling of leukocytes on the endothelium.
- **Chemokines** guide leukocyte migration via chemotaxis.
- **MHC class I** presents antigens to CD8+ T cells but is not involved in leukocyte migration.

Reference:

Abbas et al., Cellular and Molecular Immunology, 10th Edition, Chapter 5: Inflammation, Page 122-125.

47. Which complement protein acts as a potent anaphylatoxin, triggering mast cell degranulation?

A. C3a

B. C4b

C. C5b

D. C9

47. Which complement protein acts as a potent anaphylatoxin, triggering mast cell degranulation?

A. C3a

B. C4b

C. C5b

D. C9

Explanation:

C3a is a potent **anaphylatoxin** that stimulates **mast cell degranulation**, leading to the release of histamine and other mediators of inflammation. This results in increased vascular permeability and recruitment of immune cells to the site of infection.

- C4b: Functions in opsonization and complement activation.
- C5b: Initiates the formation of the Membrane Attack Complex (MAC).
- C9: Forms pores in the target cell membrane as part of the MAC.

Reference:

Roitt's Essential Immunology, 13th Edition, Chapter 14: Complement System, Page 271-274.

48. What is the primary site of maturation for T cells?

A. Bone marrow

B. Spleen

C. Thymus

D. Lymph nodes

48. What is the primary site of maturation for T cells?

A. Bone marrow

B. Spleen

C. Thymus

D. Lymph nodes

Explanation:

T cells originate in the **bone marrow** but migrate to the **thymus** for maturation. In the thymus, T cells undergo positive and negative selection processes to ensure that they are functional and self-tolerant:

- **Positive selection:** Ensures T cells recognize self-MHC molecules.
- **Negative selection:** Eliminates T cells that strongly bind to self-antigens, preventing autoimmunity.

  Once matured, naive T cells enter the peripheral lymphoid organs to participate in adaptive immunity.

Reference: Janeway's Immunobiology, 9th Edition, Chapter 9: T Cell Development, Page 215-218.

49. **Which molecule expressed on T cells interacts with B7 molecules on antigen-presenting cells (APCs) to provide co-stimulation?**

A. CD28

B. CTLA-4

C. CD40

D. ICAM-1

49. **Which molecule expressed on T cells interacts with B7 molecules on antigen-presenting cells (APCs) to provide co-stimulation?**

A. CD28

B. CTLA-4

C. CD40

D. ICAM-1

Explanation:

CD28 is expressed on **T cells** and interacts with **B7 molecules (B7-1/CD80 and B7-2/CD86)** on APCs to deliver the **second signal (co-stimulation)** required for T cell activation. This interaction ensures that T cells are activated only in the presence of a genuine immune threat.

- **CTLA-4:** A negative regulator that competes with CD28 for B7 binding to inhibit T cell activation.
- **CD40:** Found on B cells and APCs, interacts with CD40L on T cells to support B cell activation.
- **ICAM-1:** Facilitates adhesion but does not provide co-stimulation.

Reference:

Kuby Immunology, 8th Edition, Chapter 12: T Cell Activation, Page 299-301.

50. **What is the role of the enzyme perforin in immune responses?**

A. Facilitates antigen presentation

B. Forms pores in target cell membranes

C. Neutralizes toxins

D. Activates complement

50. **What is the role of the enzyme perforin in immune responses?**

A. Facilitates antigen presentation

B. Forms pores in target cell membranes

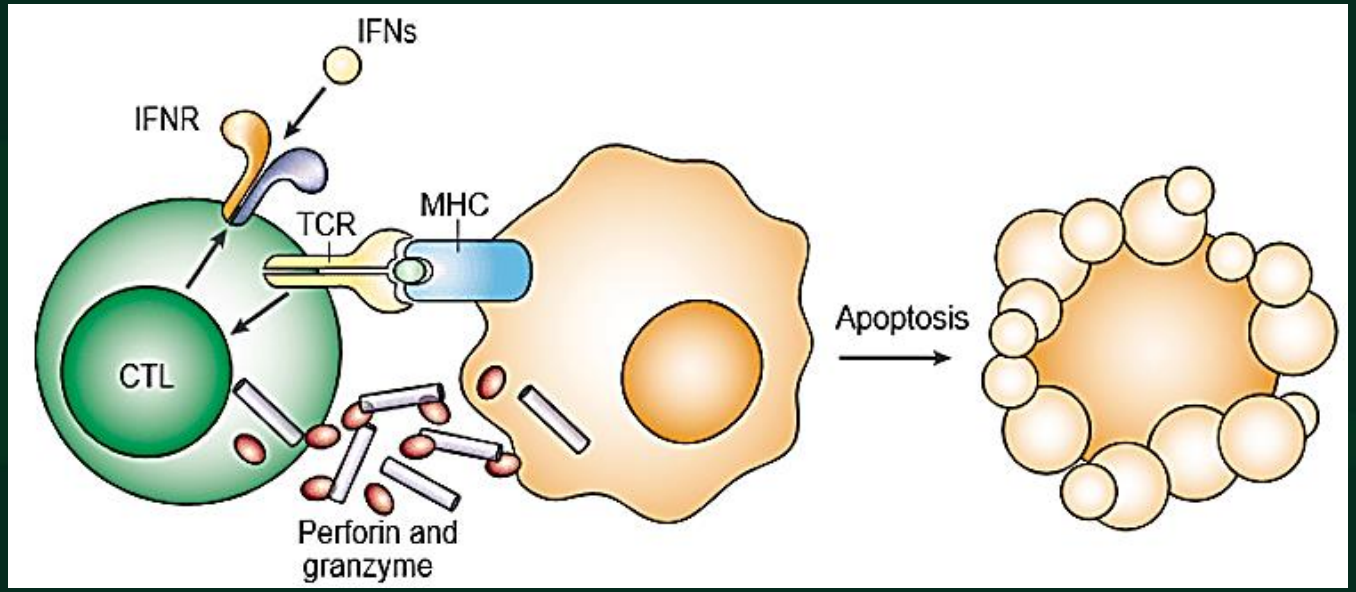
C. Neutralizes toxins

D. Activates complement

Explanation:

Perforin is a cytotoxic protein released by **cytotoxic T cells (CD8+)** and **natural killer (NK) cells**. It forms pores in the membranes of target cells, allowing the entry of **granzymes**, which induce apoptosis. This mechanism is crucial for eliminating virally infected and cancerous cells.

- Antigen presentation is mediated by MHC molecules.
- Neutralizing toxins is a function of antibodies.
- Complement activation involves complement proteins.



Reference: Abbas et al., Cellular and Molecular Immunology, 10th Edition, Chapter 14: Effector Mechanisms, Page 330-332.

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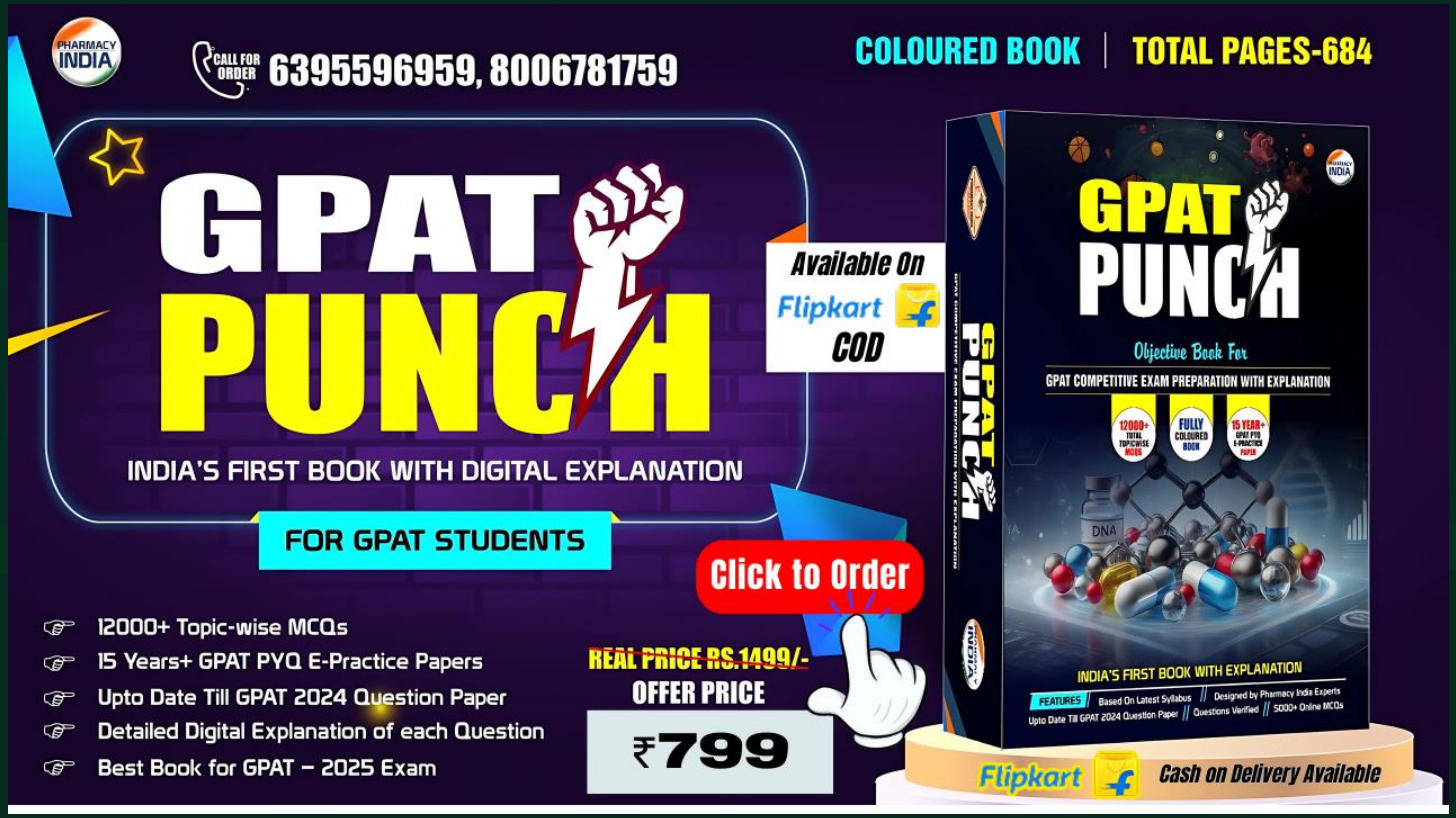

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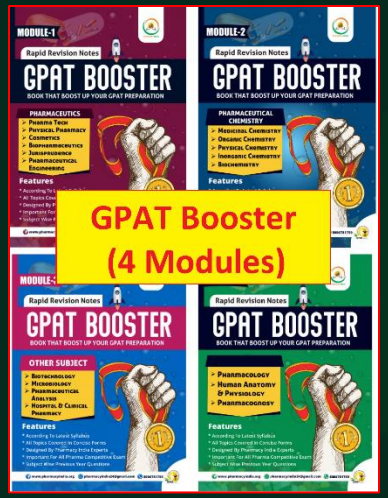

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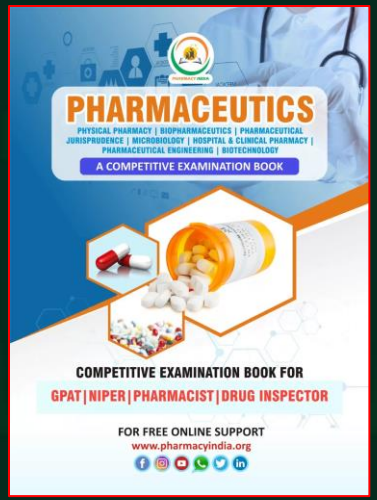

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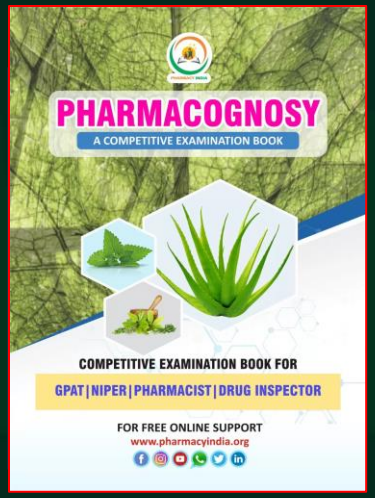

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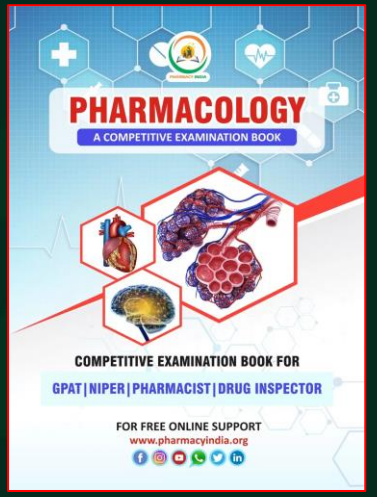

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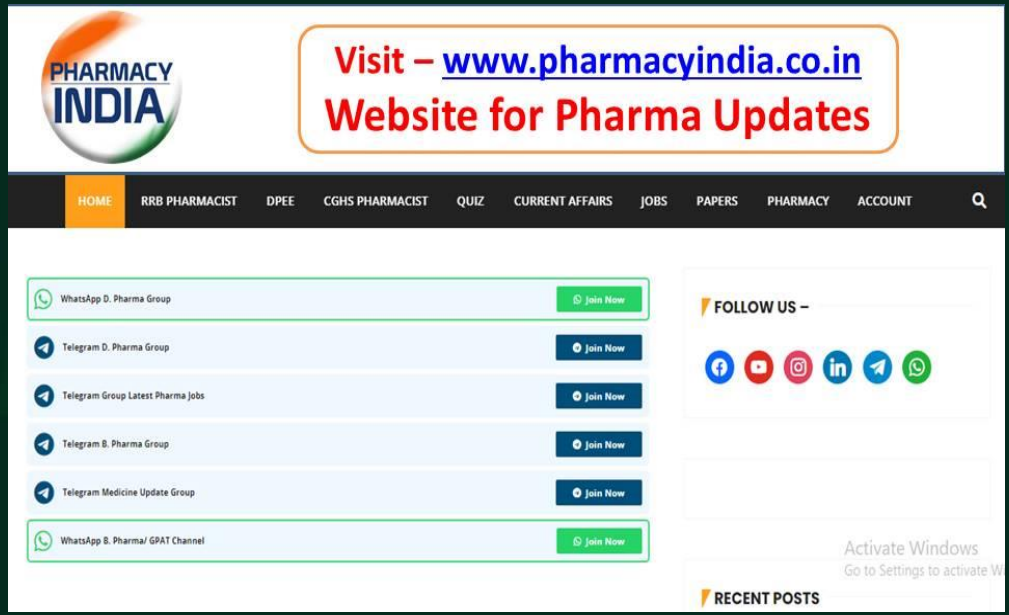

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