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RUHR-UNIVERSITÄT BOCHUM

ALLERGY AND ALLERGIC DISEASES

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What is an Allergy?

- “I can’t eat that — I’m allergic!” 🦐🥜
- “I sneeze every spring!” 🤧
- “My eyes itch when I’m near cats.” 🐱
- “I get rashes from certain creams.” 🧴
- “My child has asthma from dust.” 🫁

Common symptoms — but what’s actually happening inside the body?

→ Let’s find out what causes these reactions…

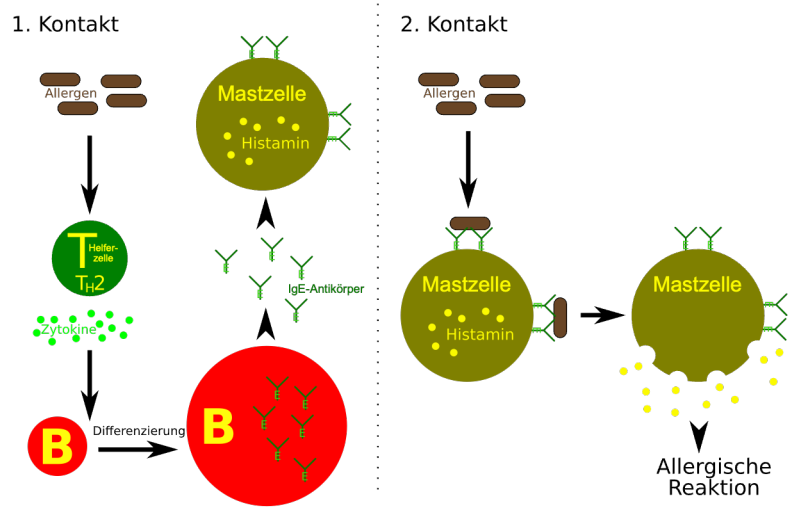
What Are Allergens?

- Found in common **environmental sources**
- Can be **inhaled, ingested, or injected**
- Examples: **pollen, house dust mite, pet dander, food, insect venom**
- Usually **harmless**, but trigger **IgE responses** in atopic individuals (= genetically prone to allergies)

What makes a protein an allergen?

- **Small, stable,** and **soluble proteins**
- Often **enzymes** like. *Der p 1* from house dust mite
- Can penetrate **epithelial barriers** (e.g. skin, mucosa)
- Trigger **TH2** → **B cells** → **IgE** production
- **IgE** binds to **mast cells** (→ **sensitization**)
- **Phase 1**: Sensitization
- **Phase 2**: Effector

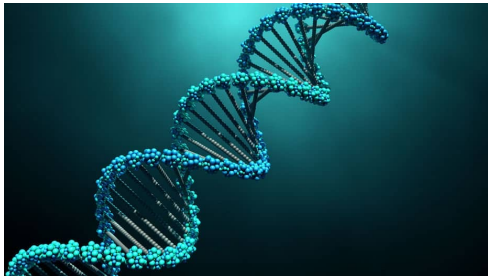
→ No single feature defines all allergens — but **common patterns** exist



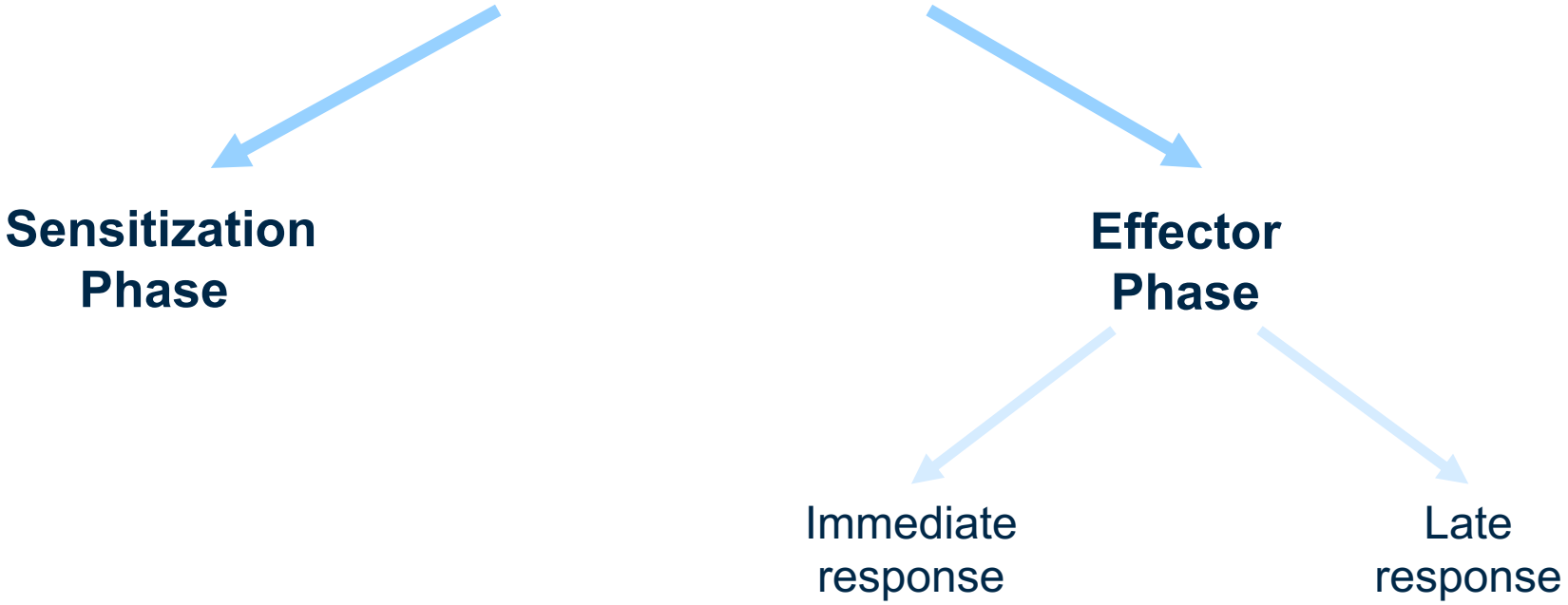
https://www.biologie-seite.de/Biologie/Allergie

Why Do Some People Develop Allergies?

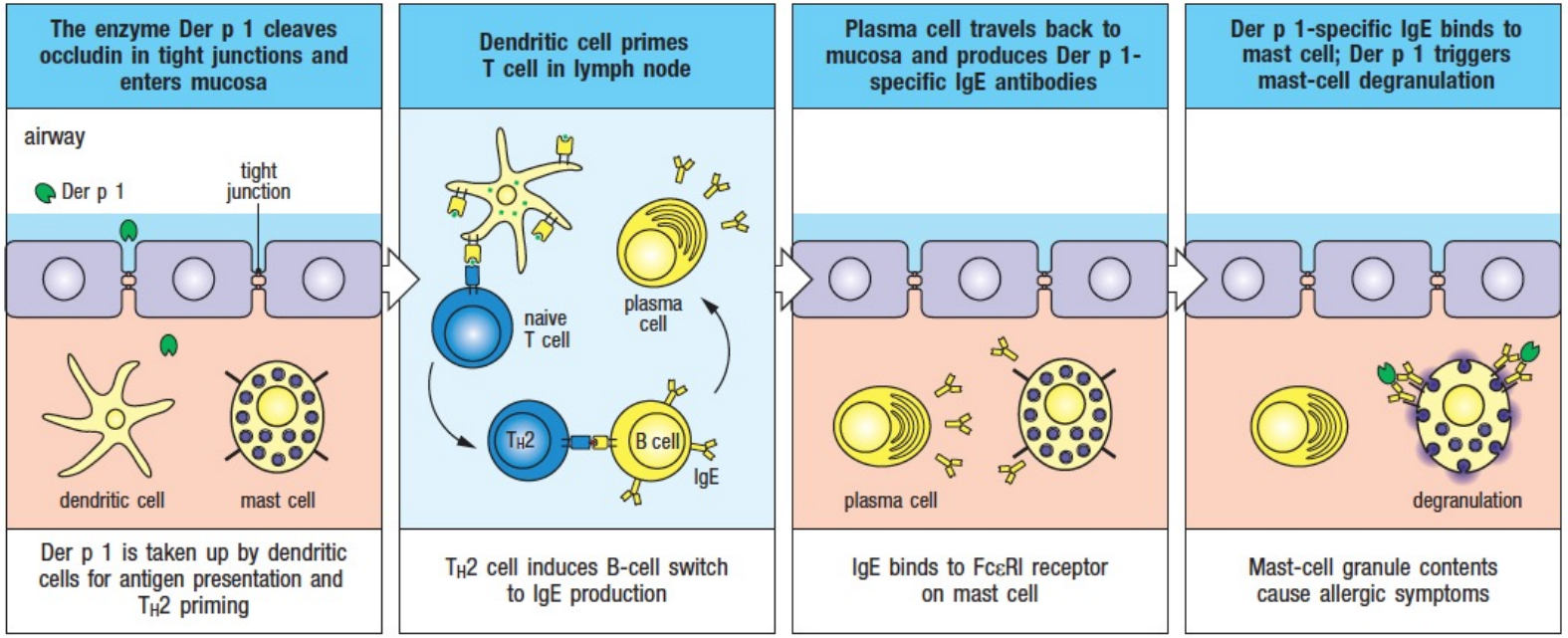
- **Genetic predisposition** (e.g. atopic parents → ↑ allergy risk)
- **Early-life exposures** (e.g. C-section, antibiotics, lack of breastfeeding)
- **Urban lifestyle / Western environment**
- **Low microbial diversity** (“Hygiene hypothesis”)
- **Air pollution and tobacco smoke**
- **Allergen exposure (type, dose, and timing matter)**



Phases of the Allergic Response



Phase 1 – Sensitization: Priming the Immune System



Phase 1: Sensitization

- **Allergen** enters the body (via skin, airways, or gut)
- Captured by **antigen-presenting cells (APCs)**
- APCs activate **naïve T cells** → differentiation into **TH2 cells**
- **TH2 cells** stimulate **B cells** → class switching to **IgE**
- **B cells** differentiate into **plasma cells**
- **Plasma cells** produce allergen-specific **IgE**
- **IgE** binds to **FcεRI receptors** on **mast cells**

→ The immune system is now **sensitized**

Conclusion – Key Takeaways

- **Allergens** are harmless environmental proteins that trigger an immune response in **atopic individuals**
- **IgE-mediated allergies** involve a two-phase reaction: **sensitization and effector**
- **Genetic and environmental factors** influence allergy risk

Quiz

1. What is an allergen?

A) A virus that causes infection

B) A harmless substance that triggers an immune reaction in some people

C) A type of bacteria

D) A hormone produced by the body

Correct Answer:

B) A harmless substance that triggers an immune reaction in some people

Quiz

2. Which of the following are common allergens?

(Multiple answers possible)

A) Pollen

B) House dust mite

C) Glucose

D) Peanuts

Correct Answer:

A) Pollen, B) House dust mite and D) Peanuts

Quiz

3. What does “atopic” mean in the context of allergies?

A) Someone with a strong immune system

B) Someone prone to infections

C) Someone genetically predisposed to develop allergic reactions

D) Someone who has asthma

Correct Answer:

C) Someone genetically predisposed to develop allergic reactions

Quiz

4. What happens in the sensitization phase?

A) The person shows allergy symptoms immediately

B) The immune system ignores the allergen

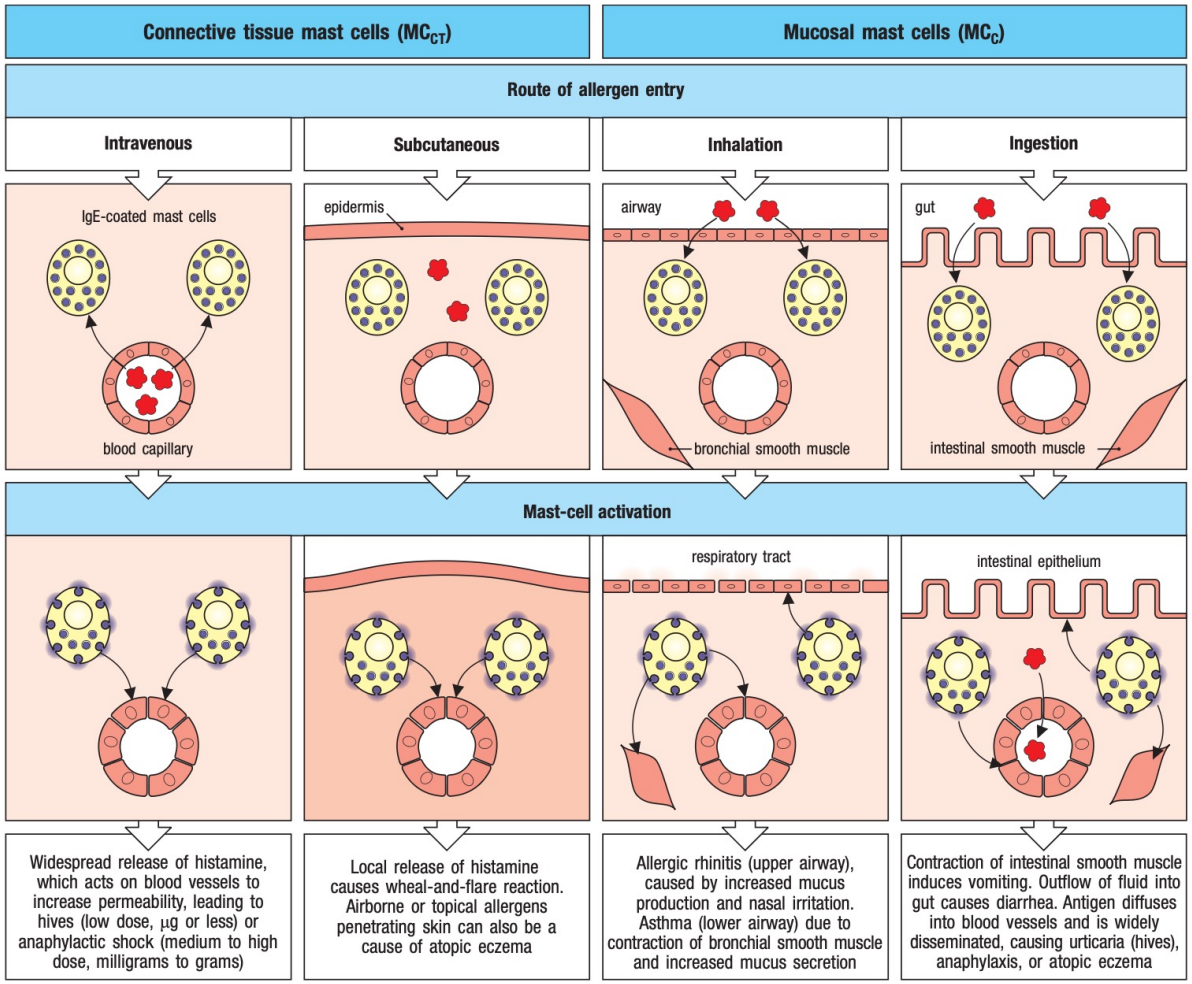
C) The body produces IgE that binds to mast cells

D) The allergen is destroyed

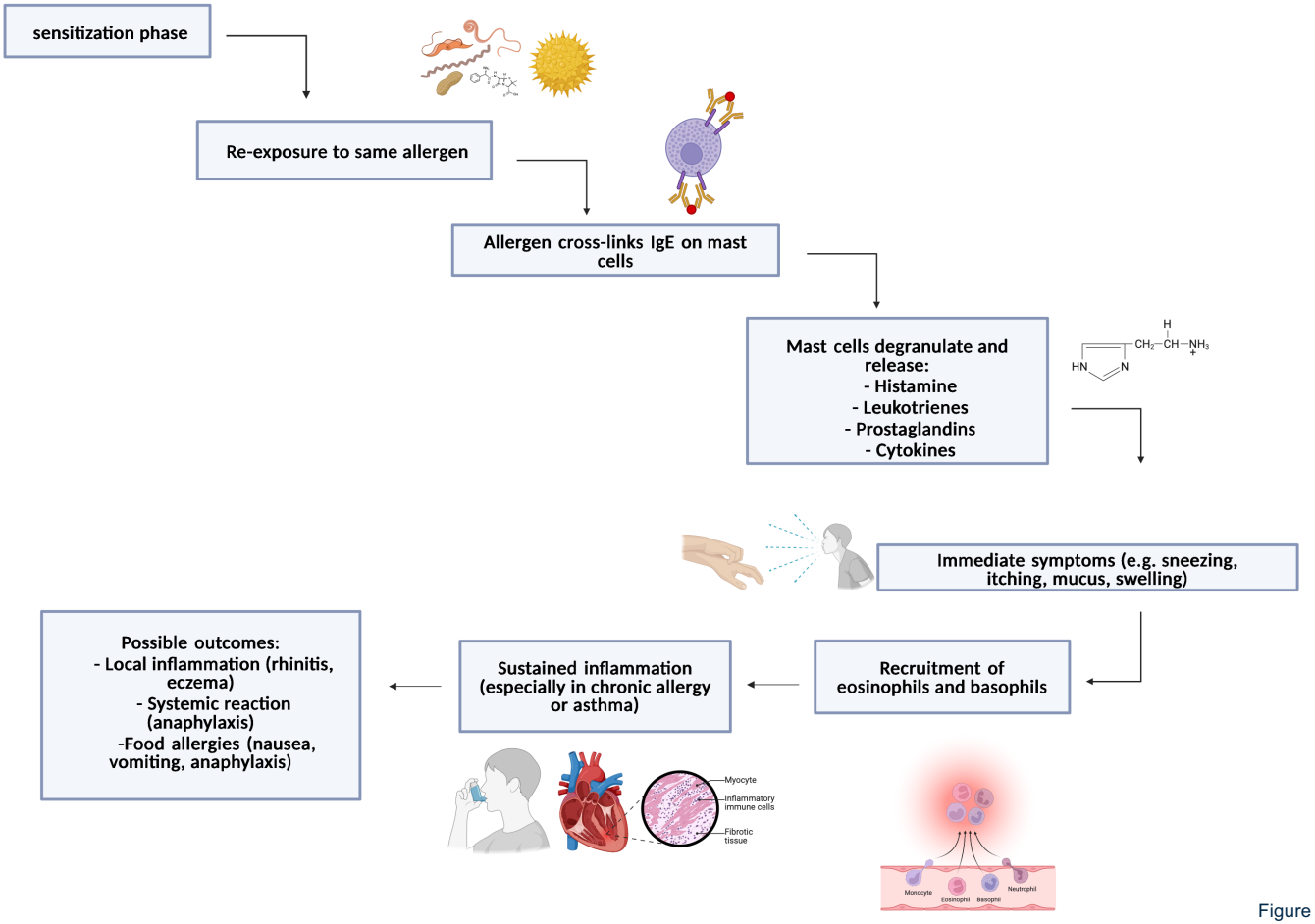
Correct Answer:

C) The body produces IgE that binds to mast cells

Routes of Allergen Entry and Mast Cell Activation



The effector phase:
IgE-Mediated allergies (Type I Hypersensitivity)



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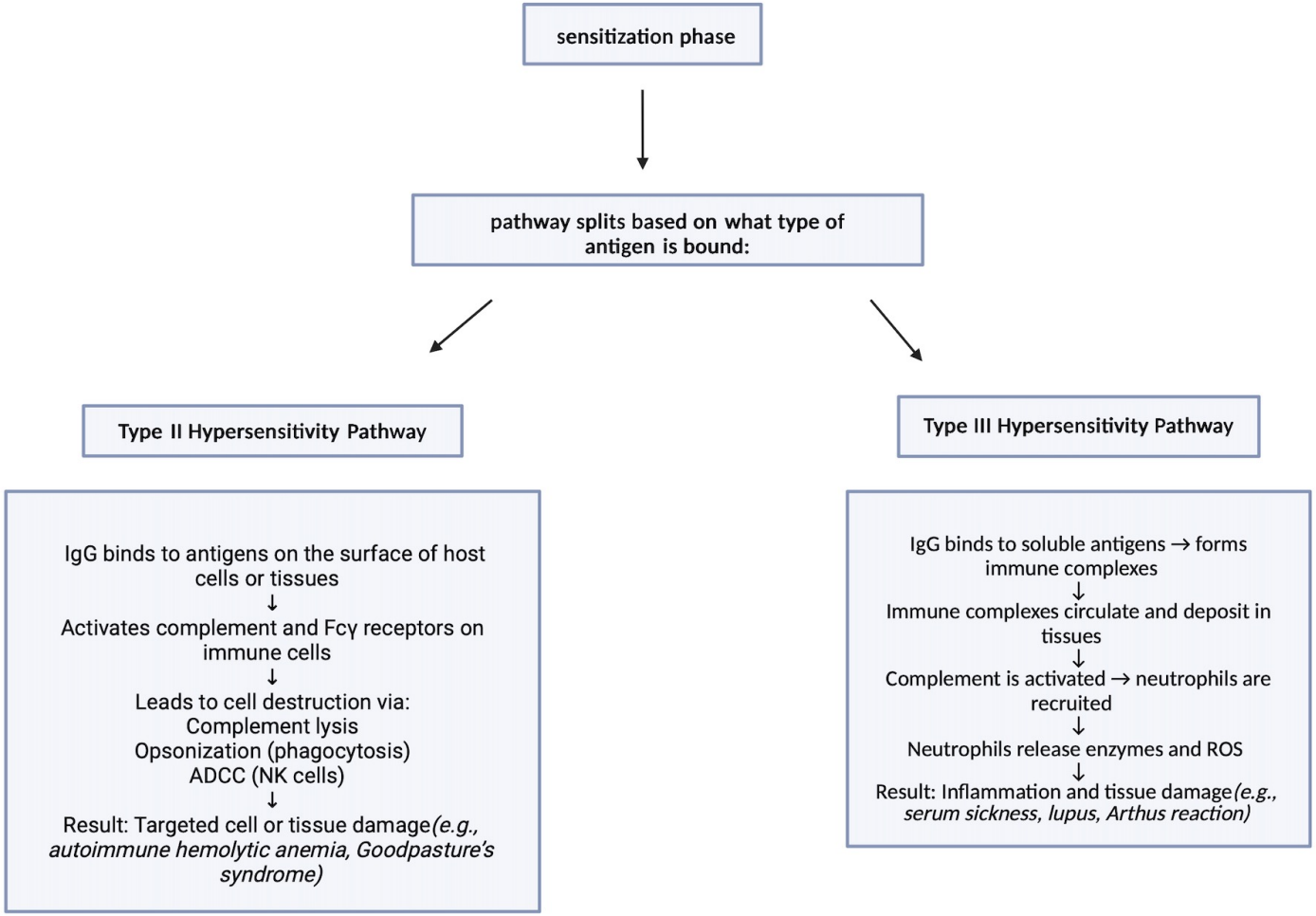
non IgE allergies
IgG mediated
T-cell mediated

The effector phase:
IgG mediated allergies (Type II and III hypersensitivity)



ADCC=Antibody-Dependent Cellular Cytotoxicity

The effector phase:
T-cell mediated allergies (Type IV hypersensitivity)

sensitization phase

↓

Upon re-exposure to the same antigen →
memory T cells are reactivated
↓
Reactivated T cells secrete cytokines such as:
IFN-γ → activates macrophages
TNF-α, IL-17 → promote inflammation
↓
Macrophages and other immune cells are recruited to the site
↓
Inflammation causes local tissue damage
↓
Result: Delayed inflammatory reaction (24–72 hours after exposure) *(e.g., contact dermatitis, TB skin test reaction, celiac disease)*

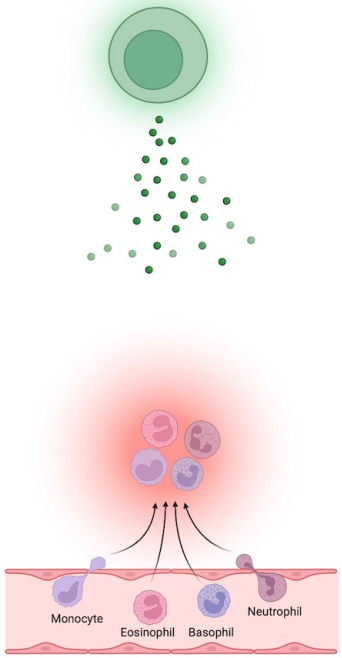


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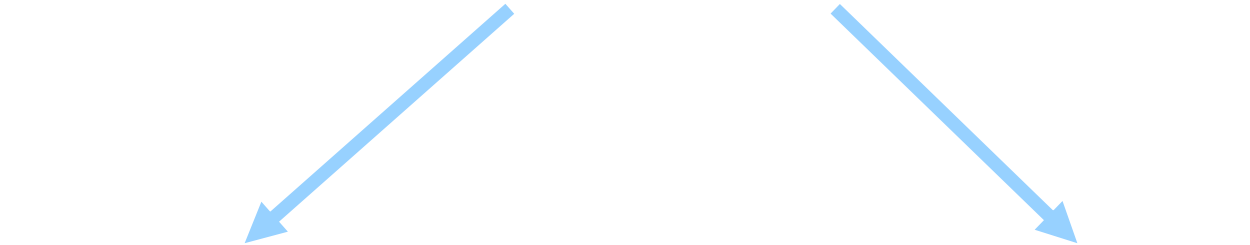
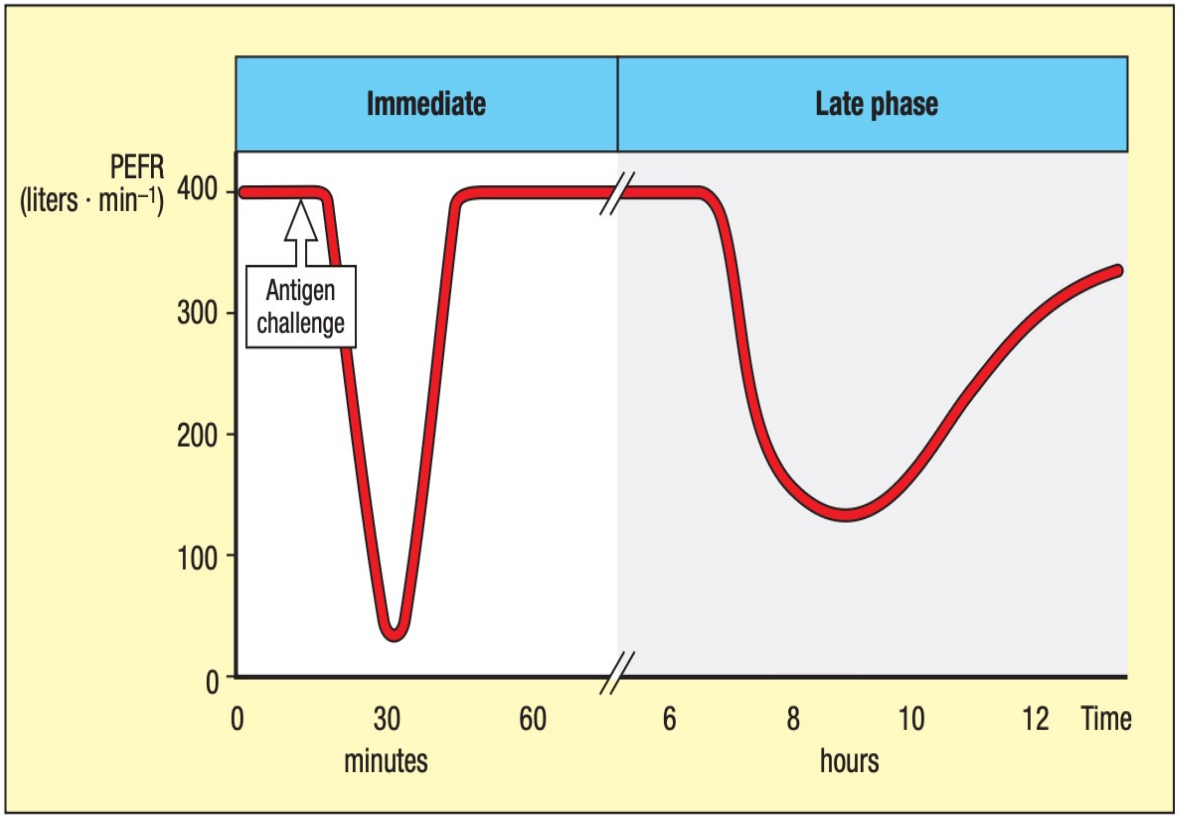
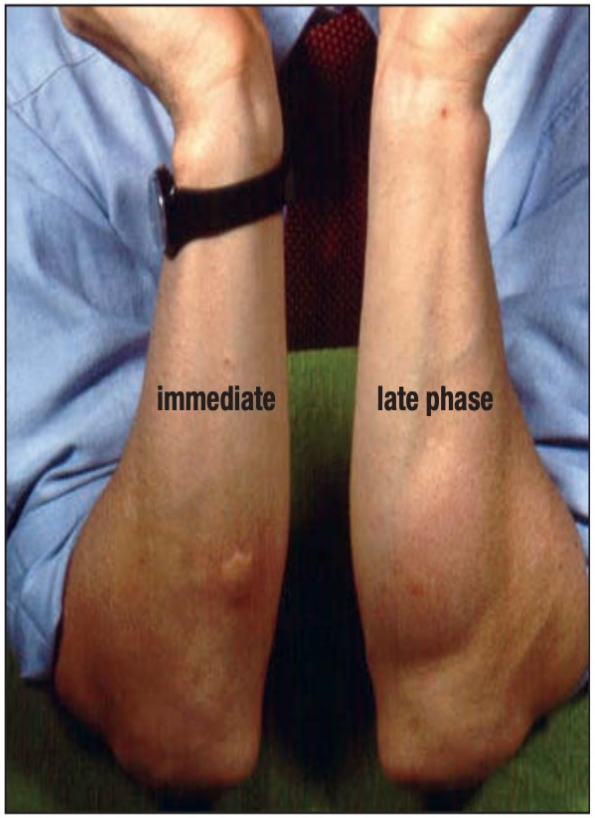
Fig. 14.23 Blistering skin lesions on the hand of a patient with allergic contact dermatitis caused by poison ivy. Photograph courtesy of R. Geha.

Effector Phase







y-axis: shows PEFR, or Peak Expiratory Flow Rate, which is a measure of how easily someone can breathe out

x-axis: shows time in minutes to hours after allergen exposure

Treatment of Allergies

Symptomatic Treatment:

- Antihistamines
- Corticosteroids
- β-agonists (for asthma)
- Epinephrine (for anaphylaxis)

Biological Therapies:

- Anti-IgE therapy (e.g. omalizumab) → blocks IgE from binding receptors
- Anti-IL-5 for eosinophilic asthma

Immunotherapy:

- Allergen desensitization (gradual exposure to allergen)
- Leads to shift from IgE to IgG4 and activation of Treg cells → tolerance
- Can be done subcutaneously or sublingually

Conclusion – Key Takeaways

- During the effector phase of the immune response, four types of hypersensitivity reactions can occur.
- **Type I** involves IgE and causes immediate or late allergic reactions through mast cell degranulation.
- **Type II** involves IgG leading to cell destruction and can take hours or days.
- **Type III** involves IgG complexes causing inflammation and can also take hours or days.
- **Type IV** is T cell–mediated and cause delayed tissue damage.

Hypersensitivity	Key Mediators	Timing
Type I	IgE, mast cells	Immediate + late
Type II	IgG	Hours–days
Type III	IgG (complexes)	Hours–days
Type IV	T cells	1–3 days (delayed)

Quiz

1. What is the effector phase of a hypersensitivity reaction?

A) The phase when immune tolerance develops

B) The phase when the allergen is first encountered

C) The phase when immune cells cause symptoms

D) The phase when antibodies are produced

Correct Answer:

C) The phase when immune cells cause symptoms

Quiz

2. Which antibody is involved in Type I hypersensitivity?

A) IgG

B) IgE

C) IgA

D) IgM

Correct Answer:

B) IgE

Quiz

3. What happens during the late-phase allergic reaction?

A) Mast cells release histamine

B) Immune complexes form

C) T-cells destroy target cells

D) Inflammatory cells are recruited, causing sustained inflammation

Correct Answer:

D) Inflammatory cells are recruited, causing sustained inflammation

Quiz

4. In Type II hypersensitivity, antibodies bind to:

A) Soluble allergens

B) Cell surface antigens

C) MHC I molecules

D) Bacterial toxins

Correct Answer:

B) Cell surface antigens

Quiz

5. Type III hypersensitivity is caused by:

A) IgE cross-linking on mast cells

B) T cell-mediated tissue damage

C) Immune complex deposition in tissues

D) Antibodies targeting viruses

Correct Answer:

C) Immune complex deposition in tissues

Quiz

6. What is an example of a Type IV hypersensitivity reaction?

A) Asthma

B) Contact dermatitis

C) Serum sickness

D) Anaphylaxis

Correct Answer:

B) Contact dermatitis

Questions?
Feel free to ask!