

Classification of skin infections, skin defence, and skin microbiome

Malik Sallam, M.D., Ph.D.

School of Medicine

The University of Jordan

Overview of the skin structure and its relation to infections

- Two primary layers:
- **Epidermis:** Outermost layer, featuring a protective **stratum corneum** made of **keratinocytes**.
- **Dermis:** Denser, thicker layer with connective tissue, blood vessels, nerve endings, **sebaceous glands**, and **hair follicles**.

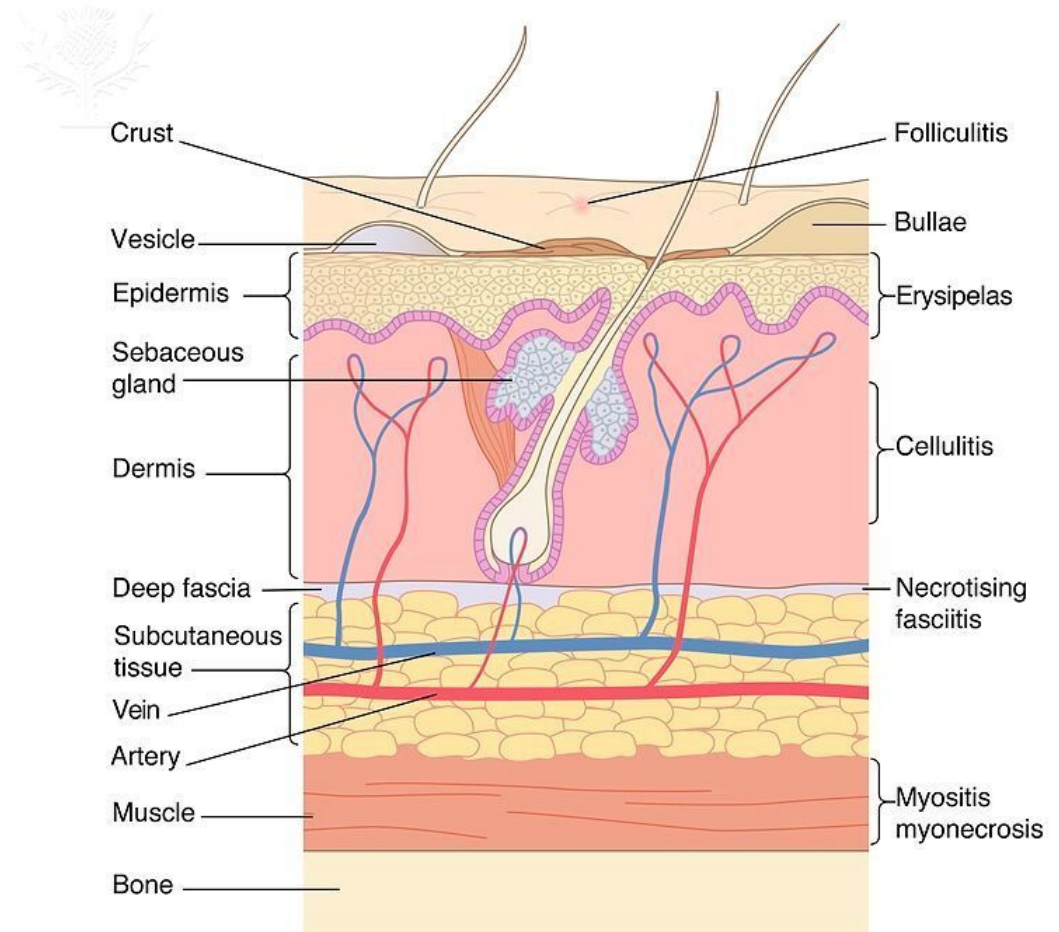


Credit: Patrick McDonnell / Photo Researchers /
Universal Images Group
Rights Managed / For Education Use Only

Overview of the skin structure and its relation to infections

Infections:

- **Surface-level:** Dermatophyte infections (e.g., tinea or ringworm) primarily affect the epidermis, especially the stratum corneum.
- **Deeper skin conditions:** Infections like furuncles, carbuncles, and erysipelas can invade the dermis when the protective epidermis is compromised.



How the skin prevents infection?

- **Dry environment:** Limits colonization by certain microorganisms, including Gram-negative bacteria.
- **Renewal of the epidermis:** Regular shedding of keratinocytes prevents overgrowth of potential pathogens.
- **Protective barrier:** The keratinocytes form a waterproof barrier, blocking the entry of infectious agents.
- Skin secretions include **beta defensins**, peptides that destroy microorganisms by disrupting their **cell membranes**.
- **Skin-resident immune cells:** Langerhans cells, dermal dendritic cells, macrophages, mast cells, and eosinophils.

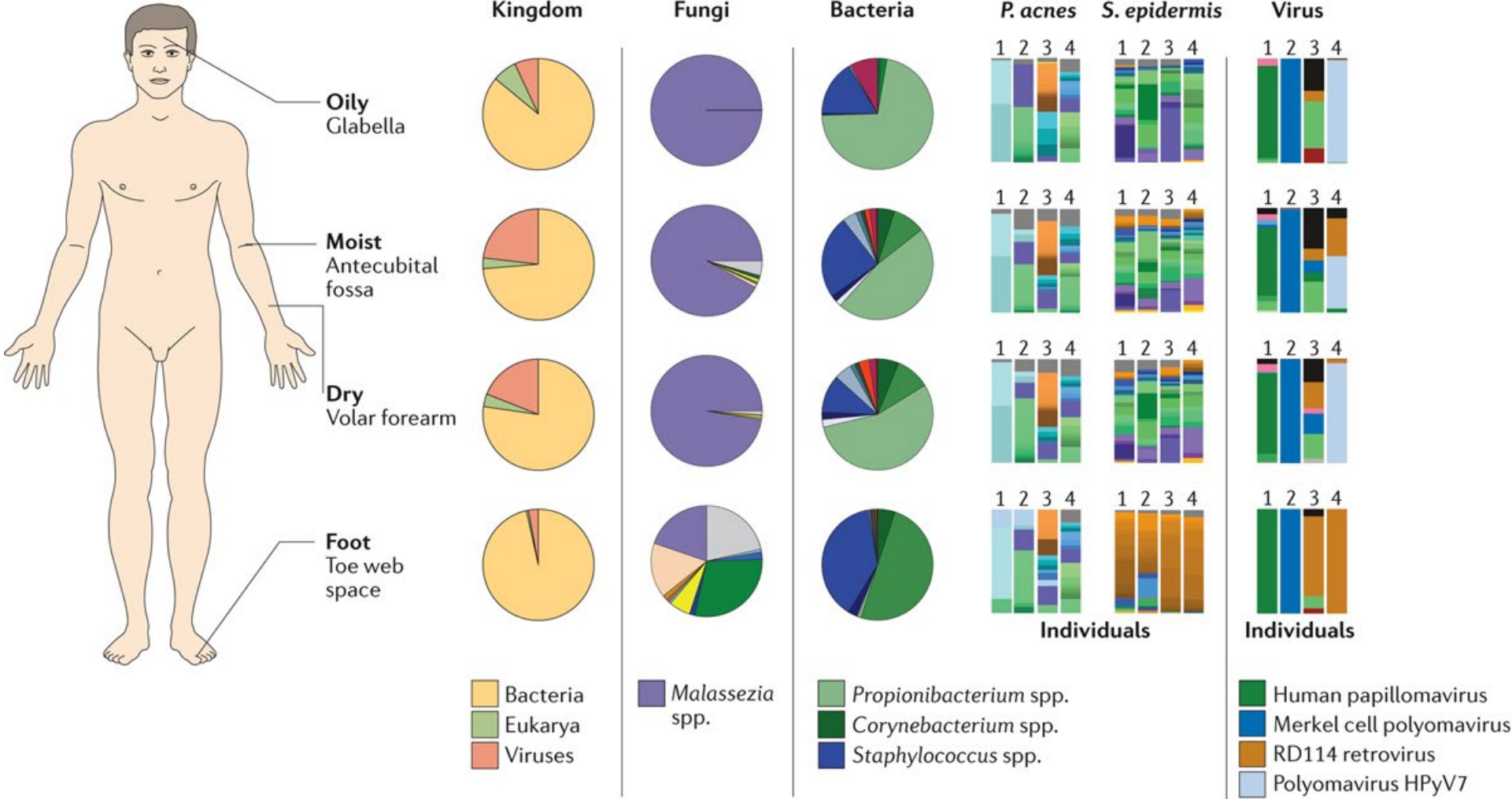
How the skin prevents infection?

- **Skin pH:** Sebaceous glands secrete sebum rich in fatty acids and lactic acid.
 - Fatty acids are effective against most gram-positive bacteria and gram-negative cocci (e.g., *Neisseria*)
 - Lactic acid lowers skin pH, inhibiting many microorganisms.
- **Sweat glands** produce sweat containing lysozyme and high levels of sodium chloride.
 - **Lysozyme** breaks down bacterial **cell walls**.
 - Sodium chloride concentration can inhibit bacterial growth.

Skin microbiome

- Resident microorganisms: Despite a hostile environment, skin is colonized by specific microbes, including Diphtheroids, *Propionibacterium acnes*, *Staphylococcus*, and *Malassezia*.
- Skin normal flora help to prevent pathogen colonization by:
 - Blocking attachment to the skin surface.
 - Producing substances that inhibit the growth of other microbes.
- Habitats on skin:
 - Most reside in the superficial stratum corneum and upper hair follicles.
 - Moist areas (e.g., scalp, axilla, perineum) have higher colonization than drier regions (e.g., arms, legs, chest, back).

Skin microbiome



Nature Reviews | Microbiology

Credit: Byrd, A., Belkaid, Y. & Segre, J. The human skin microbiome. Nat Rev Microbiol 16, 143–155 (2018).

<https://doi.org/10.1038/nrmicro.2017.157>

Skin microbiome

- **Key colonizers:** Predominantly gram-positive bacteria, including coagulase-negative *Staphylococcus*, *Corynebacterium*, and *Propionibacterium*.
- *Staphylococcus epidermidis* is the most prevalent skin microorganism.
- *Candida* and *Malassezia* are the main fungi found on the skin.
- **Moist area microbes:** Gram-negative bacilli such as *Enterobacter*, *Pseudomonas*, *Klebsiella*, *Escherichia coli*, and *Proteus* are typically found in the skin moist regions.

Primary bacterial agents:

- *Staphylococcus aureus*
- *Streptococcus pyogenes*
- *Propionibacterium acnes*

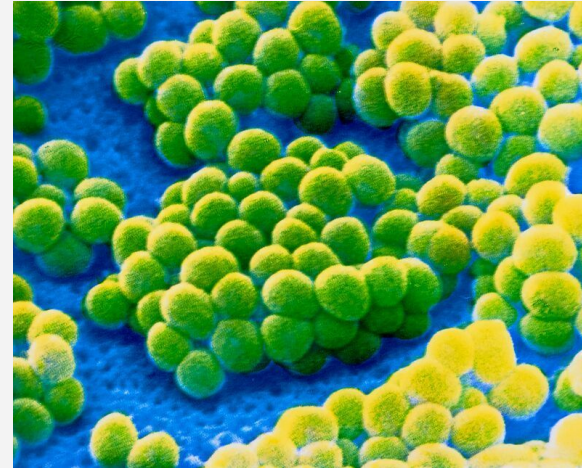
Infections caused by *S. aureus*:

- Bullous impetigo
- Folliculitis
- Furuncles and carbuncles
- Cellulitis and myositis
- Scalded skin syndrome (SSS)
- Toxic shock syndrome (TSS)

Mechanisms of disease:

Most staphylococcal infections involve invasion and destruction of skin tissue. SSS and TSS are toxin-mediated, resulting from exfoliative or epidermolytic toxins and TSS toxin, respectively.

Common bacterial skin infections



Credit: Science Photo Library \ UIG

Rights Managed / For Educational Use Only



Credit: DR P. MARAZZI / SCIENCE PHOTO LIBRARY / Universal Images Group

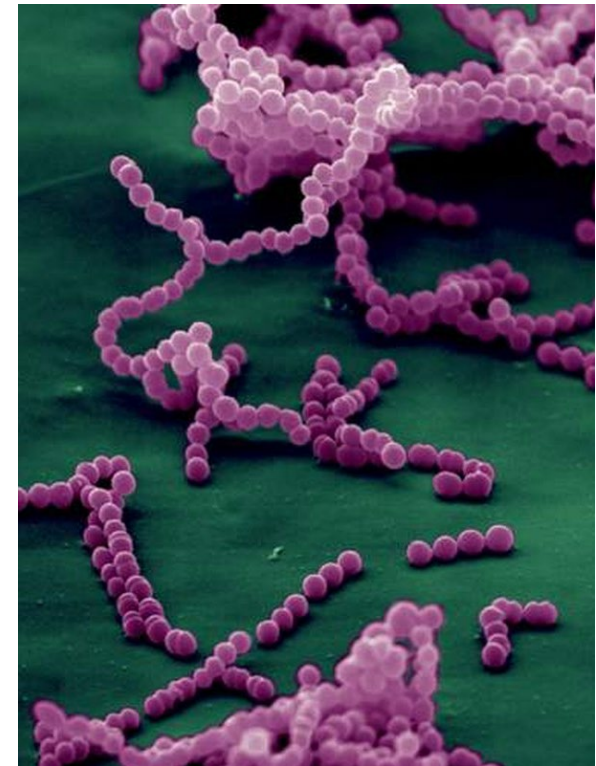
Rights Managed / For Education Use Only

Common bacterial skin infections

- *Streptococcus pyogenes* infections:
 - Impetigo
 - Scarlet fever
 - Erysipelas
 - Necrotizing fasciitis
 - Streptococcal toxic shock syndrome (TSS)
- Mechanisms of *S. pyogenes* infections:
 - Impetigo, erysipelas, and necrotizing fasciitis arise from skin colonization or invasion.
 - Scarlet fever and streptococcal TSS are toxin-induced, linked to streptococcal pyogenic exotoxin (SPE) or erythrogenic toxin.



Credit: Science Photo Library
Rights Managed



Credit: Eye of Science / Photo
Researchers / Universal Images Group
Rights Managed / For Education Use Only

Common bacterial skin infections

Role of
Propionibacterium
acnes:

Colonizes hair follicles,
playing a significant role
in development of acne
vulgaris.



Credit: SCIENCE PHOTO LIBRARY
Rights Managed



Credit: Science Photo
Library
Rights Managed

Viral skin infections

- **Herpes Simplex Virus (HSV):**
 - Oral and genital herpes caused by HSV-1 or HSV-2.
- **Human Papillomavirus (HPV):**
 - Various strains cause warts, infecting millions annually worldwide.
- **Childhood exanthems:**
 - Common viral rash illnesses in children.

Common fungal causes of skin infections

- Main fungal pathogens:
 - *Malassezia furfur*
 - Dermatophytes: *Microsporum*, *Trichophyton*, and *Epidermophyton*
 - *Candida albicans*
 - *Blastomyces dermatitidis*
- Infection details:
 - *Malassezia furfur* and dermatophytes target the superficial keratinized layers of the epidermis.
 - Dermatophytes can also infect hair and nails.
 - *Candida albicans* primarily causes epidermal infections, leading to conditions like intertrigo, folliculitis, paronychia, and onychomycosis.
 - *Blastomyces dermatitidis*, although less common, can cause cutaneous and systemic infections.

Parasitic skin infections

- **Arthropods:** The most frequent parasites
 - Includes *Sarcoptes scabiei* (cause of scabies), *Demodex* species (follicle mites), *Tunga penetrans* (sand **flea** causing tungiasis), and larvae causing myiasis (fly larvae infections).
 - Pediculosis capitis, pediculosis corporis, and pediculosis pubis are caused by the lice insects *Pediculus humanus* and *Pthirus pubis*.
 - *Cimex lectularius* (bedbug) feeds nocturnally on human blood meal causing skin rash and blisters.
- **Protozoa:** Common in certain regions
 - *Leishmania* species transmitted by sand **fly**, causing leishmaniasis.
- **Helminths:** Less commonly encountered
 - Flukes: e.g., *Schistosoma* spp.



Credit: SCIENCE PHOTO LIBRARY
Rights Managed

Credit: Superstock / Universal Images Group
Rights Managed / For Education Use Only

Credit: VAUGHAN FLEMING / SCIENCE PHOTO LIBRARY / Universal Images Group
Rights Managed / For Education Use Only



Credit: A. CRUMP / TDR / WHO / SCIENCE PHOTO LIBRARY / Universal Images Group
Rights Managed / For Education Use Only

فرنسا تقرر إغلاق سبع مدارس بسبب انتشار بق الفراش

قررت السلطات الفرنسية إغلاق سبع مدارس تضم 1500 طالب بسبب انتشار بق الفراش. وعقدت الحكومة سلسلة اجتماعات الأسبوع الجاري للبحث في تزايد حالات الإبلاغ عن انتشار هذه الحشرة في وقت تستضيف البلاد كأس العالم للرجبي وتستعد لأولمبياد باريس 2024. ويُعتقد أن عُشر الأسر الفرنسية عانت مشكلة بق الفراش خلال السنوات القليلة الماضية، وعادة ما تكلف عملية التطهير مئات عدة من اليورو.

نشرت في: 07/10/2023 - 11:38 3 دقائق



Credit: WIM VAN EGMOND/VISUALS UNLIMITED, INC.
/SCIENCE PHOTO LIBRARY

Rights Managed

Mechanisms of skin infections

- **Causes of skin lesions:**

- Direct microbial infection of the skin.
- Toxins produced by microbes.
- Inflammatory response to microbial infection.

- **Routes of infection:**

- Through breaks in the skin outer layer or via hair follicle infections.
- Common causes of skin breaches include insect or animal bites, human bites, needle sticks, scratches, and burns.
- Clogged hair follicles are more susceptible to infection.

- **Progression of infections:**

- Infections can extend into the dermis and, in severe cases, to the subcutaneous fat, fascia, and muscles, leading to conditions such as necrotizing fasciitis, myositis, and gas gangrene.

Skin lesions in clinical practice

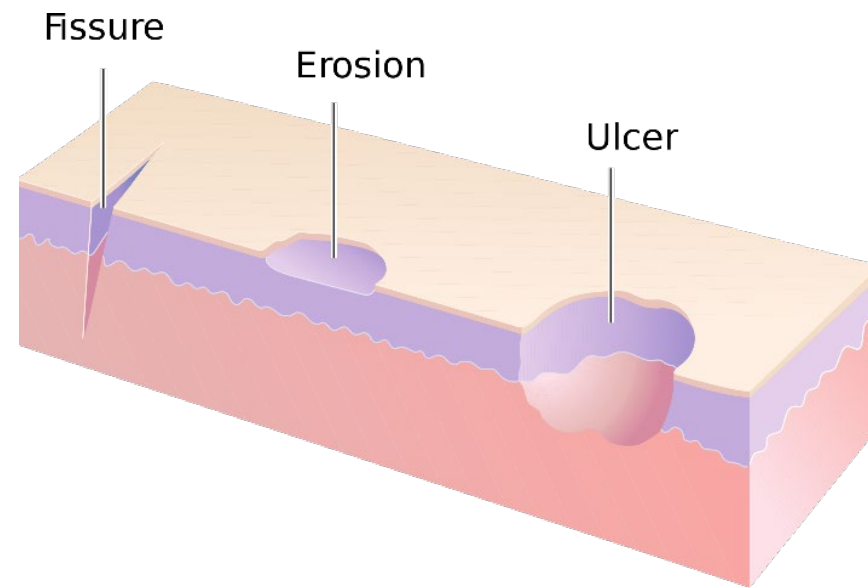
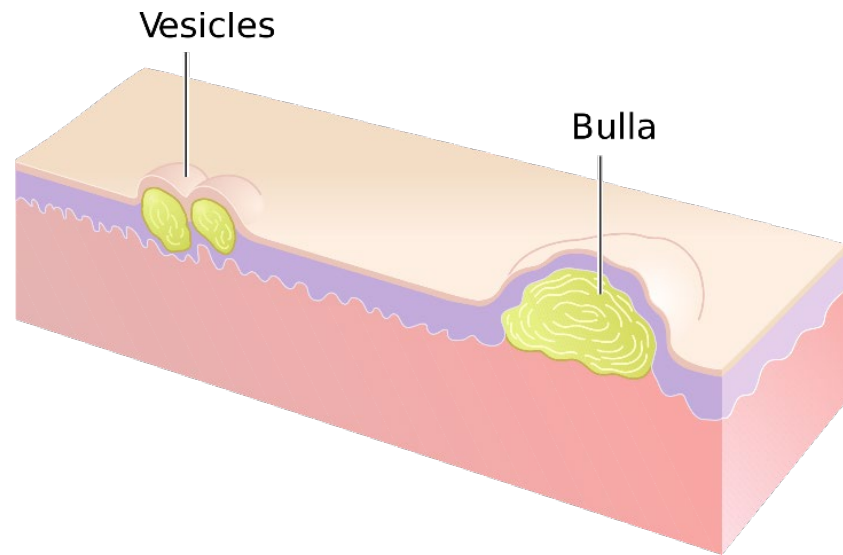
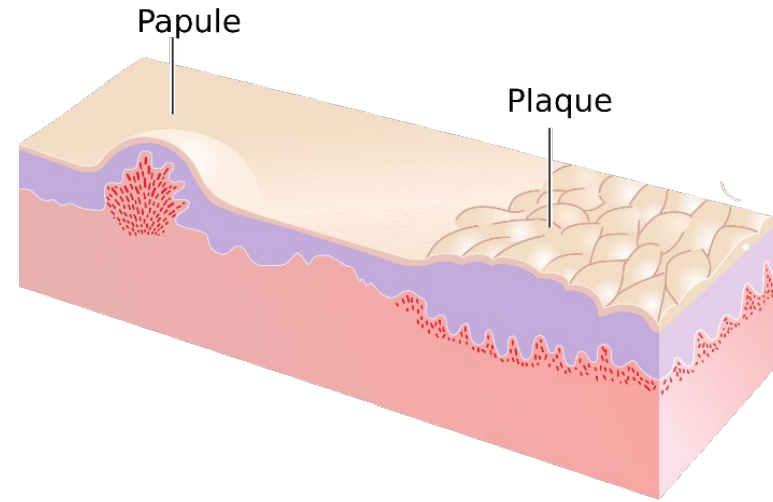
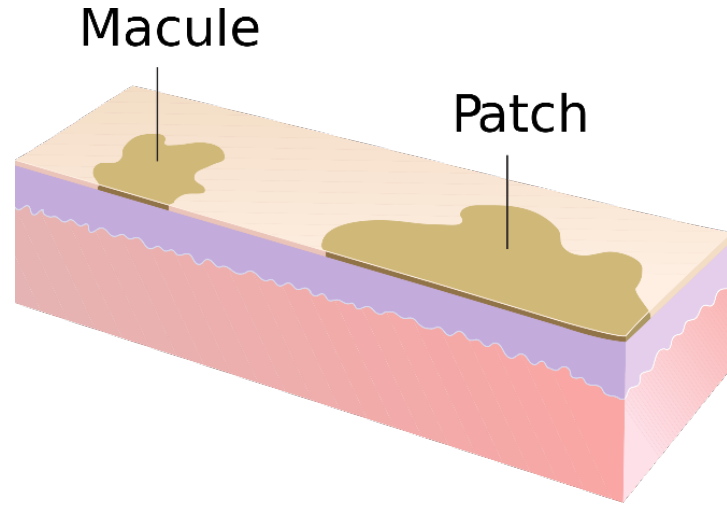
- **Classification:**

- Macules: Flat, even with the skin.
- Ulcers: Sunken, below the skin level.
- Papules: Raised, above the skin level.
- Petechiae: Tiny spots from minor bleeding under the skin.
- Purpura and ecchymosis: Larger blotches or bruises from more extensive bleeding.

- **Infections are not the only causes!**

- E.g., Some lesions develop after exposure to toxins; damage to capillaries, and inflammatory responses

Skin lesions in clinical practice



Thanks for listening!