Learning Outcomes

In today’s topic you will learn:

- The structure and function of the **integumentary system**
- The clinical presentations, investigation procedures & some orthodox treatments of skin pathologies
- The structure and function of the **lymphatic system**
- The clinical presentations & some orthodox treatments of lymphatic system pathologies

Discuss: What can a patient’s skin tell you?
Skin Structure

- Skin forms the integumentary system
- **It is the largest organ of the human body**
- 2 square metres (men), 0.5mm-4mm thickness
- Covers external body and continuous with mucous membranes
- An *epithelial membrane* - *cutaneous membrane*
- Contains *accessory structures*: glands, hair and nails
• **Consists of 3 main layers:**
  1. Epidermis
  2. Dermis
  3. Adipose layer/Subcutaneous layer (attaches to underlying fascia and bone/muscle connective tissue)

• **90% epidermal cells are keratinocytes** (keratin = tough fibrous protein that protects from heat, microbes & chemicals).

• **8% epidermal cells are melanocytes** (melanin = pigment that contributes to skin colour and absorbs UV light. It surrounds nuclei of keratinocytes on side towards skin surface and transfers melanin to them)
Skin Structure & Melanocytes

Skin structure:

Melanocytes:

- Cellular Extension of Melanocyte
- Melanin Granules
- Golgi Apparatus
- Melanocyte Nucleus

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The Epidermis

- **Superficial layer of skin**

- **Keratinised epithelium** (protective and waterproofing)

- Varies in thickness over the body.

- Interstitial (situated in between cells) fluid provides oxygen and nutrients.

- Drained by the lymph.

- No blood vessels (**avascular**) and no nerve endings.

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Fingerprints are ridges formed during the 3rd month of foetal development. They are downward projections of epidermis into the dermis. Increases the surface area and increases grip by creating friction. They are unique to each individual.
The Epidermis

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>corneum</td>
<td>25-30 layers of flattened dead keratinocytes. Cytoplasm has been replaced by fibrous protein keratin. Are shed (desquamated)</td>
</tr>
<tr>
<td>lucidum</td>
<td>Dead cells. 3-5 layers only present in thick skin</td>
</tr>
<tr>
<td>granulosum</td>
<td>3-5 layers of cells undergoing apoptosis</td>
</tr>
<tr>
<td>spinosum</td>
<td>8-10 layers of new keratinocytes</td>
</tr>
<tr>
<td>basale</td>
<td>Single row dividing to form new keratinocytes. Contains stem cells</td>
</tr>
</tbody>
</table>

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The Epidermis

Complete replacement of epidermis occurs in approx. 40 days.

As cells move through layers they accumulate more keratin.

The epidermis is attached to the dermis by a basement membrane.
# Skin Colour

<table>
<thead>
<tr>
<th>Colour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown</td>
<td>Pigmentation due to varying degrees of melanin produced by melanocytes</td>
</tr>
<tr>
<td></td>
<td>People of different races have the same number of melanocytes but different amount and type (2 types) produced</td>
</tr>
<tr>
<td>Pink</td>
<td>Colour due to level of blood circulation and oxyhaemoglobin.</td>
</tr>
<tr>
<td>Natural yellow</td>
<td>Colour caused by carotenenes (pigment that gives egg yolk/carrots colour)</td>
</tr>
<tr>
<td>Yellow</td>
<td>Colour from pathology due to bile pigments.</td>
</tr>
<tr>
<td></td>
<td>Albinos are unable to synthesise melanin</td>
</tr>
</tbody>
</table>

Consider **jaundice, cyanosis, pallor**

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Dermis

- Thickest layer, formed from **connective tissue**: A matrix of **collagen and elastic fibres** interlocked together.

- Collagen fibres give tensile strength and elastic fibres allow skin to stretch and recoil

- **Also contains:**
  - **Arterioles** and **capillaries** (thermoregulation)
  - **Lymph vessels** and sensory nerve endings
  - **Sweat glands** (and ducts), **hairs** and **arrector pili muscles**, **sebaceous glands**.
  - Fibroblasts and immune cells - macrophages & mast cells.

**arrector pili** = smooth muscle that elevates hair follicle
**Epidermis:**
Superficial layer of keratinised epithelium

**Dermis:**
Formed of connective tissue (collagen and elastin fibres)

*Stratum corneum (dead epidermal cells)*
Sweat (Sudoriferous) glands

- Most numerous in the palms, soles of feet, axillae & groin
- Innervated by the sympathetic nervous system
- Consists of a gland, duct and pore. Located next to a capillary
- Excretion of urea (waste). Excessive sweating leads to dehydration and sodium (Na\(^+\)) depletion.
- Smell created by action of bacteria breaking down substances present in sweat such as fatty acids.
- Body heat used to evaporate sweat - Help regulate body temperature

Kangaroos lick their forearms to cool down. How does this work?
Sensory nerve endings

- **Meissner's corpuscle**: Sensitive to light pressure.

- **Pacinian corpuscle**: Sensitive to deep pressure.

- **Free nerve ending**: Sensitive to pain & temperature.

- **1cm square skin = 200 pain receptors**

- **Merkel cells**: are oval receptor cells involved in sensing light touch discrimination of shapes and textures.
Dermis: Hairs

- Hairs are concentric columns of dead keratinised cells bonded together by proteins.

- Hair colour is genetically determined. Hormones influence distribution. Contains pigment called melanin (more=darker)

- A microscopic band of smooth muscle called ‘Arrector pili’ connect the hair follicle to the dermis.

- When the hair is erect, it traps a layer of air next to the skin (part of thermoregulation).

Grey hair is the replacement of melanin by air bubbles.

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Dermis: Sebaceous glands

- Secrete sebum which keeps hair soft, water-proofing for the skin, is an anti-microbial.
- Mostly face, scalp, lip, eye lid, nipples, labial folds, glans penis
- Activity increases in puberty, decreases with age

What happens if you don’t wash hair for a few days?
Skin Functions

- Protection
- Thermoregulation (body temperature)
- Vitamin D production
- Sensation
- Absorption
- Excretion

thermo = temperature
Protection

Protection against dehydration and external factors such as chemicals, toxins, trauma, light, microbes.

1. **Physical barrier** - closely packed keratinised cells and melanin

2. **Sebum** - contains fatty acids which inhibit microbial growth.

3. **Sweat** - contains lysozyme, an enzyme that breaks down bacteria.

4. **Desquamation** - shedding of skin cells helps remove microbes.

5. **Nerve sensors** - induce protective reflexes.
Thermoregulation

- Normal body temperature is $36.5 - 37.5^\circ C$ (98–100°F)
- Changes in the evening, during ovulation & exercise.
- Temperature control centres are the hypothalamus and medulla oblongata (brain stem)

**Temperature regulation by the skin occurs via:**
1. Activity of sweat glands (water evaporates off skin)
2. Activity of blood vessels (vasodilatation/vasoconstriction)

Sweat glands and blood vessels are stimulated by the autonomic nervous system (ANS)
Thermoregulation

High body temperature → vasodilation of peripheral blood vessels to promote heat loss

Low body temperature → vasoconstriction of peripheral blood vessels to prevent heat loss
Thermoregulation

- Heat is produced by the liver, muscles and digestive organs. Adipose tissue is an insulator.

- Heat loss also by respiration through convection and evaporation (convection describes the movement of heat through liquids and gases).

- A pyrogen is a substance that induces a fever. They act on the hypothalamus to ‘re-set’ it & activate heat promoting mechanisms.

<table>
<thead>
<tr>
<th>Hypothermia</th>
<th>Hyperthermia</th>
</tr>
</thead>
<tbody>
<tr>
<td>A condition whereby core temperature drops below that required for normal metabolism and body functions</td>
<td>A condition whereby core temperature elevates above 38.5°C</td>
</tr>
<tr>
<td>Death usually below 25°C</td>
<td>40°C - life threatening. 41°C - brain death 45°C – death.</td>
</tr>
</tbody>
</table>

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Vitamin D Formation

- UV light activates a vitamin D precursor in the skin.

- Kidneys turn the precursor to calcitriol.

- Calcitriol acts as a hormone to increase uptake of calcium and phosphorus from food into blood, thus, ultimately supporting bone density.

- Vitamin D is stored in the liver.

\[ \text{calcitriol} = \text{active form of vitamin D} \]
# Absorption & Excretion

## Absorption

- **Lipid-soluble molecules:**
  - Vit A, D, E, K
  - Some medications
  - Corticosteroids
  - O₂ and CO₂.

- **Toxins:**
  - Acetone, carbon tetrachloride, lead and mercury, arsenic, poison oak and ivy

## Excretion

- Salt (sodium chloride)
- Water
- Urea
- Ammonia

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Wound Healing

Superficial wound:

• Includes abrasions and burns

• Basal cells move across the gap until contact inhibition occurs.

• Epidermal growth factor causes multiplication of the basal cells until space is filled

contact inhibition = the cessation of cell division in cells that touch each other
# Wound Healing

**Deep wound:** (affects dermis and subcutaneous layer)

| Inflammatory phase | • Migration of leukocytes to clean up any microbes, foreign tissue and dead matter.  
| • Blood clot forms & becomes a scab. Epithelial cells migrate beneath the scab to repair the basement membrane. |

| Proliferative phase | • Granulation tissue is formed with the reformation & laying of collagen fibres & blood vessels.  
| • Extensive growth, differentiation & repair of epithelial cells. |

| Remodelling phase | • Can take 3 weeks to 6 months.  
| • Scab sloughs off and scar tissue remains (fibrosis). |

*Granulation tissue = new connective tissue that fills wound*
Wound Healing

Video: Wound Healing
www.youtube.com/watch?v=6qU-0ETo5_s
Scar Tissue

- A mark left on the skin or other body tissues where a wound, burn or sore has not healed completely and fibrous connective tissue has developed.

- Contains denser collagen fibres, fewer hairs, glands, nerve endings and blood vessels (hence whiter)

- **Divided into:**
  1. **Hypertrophic scar**: stays within the boundary of the wound
  2. **Keloid Scar**: takes up a larger space than the wound (normally raised).
1) What are the names of the three main layers of skin?

2) What is the most superficial layer of epidermis called?

3) Explain the role of the skin in thermoregulation

4) How many days does it take to completely replace the epidermis?

5) What division of the nervous system innervates sweat glands?

6) What do Meissner's corpuscles detect in the skin?

7) Name the smooth muscle that attaches hair follicles to the dermis

8) Compare hypertrophic and keloid scars
Consider how a patient might feel about a skin disease compared to an internal disease of the body?
Skin Lesions

Skin lesions = Abnormal/damaged tissue with impaired function of skin.

<table>
<thead>
<tr>
<th>Papule</th>
</tr>
</thead>
<tbody>
<tr>
<td>A small, firm, elevated lesion</td>
</tr>
</tbody>
</table>

- Circumscribed, solid elevation of skin with no visible fluid
- Varying in size from a pinhead to 1 cm.
- Can be either brown, purple, pink or red in colour.
- Can see “maculopapular rash” like in measles
### Skin Lesions

#### Pustule

<table>
<thead>
<tr>
<th>Small, elevated, erythematous lesion containing purulent exudate</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Purulent material usually consists of necrotic inflammatory cells.</td>
</tr>
<tr>
<td>• These can be either white or red</td>
</tr>
</tbody>
</table>

#### Macule

<table>
<thead>
<tr>
<th>Small, flat, circumscribed lesion of a different colour to normal skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A change in surface colour, without elevation or depression (non-palpable)</td>
</tr>
<tr>
<td>• Well or ill-defined.</td>
</tr>
<tr>
<td>• Varies in size, but generally considered &lt;5-10mm in diameter.</td>
</tr>
</tbody>
</table>

*purulent = pus forming  
erythematous = red*
Skin Lesions

**Crust**

- Collection of dried body fluid (blood plasma & exudate) & dead skin cells (a scab).
- Exudate: any fluid that filters from the blood into lesions or areas of inflammation. Consists of plasma, blood cells, water, plasma proteins.

**Nodule**

<table>
<thead>
<tr>
<th>Palpable elevated lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Morphologically similar to a papule, but is bigger &amp; deeper</td>
</tr>
<tr>
<td>• Centred in the dermis or subcutaneous fat</td>
</tr>
<tr>
<td>• May be filled with inflamed tissue or fluid</td>
</tr>
<tr>
<td>• Depth is generally what differentiates a nodule from a papule.</td>
</tr>
</tbody>
</table>
## Skin Lesions

### Lichenification

Thick, dry, rough plaques of thickened skin

- Visible thickening of epidermis, with accentuated skin markings/pronounced lines
- “Bark like” appearance
- The hallmark of chronic eczema/dermatitis or excessive scratching.
Skin Lesions

### Erosion

**Shallow, moist cavity in the epidermis**

- Wearing away with loss of superficial layers of epidermis (from chemicals, friction or pressure).
- Moist, circumscribed and usually depressed.
- **Ulcer** in diabetes

![Erosion Image]

### Keloid

**Raised, irregular, increasing mass of collagen due to scar tissue formation**

- Abnormal scar tissue that grows beyond the boundary of the original site of a skin injury.
- Firm, rubbery lesions or shiny, fibrous nodules and can vary from pink to flesh-coloured or red to dark brown in colour.
- Vaccination site, scratching, burns

![Keloid Image]
## Comedone (Acne)

Blackheads, whiteheads or red bumps due to excess sebum, keratin and debris forming a plug in the sebaceous duct of a hair follicle.

- **Hormones (puberty)** can cause more and thicker oil secretions that plug a pore

- **Open comedo:** **Blackhead** \( (acne\ vulgaris) \)
  If oil is open to air it will **oxidise** > turns dark

- **Closed comedo:** **Whitehead**
  If skin has grown over oily material it doesn’t react with oxygen and remains white.
Eczema/Dermatitis

• The terms: eczema and dermatitis are interchangeable.

• A very common chronic, pruritic, inflammatory skin condition

**SIGNS & SYMPTOMS:**

• Depends on the type, but generally: Flaky, dry, oedematous (swelling from excessive accumulation of watery fluid in cells)

• Erythematous, pruritic (itchy), crusty, weepy lesions.

• Most commonly in flexure joints.

**COMPLICATIONS:**

• Scratching and rubbing leading to lichenification
Contact Dermatitis

• An acute inflammation of the skin caused by direct contact with an agent.
  • Divided into Irritant (80%) and Allergen contact dermatitis:

1) Irritant contact dermatitis (ICD):
  • Non-specific inflammatory reaction to a substance contacting the skin

• Local inflammatory mediators released by epidermal cells (immune system not activated).

• Abrasive chemicals can corrode the epidermis causing cutaneous ulceration

• Hands are vulnerable due to frequent occupational exposure to soap (that can abrade the lipids in skin).

• A type called phototoxic dermatitis in which topical (e.g. perfumes) or ingested irritants are activated by exposure to UV rays.
2. **Allergen Contact Dermatitis (ACD):**
   - A Type IV delayed hypersensitivity reaction

   - Sensitisation occurs on first exposure

   - **Pruritic, erythematous** rash develops at the site on subsequent exposures

   - Can occur with various chemicals, rubber, plants, metals

   - Multiple allergens cause ACD and cross-sensitisation among agents is common.

   - A variant called **photoallergic contact dermatitis** in which a substance becomes allergenic only after it undergoes structural change triggered by UV light. E.g. sunscreens.
Contact Dermatitis

SIGNS & SYMPTOMS
• Location of symptoms can give a clue to the irritant/allergen

• **Pruritic rash, sometimes burning, stinging, eroded, blistered skin.**

• Irritant contact dermatitis = Ulceration, burning, prickling, soreness and quicker onset of symptoms.

• Allergen contact dermatitis = Pruritis is significant. Slower onset of symptoms.

ALLOPATHIC TREATMENT:
• Identify and then remove the allergen. Steroids & anti-histamines

ALTERNATIVE TREATMENT:
• Topical Calendula, Chickweed, St John’s Wort, Aloe Vera. Herbs, homeopathy.

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Atopic Dermatitis/Eczema

- An immune-mediated inflammation of the skin due to the interaction between genetic & environmental factors.
- Pruritus is the primary symptom.
- Usually occurs in infancy/childhood
- Primarily affects children in urban areas or developed countries, and prevalence has increased over the last 30 years.

Common allergens:
- **Foods** (milk, eggs, soy, wheat, peanuts, fish)
- **Airborne** (dust mites, moulds, pollen)
Atopic Dermatitis/Eczema

- **Family history** of atopic disorders in 2/3 of cases: asthma or allergic rhinitis

- **Genetic weaknesses** in epidermal barrier function & immune system:
  - Some patients have a **mutation in the filaggrin gene**: a structural protein in the stratum corneum
  - **Loss of filaggrin** may result in **impaired skin’s barrier function** leading to entry of foreign environmental substances that may trigger immune responses.
  - The skin may be deficient in ceramides (**fatty acids**) increasing transepidermal water loss.
  - Type 1 hypersensitivity: **IgE** involved in 70 to 80% of cases “true allergy”
  - Predominance of pathogenic *staphylococcus aureus* in the skin flora of 90% of patients
Atopic Dermatitis/Eczema

- Scratching
- Defective skin barrier
- Microbes
- Allergens
- Systemic immune abnormalities
- Leads to other allergic diseases (asthma, allergies)

- Normal skin barrier
- Filaggrin granules

- Ichthyosis vulgaris and atopic dermatitis
- Defective skin barrier
- No filaggrin granules

References:

1. https://www.researchgate.net/figure/7078592_fig1_Figure-1-Homozygous-FLG-mutations-lead-to-complete-loss-of-filaggrin-expression-in-skin
Atopic Dermatitis/Eczema

SIGNS & SYMPTOMS:
• Red scaly lesions on flexor surfaces and cheeks. Very itchy
• Broken skin on scratching → lichenification
• Infection on skin (very inflamed and with pus)

INVESTIGATIONS:
• Blood tests - IgE levels, eosinophils

TREATMENT:
• Identification of allergen, avoiding skin irritants
• Allopathic: Corticosteroids, soap substitutes.

• Alternative: Quercetin & bromelain, licorice. Essential fatty acids, zinc, vitamin D, GIT health – gut flora, allergy investigation & treatment, use natural fibres e.g. cotton, avoid chemicals in cleaning products. Herbs & homeopathy.
Urticaria (Hives)

• An itchy (pruritic), red (erythematous), blotchy and raised rash resulting from swelling of the superficial skin.

• Attacks beyond 6 weeks are designated ‘chronic’ urticaria. Normally transient episodes.

• Can develop in the pharyngeal mucosa causing swelling in the throat and obstruction of the airways.

• Occurs due to the release of histamine from mast cells (causing vasodilation and capillary leakage). Some causes include medications, food allergies, stings, stress

• ALLOPATHIC TREATMENT: Anti-histamines.

• ALTERNATIVE TREATMENT: Immune support, address causal factors, elimination diet, lower endogenous histamine

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Psoriasis

- A chronic inflammatory skin disease

- Keratinocytes divide 1000x faster than normal cells and move quickly through epidermis.

- The immature cells shed prematurely (little as 7 days) and make abnormal keratin that forms silvery flakes on skin surface.

hyper = elevated
kerato- = keratin
osis = a process

Hyperkeratosis

Capillary loop dilation often seen in psoriasis
Psoriasis

CAUSES:

• Environmental, genetic and immunologic factors

• T-Lymphocyte mediated hyperproliferation of keratinocytes

• Genetic defect in mitotic control

• Certain drugs can worsen condition (lithium, beta blockers, anti-malarials). Susceptibility may be due to genetic defects in detoxification enzymes

TRIGGERS:

• UV light, infection, chemicals, alcohol abuse, stress, anti-malarials, beta-blockers.
Psoriasis

SIGNS & SYMPTOMS:
• **Red scaly plaques covered with overlapping silvery shiny scales that may bleed**
• Characteristically involves **extensor surfaces** (wrists, elbows, knees) and **scalp**.
• Possibly tiny dents in finger/toenails.
• **Arthritis** (14% → autoimmune)

ALLOPATHIC TREATMENT:
• Corticosteroids, UV light therapy, methotrexate

ALTERNATIVE TREATMENT:
• Diet, EFAs, Vit D, detoxification, GIT treatment, liver support, Aloe Vera, epsom salt baths.

An immunosuppressant – consider the side effects!
Acne Vulgaris

- Blockage of sebaceous/hair follicle duct
- Common in teenagers.
- Associated with excess sebum production. Epithelial cells can “plug” the follicle.
- Tends to affect the face and back

CAUSES:
- Hereditary
- Excess androgen levels
- Premenstrual hormonal imbalances
- Oily creams
- Some drugs (anabolic).
Acne Vulgaris

• **Closed comedones (white heads):** Accumulation of sebum

• **Open comedones (black heads):** Oxidised lipids causes dark colour.

• **Inflammatory acne** can occur which begins as closed comedones. Distension of the follicle occurs causing inflammation (red papules)

• **Cysts** can occur when follicles rupture resulting in a pustule/nodule

• Large, deep pustules can break down adjacent tissue and cause scarring
Acne

Infantile acne:
• ‘Milk spots’ due to maternal androgens.

Steroid acne:
• Due to steroid intake - usually on the back and shoulders.

Oil acne:
• From workers that work with oils.
Allopathic Treatment:
- **Roaccutane** – often short lived.
- Facial cleansers
- Topical or oral antibiotics for 3-4 months
- OCP with anti-androgen
- UVB therapy

Alternative Treatment:
- Hormone balancing
- Alkaline diet, plenty of water, remove dairy & wheat, detox, skin hygiene, nutrients – zinc, sulphur, Vit E, Vit A (not if on Roaccutane!).
- Herbs & homeopathy.
Acne Rosacea

- Chronic Inflammation of the skin associated with vascular changes, which results in flushing.
- Often accompanied by seborrhoea (excessive discharge of sebum) but is not an inflammation of the follicles.
- The eyes may be affected and inflamed (ocular rosacea)
- Suspected that other organs are affected too, such as the stomach, intestines, bile ducts, blood.
- More common in women

SIGNS & SYMPTOMS:
- Facial flushing - redness across nose & cheeks, seborrhoea (oily skin) with papules, pustules
Acne Rosacea

CAUSE(S):
• Exaggerated vasodilatory response to hyperthermia

• **High incidence of gastric H.Pylori found in rosacea patients (88%).**
  Flushing reaction may be caused by gastrin (gastrin = H.Pylori growth)

• Other causes include **environmental** (oil, chlorine, UV), **cosmetics** (e.g. paraffin), poor **hygiene**, **medication** (steroids, vitamins, psychotropic drugs, OCP), **infection** (fungal), **stress** (increases production of androgens).

ALLOPATHIC TREATMENT:
• Mild local treatment with NSAIDs and antibiotics

ALTERNATIVE TREATMENT:
• Treat digestive system, identify food allergies/intolerances, probiotics, zinc, Vit. C to support the blood vessels, B vitamins, local packs with black tea (strong, lukewarm for the tannins), light therapy, Aloe Vera (internally & externally), homeopathy.
Warts & Verruca's

- Benign proliferation of the skin and mucosa caused by infection with the Human Papilloma Virus (2 and 4)

- Viral replication occurs in the upper level of the epithelium, however viral particles can be found in basal layers.

**SIGNS & SYMPTOMS:**
- Papular lesions with a coarse roughened surface
- Usually red margin. May crack or bleed.

**TREATMENT:**
- **Allopathic:** Laser or freezing (*suppression, not a cure*)

- **Alternative:** Often disappear spontaneously, antiviral herbs - Thuja, Olive leaf, St John's Wort, lysine, homeopathy
Skin tags

- Small growths attached to skin by stalk
- Often neck, axilla, groin, eye lid, anus. Generally occurs in areas where skin rubs.
- Skin coloured or darker and can bleed when knocked. They often drop off.
- Associated with hyperinsulinaemia (common in type 2 diabetes)

hyper- = elevated
Insulin = hormone that lowers blood sugar
-aemia = in blood
Vitiligo

• The skin loses its pigmentation due to the loss of Melanocytes.

• Onset at any age, 50% under 25 years.

• Not contagious.

• Noticeable in races with darker skin

CAUSE(S):
• May be a genetic susceptibility
• Autoimmune link: Increased number of Langerhan cells → hypothesised these cells may inhibit the proliferation of melanocytes)
Burns

- Injury to the skin or tissues caused by heat, cold (frostbite), electricity, radiation, chemicals (strong acid/bases)

**SIGNS & SYMPTOMS:**
- Damage of the skin with necrosis → pain
- Electrical burns injuries may extend beyond tissue damage (cardiac arrhythmia/fibrillation) etc.

**TREATMENT:**
- **Allopathic**: Skin grafting for deep burns, fluid and electrolyte replacement, pain management
- **Alternative**: Aloe Vera, Calendula, homeopathy.
CLASSIFICATION:

- **1<sup>st</sup> degree**: affects the epidermis
- **2<sup>nd</sup> degree**: all of epidermis and some dermis
- **3<sup>rd</sup> degree**: extends into subcutaneous tissue
- **4<sup>th</sup> degree**: extends into muscles and tendons

http://www.wisegeek.com/what-is-the-treatment-for-third-degree-burns.htm
Burns

COMPLICATIONS:

- **Dehydration** – due to loss of water and plasma through damaged skin surface.

- **Hypothermia** – due to impaired thermoregulation and heat loss

- **Hypovolaemic shock.**

- **Infection.**

- **Renal failure** – if the kidneys cannot filter waste from broken down red blood cells and damaged tissue.

- **Contractures** – scar tissue contracts distorting skin and impairs movement.

*Note: hypo = low, vol- = volume, -aemic = blood*
The Lymphatic System

• Closely allied to the cardiovascular & immune system

• The lymphatic system consists of thin-walled vessels that transport fluid throughout the body, resembling veins in structure

• Lymph travels from lymphatic capillaries, which unite to form larger lymphatic vessels.

• Lymphatic vessels ultimately drain into the thoracic duct or the right lymphatic duct.

• Functions:
  1. Return proteins, lipids and water from the interstitial fluid to the blood.
  2. Immunity against harmful organisms
Resemble veins but have thinner walls and more valves
The lymphatic system consists of:

- **Lymph fluid** (lymph)
- **Lymph vessels** which start in the tissue
- **Lymph nodes**
- **Lymph organs** (spleen & thymus)
- **Lymphoid tissue** (e.g. tonsils)
- **Bone marrow**

**Metastasis of malignant tumours can occur via lymphatic vessels and establish new tumours where they lodge causing secondary cancers.**

*Metastasis = spread to a secondary site*
Lymph

- **A watery fluid** similar to blood plasma but with less plasma proteins.

- Same composition as interstitial fluid, which is found between cells & lymph is in lymphatic vessels, tissues & between organs.

**Contains:**
- Water
- Leukocytes
- **Plasma proteins** (seeped out of capillaries)
- Fats absorbed from the small intestine
- Bacteria and cell debris from damaged tissue
**Lymphatic Vessels**

**CAPILLARIES**
- Located in spaces between cells
- Blind end tubes - one way structure.
- Recall: lacteal is a blind ended lymph vessel in the small intestine.

**LARGER LYMPH VESSELS**
- Have 3 layers like veins.
- Numerous cup shaped valves.
- Vessels unite to form lymph trunks

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The cardiovascular system is a \textit{circular and closed system} in which the fluid (blood) leaves from and returns to the heart.

In comparison, the lymphatic system is a \textit{linear system} in which the lymphatic capillaries at the peripheral tissues drain lymphatic fluid containing cells, proteins, and macromolecules and transport it back to the vascular system.

(Diagram modified from Karkkainen et al. 2002.)
Lymphatic Nodes

- Lymph nodes filter lymph and remove foreign matter such as microbes, cell debris and tumour cells.
- Lymph passes through a number of lymph nodes before returning to blood.
- 600 Bean shaped structures located in groups along lymph vessels throughout the body.
- Generally follow same route as veins
- Filled with immune cells (lymphocytes & phagocytes).

Lymphatic Nodes

- Lymph enters via *afferent* vessels
- Foreign substances are *trapped* in irregular channels by reticular fibres
- *Macrophages* destroy foreign substances by phagocytosis
- Whilst *lymphocytes* destroy remainder by immune response
- Filtered lymph leaves via *efferent* vessels
- Many afferent vessels, very few efferent. This slows down the flow of lymph
Lymph Nodes

- 5 locations contain many: Cervical, axillary, inguinal, vertebral column, mesenteric (intestinal)

- Develop during childhood, **atrophy begins in adolescence**

- Material not filtered passes on to the next node so by the time the lymph returns to the blood stream it should be clean.

- During the early stages of infection, incomplete phagocytosis of microbes & other material can cause swelling / inflammation of the lymph nodes – **lymphadenopathy**.
Spleen

- **The largest lymph organ** – same size as the heart.
- Located between the stomach and diaphragm on the left
- Similar in shape & structure to lymph node
- Contains white pulp and red pulp:
  - White pulp contains lymphocytes & macrophages
  - Red pulp contains all the components of circulating blood
- **Functions:**
  1. Haemopoiesis in foetus
  2. Blood reservoir
  3. Phagocytosis of worn out of defective erythrocytes & platelets

**Haemopoiesis = production of all blood cells**
Spleen

- Spleen rupture can occur following trauma
- Damage to the thin-walled veins (sinuses) can cause significant haemorrhage and shock.
- Removal is needed to prevent death.
- Liver and red bone marrow can take over some function, however immune function is compromised.
**Thymus**

- A bi-lobed organ that plays important role in immune development & antibody production in early life.

- Contains epithelial cells, T-cells, dendritic cells & macrophages

- Epithelial cells produce thymosin which promotes the maturation of T-lymphocytes (produced in the red bone marrow)

- T-cells that leave the thymus via the blood migrate to lymph nodes and other lymphatic tissues where they colonize.

- Atrophy begins in puberty (age 12), declining throughout life – tissue is replaced by fat

Implicated in autoimmune diseases
Mucosa Associated Lymphoid Tissue

- Small aggregations of lymphoid tissue found in areas of the body exposed to the external environment → First line of defence

- MALT that is found in the digestive system is also called GALT (Gut Associated Lymphoid Tissue).

- Some examples where MALT can be found:
  - **Adenoids** (MALT but not GALT as found in nasal cavity not GIT)
  - **Tonsils**
  - **Small intestine (Peyer’s patches)**
  - **Appendix & large intestine**
Lymphatic System Functions

1. TISSUE DRAINAGE:

• **Blood arrives at the tissue at high pressure** so some of the fluid and nutrients are forced out of the capillaries into the interstitial fluid.

• The remaining cells and plasma proteins in the blood create a **osmotic pressure which maintains blood volume**. Tissue fluid is at lower pressure.

• Interstitial fluid contributes to the nourishment of tissues. 90% returns to circulation via veins. The other **10%** containing high molecular weight proteins is absorbed into lymphatic capillaries.

• **The lymphatic system is responsible for draining and recirculating this extra fluid and returning it to the blood stream**.
Lymphatic System Functions

Wall of lymphatic capillary

Opening into lymph vessel

Tissue cell

Tissue fluid

Venous system

Arterial system

Heart

Lymph duct

Lymph trunk

Lymph node

Lymphatic system

Lymphatic collecting vessels, with valves

Lymphatic capillary

Blood capillaries

Loose connective tissue around capillaries

Arteriole

Tissue fluid

Filaments anchored to connective tissue

Endothelial cell

Flaplike valve

Fibroblast in loose connective tissue

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Lymphatic System Functions

- Lymphatic fluid is drained with assistance of this following:

- **Mild, rhythmical contractions of the lymphatic vessels** (lymphatic pump)

- **Skeletal muscle pump**: Movement/exercise drains fluid. Especially the calf muscles (gastrocnemius & soleus)

- **Respiratory pump**: During inhalation air pressure drops in the thoracic region. Lymph moves from high to low pressure
Lymphatic System Functions

2. ABSORPTION:

- Lacteals absorb fat-soluble substances/nutrients from the small intestines into the body:
  - Dietary fats
  - Fat-soluble vitamins (A, D, E & K)

3. IMMUNITY:

- Lymph organs are concerned with the production and maturation of lymphocytes:
  - Lymph nodes
  - Spleen
  - Thymus
  - Bone marrow
Cellulitis

- A diffuse bacterial infection & inflammation of dermal and subcutaneous layers.
- Usually occurs through broken skin: cracks, cuts, blisters, burns, insect bites, surgical wounds or sites of intravenous insertion.
- Skin on the lower legs or face are most commonly affected and present as very red, inflamed skin.
- Also causes malaise and fever.

**TREATMENT:**
- **Allopathic:** Antibiotics (*side effects!*)
- **Alternative:** Antimicrobial herbs & essential oils topically, immune support, homeopathy.
Lymphangitis

• Inflammation of the lymph vessel.

• Bacterial infection - usually *Streptococcus*.

**SIGNS & SYMPTOMS:**

• **Swelling, painful red lines** below skin surface along the lymph vessel course

• Fever, malaise, muscle ache, low appetite.

**COMPLICATIONS:**

• Infection may spread to the blood → **septicaemia** *(hence a medical emergency)*

*lymph = lymphatics
angi(o)- = vessel
-itis = inflammation*
Lymphoedema

• Localised lymphatic fluid retention associated with a compromised lymphatic system so reduced lymphatic return

• Obstruction of lymph vessels causes an increase in protein accumulation in the interstitial fluid

↑protein = water retention, swelling of soft tissue [stage 1 – pitting oedema]
↑protein = inflammation and activation of fibroblasts [stage 2 – fibrosis of vessels]

CAUSES:
• Primary: Congenital, poorly developed, missing lymph nodes

Secondary:
• Damage to the lymphatic system caused by radiotherapy or lymph node removal
• Infections: Elephantiasis, cellulitis etc.
Lymphoedema

SIGNS & SYMPTOMS:
• Severe **fatigue**
• Heavy, painful, **swollen** limb/area (**pitting oedema**)  
• Discolouration of the skin overlying the lymphoedema
• Recurring skin infections in the effected limb which may lead to thickening & hardening of the overlying skin.

COMPLICATIONS:
• Recurrent infection, cellulitis, lymphangitis, **septicaemia**.

TREATMENT:
• Incurable but controlled with compression bandages, manual lymph drainage and therapeutic exercise.
Elephantiasis

• The third irreversible stage of lymphoedema.

CAUSES:
• Cancer, surgery, genetic, injury, radiation therapy, obesity, liposuction, burns, circulatory disease, multiple sclerosis
• Parasitic infection: Wucheria bancrofti

SIGNS & SYMPTOMS:
• Swelling, skin hardening / breakdown
• Extensive fibrosis

TREATMENT:
• Treat the cause. Surgery if essential.
Lymphadenitis

- Inflammation of lymph nodes.
- Usually a bacterial infection

**SIGNS & SYMPTOMS:**
- Often following upper respiratory infection (ie. Sore throat)
- **Enlarged lymph nodes** that are often painful on palpation

**COMPLICATION:**
- Lymphangitis.

**TREATMENT:**
- **Allopathic:** Antibiotics (*side effects!*)
- **Alternative:** Antimicrobial herbs, immune herbs & nutritional supplements, homeopathy.
Splenomegaly

- Enlargement of the spleen due to increased workload that may be associated with many diseases.

**CAUSES:**
- **Viral or bacterial infections** e.g. infectious mononucleosis (glandular fever), syphilis, endocarditis, malaria
- **Liver diseases** such as cirrhosis leading to portal vein hypertension
- **Haemolytic anaemias** e.g. Thalassemia, Sickle cell anaemia
- **Blood malignancies:** Leukaemia & Hodgkin's disease

Remember the spleen is the graveyard for erythrocytes (site of haemolysis)

spleno- = spleen
-megaly = enlargement
Splenomegaly

SIGNS & SYMPTOMS:
- Abdominal pain
- Early satiety (due to splenic encroachment)
- Symptoms of haemolytic anaemia due to accompanying cytopenia
- Palpable left upper quadrant abdominal mass.

COMPLICATIONS:
- Anaemia, increased bleeding, frequent infections
- Ruptured spleen.

TREATMENT:
- Treat the cause.
- Herbs, acupuncture, Homeopathy, diet.
Summary Quiz!

1) What is the function of lymph nodes?

2) Explain the similarities in structure between a lymphatic vessel and vein.

3) What is the role of the thymus?

4) What does lymph transport?

5) What is the difference between the red and white pulp of the spleen?

6) What is meant by splenomegaly? Give two causes of splenomegaly.

7) What is meant by the term lymphangitis? How might this present clinically?

8) Explain what assists lymphatic fluid draining.