Principles of Lymphatic System

Haemopoietic system
- Red bone marrow – active bone marrow, where red blood cells, certain white blood cells, and platelets are produced.
  - Remains in axial skeleton for life.
  - Becomes yellow marrow in limbs during adolescence.
- Yellow bone marrow – may revert to red after severe blood loss.
- Haemopoietic tissues in other organs.

Lymphatic system – lymph vessels, lymph nodes, lymphoid organs, lymphoid tissue in other organs.

Roles of lymphatic system
- Lymph return
  - Net fluid loss from arteriovenous capillaries to interstitial compartment.
  - All lymph is normally returned to venous system.
- Defence – foreign material is carried in lymph to lymph nodes → filtered and brought into contact with defence cells.

Lymphatic pathways
- Superficial lymph capillary → deep lymph capillary → afferent lymphatic → lymph node → efferent lymphatic → lymph trunk → thoracic or right lymphatic duct → venous system.
  - Multiple afferents → node → single efferent.
- Major palpable lymph node groups typically subdivided into superficial and deep groups.
  - Each located adjacent to a major vein.
  - Lymph drains from superficial to deep nodes.
  - Example: superficial cervical nodes (EJV) → deep cervical nodes (IJV).
- Skin of almost entire body drains to superficial groups.
  - Except parasternal skin and glans (penis/clitoris).
- Lymph from particular organ or body area drains through at least one set of lymph nodes before reaching venous system.

Lymph capillaries are present only in tissues derived from the mesoderm.
- Not present in epithelia.
- Abundant in subepithelial layer – particularly dermis (skin) and lamina propria (mucous membrane).

Absence of lymph capillaries in:
- Non-mesoderm tissues – epidermis and cornea (ectoderm), other epithelia (endoderm), CNS (neuroectoderm).
- Avascular structures – articular cartilages.
  - Articular cartilage is mesoderm-derived, but solid matrix subject to continuous compression would collapse any lymph capillaries if present.
- Where they are abundant, lymphatic capillaries link freely to form communicating networks.
  - Dermal plexuses – lymph capillary plexuses in skin comprising superficial dermal and deep dermal.
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<table>
<thead>
<tr>
<th>Superficial (‘initial’) lymph capillaries</th>
<th>Deep lymph capillaries (pre-collectors)</th>
</tr>
</thead>
<tbody>
<tr>
<td>found directly under an epithelium</td>
<td>internally capillaries and lymphatics</td>
</tr>
<tr>
<td>papillary layer of dermis</td>
<td>reticular layer of dermis</td>
</tr>
<tr>
<td>blind origin</td>
<td>between initial capillaries and lymphatics</td>
</tr>
<tr>
<td>single endothelial layer</td>
<td>patches of smooth muscle cells in surrounding wall</td>
</tr>
<tr>
<td>tiny filaments of fibrillin between cells → temporary intercellular gaps when ISF volume ↑</td>
<td>transitional in structure</td>
</tr>
<tr>
<td>saccular, no basement membrane</td>
<td>intermittent basement membrane</td>
</tr>
</tbody>
</table>

Lymphatics
- Larger tributaries that lymph capillaries drain into.
- Very thin walls, but thicker than lymph capillary walls.
  - Low luminal pressure → easily compressed.
- Possess basement membrane, circumferential smooth muscle cells and pacemaker cells → spontaneous rhythmic contractions.
- Larger vessels have valves – formed by infolding of endothelium → one way flow → directed to venous system.

Lymph drainage
- Lymph vessels tend to accompany veins – superficial and deep lymphatics accompany superficial and deep veins respectively.
  - Except where they don’t – in abdominal cavity, lymphatics accompany arteries to front of aorta rather than accompany portal vein to liver.

Lacteals – intestinal lymphatics.
- Contain chyle – lymph rich in lipid absorbed after a meal.
- Do not accompany intestinal veins to portal system of liver.
  - Accompany artery → lymph duct → systemic veins.
  - Other nutrients absorbed into portal venous blood.

Lymph trunks

<table>
<thead>
<tr>
<th>Lymph trunks</th>
<th>Drains lymph from</th>
<th>Accompaniess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jugular</td>
<td>head and neck</td>
<td>internal jugular vein</td>
</tr>
<tr>
<td>Subclavian</td>
<td>upper limb</td>
<td>subclavian vein</td>
</tr>
<tr>
<td>Bronchomediastinal</td>
<td>thorax</td>
<td>runs independently of blood vessels</td>
</tr>
<tr>
<td>Lumbar</td>
<td>abdomen, pelvis and lower limb</td>
<td>aorta or its branches</td>
</tr>
<tr>
<td>Intestinal (unpaired)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lymph ducts
- Where jugular, subclavian and bronchiomediastinal lymph trunks drain into.
- Right lymphatic duct – short common channel formed by the lymph trunks.
- Thoracic duct
  - Traverses entire length of thorax – aortic opening of diaphragm to root of neck.
  - Thin walls with valves → beaded appearance.
  - Flow dependent on thoracic pump.
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- Variable and each often enters venous system independently.
  - Right lymphatic duct may be absent.

Cisterna chyli – small sac adjacent to aortic opening of diaphragm.
- From which thoracic duct typically originates.
- Drains lymph below diaphragm.
  - Receives intestinal lymph trunk (with chyle).
  - Receives lumbar lymph trunks.

Lymph flow
- Vascular pump – ‘milking effect’
  - Intimate contact with veins, common direction of flow.
- Muscular pump – ‘squeezing effect’
  - Contraction of adjacent muscles.
- Thoracic pump – ‘sucking effect’
  - Oscillation of intrathoracic pressure with respiration.

The termination of lymph ducts occurs where the venous pressure is about zero, whether upright or supine.
- About level of heart at thoracic inlet.
- Empty into origin of brachiocephalic veins.
- Lymphatic ducts have valves and arch up into root of neck just prior to entry into venous system → prevent backflow of blood into lymphatic system.

Lymphovenous communications
- Peripheral connections between some lymphatics and veins.
- Some veins emerge from hila of lymph nodes.
- Numerous communications between thoracic duct and tributaries of azygos veins in thorax.
→ Accounts for significant proportion of fluid return.

Lymphatic spread
- Tumour cells and microbes carried along with lymph → spread tumours and infections.
- Exposed to defence cells at lymph nodes → lymph nodes enlarge.
  - Infection → tender.
  - Tumour → firm.
- Difficult to predict path of tumour cells carried by lymphatics because:
  - Occlusion of some lymphatics by tumour cells.
  - Variation and overlap of lymph drainage territories.
  - Posture and external compression influence lymph flow.
  - Lymphovenous communications → potential avenues for short circuit.
  - Certain tumours produce growth factors → generate new lymph capillaries.

Lymph nodes: Discrete encapsulated collections of lymphoid tissue.
- Contain lymphocytes and associated cells.
  - Release lymphocytes into venous system.
- Kidney-shaped with a hilum – where efferent lymphatic and vein leave, and artery enters.
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- Mechanical filter of lymph – remove particulate matter.
  - Example: Carbon in lungs → lymph nodes appear black.
- Exposes antigens to immune system – humoral and cellular mechanisms.
- Somatic and visceral
- Numerous near viscera, along aorta and at major junction areas of the trunk.

Sentinel lymph node.
- The first lymph node encountered in the path of lymph drainage from a particular organ or area of body.
- Guard the rest of the body from dissemination of tumour cells or microbes.
- Significant for clinical assessment of tumour spread.

Major lymph node groups
- At gateways of trunk – cervical, axillary, inguinal.
- Palpable on physical examination.

After puberty, lymphoid tissue (especially the thymus) involutes with age.
- Lymphoid organs
  - Thymus – release T cells, lymphocytes involved in cell-mediate immunity.
  - Spleen – filters blood, picks up antigens, releases lymphocytes into bloodstream, removes old rbc from circulation, rbc storage.
- Lymphoid tissue
  - Mucosal associated lymphoid tissue (MALT) – in digestive, respiratory and urinary tracts.
  - Tonsils – Waldeyer’s ring at junction of upper digestive and respiratory tracts.
  - Peyer’s patches – arranged longitudinally in ileum, along anti-mesenteric border → lymphatics pass transversely.

Watershed areas: Zones of overlap where lymph may drain in more than one direction.
- Numerous communicating networks of lymph capillaries → overlap across adjacent lymphotomes.
  - Associated with more than one direction of venous drainage.
- Vertical watersheds – along lines of fusion during development.
  - Midline watershed – lymph drains to corresponding node on both sides of body.
  - Vertical cutaneous watershed – centred on nipple lines over thorax.
- Horizontal watersheds
  - Cervical-axillary watershed, axillary-inguinal watershed.
  - Junctional zones in mucous membranes, mucocutaneous junctions.
- Clinically important in spread of cancer or infection.
  - Tumour cells or microbes may be carried in more than one direction → need to anticipate routes of spread.