Review:
Organs of the Immune System

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Review Objectives:

- Understand structure and function of primary and secondary lymphoid organs.
The immune system involves multiple organs, tissues, cell types, and proteins.

- Primary and Secondary Lymphoid Tissues.
Primary/Secondary Lymphoid Tissues

Primary:
- Foetal Liver
- Adult Bone Marrow
- Thymus Gland

Secondary:
- Spleen
- Lymph Nodes
- Tonsils
- Appendix
- Peyer’s patches
- Aggregates of cells in lamina propria (GALT, BALT, MALT)
- Bone Marrow
Thymocytes are educated to become T lymphocytes.

- Expression of specific receptors.
- T cells learn to recognize self as self.
Secondary: The Spleen

• The spleen is a filter for blood.

• **Red pulp** = splenic cord and sinuses (RBCs).
  - Cord of Billroth

• **White pulp** = lymphoid tissue.
Splenic Circulation

- Splenic artery enters at hilum and branch into trabecular arteries.
- Trabecular arteries branch repeatedly and eventually enter splenic pulp as central arteries.
- Central arteries are sheathed by T lymphocytes.
  - Periarterial Lymphatic Sheath (PALS)
  - PALS and follicles form the white pulp
- Central arteries form peniciller arterioles that empty into capillaries.
- Capillaries empty into sinusoid, which are drained into trabecular veins.
- Emptying of blood completed by exiting through splenic vein.
Splenic Circulation
• Red pulp contains RBCs, splenic cords and splenic sinuses.  
• Splenic cords (cords of Billroth) are a network of reticular fibers.  
• Splenic sinuses are lined by endothelial cells  
  • Not tightly bound together  
  • Allows macrophage movement to filter damaged cells and foreign particulates
The white pulp contains the lymphoid tissue, arranged around a central arteriole as a periarteriolar lymphoid sheath (PALS). PALS composed of a Germinal Center surrounded by a Mantle and Marginal Zones.

- Central Artery
- Periarterial Lymphatic Sheath
- Follicle/Germinal Center
- Mantle Zone (B cells)
- Marginal Zone (B and T cells)
- Follicle/Germinal Center
- Periarterial Lymphatic Sheath
- Central Artery
- Mantle Zone (B cells)
- Marginal Zone (B and T cells)
• A network of reticular fibers also supports the parenchyma of the white pulp.
Lymphatics – On the Road to the Lymph Node

- Lymph nodes receive lymph via terminal lymphatics
  - blind-ended, endothelium-lined tubes
  - present in most tissues in similar numbers to capillaries.

- In acute inflammation, the lymphatic channels become dilated and drain away fluid (inflammatory exudate)
  - Limits the extent of tissue edema.

- Antigens are also carried to the regional lymph nodes
  - Processing by APCs
  - Recognition by lymphocytes (immunologic surveillance).
Lymphatics and Circulation

- Vessels capture extracellular fluid in spaces between tissues.
- Terminal Lymphatics are blind-ended, endothelium-lined tubes
  - Present in similar numbers to capillaries.
  - Pass through collecting lymph nodes or lymphoid organs
  - Contents are sampled by immune system cells
  - Vessels empty into thoracic duct to rejoin venous system
Lymphatics to Lymph Nodes

• Lymphatics drain in one direction, using specialized valves.
• Lymph drains into collecting lymph nodes via afferent lymphatic vessels.
• Fluid leaves lymph nodes via efferent lymphatics.
• Lymphatic vessels empty into the thoracic duct which joins the venous system at the junction of the internal jugular and subclavian veins.
Lymph Nodes

• Ovoid- to kidney- shaped organs that filter lymph.
• Has a dense irregular collagenous connective tissue capsule.
• Made up of a network of reticular tissue that acts as a framework for housing lymphocytes and APCs.
• Has medula and cortex, separated by a paracortex.
Secondary: They Lymph Node

- Lymphoid secondary (mostly B cells) follicle
- Trabecula
- Antigen presenting cells
- Germinal Center
- Mantle zone
- Medulla
- Paracortex (mostly T cells)
- Primary lymphoid follicle
- Medullary sinus
- Subcapsular sinus
- Post-capillary venule (arrow indicates flow of lymphocytes)
- Efferent lymphatic vessel (arrow indicates flow of lymphocytes)
- Afferent lymphatic vessel (arrow indicates flow of lymph and lymphocytes)
Figure 13.18. Structure (a) and photomicrograph (b) of a lymph node. X18.

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Lymph Node – Cortex and Paracortex

- Subcapsular sinus located beneath the capsule. Lymph empties into the medullary sinuses via the cortical or paratrabecular sinuses.

- **Outer cortex comprised of diffuse lymphoid tissue**
  - macrophages, T-lymphocytes, plasma cells, and reticular cells
  - lymphoid nodules (primary follicles) composed of B-lymphocytes
  - germinal centers (2° follicles) composed of activated B, T, and macs

- **The inner (or deep) cortex (paracortex) is a continuation of the outer cortex.**
  - contains diffusely arranged T-lymphocytes
  - lymphoid nodules are not normally present.
Lymph Node Follicles

- Connective tissue sends trabeculae throughout the node.
- Primary follicles contain quiet B cells.
- Secondary follicles have active centers.
- Sinusoids can be seen in the medulla region.
Lymph Node Follicles

- Secondary follicles have active germinal centers, surrounded by a mantle zone.
  - Tingible body macrophages may be present with large cytoplasm
High Endothelial Venule (HEV) in Paracortex

Specialized vessels which serve as the point of entry for lymphocytes from peripheral blood into the lymph node parenchyma.
Major Organs of the Immune System (Lymph Node)

- Lymphoid follicle (mostly B cells)
- Medullary sinus
- Artery
- Vein
- Efferent lymphatic vessel
- T-cell area
- Afferent lymphatic vessel
- Germinal center
- Marginal sinus
Secondary Lymphoid Tissue

Remember: MALT, GALT, BALT (aggregates of cells in the lamina propria of mucosa-, gut- bronchus).
Tonsils

- **Palantine Tonsils**
  - Stratified squamous nonkeratinized epithelium
  - Tonsilar crypts, germinal centers
  - Dense irregular capsule, septa present

- **Lingual Tonsils**
  - Stratified squamous nonkeratinized epithelium
  - Lymphatic nodules with germinal centers
  - Thin, ill-defined capsule
  - Seromucous glands open into crypt base

- **Pharyngeal Tonsils (adenoids)**
  - Pseudostratified ciliated columnar epithelium
  - Thin capsule, germinal centers, lack true crypts
  - Seromucous glands, ducts present
Secondary Lymphoid Tissue

MALT, GALT, BALT (aggregates of cells in the lamina propria of mucosa-, gut- bronchus).

- Unencapsulated lymphoid aggregates.
- Structure of the lymphoid follicles is same as in lymph nodes.
- Mucosal B cell response usually produces IgA.
- Protects against exposure to foreign antigens that enter the respiratory or GI tract.

- Peyer’s Patch is a prime example.
  - Located in ileum
  - Each “patch has up to 200 nodules
  - Contains Microfold (“M”) cells to transfer antigen across gut

We will look at some examples under the microscope.
Appendix

• A blind-ended tube connected to the cecum; a pouch-like structure of the colon.
• Located near the junction of the small intestine and the large intestine.
• May harbor and protect bacteria that are beneficial in the function of the human colon.
General Inflammation

Accumulation of lymphoid cells can be evident during inflammatory responses.

- Infection
- Tissue Damage
- Stress
- Autoimmunity
Dermatitis
That's All Folks!
Which cell type is not an antigen presenting cell?

A. Astrocytes
B. Dendritic cells
C. Langerhans cells
D. T lymphocytes
E. B lymphocytes

Option D (T lymphocytes) is correct. Antigen Presenting Cells (APCs) are found primarily in the skin, lymph nodes, spleen and thymus. They may also be present throughout the diffuse lymphoid system. Their main role is to present antigens to antigen-sensitive lymphoid cells. Facultative antigen presenting cells are those that may be induced to present antigens, and include multiple cell types such as astrocytes in the brain, follicular cells of thyroid and fibroblasts in connective tissue. B lymphocytes are extremely good at presenting antigen, especially after recognition by its specific surface expressed immunoglobulin.
A 7-year old child involved in a car accident developed complications leading to removal of her spleen. Which statement accurately describes the physical characteristics of the spleen?

A. The spleen is a filter for lymph
B. The red pulp contains the lymphoid tissue, arranged around a central arteriole as a periarteriolar lymphoid sheath.
C. Eosinophils cells are found in marginal centers where they present antigen to lymphocytes
D. The periarteriolar lymphoid sheath is composed of a germinal center surrounded by a mantle and marginal zones
E. Hassels corpuscles are located in the medulla

Option D (The periarteriolar lymphoid sheath is composed of a germinal center surrounded by a mantle and marginal zones) is correct. The spleen is a filter for blood that is histologically comprised of red and white pulp. The red pulp is composed of vascular sinusoids containing large numbers of macrophages, and is actively involved in the removal of dying and dead erythrocytes, as well as in the removal of infectious agents. The white pulp contains the lymphoid tissue, arranged around a central arteriole as a periarteriolar lymphoid sheath (PALS). The PALS is composed of T and B cell areas, and follicles containing germinal centers. The germinal centers are where B cells are stimulated to become plasma cells which produce and secrete antibodies.
The appropriate medical care and clinical course of action associated with loss of the spleen in this child includes all except which?

A. Updating immunizations  
B. Aggressive antibiotic therapy  
C. Vigilant monitoring for bacterial agents  
D. Parental education

All answers are correct. Loss of a spleen would be more detrimental to a child than an adult, primarily due to a pre-established immune response (B cells and their ability to produce specific antibodies) to bacterial antigens in the adult. In the adult, pre-existing memory B cells surviving in other tissues (e.g. lymph nodes, GALT, MALT, BALT) may be activated, although the overall response in these adults is typically diminished. In the child, there is less likely to be a preexisting memory population. The lack of splenic lymphoid tissue to process antigen greatly decreases the opportunity for B cell activation and further production of plasma cells and memory B cells. Appropriate medical care involves antibiotic prophylaxis and updating immunizations. Antibiotic prophylaxis is initiated immediately upon the diagnosis because patients are considered immuno-compromised. Patients should receive standard immunizations, with emphasis given to receive conjugated H. influenzae type b and pneumococcal vaccines. Asplenic patients are at an increased risk of sepsis, especially from gram-positive organisms.