up to cortex. The collecting ducts of the renal tubules descend into base then into renal pelvis then to ureter then bladder.

- The glomerulus = tuft of capillaries with blood entering by afferent arteriole and leaving by efferent arteriole. The tuft of capillaries is encased in Bowman's capsule where solutes, water and wastes pass through before enter renal tubule. The cells that line capillaries have pores called fenestrae. The filtration barrier of glomerulus made up of 3 layers : endothelial cells, basal lamina, layer of cells called podocytes that loosely interlock.
- Renal tubule → proximal convoluted tubule, loop of Henle, distal convoluted tubule.
  PCT →Electrolytes and other nutrients that the organism requires are reabsorbed into the blood (have microvilli and cells with mitochondria to provide ATP needed to actively reabsorb solutes); permeable to water, so water diffuses out in same direction as electrolytes.
  LOOP OF HENLE → produces concentration gradient (higher solute concentration in medulla than in cortex) the ascending portion is impermeable to water but actively transports electrolytes out of filtrate. The descending portion is permeable to water so water passively diffuses out into concentrated interstitial fluid. The filtrate has the same concentration leaving as going in but produces gradient in outside fluid. **Countercurrent multiplier**
- Blood vessels lose water then? NO, because they also move in opposite direction
- DISTAL CONVULUTED TUBULE(cortex) → filtrate is hypotonic(less solutes, having lost electrolytes with urea as main solute; other wastes enter (dilute)) → collecting ducts which allows water to be reabsorbed because of gradient
- ADH hormone controls water permeability of collecting ducts. Presence of ADH = is permeable and water leaves making urine more concentrated. Absence = impermeable making urine dilute.

Chapter 42 Notes

42.1 The Evolutionary History of Reproduction

A. Reproduction

- two potential ways to reproduce:
  1. the production of genetically identical cells or individuals called **clones --> asexual reproduction.**
     - Prokaryotes (bacteria and archaeons) reproduce by binary fission. Prokaryotes can increase genetic variation, however. They can transfer DNA from one individual to another through conjugation and they can obtain DNA directly from the environment.
     - Eukaryotes : mitosis
     - **budding** (fungi, plants, and some animals) : a bud, or protrusion, forms on an organism and eventually breaks off to form a new organism that is smaller than the parent.
     - **fragmentation** - new individuals arise asexually by the splitting of one organism into pieces, each of which develops into a new individual.
     - **parthenogenesis** - "virgin birth" Females produce eggs that aren't fertilized by males but divide by mitosis and develop into new individuals.
  2. combining a complete set of genetic information from two individuals to make a new genetically unique individual --> **sexual reproduction**

1) the first is **specificity**: the adaptive immune system targets responses to a specific pathogens
2) The second is **memory**: the adaptive immune system remembers past infections and mounts a stronger response on re-exposure

➔ Two types of cells are particularly important: **B lymphocytes**, or **B cells** and **T lymphocytes** or **T cells**. B cells mature in the bone marrow. Tcells matures in the thymus. B and T cells circulate in blood and lymphatic vessels and can be found in the spleen, liver, and lymph nodes.

A. B cells produce antibodies

➔ The specificity of the adaptive immune system is in part the result of **antibodies** produced by B cells. An antibody is a large protein that carries sugar molecules attached to some amino acids(glycoprotein). An antibody binds to foreign molecules that occur naturally on or in microorganisms and participate in normal cellular functions. Such a molecule is an **antigen**, which is a molecule that binds to and leads to the production of antibodies. The great diversity of antigens on different microorganisms is matched by a great diversity of antibodies.

➔ Antibodies can be found on the surface of B cells or free in the blood or tissues. Because antibodies are present in the blood, tissue fluid, and secretions, which used to be called humors, this part of the adaptive immune system is called **humoral immunity**.

➔ STRUCTURE→ the simplest antibody molecule is a Y-shaped protein made up of four polypeptide chains—two identical **light (L) chains** and two identical **heavy (H) chains.** Covalent disulfide bonds hold the four chains together. The light and heavy chains are further subdivided into **variable (V)** and **Constant (C)** regions. Within the variable regions of the L and H chains are regions even more variable → **hypervariable regions** → interact in a specific manner with a portions of the antigen called the **epitope**. Each of the diff. antibodies have different hypervariable regions that recognizes a unique epitope.

➔ Binding of antibodies to antigens is the first step in recognition and removal of microorganisms. Binding alone is sometimes enough to disable a microorganism → binding alone can lead to precipitation of the antibody-antigen complex(agglutination)

➔ More often, the microorganism is destroyed by a different component of the immune system: the function of the antibody is to recognize the pathogen, then recruit other cells of the immune system or activate the complement system. These latter functions are handled by a different part of the antibody from recognition.

➔ Proteolytic enzymes(cut proteins at specific locations) breaks the molecule at the hinge region, producing two **Fab fragments** and one **Fc fragment**. The letters "ab" stand for antigen binding and "c" stands for crystallizing. Each Fab fragment has an antigen-recognition site and the Fc fragment activates the complement system and binds to cell-surface receptors of other cells of the immune system.

B. Mammals produce five classes of antibody with different biological functions

➔ Antibodies are members of a family of proteins with common structural features. As a group they are called **immunoglobulins (Ig)**. There are five classes of immunoglobulin : **IgG, IgM, IgA, IgD, IgE**, each with a different function

➔ These classes are defined by their heavy chains which differ in the amino acid sequences of their constant regions. There are also two types of light chains which occur in all 5 classes, but any given antibody contains only one type of light chain.

➔ IgG is the most abundant of the five classes. It is the Y shaped antibody. It circulates in the blood and is effective against bacteria and viruses. It is the only class that can cross the placenta.

➔ IgM is a pentamer in mammals and tetramer in fish. It also exists as a monomer on the surface of B cells. It is important in the early response to infection and is efficient in activating the complement system

➔ IgA is usually a dimer and is the major antibody on mucosal surfaces and secretions

➔ IgD and IgE, like IgG are monomers. IgD is found on the surface of B cells and helps initiate inflammation. IgE plays a role in allergies, asthmas, and other **immediate hypersensitivity reactions** which are characterized by a heightened or an inappropriate immune response to common

- ➔ Falling phase – voltage gated sodium channels close automatically after a brief period of time. Voltage gated K+ channels open in response to the change in voltage → the membrane voltage peaks and then rapidly falls as K+ ions diffuse out of the axon.
- ➔ The voltage briefly falls below resting potential in **hyperpolarization** and then returns to the resting potential as K channels close to restore the resting concentration of K and Na. the continuous action of the sodium potassium pumps also help to restore resting potential.
- ➔ The period during which the inner membrane voltage falls below and then returns to resting potential= **refractory period** – period where neuron cannot fire a 2nd action potential- results in part because it takes time for Na channels to open again after they close. In addition, open voltage gated K channels make it difficult for the cell to reach threshold potential.

C. Neurons propagate action potentials along axon

- ➔ Depolarization initiated at the axon hillock triggers the opening of voltage gated Na+ channels. **Fig 35.10**. The inward sodium current depolarizes the membrane above threshold, triggering the opening of nearby voltage gated Na+ channels still farther along the axon →The depolarization spreads down the axon. Neighboring voltage gated potassium channels subsequently open and close to reestablish a resting membrane potential after an action potential has fired.
- ➔ Action potentials are **self-propagating** only in one direction. The refractory period prevents action potentials from firing in the other direction.
- ➔ The myelin sheath spreads the charge from a local action potential over a much greater distance along the axon's length. At regular intervals, the axon membrane is exposed at "gaps" called **nodes of Ranvier**. Votage gated Na and K channels are concentrated at these nodes→ action potentials in myelinated axons "jump" from node to node = **saltatory propagation**- increases the speed of signal transmission.

D. Neurons communicate at synapses

- ➔ There are two types : electrical and chemical
- ➔ Chemical synapses- signals conveyed are neurotransmitters which are contained in small vesicles in axon terminal. When an action potential reaches the end of an axon, the resulting depolarization induces voltage gated Ca2+ ion channels to open which are only found in the terminal. Because of higher concentration outside the cell, calcium ions diffuse into the axon terminal causing the vesicle to fuse with the presynaptic membrane and release the neurotransmitters into synaptic cleft by exocytosis
- ➔ **Fig 35.13**
- ➔ the neurotransmitters diffuse rapidly across the cleft and bind to postsynaptic membrane receptors which causes a change in the postsynaptic cell membrane potential. This is short lasting as neurotransmitters become unbound shortly after binding

E. Signals between neurons

- ➔ Binding of some neurotransmitters depolarizes the postsynaptic membrane making it more positive=**excitatory postsynaptic potential, EPSP**
- ➔ Binding of other neurotransmitters can hyperpolarize the postsynaptic membrane, making it more negative=**inhibitory postsynaptic potential, IPSP**
- ➔ Excitatory synapses tend to transmit relevant information b/w nerve cells, and inhibitory synapses often serve to filter out unimportant information.
- ➔ A neurotransmitter binds to receptors that trigger the opening or closing of ligand gated ion channels in the postsynaptic membrane. The binding of excitatory neurotransmitters causes Na channels to open causing the cell to become depolarized as Na ions flow into the cell
- ➔ The binding of inhibitory neurotransmitters causes Cl- or sometime K+ ion channels to open. Cl- ions then diffuse into the cell as K+ ions flow out causing the membrane potential to become hyperpolarized

- Ventilation and circulation each require a pump to produce a pressure(P) that drives flow (Q) against the resistance (R) to flow. **Q = P/R**
  If the resistance to flow doubles, the flow rate is halved. The longer the network of vessels and the narrower the vessels themselves, the greater the vessels' resistance to the fluid moving through them.
- Summary : Fig 39.3 --> (1) to deliver O2 to the mitochondria within their cells, animals move fresh air or water past their respiratory exchange surface in the process of ventilation. (2) the buildup of O2 favors the diffusion of O2 into the animal across its respiratory surface. (3) Following diffusion into the blood, O2 is transported by the circulation (bulk flow) to the tissues maximizing the concentration of O2 outside of cells. (4) O2 diffuses from blood across the membrane and into mitochondria of cells.
- to remove CO2, same process but in reverse. It moves from cells to blood
- by diffusion, then carried by bulk flow, diffuses across respiratory surfaces, goes out of body.

39.2 Respiratory Gas Exchange

- Aquatic Animals - take in O_2 from water --> **gills**, highly folded delicate structures that facilitate gas exchange with the surrounding water (**Fig. 39.4a**). In contrast, many terrestrial animals, such as reptiles, birds, and mammals, have internal **lungs** for gas exchange (**Fig. 39.4b**). Instead of lungs, terrestrial insects evolved a system of air tubes called **tracheae** that branch from openings along their abdominal surface into smaller airways(tracheoles) that supply air directly to the cells within their body.
- Recall that diffusion is much slower than the bulk flow of ventilation --> So, the gas exchange surface must have a large surface area and be extremely thin. Also highly folded --> shorter dist.

A. Aquatic Animals - Gills

- invertebrates with internal gills often have cilia that direct water over the gill's surface
- fish actively pump water through their mouth and over the gills, which are located in a chamber behind the mouth cavity.
- consist of a series of gill arches located on either side of the animal behind the mouth cavity and, in bony fishes, beneath the operculum. Each gill arch consists of two stacked rows of flat leaf-shaped structures called gill filaments. Numerous **lamellae**, thin sheetlike structures, are evenly but tightly spaced along the length of each gill filament and extend upward from the filament's surface. A series of blood vessels brings 0_2-poor blood from the heart to the lamellar surfaces. The lamellae are composed of flattened epithelial cells and are extremely thin, so short distance b/w water and blood. (fig 39.5)
- lamellae are oriented so blood flowing through them in a capillary network moves in a direction opposite to the flow of water --> **countercurrent exchange :** the two essentially exchange properties (fig 39.6)

B. Insects

- evolution to life on land --> 1. O2 content of air is typically 50 times greater than that of a similar volume of water. 2. O2 diffuses 8000 times faster in air than water. 3. water is 800 times denser and 50 times more viscous than air which requires more energy to pump
- Insects --> no respiratory surface. Two step process --> First, air enters an insect through openings, called **spiracles**, along either side of its abdomen. Inside the insect body, air is ventilated through a branching series of air tubes—the tracheae and tracheoles—directly to the cells. Second, diffusion occurs at the cell: O_2 supplied by the fine airways diffuses into the cells, and CO_2 diffuses out and is eliminated through the insect's tracheae.

C. Terrestrial Vertebrates