

11.4: Structural Barriers to Distribution

Structural Barriers to Distribution

Organs or tissues differ in the amount of a chemical that they receive or to which they are exposed. This is primarily due to two factors: the 1) **volume of blood** flowing through a specific tissue and the 2) **presence of special barriers** to slow down a toxicant's entrance.

Volume of Blood and Tissue Affinity

Organs that receive larger **blood volumes** can potentially accumulate more of a given toxicant. Body regions that receive a large percentage of the total cardiac output include the liver (28%), kidneys (23%), heart muscle, and brain. Bone and adipose tissues have relatively low blood flow, even though they serve as primary storage sites for many toxicants. This is especially true for toxicants that are fat-soluble and those that readily associate (or form complexes) with minerals commonly found in bone.

Tissue affinity determines the degree of concentration of a toxicant. In fact, some tissues have a higher affinity for specific chemicals and accumulate a toxicant in great concentrations despite a rather low flow of blood.

For example, adipose tissue, which has a meager blood supply, concentrates lipid-soluble toxicants. Once deposited in these storage tissues, toxicants may remain for long periods, due to their solubility in the tissue and the relatively low blood flow.

Structural Barriers

During distribution, the passage of toxicants from capillaries into various tissues or organs is not uniform. **Structural barriers** exist that restrict the entrance of toxicants into certain organs or tissues. The primary barriers are those of the brain, placenta, and testes.

Blood-Brain Barrier

The **blood-brain barrier** protects the brain from most toxicants. Specialized cells called astrocytes possess many small branches, which form a barrier between the capillary endothelium and the neurons of the brain. Lipids in the astrocyte cell walls and very tight junctions between adjacent endothelial cells limit the passage of water-soluble molecules. The blood-brain barrier is not completely impenetrable and its penetrability can vary with health status/disease state, but it does slow down the rate at which toxicants cross into brain tissue while allowing essential nutrients, including oxygen, to pass through.

Placental Barrier

The **placental barrier** protects the sensitive, developing fetus from most toxicants distributed in the maternal circulation. This barrier consists of several cell layers between the maternal and fetal circulatory vessels in the placenta. Lipids in the cell membranes limit the diffusion of water-soluble toxicants. However, nutrients, gases, and wastes of the developing fetus can pass through the placental barrier. As in the case of the blood-brain barrier, the placental barrier is not completely impenetrable but effectively slows down the diffusion of most toxicants from the mother into the fetus.

Knowledge Check

1) Organs may differ greatly in the concentration of a toxicant in them, due primarily to the:

- a) Rate of elimination of the toxicant by the kidneys
- b) Distance of the organ from the heart since the toxicant disintegrates quickly in the blood plasma
- c) Volume of blood flow and the presence of special barriers

Answer

Volume of blood flow and the presence of special barriers - **This is the correct answer.**

Organs or tissues differ in the amount of a chemical that they receive or to which they are exposed. This is primarily due to

two factors, the **volume of blood** flowing through a specific tissue and the **presence of special "barriers"** to slow down toxicant entrance. Organs that receive larger blood volumes can potentially accumulate more of a given toxicant.

2) The placental barrier protects the fetus from toxicants in the maternal blood because:

- a) Substances in the maternal blood must move through several layers of cells in order to gain entrance to placental blood
- b) The placenta does not contain circulating fetal blood that can absorb toxicants from the maternal blood
- c) Toxicants in maternal blood are usually lipid soluble and must be water-soluble in order to penetrate through the placental cell layers

Answer

Substances in the maternal blood must move through several layers of cells in order to gain entrance to placental blood -

This is the correct answer.

The placental barrier protects the developing and sensitive fetus from most toxicants distributed in the maternal circulation. This barrier consists of several cell layers between the maternal and fetal circulatory vessels in the placenta. Lipids in the cell membranes limit the diffusion of water-soluble toxicants.

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