

- * The typical insect excretory system consists of the **Malpighian tubules, intestine, and rectum**. We have already discussed the intestine and the rectum to some extent, so today we will mainly discuss the Malpighian tubules.

MALPIGHIAN TUBULES

- * The Malpighian tubules are long, thin, blindly ending tubes arising from the gut near the junction of the midgut and hindgut, and lie freely in the body cavity. In some insects they clearly arise from the midgut, but in others they originate on the anterior part of the hindgut. They may open independently into the gut or they may join into an **ampulla** or a more tubular **ureter** which then enters into the gut. The wall of the tubule is one cell layer thick with one or a few cells encircling the lumen. In some insects there is muscle sheath associated with the tubules which produce writhing movements within the haemocoel. Outside this is a peritoneal sheath encircling the tubule. It is in the Malpighian tubules where **deamination** takes place.
- * Malpighian tubules are absent in the Collembola and aphids, and are represented only by papillae in Diplura, Protura, and Strepsiptera. The number of tubules can be quite variable ranging from 2 in coccids to about 250 in some insects.
- * In many Coleoptera and larval Lepidoptera the distal parts of the Malpighian tubules are closely associated with the rectum, forming a convoluted layer over its surface. This is known as a **cryptonephridial arrangement** of the tubules. This arrangement is concerned with improving the uptake of water from the rectum and is absent from most aquatic forms.

EXCRETION BY THE GUT

- * In some insects (*Periplaneta*) the Malpighian tubules do not contain uric acid, but uric acid granules are present in the wall of the hind intestine and in the contents of the hindgut. This suggests that the hindgut may have an excretory function.
- * There are three principal nitrogenous excretory products formed by animals. They are **ammonia, urea, and uric acid**. Many aquatic insects produce **ammonia** as their principal nitrogenous waste material. Ammonia is a toxic substance and must be eliminated in large amounts of water, because the ratio of hydrogen to nitrogen is 3 to 1. If appreciable amounts of ammonia are eliminated from an organism, it could cause a water imbalance within their bodies. However, aquatic insects have no problem compensating for this water loss, due to the environment in which they live. This aqueous environment also serves to dilute the toxic ammonia excretions.
- * **Urea** is the nitrogenous waste material formed in many vertebrates and is the principal waste product in man. Urea is a rather toxic substance and must be eliminated from the body in water, which serves to dilute and carry the waste products. There is a ratio of two hydrogens to one nitrogen in urea molecules.
- * Most terrestrial insects produce **uric acid** as their main nitrogenous waste product. Uric acid is a relatively non-toxic and highly insoluble waste product. Therefore, it can crystallize out of solution, and may be either retained in the body, or eliminated as a solid waste material with little water loss. This is due to uric acid containing less hydrogen per atom of nitrogen than the other two nitrogenous waste substances - the ratio being one hydrogen to one nitrogen.

FAT BODY

- * In addition to malpighian tubules, there are other cells and organs which contribute to the insect excretory system. One such contributor to the excretory system is the **fat body**. The fat body is composed of groups of cells distributed throughout the insect's body. A major function of these cells is to store food reserves such as glycogen and fat, but they are also important in numerous metabolic activities. For example, they are involved in uric acid synthesis in many insects as the enzymes for uric acid production may be present in the fat body.

URATE CELLS

- * In some insects, certain cells called **urate cells** are found scattered among the fat body. These highly specialized cells store uric acid during the life of the insect. As the insect grows older, these cells become increasingly loaded with uric acid concentrations.

NEPHROCYTES

- * Nephrocytes, or pericardial cells, are cells occurring singly or in groups in various parts of the body. They may be very large, as in dipterous larvae, or small and numerous and usually they contain more than one nucleus. They usually are present on the surface of the heart, or lie on the pericardial septum or the alary muscles. These cells have a deeply invaginated plasma membrane which buds off pinosome into its internal cavity. These coalesce, crystallize, the crystals then are degraded and the products held in a large vacuole which is ultimately discharged into the haemolymph. This transforms the original waste material into a form that can be dealt with by the normal metabolic pathways. Nephrocytes also take up dyes and probably colloidal particles from the haemolymph and they play a role in the control of the heartbeat.