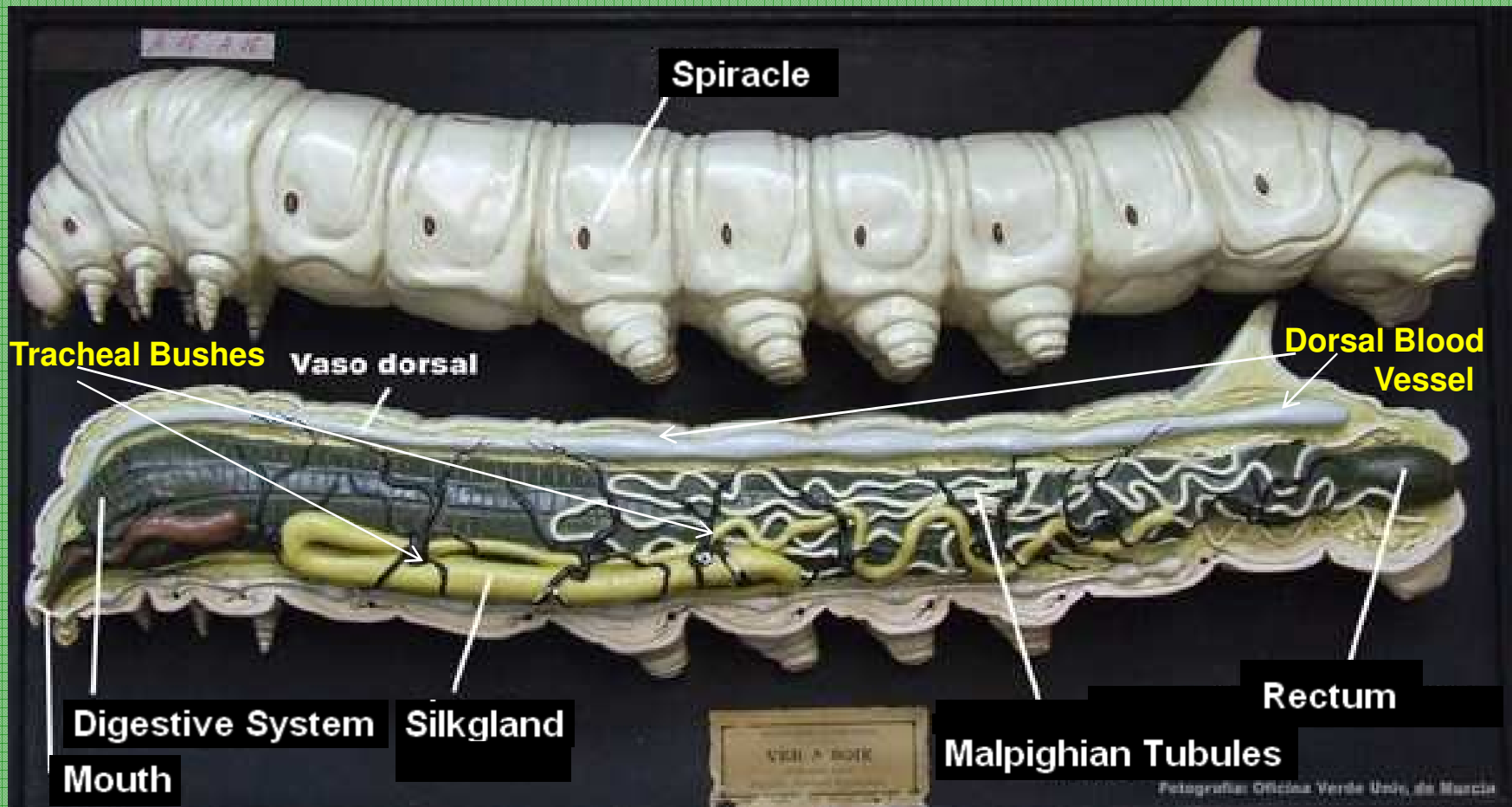


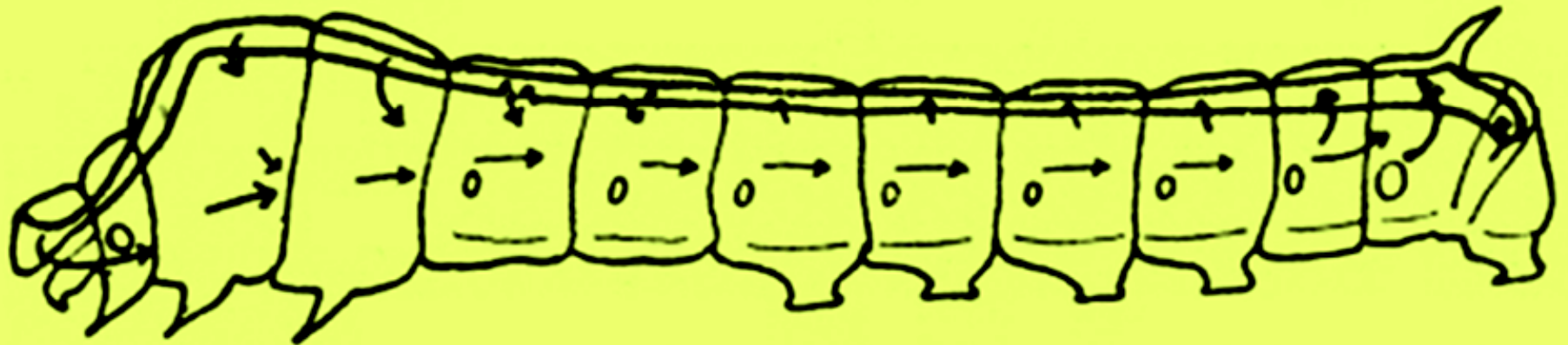
Physiology of Circulation

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Overall Morphology and Anatomy of Silkworm Larva



Dorsal Blood Vessel (Gray Colour)



Course of blood circulation in the silkworm

The circulatory system is an open one with a dorsal vessel, extending from the head to the last abdominal segment along the dorsal median line.

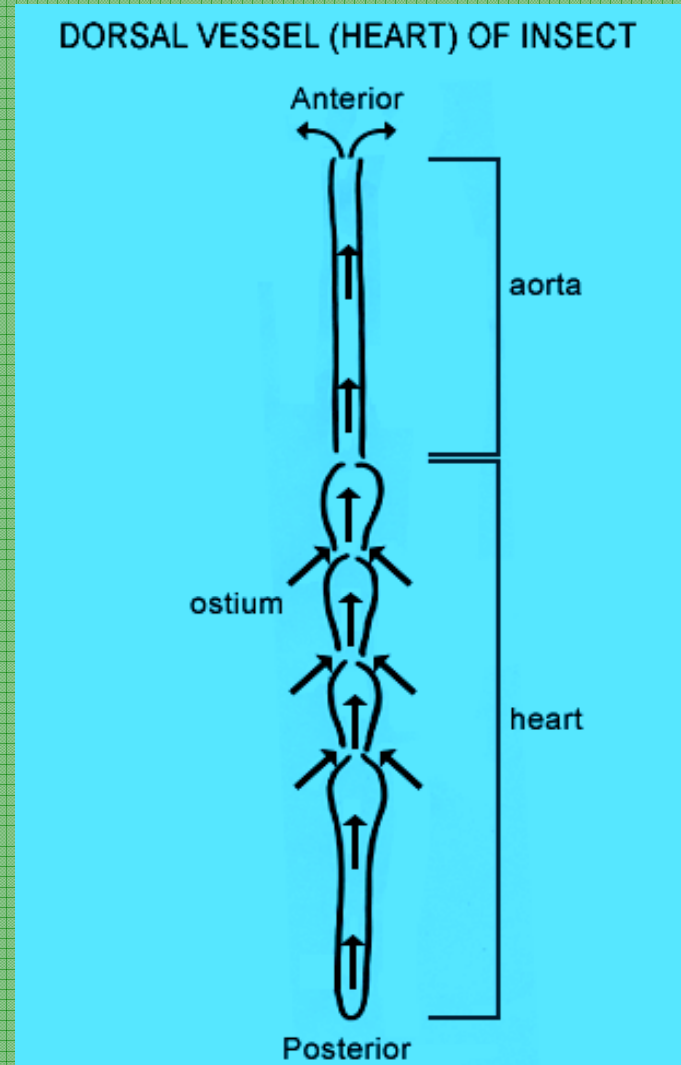
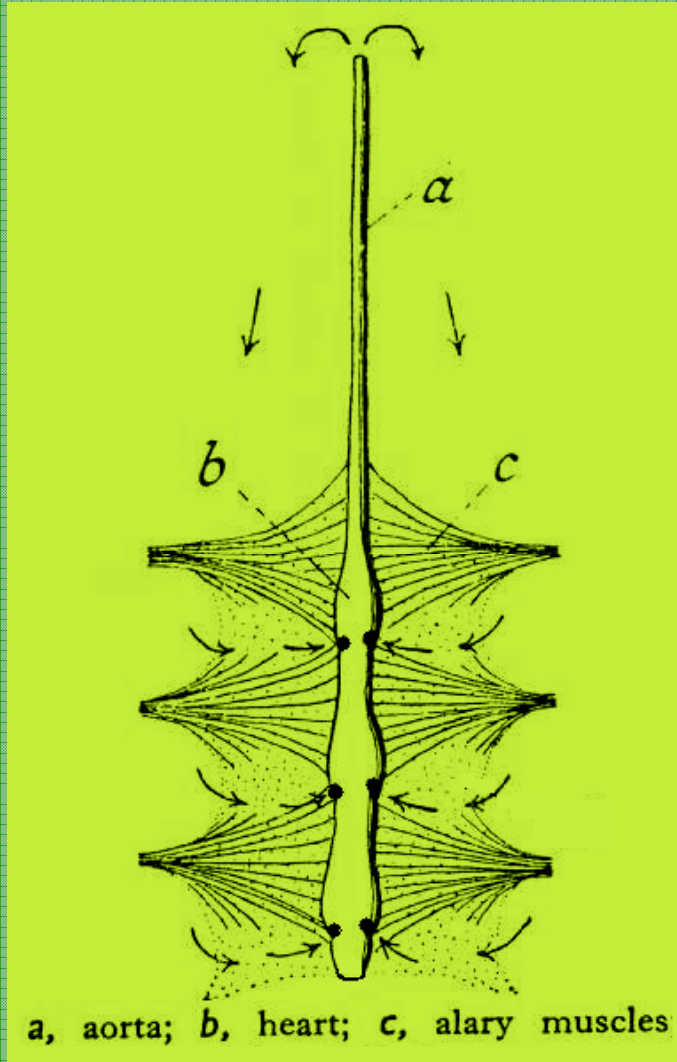
The dorsal vessel is closed posteriorly while the front end opens in the head. The anterior portion constitutes the aorta, while the posterior portion forms the heart.

Each of the segments from the 2nd thorax to the 9th abdominal segment contains a pair of ostia. There are 8 pairs of alary muscles which are attached to the body wall along the lateral parts of the dorsum.

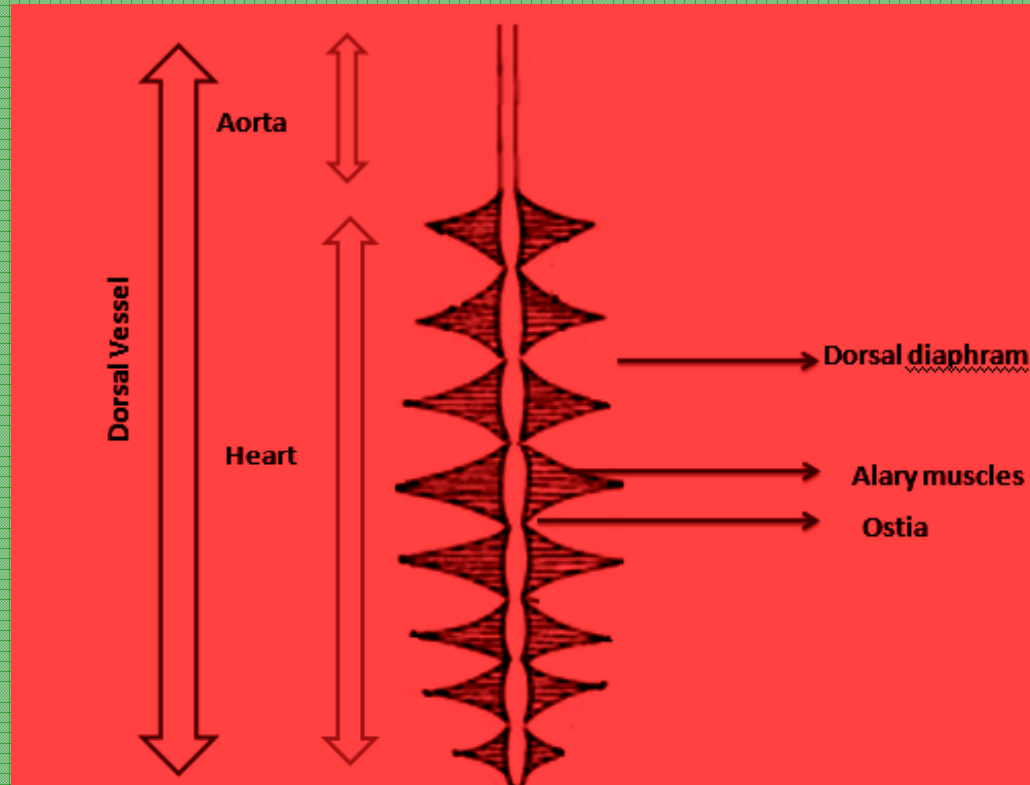
Systole (contraction) and diastole (expansion) of the heart are affected by the alary muscles and the musculature of the heart.

The alary muscles function more or less like an elastic band and cause diastole and systole.

Heart and Aorta with alary muscles



Dorsal Blood Vessel showing the movement of blood



Dorsal Vessel of silkworm larva

The blood enters the heart mainly through the ostia in the 7th & 8th segments and to a slight extent through 1-6 ostia during diastole, and is forced forward during systole.

As the heart is filled with blood, a steady wave of contraction progresses from posterior to anterior direction.

It leaves the dorsal vessel not only by the anterior end but also by the ostia in the meso and meta-thorax and sometimes by the ostia in the 1st & 2nd abdominal segments.

The blood flows backward through the body cavity.

Only cell-free plasma is circulated.

The heart pulsates rhythmically and frequency varies with age, temperature, movements and the race of the larvae.

The dorsal diaphragm

- **Septum, extends across the abdominal cavity divides the haemocoel into the pericardial sinus and the visceral sinus.**

Ventral diaphragm

- **The ventral diaphragm forms a continuous ventral sheath .**
- **It extends from the prothorax to the end of the body .**
- **It encloses the perineural sinus & encloses nerve cord.**

The Aorta

- **It is slender anterior part of the heart.**

The heart

- **It is often restricted to the abdomen, continuous and not is not divided into chambers.**

Incurrent Ostia

- They are vertical, slit-like openings in the lateral wall of the heart.
- The anterior and posterior lips of each ostium are reflexed into the heart to form a valve which permits the flow of blood into the heart at diastole (expansion of the heart), but prevents its outward passage at systole.

Excurrent Ostia

- These are ventro-lateral openings in the wall of the heart.
- Externally each opening is surrounded by a papilla of a spongy multinucleate cells which expand during systole, so the hemolymph is forced out, and contracts during diastole, so that entry of blood is prevented.

Alary muscles

- **These are muscles that are closely associated with the heart.**
- **In silkworm larva 8 pairs of alary muscles are present.**
- **In other insect species the number is reduced.**
- **They form integral part of the dorsal diaphragm which spreads between them as connective tissue membrane .**

COMPOSITION OF HAEMOLYMPH

- **Haemolymph contains a fluid portion called plasma and cellular fractions called haemocytes.**
- Plasma is an aqueous solution of inorganic ions, lipids, sugars, amino acids, proteins, organic acids and other compounds.
- **pH is usually acidic (6-7).**
- **Density is 1.01 to 1.06.**
- **Water content is 84-92 per cent.**
- **Inorganic ions 'Mg' and 'K'.**
- **Blood lacks vitamin 'K'**
- **Carbohydrate is in the form of trehalose sugar.**
- **Major proteins are lipoproteins, glycoproteins and enzymes. Lipids in form of fat particles or lipoproteins.**
- **Glycerol is present which acts as a anti freezing compound.**

HAEMOCYTES

The blood cells or haemocytes are of several types and all are nucleate. The haemolymph of insects consists of liquid plasma and numerous haemocytes.

Haemocytes perform various physiological functions in the body.

They direct nutrients to various tissues and store them.

They perform phagocytosis, encapsulation of foreign bodies in the insect body cavity, coagulation to prevent loss of blood, nodule formation, transport of food materials, hormones and detoxification of metabolites.

Five types of hemocytes are recognized in *Bombyx mori* . All of them are involved in humoral and cellular immunity either directly or indirectly.

a. Prohaemocyte : Smallest of all cells with largest nucleus.

b. Plasmacyte: (Phagocyte) aids in phagocytosis

c. Granular hemocyte: Contains large number of cytoplasmic inclusions. Granulocytes involved in recognition of non-self, Plasmacytes adhere to and spread over foreign bodies and wounds, and are the main capsule-forming hemocytes.

d. Spherule cell: Cytoplasmic inclusions obscure the nucleus. The function of the spherule cells which contain a paracrystalline material (muco- or glycoproteins) is by no means clear.

e. Oenocytoids: Large cells with eccentric nucleus. The involvement of oenocytoids in the complex metabolism of phenols and particularly in the production of plasma phenolases has been reported.

Process of blood circulation in silkworm

Heart mainly function as a pulsatile organ whose expansion and contraction leads to blood circulation.

It takes place generally in an anti clock manner starting from posterior end to the anterior end in a forward direction. Circulation of blood takes place in two phases due to the action of the alary muscles as well as the muscles of the walls of the heart.

The two phases are

- 1. Diastole: Expansion of heart takes place.**
- 2. Systole : Contraction of heart takes place.**

Diastole: Expansion of heart (diastole).

It results in increase of volume of heart and decrease in the area of pericardial sinus. This creates a pressure on the blood in pericardial sinus forcing the blood to enter into the heart through the incurrent ostia. These incurrent ostia allow only the entry of blood from the sinus in to the heart and prevents its backflow from the heart to the sinus.

Systole : Contraction of heart (systole).

This creates pressure on the blood within the heart leading to its forward movement in to the aorta. From the aorta blood enters in to the head and flows back bathing the visceral organs in the visceral sinus and neural cord in the perineural sinus. In between diastole and systole there will be a short period of rest which is known as diastasis.

During each diastolic phase (relaxation), the ostia open to allow inflow of hemolymph from the body cavity. The heart's contraction rate varies considerably from species to species — typically in the range of 30 to 200 beats per minute.

Acknowledgements
to

- 1. Sericulture Manual II, FAO, Rome, 1987.**
- 2. The Principles of Insect Physiology by V B Wiggelesworth 1972.**
- 3. The silkworm – A Laboratory Tool by Y Tazima 1979.**
- 4. Internet.**