

Honeybee Heart

Life is an emergent property, defined in terms of a *cell*, limited by a *membrane*, which separates the boundary of the living system *inside* from the non-living *outside*. This is simply true for the vast world of unicellular organisms. Larger organisms - plants and animals - that are *multicellular*, have yet another layer of emergent complexity, which defines them as *individuals*. Nevertheless, it's the many individual *cells* of a larger organism that are alive and which must be maintained in an appropriate environment. The *heart and circulatory system* distribute nutrients and remove metabolic end-products, providing livable conditions for the millions of cells in each individual.

There is difficulty - unless you're a specialist in the field - in instantly appreciating the *intricate complexity* of a honeybee. After all, to a human eye, at first glance, they're pretty much just bugs that fly around and gather nectar to make honey (that we can harvest) and help (us) with plant pollination for (our) crops. However, each honeybee - though itself only relevant in the larger context of its colony, its hive - is a *self-contained, actively metabolizing multicellular organism*. The essential unit of life, the *cell*, if it is to stay alive, must be supplied with nutrients and have metabolic end-products removed ... and this must happen for each of the more than **100,000,000** cells of an adult honeybee. That's what a circulatory system does. The *heart* is a pump made of muscle that drives flow (circulation).



Now, we should not take for granted our general understanding of the heart and circulatory system. It all seems so obvious, here in the early 21st century - thanks to generally distributed biology education, availability of diagrams and illustrations and, more recently, of videos showing how blood flow works. Amazingly, however, it was not until 1628, when William Harvey published a 72-page essay, that the closed circulatory system of animals, including man, was broadly understood. Though an Englishman, Harvey studied with Fabricius at the University of Padua in Italy. The routine use of dissection to study anatomy had just been started there by Vesalius [[De Humani Corporis Fabrica ... On the Fabric of the Human Body](#) - 1543]. Harvey's book was published in Latin, the universal common language used to communicate scientific work back in the day, with an accompanying English translation. If you read just the first several pages of the introduction to this revolutionary work you will gain insight into the confusion that even then surrounded the very basics of the heart and circulation *in man*. [Here is the book in its entirety, part I in Latin, part 2 the English translation: [De Motu Cordis: On the Motion of the Heart and Blood in Animals](#), Its introduction: *Letter To The King* [Charles I] *And Dedication* : *Most Illustrious Prince! The heart of animals is the foundation of*

their life, the sovereign of everything within them, the sun of their microcosm, that upon which all growth depends, from which all power proceeds.]

Our understanding of human blood flow - *and of blood flow in the honeybee* - has progressed quite a bit since then. In humans, blood is pushed from the right side of the heart into the lungs, where O₂ is gathered onto hemoglobin molecules in red blood cells and CO₂ is released. After returning to the left side of the heart, blood is pushed into the aorta, which branches into arteries, then arterioles, then capillaries, where blood plasma is in close contact with the interstitial fluid which bathes all cells. From capillaries to venules to veins to vena cava, blood returns to the right side of the heart, completing the circuit.

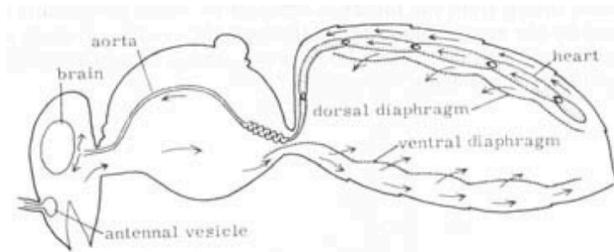
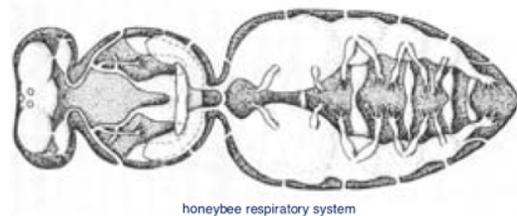


Fig. 20. Diagram illustrating the action of the heart and diaphragms.

Like the human heart, the bee heart has valves and intrinsic, spontaneous, rhythmic contractions that propel blood forward into the aorta. Many differences, however ... for one, the circulatory system of insects is open - no arterioles or capillaries or veins to take the pulsatile blood from the aorta to the tissues and back to the heart. Instead, the blood - called hemolymph, and lacking red blood cells and hemoglobin - is carried forward by the aorta to the bee's head, where it is emptied into the *interstitial fluid* bathing the cells. This hemolymph fluid returns via flow channels, among all the cells in the honeybee and re-enters the heart via ostial valves, completing the circuit.



Here's another surprise: honeybees and other insects breathe, but have no lungs. Instead, a separate respiratory system of tracheae and air sacs allow air to enter and leave the body from many openings on the surface, distributing respiratory gases and maintaining equilibrium in the interstitial fluid that bathes the cells. Red blood cells and hemoglobin, which serve well when ventilation is centralized in gills or lungs, are not needed in the honeybee.

The attached images and references give additional details regarding the heart and circulatory system of the honeybee, including some nice EKG tracings.