

Question

- When oxygen is lost in hemoglobin, the configuration of the remaining molecules change, making it easier for them to be lost to tissues. What is this process called?

Questions

- When tissues are at rest, only 50% of the oxygen is depleted from the RBC. Explain why this is an advantage.
- Explain how CO₂ release increases the amount of oxygen available to tissues.

- Quiz will cover gas exchange and animal circulation, including material covered today.

Animal Circulation

Basic needs of a cell

- Gas Exchange
- Nutrient Acquisition
- Waste Elimination

} Metabolism

- When do we NOT need a circulatory system?

Circulation

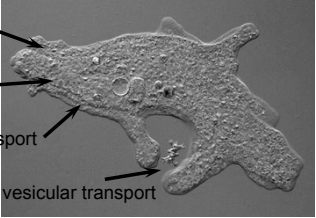
This amoeba may use:

- simple diffusion
- osmosis
- facilitated diffusion
- active transport
- vesicular transport

Gas Exchange →

Nutrient Absorption →

Waste Elimination →



osmosis

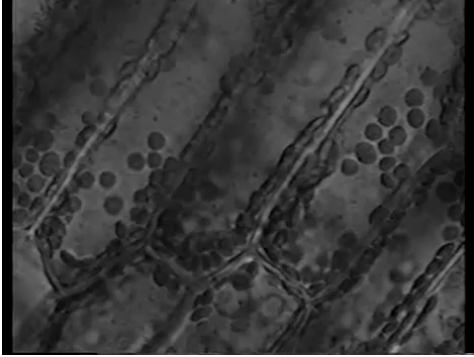
diffusion

active transport

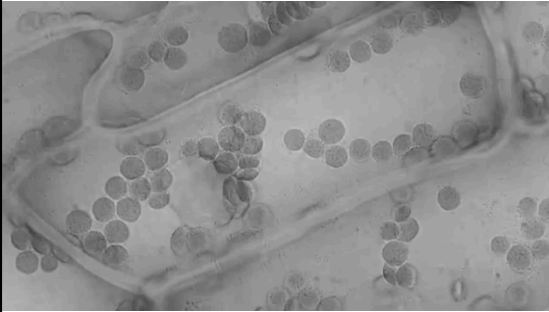
vesicular transport

<http://www.microscopy-uk.org.uk/mag/imagesmall/amoebafeeding3.jpg>

Cyclosis, Cytoplasmic Streaming



Cyclosis, Cytoplasmic Streaming



Cyclosis, Cytoplasmic Streaming



Size Matters: Surface/Volume Ratio

surface = 6 cm² volume = 1 cm³ S/V=6.0

surface = 24 cm² volume = 8 cm³ S/V=3.0

Conclusion? Larger organisms have less surface area relative to volume than do smaller organisms. Food and wastes cannot be exchanged by diffusion alone. Circulation is necessary!

Gas Exchange, Food Intake, Waste Elimination

Tentacle

Mouth and anus

Cnidarian (*Hydra*)

Gastrovascular cavity

Body wall

Flatworm (*Planaria*)

Pharynx

simple metazoans use:
simple diffusion
osmosis
facilitated diffusion
active transport

Look at all that surface area!

<http://biostonline.blogspot.com/animals-circulatory-system/invertebrate-circulatory-system/>

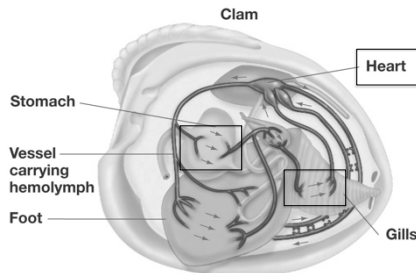
Circulatory Systems

Open vs. Closed Circulatory System

Open Circulatory System

- What is exchanged?
 - Not blood, but hemolymph:
 - Wastes, nutrients, immune cells, hormones, water
- Blood vessels empty into an open, fluid-filled space
- Organs are bathed in hemolymph

Open Circulatory Systems



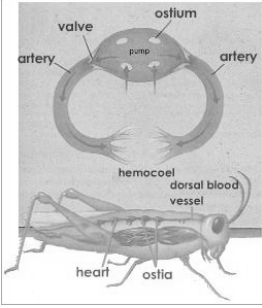
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Open Circulatory System

- Characteristics
 - Hemolymph is under low pressure
- Suitable for relatively sedentary organisms
 - No way to redirect O₂ to high demand tissues
 - Exception = Insects (why?)
 - Circulatory system separate from respiratory system
 - Body movements help move hemolymph
- Suitable for high-pressure environments

In insects, circulation is an open system


The hemolymph reenters the circulation system via the ostia



Circulation is not for gas exchange in insects

<http://www.tutorvista.com/content/biology/biology-ii/transportation/blood-circulatory-system.php>

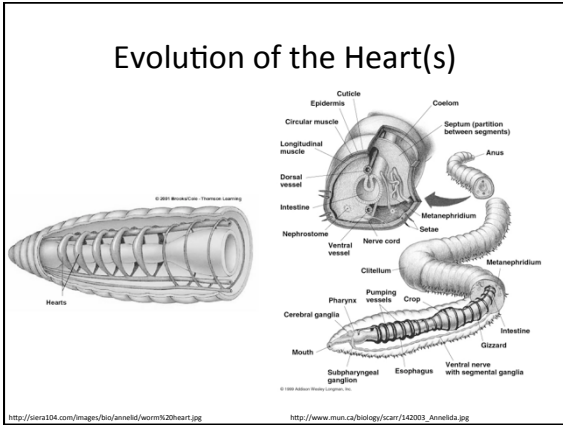
Dorsal Blood Vessel of Insect

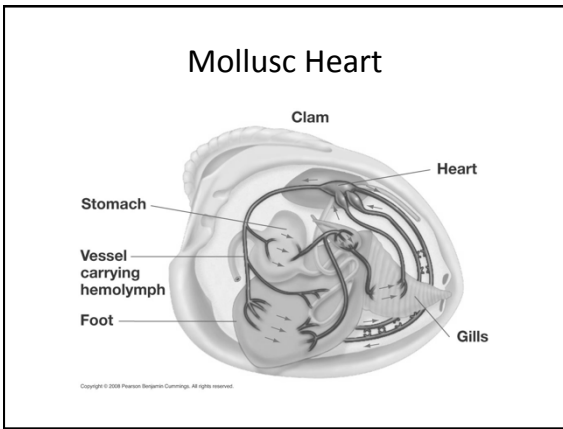


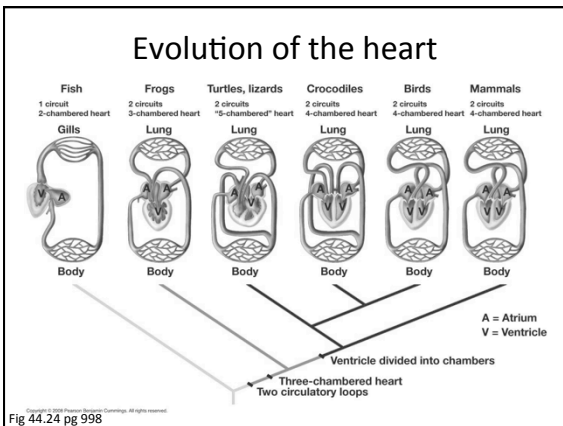
<http://www.youtube.com/watch?v=Cq-zXVzRWw>

Closed Circulatory System

- Blood flowing in a continuous circuit through the body
- Seen in animals with an active and/or predatory lifestyle
- High flow rate, high pressure system







High pressure system

***Erythrocyte
Circulation Cycle
in Real Time***

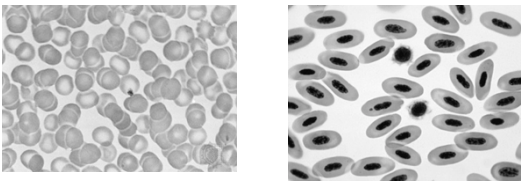
<http://www.youtube.com/watch?v=3Auz2Q14-G8&NR=1>

Comparison

<u>Open Circulatory system</u>	<u>Closed Circulatory system</u>
• Well suited to high pressure environments	• Well suited to active lifestyles
• Organs bathed in hemolymph	• Organs surrounded by capillaries
• Heart with ostia	• Heart without ostia

Red Blood Cells

Which is human?

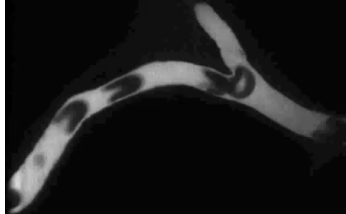


Mammal RBCs have no nucleus

<http://www.britannica.com/E/checked/meda/3395/Human-red-blood-cells> <http://ahdc.vet.cornell.edu/clinpath/modules/rbcmorph/avian.htm>

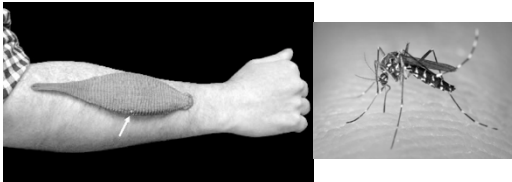
Enucleated RBCs

Without a nucleus, red blood cells can carry more hemoglobin and fit into tighter spaces.



Mammal blood

- No nucleus means more room for hemoglobin!
– 280 million copies of hemoglobin/RBC

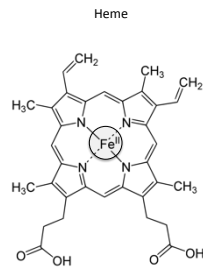
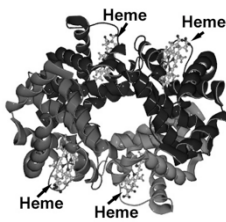


<http://invertebrates.si.edu/Features/stories/haementeria.html>

<http://extension.entm.purdue.edu/publichealth/insects/mosquito.html>

Hemoglobin and Heme

- 1 oxygen molecule can bind to each heme group
- 4 oxygens / hemoglobin protein
- 1.1 billion oxygen molecules / RBC!



http://en.wikipedia.org/wiki/File:Heme_b.svg

<http://www.chemistry.uw.edu/~redner/publ/2004/hemoglobin/AMe1Comp466604.html>

Other benefits
Countercurrent heat exchange

As warm blood passes down the arteries, the blood gives up some of its heat to the colder blood returning from the extremities in these veins.

Blood from body core in artery
35°C
30°
20°
10°

Blood returning to body core in vein
27°
18°
9°

Blood from body core in artery
33°C
27°C

Blood returning to body core in vein

ARTERY
carries blood very warm blood from core of body

VEIN
carries blood very cool blood from periphery of body

HEAT TRANSFERRED
from artery to vein.

http://mycoyrock.com/10286G0250H.htm http://www.seaworld.org/infobooks/KillerWhale/Images/arteriesw99.JPG

Other benefits
Countercurrent heat exchange

heat ex. change

artery

vein

IC0

heat loss

With counter-current heat exchange

http://www.bbc.co.uk/1/health/2005/05/050511_heart.shtml

Questions

- Discuss the differences between the 2-chambered and 4-chambered heart in terms of blood pressure.
- What is the advantage of a 4-chambered heart over a 3-chambered heart?

Questions

- Why does the insect circulatory system operate without regard to oxygen demand of the tissues?
- What is the circulation of material inside an individual cell called?

- What are the advantages to not having nuclei in red blood cells?
