Circulatory System

Is the heart and circulatory system in birds drastically different than other vertebrates?

No, it is basically the same with some modifications. The four-chambered heart in birds is similar to mammal hearts in most structural details.

What is the characteristic that birds and mammals have in common that demands an efficient four-chambered heart?

Because both birds and mammals are homoeothermic, their hearts must work efficiently to supply the body tissues with enough oxygen to support a high metabolism. Therefore both have developed a four-chambered heart that separates the circulation of oxygenated and unoxygenated blood. Even in such advanced reptilian groups as the crocodilians the heart mixes some arterial and venous blood and is thus less effective in keeping the oxygen content of arterial blood high. These reptiles have a three-chambered heart and only one ventricle.

What is the most prominent exception to the generalization that the hearts in birds and mammals are very similar?

- the structure of the aortic arch, which arches to the right in birds – and continuing down the right side of the spinal column, while the aortic artery goes to the left in mammals. Furthermore, the two jugular veins of the head are cross-connected so that a severe twist of the head doesn't cut off blood drainage.
- a secondary STRUCTURAL observation of a difference between the bird and mammal heart is the fact that the arteries going to the pectoral muscles used in flight are very large. In birds these two arteries are almost as large as the aortic artery. Since they branch off the base of the aorta, it almost appears that the heart has three aortas coming from the left ventricle of the heart. In mammals these arteries are less than half the size of the aorta.

Relative to reptiles and mammals of similar size, what is the relative size of a bird's heart?

The heart of a bird is relatively <u>larger</u> and <u>more powerful</u> than that of reptiles and mammals of similar size – ranging from 50% 100% larger. In fact, to support the intense demand for oxygen and nutrients produced by active flight, birds have developed the largest hearts relative to their body mass of all the vertebrates.

Which groups of birds have even larger hearts - relative to their body mass?

- The heart of small birds is also proportionately larger than that of larger birds and is related to their respiratory rate.
- Birds that undertake long migrations over water
- Birds that hover, e.g., hummingbirds
- Birds of northern latitudes and alpine environments.

What are some examples of heart rate in birds?

Heart rates, in general are inversely proportional to body mass.
ostrich – 40 bpm, most song birds 350 – 480 bpm, hummingbird 1200.

Note: resting bird heart rates are about half of similar sized mammals. HOWEVER, bird cardiac outputs are similar because of large stroke volumes. Not only is the avian heart large, but the ventricles empty more completely than do those of mammals on each contraction. Furthermore, the ventricles fill more completely between contractions.

Note: The heart rate of birds will greatly increase when flying – doubling in small birds and going up usually 3 to 4 times in larger birds. One study of pigeons showed a resting heart rate of 115 bpm and 670 bpm when active - or an increase of 5.8 times as fast.

What is the diving reflex in birds and how is it triggered?

The diving reflex is a drastic reduction in heart rate and rationing of oxygen to certain parts of the body when diving under the water surface. Oxygen is delivered to the central nervous system, sensory organs, and endocrine glands, but blood flow to most other organs and skeletal muscles stops during a dive. They rely on stored oxygen and anaerobic metabolism in these regions during this period. Heart rate is greatly reduced to about half that of pre-dive levels within 8 seconds. The diving reflex is triggered when water touches special receptors in the nares. Divers, such as penguins, store lots of oxygen in their muscles.. Myoglobin binds oxygen just like hemoglobin but actually has a higher affinity for oxygen than does hemoglobin. This means that when blood passes through muscle , lots of oxygen is transferred from the blood to muscle. For comparison:
<u>human</u>
total oxygen 20 milliliters per kilogram of body weight,
24% in lungs, 57% in blood, 15% in muscle
<u>Emperor Penguin</u>
total oxygen 55 milliliters per kilogram of body weight,
19% in lungs, 34% in blood, 47% in muscle
Brain tissue still depends on oxygen being transported in the blood. However, the skeletal muscles use stored oxygen in the myoglobin during a dive.

What are some examples of blood pressure in birds?

pigeon – 135/105 mmHg, chicken – 180/160
starling – 180/130, turkey – 235/141

What are the relative amounts of oxygenated cardiac output - blood - going to the pectoral muscles, brain, and legs?

relative to the pectoral muscles – X
legs – 3X
brain – 2X
note: the legs and brain receive 10%-20% of the total cardiac output.

Birds have a “countercurrent heat exchange.” What does this mean?

The veins and arteries lie next to each other. The warm blood leaving the heart and going to the extremities warms the cooler blood going to the heart from the extremities. Therefore,, some heat is returned to the body core and conserved. This is especially important in cold environment birds. In warmer environments, the venous return from the appendages is near the surface so that heat is lost.

What is the difference between bird blood and mammal blood?

Bird red blood cells, unlike those of mammals,

- are elliptical in shape
- and nucleated.
- There is a range of sizes of red blood cells and some are larger in birds than mammals.
- Bird red blood cells have a shorter lifespan than in mammals. 28-45 days for birds and about 120 days in humans.
- blood clotting thrombocyes are nucleated in birds and correspond to the non-nucleated platelets in mammals.