Finding is a feather in the cap for researchers studying birds' big, powerful eyes

June 23 2011

Say what you will about bird brains, but our feathered friends sure have us -- and all the other animals on the planet -- beat in the vision department, and that has a bit to do with how their brains develop.

Consider the in-flight feats of birds of prey: They must spot their dinner from long distances and dive-bomb those moving targets at lightning speed. And then there are the owls, which operate nimbly on even the darkest nights to secure supper in swift swoops. Some birds have ultraviolet sensitivity; others have infrared sensitivity. To boot, some birds can even see the Earth's magnetic field.

Much of the credit for avian visual acuity goes to the extraordinary retina, which grows out of the brain during development, making it an official component of the central nervous system. Indeed, the avian retina is far more complex in structure and composition than the human retina, and it contains many more photoreceptors -- rod- and cone-shaped cells that detect light and color, respectively.

While researchers over the years have come to better understand much about the avian retina, many nagging questions remain. For Thorsten Burmester's research team at the University of Hamburg, the question was this: How does such a productive retina sustain itself when the avian eye has very few capillaries to deliver oxygen to it? After all, it has to "breathe," so to speak.

"The visual process in the vertebrate eye requires high amounts of metabolic energy and thus oxygen," Burmester's group writes in this week's Journal of Biological Chemistry. "Oxygen supply of the avian retina is a challenging task because birds have large eyes, thick retinas and high metabolic rates, but neither deep retinal nor superficial capillaries."

To answer the question, Burmester's team took a closer look at a protein that they discovered exists in large quantities in photoreceptor cells of the avian eye -- and only of the avian eye. They named the protein globin E. (The "E" is short for "eye," of course.)

Burmester's team used a number of techniques to characterize globin E and found that it is responsible for storing and delivering oxygen to the retina.

The finding is intriguing for a number of reasons.

Firstly, it helps explain how birds evolved to have such large eyes, relative to their body mass, without a dense network of ocular capillaries for blood delivery. (Some owls, for instance, have bigger eyes than humans.)

"The exact origin of globin E is still somewhat a mystery," Burmester said. "It clearly evolved from some type of globin, but it has no obvious relative outside the birds."

The globins are all thought to share a common ancestor, and the most well-known members of the family are myoglobin and hemoglobin. Myoglobin is responsible for oxygen storage and release in heart and skeletal muscle fibers. Hemoglobin, meanwhile, transports oxygen from the lungs to other parts of the body in red blood cells.

Burmester explains: "Bird eyes have evolved to have a system not unlike those in our heart, which uses myoglobin to store and release oxygen to maintain respiration and energy-consumption during muscle contraction. In eyes, oxygen and energy are needed to generate neuronal signals."

Secondly, the finding puts to rest an earlier hypothesis that another molecule, neuroglobin, might be the oxygen-delivery vehicle for the avian eye. Neuroglobin is known to deliver oxygen to brain tissue, so it was only natural to suspect it. But it turns out that the messenger RNA fingerprint of globin E was 100-fold more prevalent than that of neuroglobin in Burmester's chicken retina samples, indicating that neuroglobin probably has another, yet-to-be defined function in the avian eye.

Lastly, globin E is another interesting illustration of the convergent evolution of "myoglobin-like" molecules. Among the organisms with proteins with similar functions are the soybean, which needs its leghemoglobin to deliver oxygen to the Rhizobium soil bacteria that colonize in root nodules, and the 2-foot-long sea worm Cerebratulus lacteus, which needs its mini-hemoglobin to keep its brain and neurons oxygenated when it burrows deep into the sea floor, where oxygen levels are low, in search of clams.

More information: The abstract for the paper, which was titled "Oxygen supply from the bird's eye perspective: Globin E is a respiratory protein in the chicken retina," is available at www.jbc.org/content/early/2011 … M111.224634.abstract.

Provided by American Society for Biochemistry and Molecular Biology powerful.html