How fish won the oxygen war

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(Phys.org) —A missing link in the story of how the fishes triumphed over toxic oceans and past climate changes has been revealed by an international team of scientists.

The key to the evolutionary success of fish – and their possible survival in future – may lie with a molecule that they ultimately bequeathed to humans: hemoglobin, the precious carrier of oxygen into our brain, heart, muscles and other organs.

In a paper in the latest edition of the journal *Science*, Dr Jodie Rummer of the ARC Centre of Excellence for Coral Reef Studies and colleagues from the University of British Columbia report a groundbreaking discovery about how fish manage to survive in hostile water conditions.

"Four hundred million years ago the oceans were not what they are today. They were low in oxygen, high in CO2 and acidic," says Dr Rummer. "Yet the fishes not only survived in these unpromising circumstances, they managed to thrive. Their secret weapon was a system for unloading huge amounts of oxygen from the hemoglobin in their blood, whenever the going got really tough.

"Hemoglobin in the blood takes up oxygen in the gills of fish and the lungs of humans. It then carries it round the body to the heart, muscles and organs until it encounters tissues that are highly active and producing a lot of CO2." "The acid is a signal to the hemoglobin to unload as much of its oxygen as possible into the tissues," she explains.

"These early fish managed to develop a way to maximize the delivery of oxygen, even when the water they lived in was low in it. They had a phenomenal capacity for releasing oxygen just when needed: it was one of the big secrets of their evolutionary success, to the extent they now make up half the vertebrates on the planet."

The fishes' oxygen release system became even more efficient over the ensuing 150-270 million years, when it was necessary to deliver large amounts to organs such as the eye – which requires very large O2 loads to function well and avoid vision cell death – and which was essential to seeing clearly under water, to hunt or avoid predators.

The researchers made their discovery by deciphering the biochemistry of how rainbow trout manage to rapidly double oxygen release in certain tissues, when they swim in waters that cause them stress.

The fish system is many times more efficient than the one inherited by humans (as our amphibian ancestors branched away from higher fishes around 350-400my ago when the hemoglobin system was still in its early stages of development), but its discovery may lead to new ways of understanding and tackling conditions influenced by oxygen levels in the body.

"Also, we feel that if we can understand how fish coped with low-oxygen, high CO2, acidic waters in the past, it will give us some insight into how they might cope with man-made climate change which appears to be giving rise to such conditions again," Dr Rummer says.

Their paper 'Root Effect Haemoglobin May Have Evolved to Enhance General Tissue Oxygen Delivery' by Jodie L. Rummer, David J. McKenzie, Alessio Innocenti, Claudiu T. Supuran and Colin J. Brauner appears in the 14 June 2013 issue of the journal *Science*.

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