Evolution of myoglobin molecular surface and whole organism diving capacity in mammals

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The diving abilities of whales and seals have fascinated respiratory physiologists for decades. Since the use of time depth recorders, maximal diving capacities are being revealed in an increasing number of diving mammals. However, efforts to explain inter specific differences in diving capacity by variations in available oxygen stores and their rate of usage had mixed success. In addition, little is known about the evolution of oxygen stores in diving mammals.

Here we show that among the principal oxygen stores in the body, muscle myoglobin alone is a surprisingly accurate predictor of maximum dive times across all mammalian divers, from water shrew to sperm whale. We further show a strong correlation between maximal muscle myoglobin content and myoglobin net surface charge, as modeled from its amino acid sequence. Mapping the molecular evolution of more than a 100 myoglobin sequences from diving and terrestrial mammals onto a mammalian phylogeny, we find multiple parallel evolution of elevated myoglobin surface charge in all mammalian divers.

These data are now used to reconstruct maximal muscle myoglobin content and thereby diving capacity in the ancestors of living mammals at the transition between a terrestrial and aquatic lifestyle, such as *Pakicetus* and other early whales.