frontiers in
PHYSIOLOGY

OPINION ARTICLE
published: 18 May 2010
doi: 10.3389/fphys.2010.00006

Frontiers in Aquatic Physiology – grand challenge

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Life originated in an aqueous environment, and extant aquatic species face special challenges due to the physics and chemistry of water. Such functions as feeding and digestion, waste excretion, ion and volume regulation, acid-base regulation, biomechanics, gas exchange, responses to thermal changes, and reproduction are dictated by the constraints of temperature, salinity, gas solubility, viscosity, hydrostatic pressure, water currents, periodic dehydration, and human impact including pollution and eutrophication.

The physiology of aquatic animals can be studied at a variety of levels, from gene expression to cell and tissue responses to behavior. In a recent review, Schwenk et al. (2007) listed five "grand challenges in organismal biology": "Understanding the organism's role in organism-environmental linkages"; "utilizing the functional diversity of organisms"; "integrating living and physical systems analysis"; "understanding how genomes produce organisms"; and "understanding how organisms walk the tightrope between stability and change." These broad areas of interest certainly apply to aquatic organisms and, thereby, are of interest to *Frontiers in Aquatic Physiology*. One underlying, major theme is the suggestion to make more use of the emerging, molecular techniques (combined with tissue/organ or whole animal studies) on a larger variety of animal taxa, in a wider range of environments, to study the evolution of physiological strategies. Another is the need for a greater understanding of the redundancy, limitations, and plasticity of homeostatic mechanisms over long terms in order to understand the effects of global biological change on organismal physiology. More specific examples of emerging areas of research interest (one might say Frontiers) in aquatic physiology include the suggestions below, which is not meant to be an exhaustive list.

- The evolution and coupling of osmoregulatory and ion transport processes with acid–base regulation and nitrogen metabolism by the formation of complex transport metabolons, using a greater variety of fish species
- The responses of osmoregulatory cells to different environmental conditions by changing subcellular location and turnover of their components
- The differentiation factors involved in the formation of the gill and mitochondrion-rich ionocytes and distinct segmentation of renal tubules of freshwater and seawater fishes
- The adaptive role of organic osmolyte transport mechanisms
- The roles of hormones and other regulatory factors in osmoregulation, acid–base and nitrogen balance
- The use of reverse genetics (e.g., mRNA knockdown) to delineate specific mechanisms and cellular localization of osmoregulatory pathways
- The physiological responses of aquatic animals to anthropogenic impact and changes
- The molecular and cellular mechanisms of ammonia toxicity and tolerance
- The role(s) of the excretion of other nitrogenous compounds (e.g., allantoin, creasine, amino acids) in nitrogen excretion
- The role(s) of ammonia and urea carriers in nitrogen excretion in freshwater vs marine species of both invertebrates and vertebrates
- The comparative constraints of gas exchange in an aqueous environment
- The neural, cellular, and molecular mechanisms underlying cardiorespiratory reflexes
- The role(s) of gill epithelial remodeling under different gas and pH stresses
- The effects of climate changes on eutrophication, microbial activity, and enhanced thermal stratification, as they impact gas exchange
- The use of functional genomic, proteomic, and metabolomic approaches to study the water–land transition in intertidal and semi-terrestrial species
- The use of biomarkers and new modeling approaches to quantify the important differences between food intake and nutrient uptake
- The role of the gut microflora in aquatic animal nutrition
- The identification of new, sustainable components for aquaculture feed production

- The relationships between host-mediated and symbiont-mediated digestive processes
- The use of a greater variety of "model species" to study the physiology of gas exchange, cardiovascular dynamics, thermal tolerance, etc.
- The integrated study of combined effects of different environmental stimuli, such as temperature and ocean acidification on routine and maximal metabolic scope and regional blood flow distribution
- The cellular bases of thermotolerance and heat production, interactions among temperature and other physical/chemical stressors, and the molecular mechanisms of gene regulation and signaling in response to temperature changes
- The matching of diving limitations due to physiology/biochemistry with ecological constraints, niche exploitation and social requirements for time spent underwater
- The study of the developmental limits of young diving mammals, the cues and the adjustments that are made (and in what sequence) that get the young animals into the water and survive past their first or second year
- The application of biomechanical principals to a variety of physiological processes including feeding, respiration, reproduction, development, and locomotion
- The application of genomics and proteomics to a broad group of aquatic species, in an effort to understand the molecular underpinnings of learning and memory mechanisms, sensory processing, and motor control.

Frontiers in Aquatic Physiology intends to publish original research articles, review articles, hypothesis and theory articles, methods articles, commentaries, perspective articles, opinion articles, book reviews and conference proceedings in these and other areas of interest in the physiology of aquatic animals.

REFERENCE

Schwenk, K., Padilla, D. K., Bakken, G. S., and Full, R. J. (2009). Grand challenges in organismal biology. *Integr. Comp. Biol.* 49, 7–14.

Received: 12 April 2010; accepted: 13 April 2010; published online: 18 May 2010.

Citation: Evans DH, Axelsson M, Beltz B, Burggren W, Castellini M, Clements KD, Crockett L, Gilmour KM, Henry RP, Hirose S, Ip AYK, Londraville R, Lucu C, Poertner HO, Summers A and Wright P (2010) Frontiers in Aquatic Physiology – grand challenge. Front. Physio. ***1****:6. doi: 10.3389/fphys.2010.00006*

This article was submitted to Frontiers in Aquatic Physiology, a specialty of Frontiers in Physiology.