# Book Reviews

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## Surviving Antarctica

*David N. Thomas*
Natural History Museum, London. 2007.
ISBN 978 0-565-09217-7, 96 pp, £9.99

Writing good science material for a young audience is an exacting task. With less than 100 pages of simple text and many colour photographs the Natural History Museum commissioned this book to accompany their new travelling exhibition "Ice Station Antarctica". Designed as educational family entertainment the exhibition attempts to give young people some idea of what it is like to work in Antarctica and a small insight into some parts of the science. The book reflects this approach. To reach such an audience I appreciate that the author felt severely constrained to keep the book both short and simple, elements which can result in errors or misunderstandings. For instance, there are some inaccuracies in his generalizations: the Antarctic Treaty does not cover all the area south of 60°S, only the land and ice shelves; in listing the objectives of the Treaty he left out the key principle in Article II - freedom for scientific investigation; there have been more tourists than scientists/logistics people visiting Antarctica for some years now; many of the coastal stations use desalination plants rather than snow melters; frostbite is rare but frost nip is not uncommon; and the vegetation down the west side of the Antarctic Peninsula can be very lush (for example at Argentine Islands and Leonie Island). In his description on p. 90 of protected areas he fails to mention Antarctic Specially Protected Areas at all and in talking about the quite different Antarctic Specially Managed Areas (ASMA) he wrongly states that the McMurdo Dry Valleys ASMA is the first of its type. There are also still many stations that do not have sewage plants and most inland stations deposit human wastes in a cavern in the ice sheet. In a few instances his descriptions are misleading as they deal only with his personal Antarctic experience. For example, his account of project funding is typical for a university scientist but he fails to mention that several governments support long term research in Antarctica through institutes. The transit time by air to the Antarctic is not 8 hours (which is typical for the Christchurch-McMurdo flight) but dependent on the flight origin and destination - for Rothera for example it is typically 4–5 hours. Whilst the book provides interesting details about emperor penguins there is less on Adélie penguins, only a brief mention of albatrosses and giant petrels and no mention at all of the other birds such as skuas, sheathbills, Wilson's petrels etc. On p. 70 the reader has to conclude that incubation of emperor penguin eggs apparently takes place at 80°C, instead of 38°C. I find myself also disagreeing with the implication in his final statements about the extent and importance of environmental damage caused by scientists. True, there is some but it is all localized and at the continental level Antarctic pollution is due to industrial activities elsewhere in the world and not those on the continent. Surprisingly there are some spelling errors - sore for soar, wierdest for weirdest, Comandente for Comandante - and not all the photographs are recent - the one of Rothera is long out of date. Many of the photos came from the author and it seemed to me that a wider trawl could have produced some better illustrative material. Perhaps some of the errors could also have been picked up if the manuscript had been read by other Antarctic experts?

In spite of all these critical comments the book is well written, well designed, easy to read and a really useful addition to the public outreach. I hope that it sells many copies!

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## The Physiology of Polar Fishes

Fish Physiology Volume 22
*edited by* A.P. Farrell and J.F. Steffensen
Academic Press, 2005
ISBN 0-12-350446-5, 394 pages, £66

Despite very cold waters, polar regions are very productive and support a large population of birds and mammals that rely on fish for their food. The challenge for fishes come largely in the winter, when thick ice limits atmospheric gas exchange, although high oxygen solubility in the cold may avoid serious problems, and the lack of sunlight shuts down primary production. This volume provides a timely overview of the physiology of fishes that have successfully adapted to one of the most challenging aquatic environments on earth. It updates one aspect of the wide-ranging 'Antarctic Fish Biology'[1], and various specialist books since, but importantly fills a gap for the Arctic fauna, where the biology and systematics are much less well served[2]. The authors address three important questions: What is special about the physiology of fish from the stenothermal Arctic and Antarctic environments? Are there common themes to the physiology for fishes that live in frigid waters but poles apart? How do polar fishes differ from more eurythermal temperate species that can acclimatize to seasonally cold waters?

Opening of the Drake Passage occurred about 25 m.y.a., and the circumpolar current thus formed physically isolated the waters around Antarctica that reached freezing point 10–15 m.y.a. This caused a loss of species diversity, with extinctions being replaced by a benthic blennioid ancestor, and the subsequent radiation into vacant niches. In contrast, Arctic ice cover is more recent, beginning only 2–3 m.y.a., and is an open system allowing migration to and from the warmer Atlantic and Pacific oceans, leading to a lower degree of endemism than in the Antarctic. An annotated list of fish families occurring in Arctic and Antarctic regions usefully updates and extends the scope of previous guides. Physical isolation led to a high degree of endemism and the dominance of the notothenioids around Antarctica, (which have attracted the lions share of research effort) although there appears to have been several invasions by deep water zoarcids and liparids. The Arctic fauna shows much less endemism and is dominated by phylogenetically young families, probably of both Pacific and Atlantic origins. A major challenge for evolutionary biologists is mapping physiological characteristics onto molecular phylogenies, especially as many families have not been studied in this way.

A particularly good example of how the physical environment largely shapes animal physiology is how geography of the two polar regions defines the two fish faunas. Perhaps the most important ecological process limiting polar fish diversity is the extreme seasonality of food resources and primary productivity. The year-round frigid waters and abundance of ice provided a powerful selection pressure driving adaptive radiation in the ancestral Antarctic fish stock, and exploitation of the shallow Arctic shelf regions. The younger Arctic fish fauna may be displaying an intermediate position on the evolutionary path towards a common polar phenotype. For example, freezing is always lethal in teleost fish as their bodies are hyposmotic to seawater, and colonization of the frigid Antarctic waters was made possible by evolution of a biological antifreeze system, with both similar and unrelated antifreezes found in Arctic fishes. Their identification and characterization provides a classic example of convergent evolution at the protein level, and the description of how these APs disrupt or arrest the growth of ice crystals is a real *tour de force*. Importantly for such a volume, the limited understanding of the *in vivo* role played by APs is highlighted, in particular how epithelial surfaces resist ice entry and the fate of ice that enters the gut.

The metabolic physiology, biochemistry, and functional genomics of cold adaptation in marine fish is nicely outlined. One of the major challenges for ectothermic animals is to generate sufficient energy for activity, growth and reproduction, as physiological processes are depressed by a factor of 2–3 for every 10°C drop (Q10 of 2–3). The limits and benefits of thermal specialization require an understanding of the trade-offs and constraints in thermal adaptation, and a particularly emphasis is placed on oxygen delivery. A conceptual framework is developed that involves pejus (‘getting worse’) temperatures that characterize the onset of thermal limitation at high and low temperature thresholds, with shifts in thermal tolerance being of interest in light of global warming. Thermal acclimatization or adaptation to permanent cold may include increased aerobic metabolism, reduced proton leakage and ionoregulation, and modifications to protein synthesis and structure. With the possible exception of the haemoglobinless icefish, it seems unlikely that the role of branchial or cutaneous oxygen uptake in transfer of oxygen from water to tissue is fundamentally different to that in temperate fishes, so other adaptations must provide for the maintenance of aerobically-based metabolic activity. The long-running debate over metabolic cold adaptation, where polar species were assumed to have a higher metabolic rate than temperate counterparts at the same temperature, is extensively discussed and shown to be an artifact of earlier studies. This has important implications for maintenance costs in fish that have to synthesize antifreeze proteins and maintain high muscle mitochondrial densities, and complements a discussion about repartitioning of the energy budget.

A perennial problem in comparative physiology, how can one be sure that observed traits in one of the polar regions are adaptations to low temperature that have arisen through natural selection, or the consequences of genetic drift or phylogenetic constraints, is explored by means of the cardiovascular system and oxygen transport. While the effects of cold on blood viscosity, splennic control of haematocrit and vascular resistance are all thought to reduce cardiac afterload, and the low heart rate and high stroke volume (particularly in icefishes) is explained by unusual autonomic control, differences in vascular control may reflect phylogeny rather than temperature. Some unusual findings are of unknown function, e.g. an apparently widespread blunted catecholamine-mediated stress response, but the unusual response to exercise and hypoxia may reflect the few species examined and/or experimental protocols adopted, highlighting the need to study sub-Antarctic and temperate relatives to distinguish between true adaptations to the cold and phylogenetic traits, and for bipolar comparisons. A further caution, however, is that given the limited ecological opportunities offered by the deep Antarctic continental shelf, the slower rate of cooling, and the development of secondary pelagicism in the endemic species, there is no *a priori* reason that their adaptations for energy expenditure should parallel those seen in Arctic fishes.

Notothenioid fish are not great swimmers, using sluggish labriform locomotion, but red muscle has an extremely high mitochondrial content (> 50% of fibre volume in pectoral muscle) supporting other evidence that cold adaptation has maintained aerobic capacity. However, the low capillary density suggest limitations for peripheral oxygen exchange which contrast nicely with those described for oxygen uptake. While specific protein isoforms mean that it is energetically cheaper for Antarctic fishes to maintain muscle tension and its development appears to be temperature independent, contraction velocity and fuel use show little thermal compensation. Consequently, sprint performance is comparable to that of temperate species over a 9°C range. More significant for the consequences of global warming is exciting new data showing that notothenioids are capable of distinct warm acclimation, rather than just tolerating higher temperatures, which calls into question the dogma that Antarctic fishes are extreme stenotherms. As with these other processes, the principles of adaptation to the cold, dark and relatively quiet world they inhabit should be common to both faunas with respect to neuro/sensory physiology where it is important to distinguish between resistance adaptations (change in tolerance of physiological processes outside of normal limits) and capacitance adaptations (compensatory changes to offset the effects of cold). It appears that nerve conduction velocities are higher than temperate species at a common temperature, but with the trade-off that they fail at relatively low temperature, providing interesting parallels between fishes of high latitudes and deep sea (see vol. 16).

This is an excellent summary of current knowledge written by the acknowledged experts in the field. It will be a valuable resource about the physiology of fishes living at high latitudes for many years, as well as providing a good overview of general topics in fish physiology. With its emphasis on the challenges and adaptations of fishes at high latitudes, it is also timely for those with an interest in the effects of global change in polar regions. The audience will include comparative physiologists, thermobiologists, ichthyologists, and fishery scientists. It is highly recommended.

### References

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S. Egginton

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## The Periglacial Environment

*Hugh M. French*
John Wiley and Sons, 2007
ISBN 13:978-0-470-86588-0, 458 pages, £80

The updated and larger Third Edition (458 pages compared to 341 of 2nd ed.) has 15 chapters grouped in four sections: I. the Periglacial Domain, II. Present-Day Periglacial Environments, III. Quaternary and Late-Pleistocene Periglacial Environments, and IV. Applied Periglacial Geomorphology; section II is by far the largest with seven chapters and 234 pages. With *c.* 1350 references to 2006 this an 'up-to-date' volume. It is reasonably easy to read, easy to find information, with many figures and photographs. Each chapter has "Advanced Reading" suggestions at the end together with "Discussion Topics" presumably aimed at helping focus thought and/or classroom discussion. It is an interesting reflection on advances (or the absence thereof) in periglacial research that several discussion topics remain the same as those in the 1996 (2nd) edition.

It is clear that there is more detail and confidence in the writing where the author is dealing with his own expertise (notably permafrost, permafrost-related topics and applied aspects), and less so in other areas (notably weathering and weathering-related landforms and sediments). Indeed, it is within weathering that I found some of the greatest weaknesses. The concept of "thermal *fatigue*" is not mentioned at all, only thermal *shock*, within the framework of thermal *stress* and "Insolation Weathering", but it is very encouraging indeed to see the start of some questioning of the ubiquitous application and assumption of the freeze-thaw concept. However, one is still told that (p. 61) "…an exposure of shattered fissile sandstone is almost certainly the result of frost action.." but there yet to be a single field instance of *proving* (rather than assuming/speculating) weathering was actually the result of freeze-thaw and, equally, that no other processes played a role. That said, the overall presentation does offer new insights and opens the way for new thinking on these topics and thus the volume does, especially for the undergraduate audience, do a good job; the criticisms reflect my personal frustrations regarding the present state of weathering research. Perhaps that would be my biggest concern for undergraduate use - it provides a good, solid, well-referenced text for the undergraduate but does not really (for a number of topics) "step outside of the box" and suggest either how little we really know or encourage us to question some of our long-cherished concepts. This is clearly the case with respect to "nivation/cryoplanation" - with (interestingly) the Index citation for 'Nivation benches' indicating "see cryoplanation terraces". Indeed, while there are a couple of pages on 'Cryoplanation' (p. 244–246) 'Nivation' *per se* does not even warrant a sub-section heading but rather is noted *within* the sections 9.2.2 Rectilinear Debris-Mantled Slopes, 9.2.5 Stepped Profiles, and 9.6 Slopewash. None of this reflects the recent questioning regarding these two concepts and the almost total absence of *any* data from 'cryoplanation' terraces or actual testing of the cryoplanation concept.

It is always easy to find fault but, at this time, there are no other up-to-date periglacial texts available and this one *does* do a good job. Graduate students would also find this a very valuable resource for a broad-based background on almost every periglacial topic (the biggest absence would be that of periglacial processes and landforms on other planets for which there is a growing body of literature) and offer sufficient literature resources to allow follow-up into more detailed studies. Thus I strongly recommend this volume,