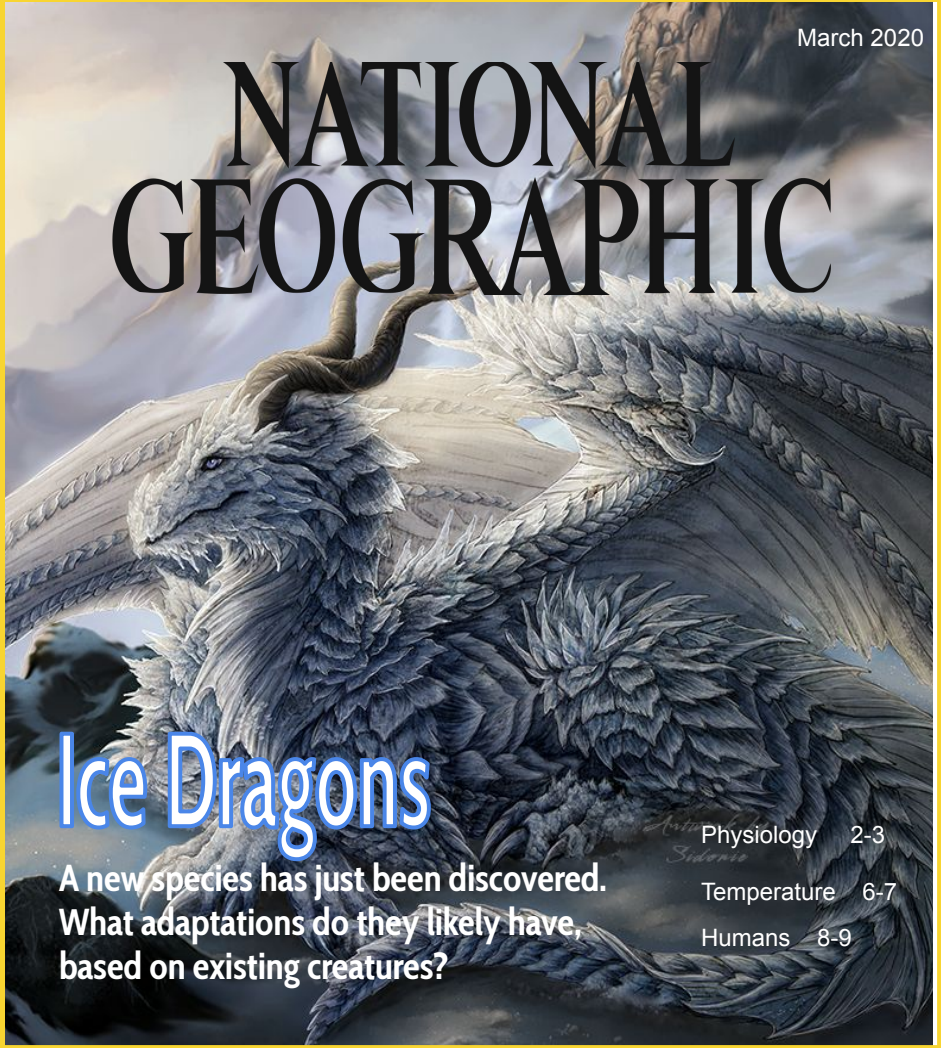

March 2020
NATIONAL GEOGRAPHIC
Ice Dragons
A new species has just been discovered. What adaptations do they likely have, based on existing creatures?
Physiology 2-3
Temperature 6-7
Humans 8-9

Physiological Changes

Hemoglobin

In animals, hemoglobin in the blood carries oxygen to tissues. The reaction where oxygen binds to hemoglobin releases heat. However, in the Arctic it releases less heat than usual.[6] That doesn't seem to make much sense. Wouldn't you want to generate more heat when living in the Arctic? Perhaps then breathing could help keep the animal warm.

Actually no, because the reverse reaction (where oxygen leaves hemoglobin) has to occur at the tissues, and it requires the same amount of heat that was released previously. Thus, by releasing a smaller amount of heat, less heat is needed to oxygenate tissues in an environment where heat is very scarce. This lower heat requirement will likely be seen in the dragons.[3]

Arctic terns are born with low hemoglobin levels, which increase throughout life. This increase is due to demand for oxygen, both due to activity and temperature regulation (birds are warm blooded).[1]

Hemoglobin levels have not yet been measured in ice dragons, and it is difficult to predict them. Flight for such a large animal likely requires much energy, but they are cold blooded.

NATIONAL GEOGRAPHIC

Hibernating Hemoglobin

In humans, warmth and certain organic compounds in the blood help oxygen bind to hemoglobin. But when the forest dormouse, an animal that lives just below the arctic circle, hibernates, the levels of these chemicals and body temperature decrease. Luckily for the dormouse, these factors play a less important role and hemoglobin can still bind effectively. Dormice also share the less exothermic hemoglobin noted in arctic animals.[2] It will be interesting to see which, if any, of these changes dragons share.

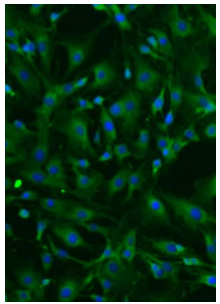
Physiological Changes

Lungs and Liver Cells

Gas exchange, when carbon dioxide and oxygen are swapped during breathing, is essential to life. Much of this process occurs in alveoli, which are tiny air sacs in the lungs. In the arctic cold, animals expose fewer alveoli to the air in order to limit exposure. This means the alveoli they do expose must work more efficiently.

Arctic alveoli are more uniformly open and never collapsed, with more pores and capillaries, and thinner barriers between the alveoli and the bloodstream. This allows gas exchange to be more efficient and requires fewer alveoli.[18] Ice dragons likely share this adaptation.

Arctic algae happens to have a lot of vitamin A. This passes vitamin A up the food chain, causing very high levels in arctic predators. Vitamin A is stored in stellate liver cells (shown).[10,17]



In fact, arctic predators can survive levels that would be toxic in other animals. This is likely a necessary evolution since there is so much vitamin A in their diet.[15,16] Thus, apex predator dragons likely share this adaptation.

NATIONAL GEOGRAPHIC

If the sun never sets, when do you sleep?

A very good question. Scientists thought it might be intensity of light, but then determined that this change is very slight and affected by weather. They believe it is more likely that light color cues animals to sleep. Light color shows large variations throughout the day, and does affect arctic birds' sleep cycles in laboratory tests.[13,14] However, researchers did find that species vary in how their activity level is synced to light cues.[20] Thus, while the ice dragon probably uses like color to set its circadian clock, we do not know what color light tells them to sleep.

Temperature Regulation

Staying warm in subzero temperatures

As an animal living in the Arctic, the ice dragon must deal with some pretty cold temperatures. Occasionally, the dragon even ends up frozen solid. Most animals cell would die in this state, but ice dragons don't. This is because their cells can rapidly lose water, preventing the formation of dangerous ice crystals. This same mechanism is used by intertidal animals in the Arctic.[12]

Arctic animals are also very good at thermal regulation. Most accomplish this with thick fur, as does the ice dragon (an unusual dragon with fur instead of scales). However, animals also need a way to let off heat. This is often accomplished through exposed feet, which allow animals to let off heat. The ice dragon similarly does not have fur on the bottom of its feet.[11]

Exposed feet are often keep very close to freezing. This prevents snow underfoot from melting, which could cause it to refreeze on the animal's feet (a dangerous hazard).[11]

But how do animals keep their feet from freezing? Arctic foxes and wolves shunt blood to the surface of their feet through special vessels, heating them more effectively. The ice dragon does this too.[9]

NATIONAL GEOGRAPHIC

Lizards in the Arctic?

You may know that lizards are cold blooded and can't make their own heat. So how could a lizard possibly survive in the Arctic? *Lacerta vivipara* is one of few lizards that lives above the Arctic Circle, and it uses some of the same strategies as its ice dragon cousin. Both lizards hibernate deep underground, where temperatures fluctuate less, with high blood glucose levels. They can also tolerate freezing for up to a week. Some can even avoid freezing below their normal freezing point, although we don't yet know how.[7,21]

Humans and Ice Dragons

Contamination and pollution

The arctic has changed a lot recently. Researchers have found high levels of organic pollutants in arctic animals, especially those higher in the food chain. This may be causing vitamin A deficiency like symptoms and immune issues, but it's unclear if the pollutants are the cause. Similarly, researchers found liver damage in polar bears, likely caused by organic pollutants.

Another group of researchers found recent increases in mercury levels, and were able to use isotopes to trace 92% of it to human sources.[4] Thus, it seems likely that ice dragons will also have higher levels of contaminants and potentially health effects from them. The full effect of pollutants on arctic animals is poorly known, and it remains to be seen how dragons were affected.

Oil spills are a potentially devastating event. One study found significant immune compromise in exposed scallops. Luckily, they found these effects are reversible after removal of contaminants.

However, long term health effects for scallops are unknown, as are the full consequences for the ecosystem at large.[8] Oil spills have to potential to cause disaster.

Beluga Whales

Cytochrome P450 1A1 (CYP1A1) is a protein expressed when beluga whales are exposed to certain organic contaminants. Even in areas with fairly low pollution levels, researchers found high levels of the protein. This suggests beluga whales are extremely sensitive to these pollutants. The researchers also suggest that the chemicals may cause the tumors seen in that population.[22] The beluga whale is a case study of how sensitive arctic populations can be to human pollution. It remains to be seen how and if ice dragons have been affected in this way.

Bibliography

1. Bech, Claus, and Marcel Klaassen. 1996. "Blood Hemoglobin Content and Metabolic Performance of Arctic Tern Chicks Sterna Paradisaea." *Journal of Avian Biology* 27 (2): 112. https://doi.org/10.2307/3677140.
2. Clementi, M. E., R. Petruzzelli, M. G. Filippucci, C. Capo, F. Misiti, and B. Giardina. 2003. "Molecular Adaptation to Hibernation: The Hemoglobin of Dryomys Nitedula." *Pflugers Archiv European Journal of Physiology* 446 (1): 46–51. https://doi.org/10.1007/s00424-002-0960-4.
3. Clementi, Maria E., Saverio G. Condo, Massimo Castagnola, and Bruno Giardina. 1994. "Hemoglobin Function under Extreme Life Conditions." *European Journal of Biochemistry* 223 (2): 309–17. https://doi.org/10.1111/j.1432-1033.1994.tb18996.x.
4. Dietz, Rune, Peter M. Outridge, and Keith A. Hobson. 2009. "Anthropogenic Contributions to Mercury Levels in Present-Day Arctic Animals-A Review." *Science of the Total Environment* 407 (24): 6120–31. https://doi.org/10.1016/j.scitotenv.2009.08.036.
5. Gabrielsen, Geir Wing, and Espen Henriksen. 2001. "Persistent Organic Pollutants in Arctic Animals in the Barents Sea Area and at Svalbard; Levels and Effects (Review)." *Memoirs of National Institute of Polar Research. Special Issue*54: 349–64. https://doi.org/N/A.
6. Giardina, Bruno, Ole Brix, Matti Nuutinen, Said El Sherbini, Astrid Bardgard, Giuseppe Lazzarino, and Saverio G. Condò. 1989. "Arctic Adaptation in Reindeer: The Energy Saving of a Hemoglobin." *FEBS Letters* 247 (1): 135–38. https://doi.org/10.1016/0014-5793(89)81256-6.
7. Grenot, Claude J., Laurence Garcin, Jérôme Dao, Jean Pierre Hérold, Bernard Fahys, and Huguette Tséré-Pagès. 2000. "How Does the European Common Lizard, Lacerta Vivipara, Survive the Cold of Winter?" *Comparative Biochemistry and Physiology - A Molecular and Integrative Physiology* 127 (1): 71–80. https://doi.org/10.1016/S1095-6433(00)00236-1.
8. Hannam, Marie L., Shaw D. Bamber, John A. Moody, Tamara S. Galloway, and Malcolm B. Jones. 2009. "Immune Function in the Arctic Scallop, Chlamys Islandica, Following Dispersed Oil Exposure." *Aquatic Toxicology* 92 (3): 187–94. https://doi.org/10.1016/j.aquatox.2009.01.010.
9. Henshaw, Robert E., Larry S. Underwood, and Timothy M. Casey. 1972. "Peripheral Thermoregulation: Foot Temperature in Two Arctic Canines." *Science* 175 (4025): 988–90. https://doi.org/10.1126/science.175.4025.988.
10. Higashi, Nobuyo, and Haruki Senoo. 2003. "Distribution of Vitamin A-Storing Lipid Droplets in Hepatic Stellate Cells in Liver Lobules - A Comparative Study." *Anatomical Record - Part A Discoveries in Molecular, Cellular, and Evolutionary Biology* 271 (1): 240–48. https://doi.org/10.1002/ar.a.10036.
11. Irving, L., and J. Krog. 1955. "Temperature of Skin in the Arctic as a Regulator of Heat." *Journal of Applied Physiology* 7 (4): 355–64. https://doi.org/10.1152/jappl.1955.7.4.355.
12. Kanwisher, John. 1959. "Histology and Metabolism of Frozen Intertidal Animals." *The Biological Bulletin* 116 (2): 258–64. https://doi.org/10.2307/1539211.
13. Krüll, Frans. 1976. "Zeitgebers for Animals in the Continuous Daylight of High Arctic Summer." *Oecologia* 24 (2): 149–57. https://doi.org/10.1007/BF00572756.
14. Pohl, Hermann. 1999. "Spectral Composition of Light as a Zeitgeber for Birds Living in the High Arctic Summer." *Physiology and Behavior* 67 (3): 327–37. https://doi.org/10.1016/S0031-9384(99)00070-0.
15. Senoo, Haruki. 2004. "Structure and Function of Hepatic Stellate Cells." *Medical Electron Microscopy* 37 (1): 3–15. https://doi.org/10.1007/s00795-003-0230-3.
16. Senoo, Haruki, Katsuyuki Imai, Yoshihiro Mezaki, Mitsutaka Miura, Mayako Morii, Mutsunori Fujiwara, and Rune Blomhoff. 2012. "Accumulation of Vitamin A in the Hepatic Stellate Cell of Arctic Top Predators." *Anatomical Record* 295 (10): 1660–68. https://doi.org/10.1002/ar.22555.
17. Senoo, Haruki, Naosuke Kojima, and Mitsuru Sato. 2007. "Vitamin A-Storing Cells (Stellate Cells)." *Vitamins and Hormones* 75 (06): 131–59. https://doi.org/10.1016/S0083-6729(06)75006-3.
18. Shishkin, G. S., and N. V. Ustyuzhaninova. 1997. "Morphological Peculiarities of Respiratory Compartments of Arctic Animal Lungs." *Anatomical Record* 247 (4): 496–500. https://doi.org/10.1002/(SICI)1097-0185(199704)247:4<496::AID-AR8>3.0.CO;2-P.
19. Sonne, Christian, Rune Dietz, Pall S. Leifsson, Erik W. Born, Robert J. Letcher, Maja Kirkegaard, Derek C.G. Muir, Frank F. Riget, and Lars Hyldstrup. 2005. "Do Organohalogen Contaminants Contribute to Hispathology in Liver from East Greenland Polar Bears (Ursus Maritimus)?" *Environmental Health Perspectives* 113 (11): 1569–74. https://doi.org/10.1289/ehp.8038.
20. Steiger, Silke S., Mihai Valcu, Kamiel Spoelstra, Barbara Helm, Martin Wikelski, and Bart Kempenaers. 2013. "When the Sun Never Sets: Diverse Activity Rhythms under Continuous Daylight in Free-Living Arctic-Breeding Birds." *Proceedings of the Royal Society B: Biological Sciences* 280 (1764). https://doi.org/10.1098/rspb.2013.1016.
21. Voituron, Yann, Bruno Verdier, and Claude Grenot. 2002. "The Respiratory Metabolism of a Lizard (Lacerta Vivipara) in Supercooled and Frozen States." *American Journal of Physiology - Regulatory Integrative and Comparative Physiology* 283 (1 52-1): 181–86. https://doi.org/10.1152/ajpregu.00378.2001.
22. Wilson, Joanna Y., Suzy R. Cooke, Michael J. Moore, Daniel Martineau, Igor Mikaelian, Donald A. Metner, W. Lyle Lockhart, and John J. Stegeman. 2005. "Systemic Effects of Arctic Pollutants in Beluga Whales Indicated by CYP1A1 Expression." *Environmental Health Perspectives* 113 (11): 1594–99. https://doi.org/10.1289/ehp.7664.