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CAN POLAR BEAR HAIRS ABSORB ENVIRONMENTAL ENERGY?

by

Ji-Huan HE [a*]***, Qing-Li WANG*** [b]***, and Jie SUN*** [a]

[a] National Engineering Laboratory for Modern Silk, College of Textile and Engineering, Soochow University, Suzhou, China

[b] Modern Textile Institute, Donghua University, Shanghai, China

Original scientific paper
UDC: 599.742.22:502.21
DOI: 10.2298/TSCI1103911H

A polar bear (Ursus maritimus) has superior ability to survive in harsh Arctic regions, why does the animal have such an excellent thermal protection? The present paper finds that the unique labyrinth cavity structure of the polar bear hair plays an important role. The hair can not only prevent body temperature loss but can also absorb energy from the environment.

Key words: *polar bear (Ursus maritimus) , thermal protection, hair*

Introduction

The hair of polar bears is white and translucent, it was considered to have good light collection to gain additional energy by harvesting solar radiation [1, 2]. However, in extremely cold ambient conditions as low as –50 °C, the little solar energy absorbed by hairs is not enough to prevent the polar bear from cooling. It is still an enigma how a polar bear can keep its body temperature unchanged as high as 37 °C.

Inner structure of polar bear's hair

In order to uncover its mechanism, we studied the polar bear hair using the scanning electron micrography, and found the labyrinth-like structure in the inner hair [3] as illustrated in fig.1. Labyrinths are separated from each other in the hollow hair by smooth membrane surrounded by the transparent cylinder of the polar bear hair. The transparent part has relatively good light and thermal conduction so does this mean that the body temperature can easily be lost through the transparent part? The answer is partly yes and partly no because it can also transfer heat flow from outside.

Mechanism of the hollow and membrane structure of the polar bear hair

After millions of years of evolution, nature endowed the polar bear with genius of thermal protection with hollow and membrane micro-structure, unmatched by any known

* Corresponding author; e-mail: hejihuan@suda.edu.cn

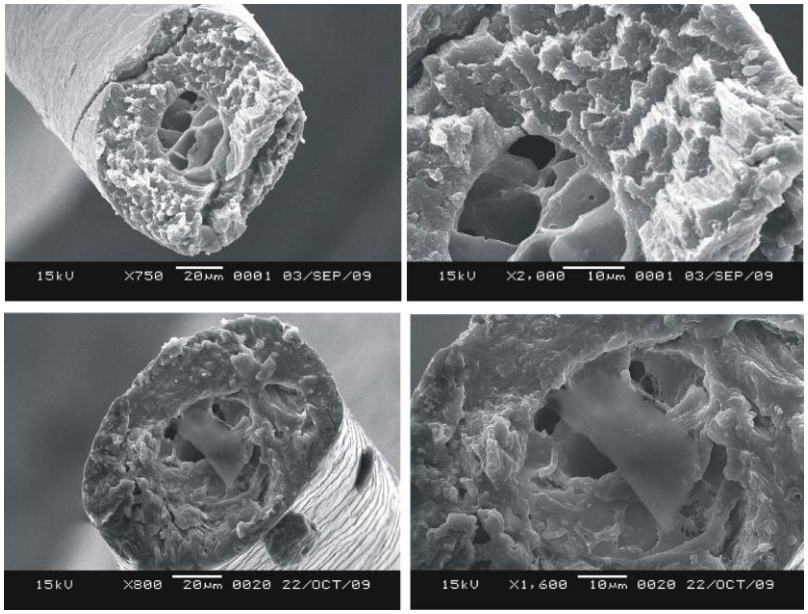

Figure 1. Scanning electron micrographs of polar bear hair (middle part of the hair); the sample was collected from abdominal hair and dorsalbodysetae of a two-year old male polar bear in the Laohutan Pole Aquarium in Dalian, China

synthetic high-performance thermal insulators. The special structure enables the hair to absorb energy from environment including solar radiation, chill wind, and cold ice-free water. Each vacuum micro-labyrinth is a good thermal insulator, and we assume at a certain time the temperature in all labyrinths are equal to the environment temperature, say –50 °C. Such case can not maintain a long time due to high temperature difference in its micro-environment, but the polar bear is clever enough to swim in the ice-free water, where compared with the harsh environment temperature, the water with temperature of about 0 °C is the warmest for the polar bear. Now the peculiar energy transparent cylinder of the hair acts as a relatively good thermal conductor to absorb energy from "cool" water. In a relatively short period, the temperature in each labyrinth gets a balanced temperature equal to that of ice-free water, see fig. 2. The polar beer can now stop swimming to do its daily work with a lowest temperature difference in its micro-environment. The

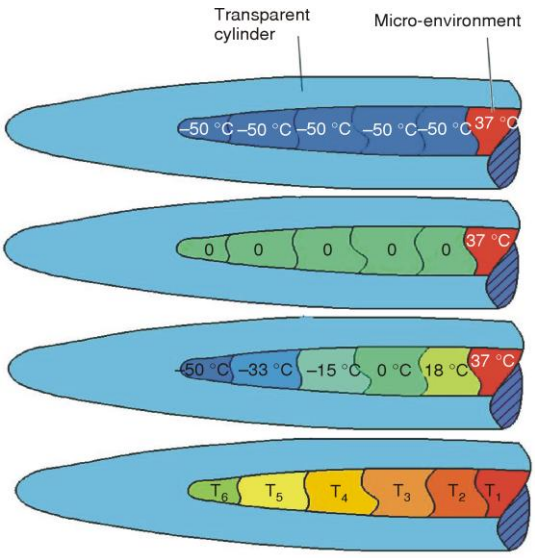

Figure 2. Hollow and membrane structure of a polar bear hair
(color image see on our web site)

temperature in each labyrinth will, however, decease gradually again until it reaches the environment temperature as low as –50°C, and the hair can absorb energy from its environment when the environment temperature is higher than the lowest one from wind, water, and ice.

Discussion

Some animals have hollow hairs without membrane structure. The hollow hairs enable animals to insulate and keep them warm. For examples, alpacas living in sub-zero climate have hollow hair. Reindeer (*Rangifer sp.*) and moose (*Alces*) have hollow hairs as well. Hollow hair, in fact, is an adaptation of animals which live in very cold climates. But the hair for polar bear is unique with labyrinth cavity structure, each labyrinth cavity is a good thermal insulator for keeping warm and the system of labyrinth cavities enable the animal to absorb energy from its environment.

Conclusions

The mechanism may find many potential applications in the future, especially in thermal insulation designs for extreme cases. A mathematical model using fractional calculus is suitable for analysis of the thermal property of the polar bear hair; see a forthcoming paper [4].

Acknowledgment

The work is supported by PAPD (A Project Funded by the Priority Academic Program Development of Jiangsu Higher Education Institutions), National Natural Science Foundation of China under Grant Nos. 10972053 , 10802021 and 50806011.

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Paper submitted: July 3, 2011
Paper accepted: July 7, 2011