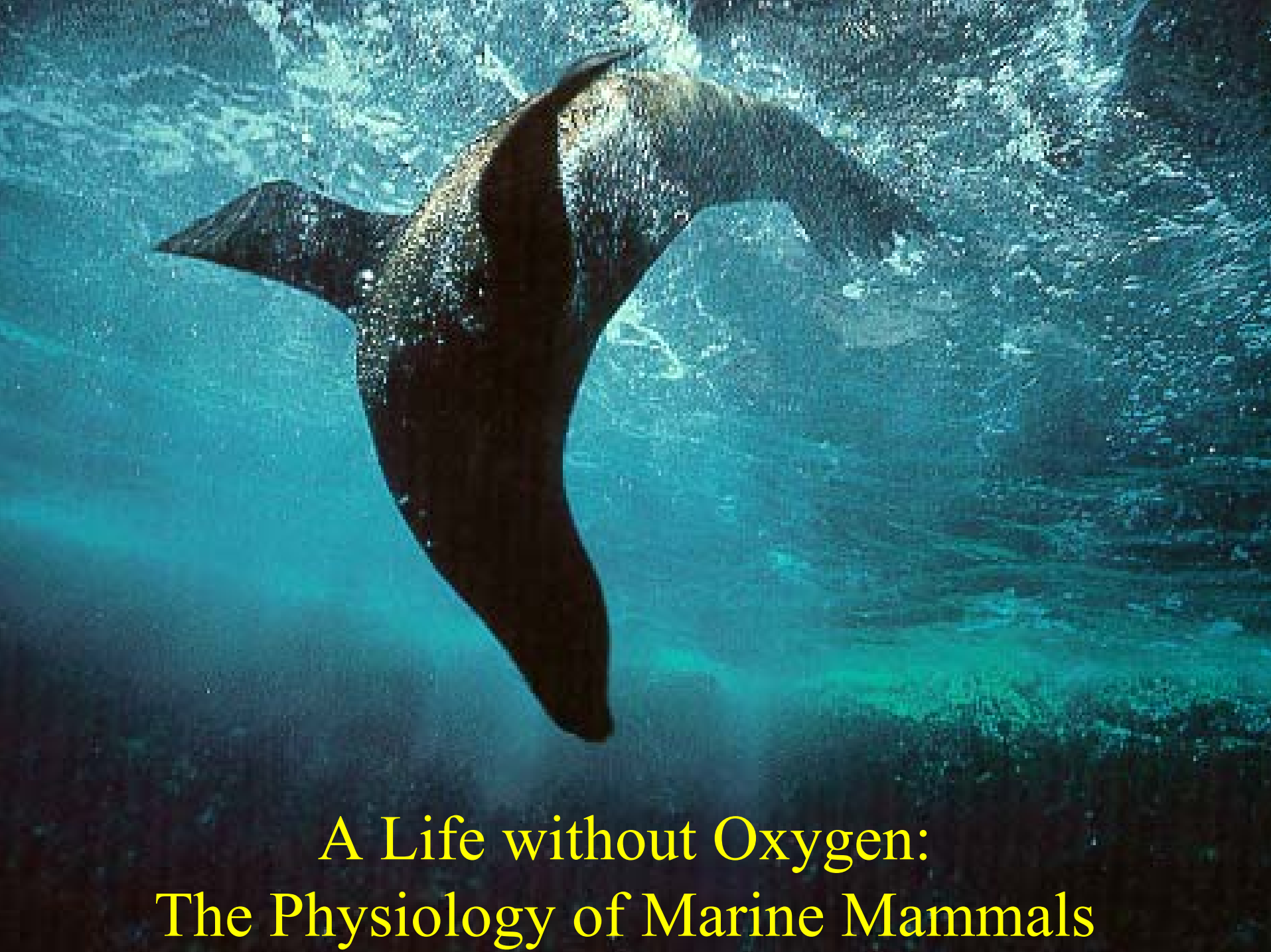
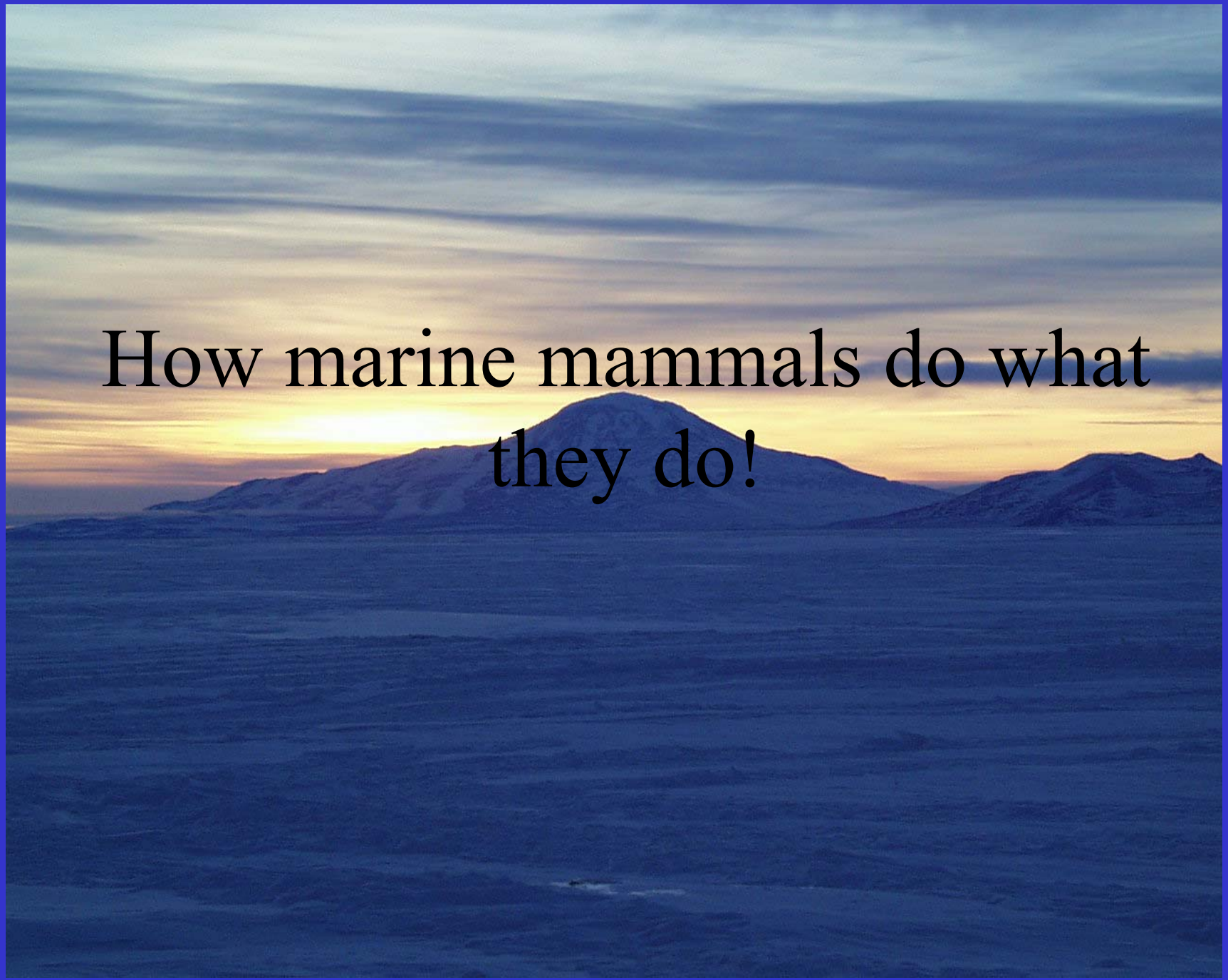
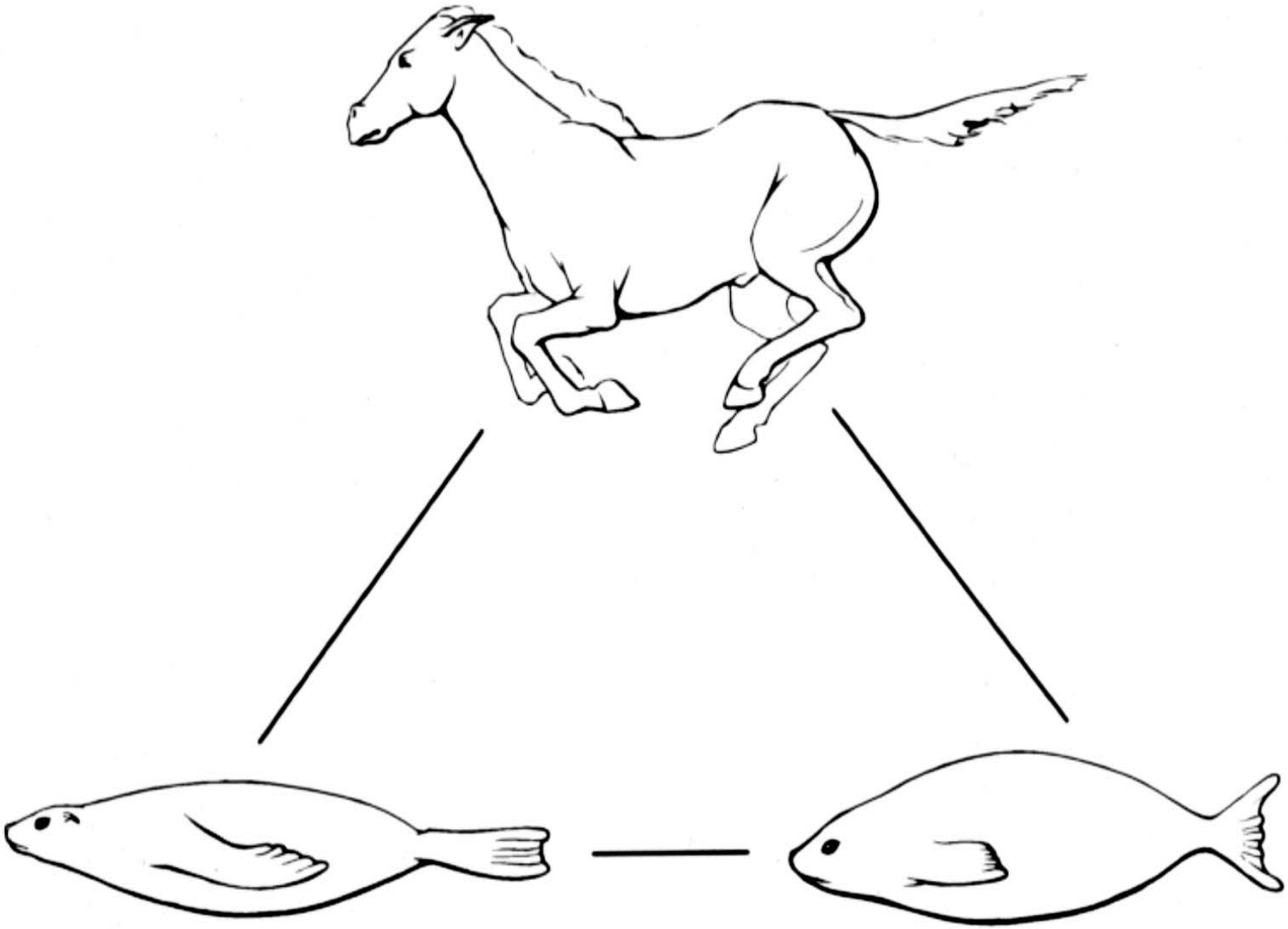

(c) by Hinrich Bäsemann - www.Polarfoto.de



A Life without Oxygen: The Physiology of Marine Mammals

COMPETITION FOR RESOURCES


How marine mammals do what they do!

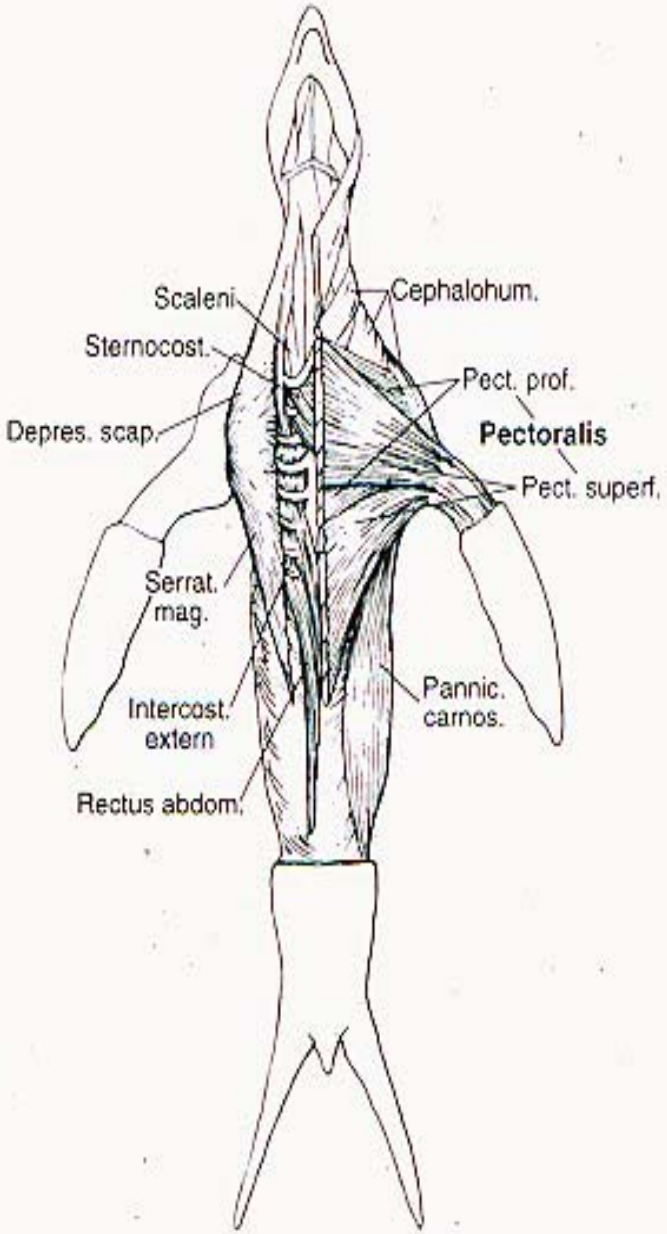


Dive Response

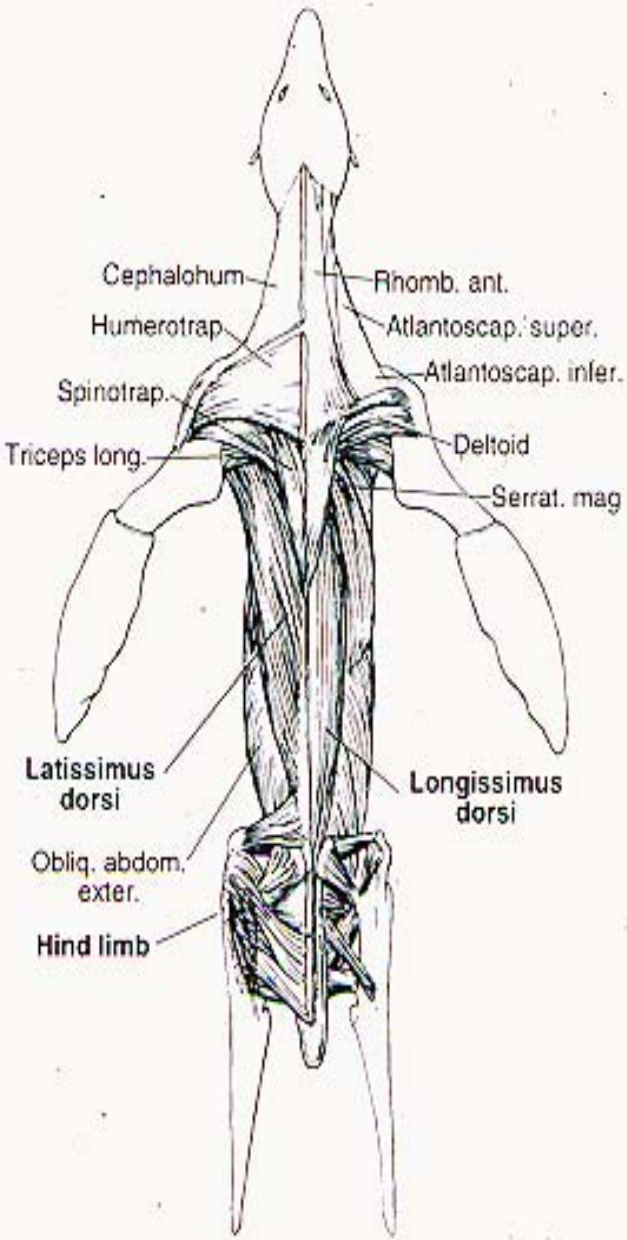
- Stop Breathing
- ↓ Cardiac Output
- ↓ Peripheral Blood Flow
- Lungs Collapse below 60m
- **But Maintain Aerobic Metabolism**


ALASKA

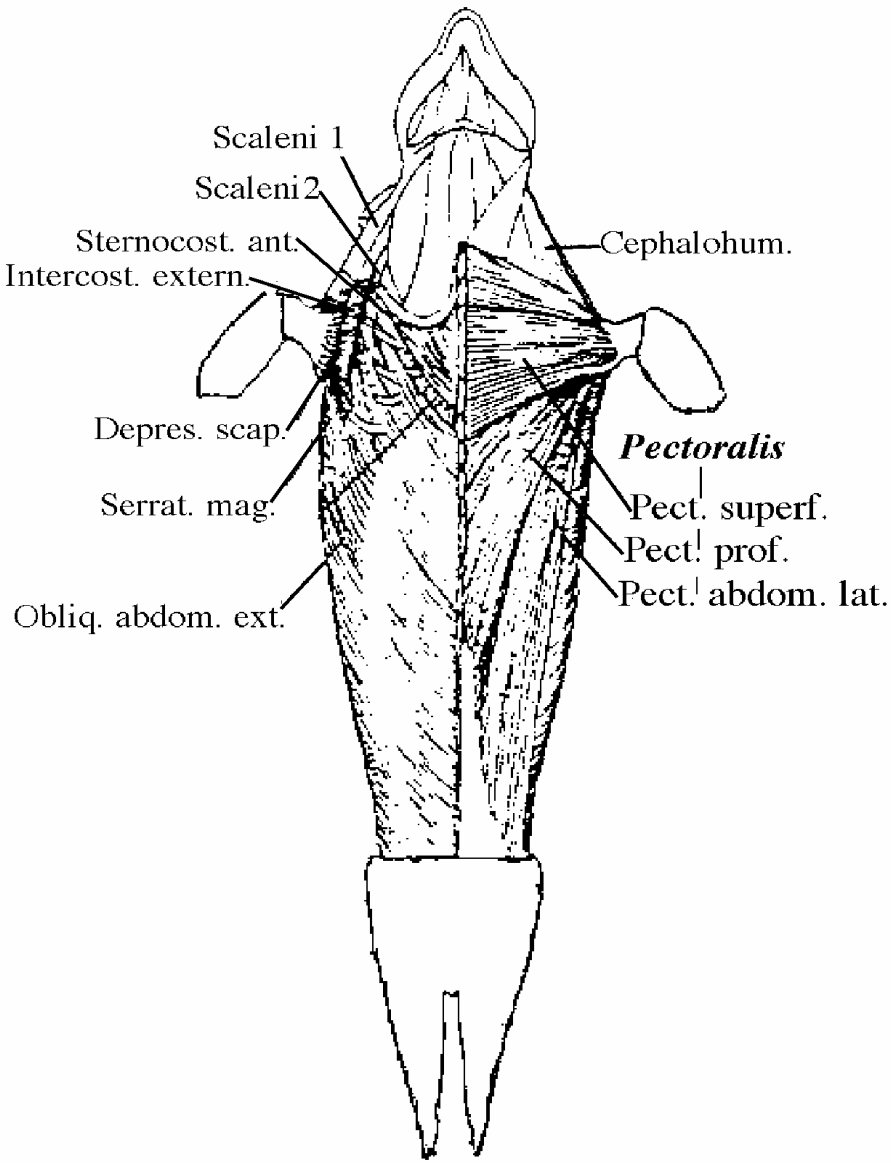
Ventral view of sea lion



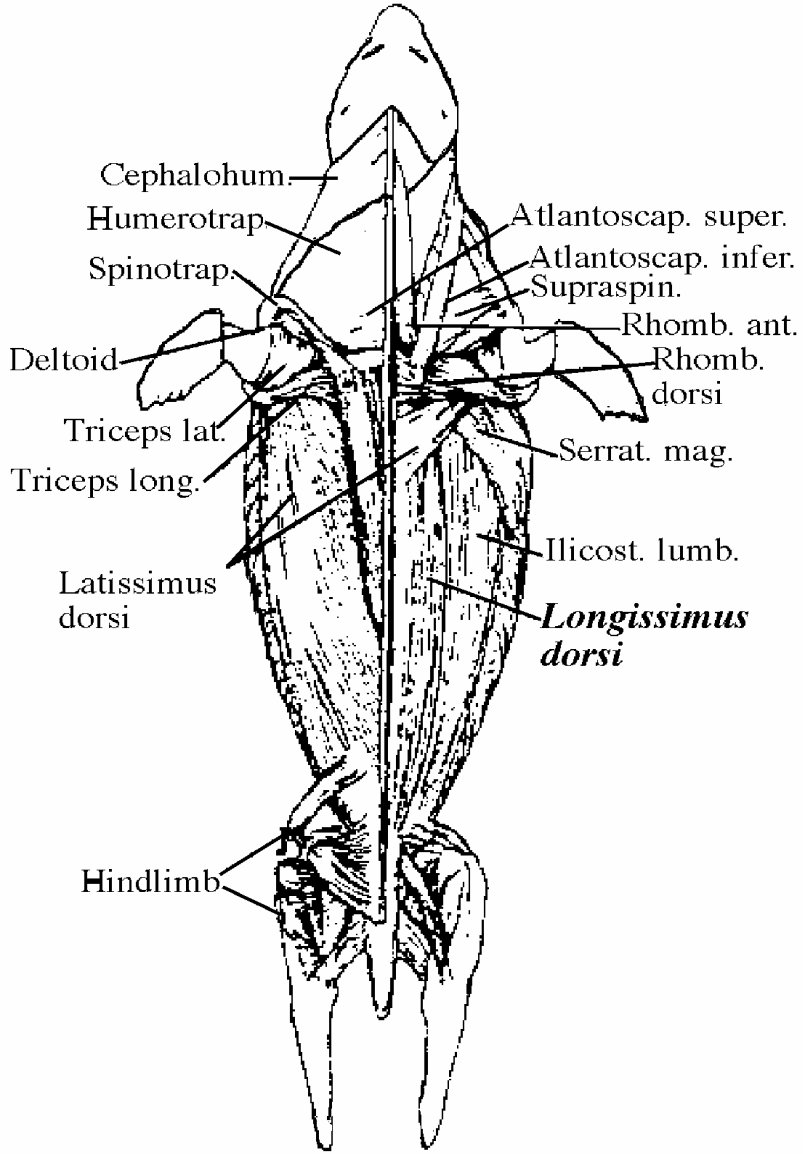
Dorsal view of sea lion

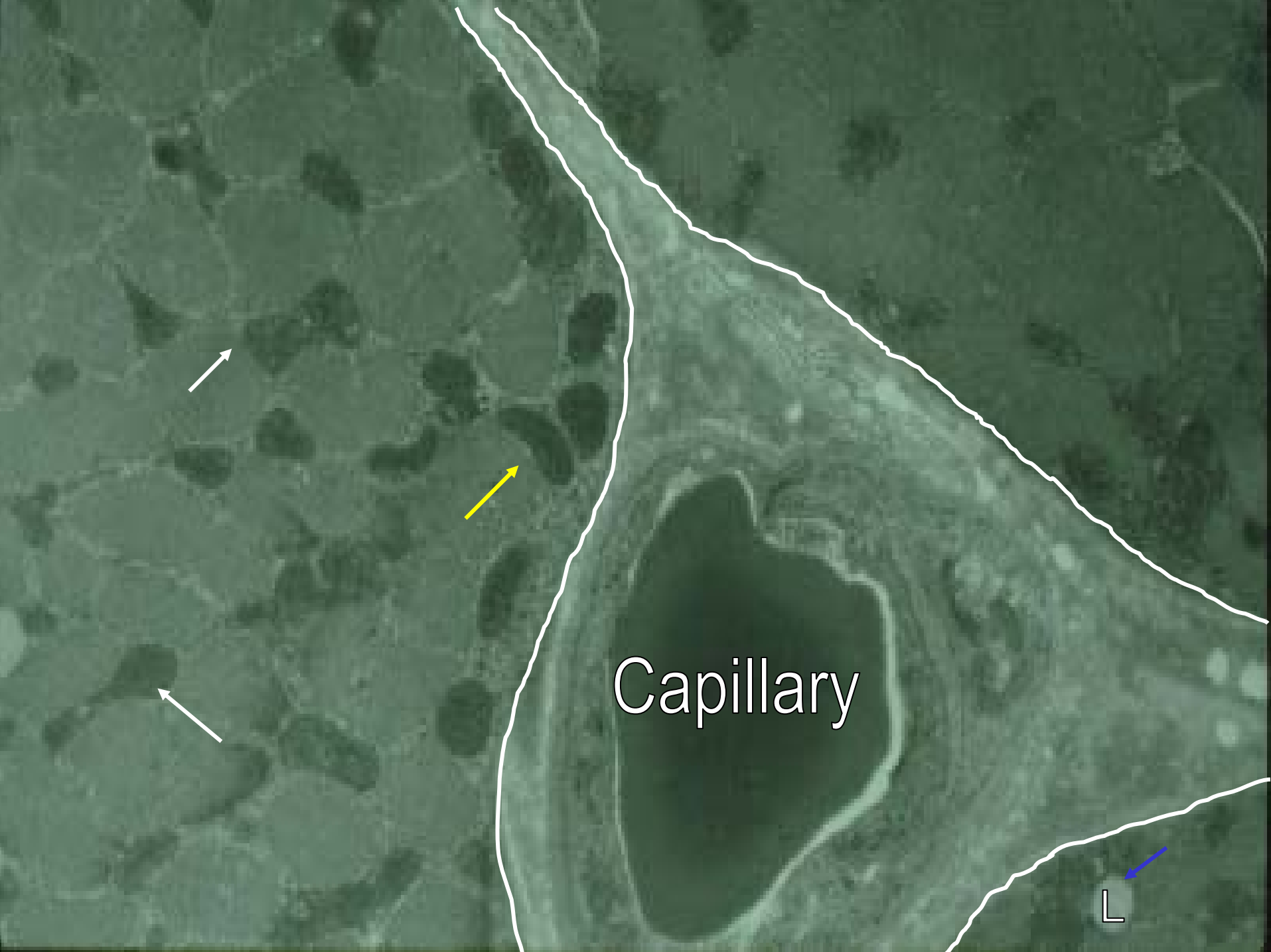


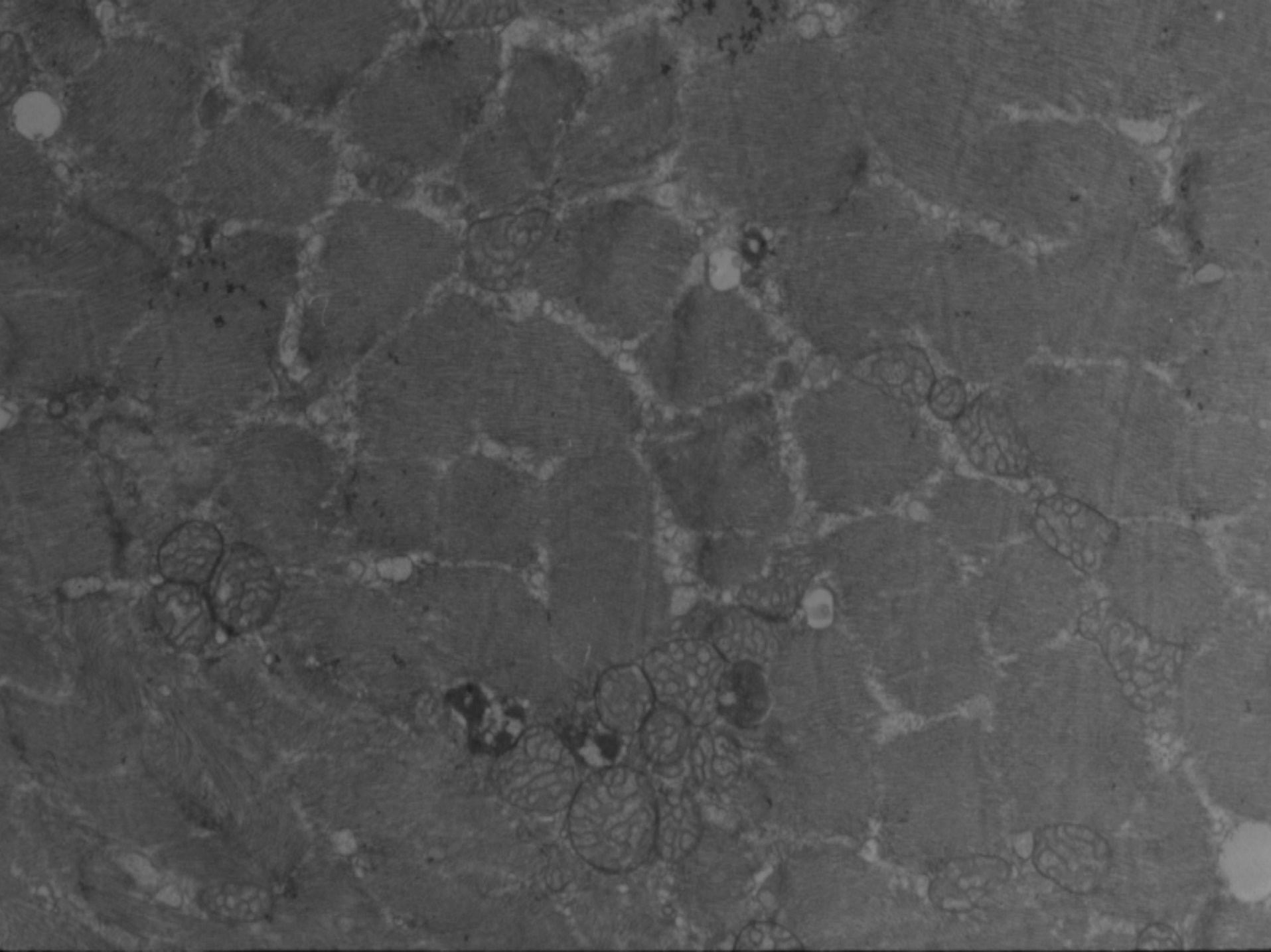
Ventral view of seal

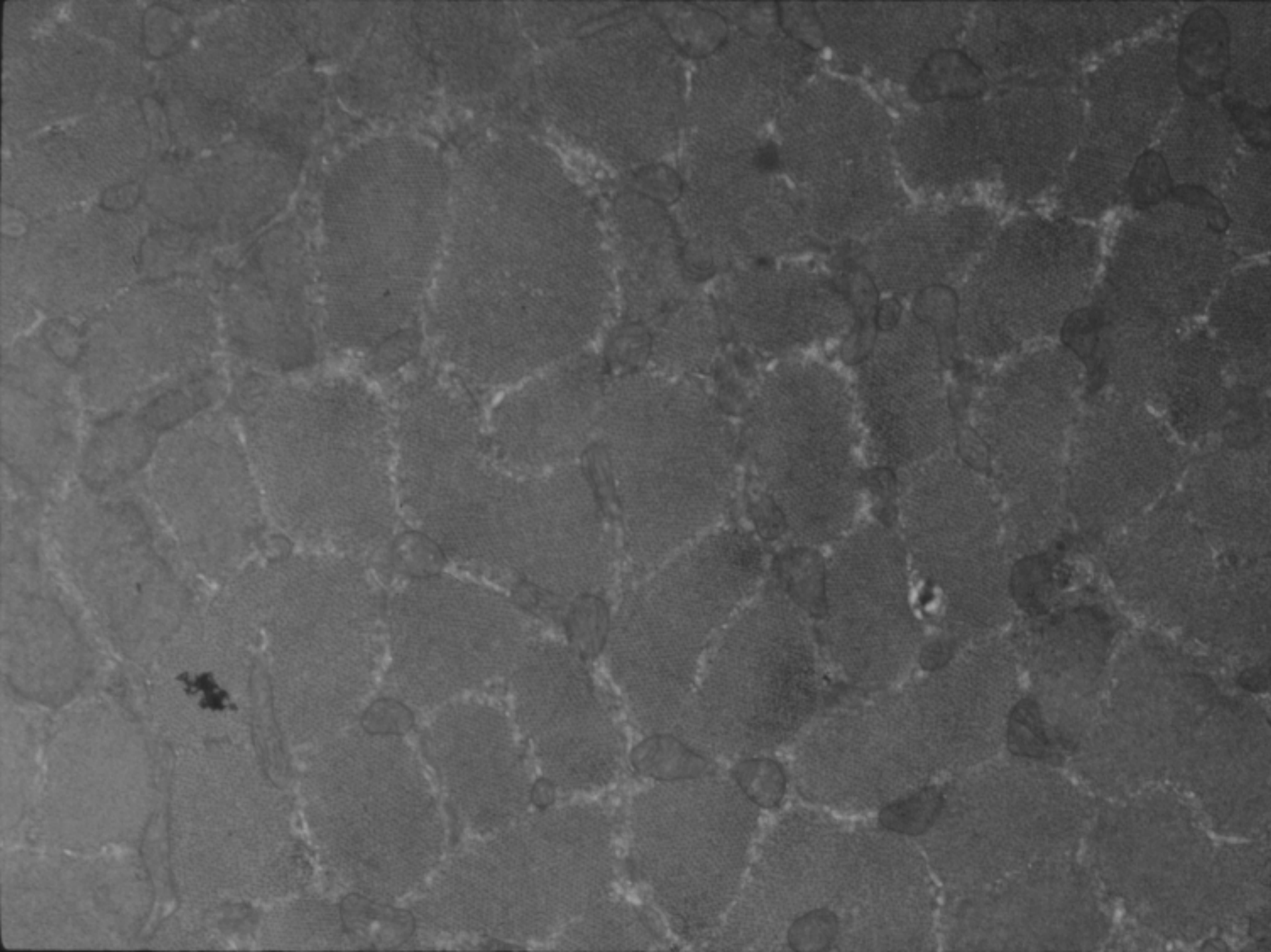


Dorsal view of seal




Capillary
L






50µm


50µm

Adaptations to Maintain Aerobic Metabolism under Hypoxic Conditions

↑ Volume Density of Mitochondria

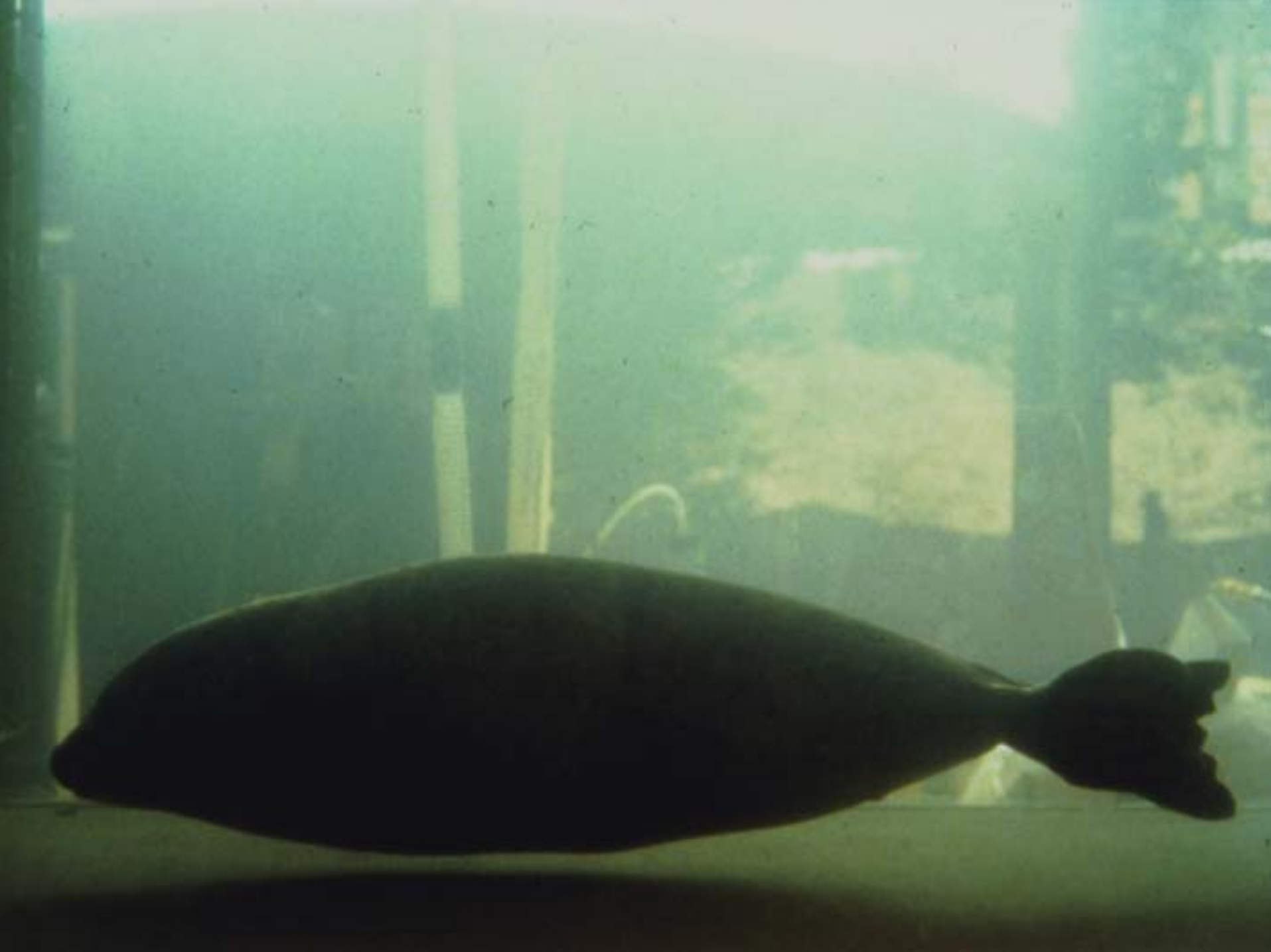
↑Aerobic Enzyme Capacities

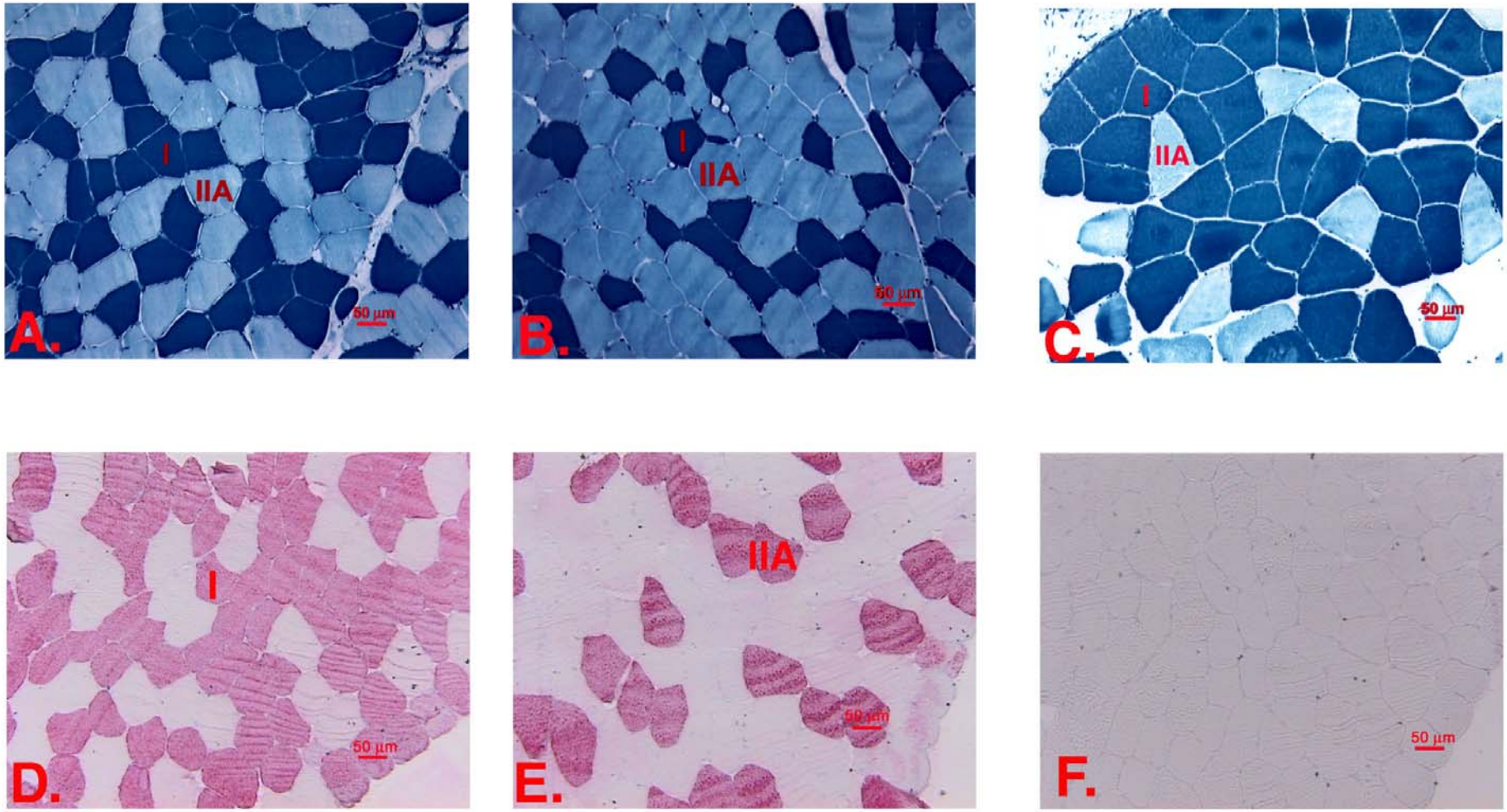
↑Myoglobin Concentrations

↑ Reliance on fatty acids As the main fuel source for aerobic metabolism

↓Intra-muscular Diffusion Distances

↓ Capillary supply





Type I-slow oxidative fibers (aerobic)

Type IIA- fast oxidative fibers (aerobic)

*Type IIB- fast glycolytic fibers (anaerobic)

Adaptations to Maintain Aerobic Metabolism under Hypoxic Conditions in Deep Divers

↓ Volume Density of Mitochondria

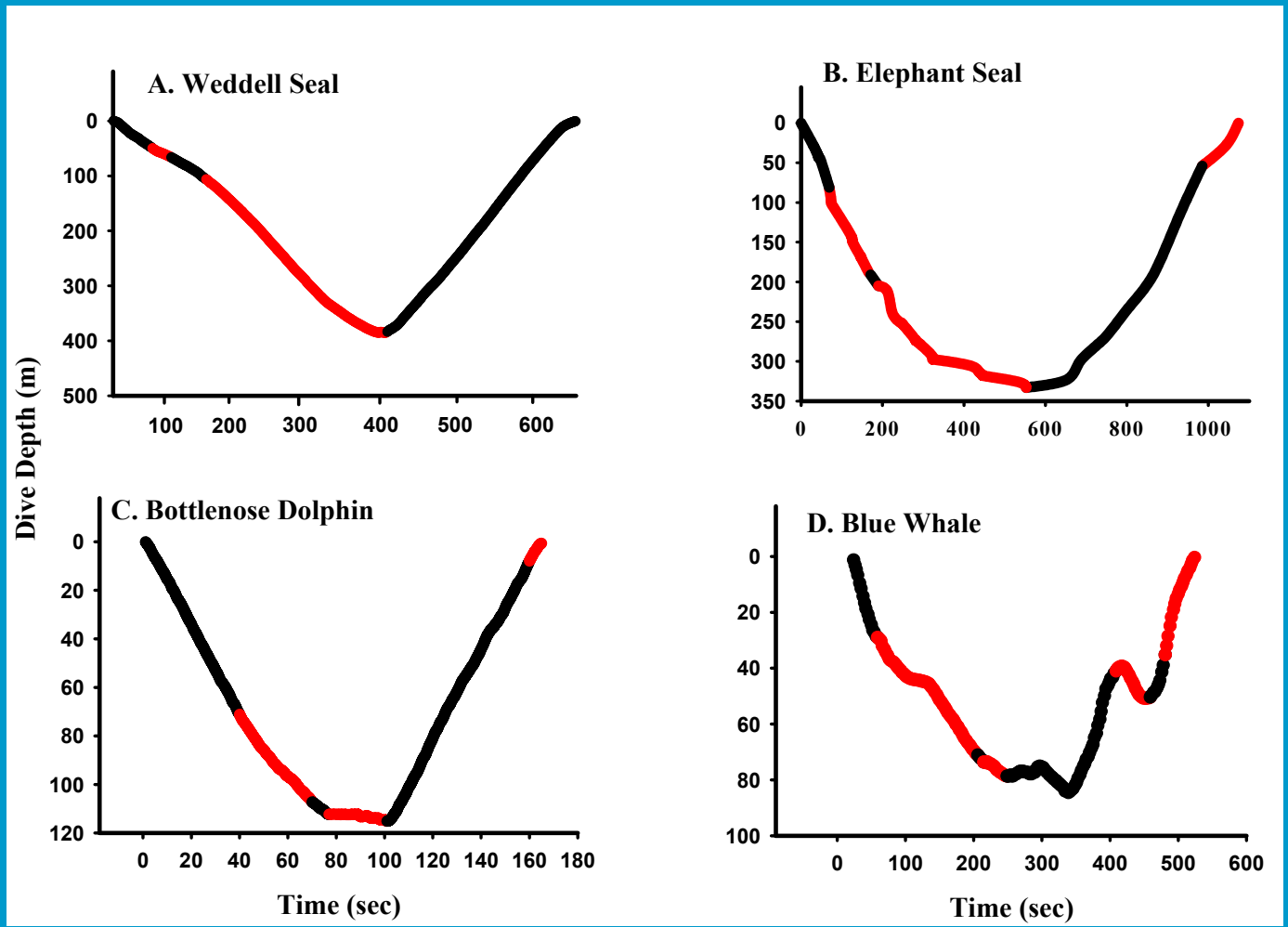
↑Aerobic Enzyme Capacities

↑Myoglobin Concentrations

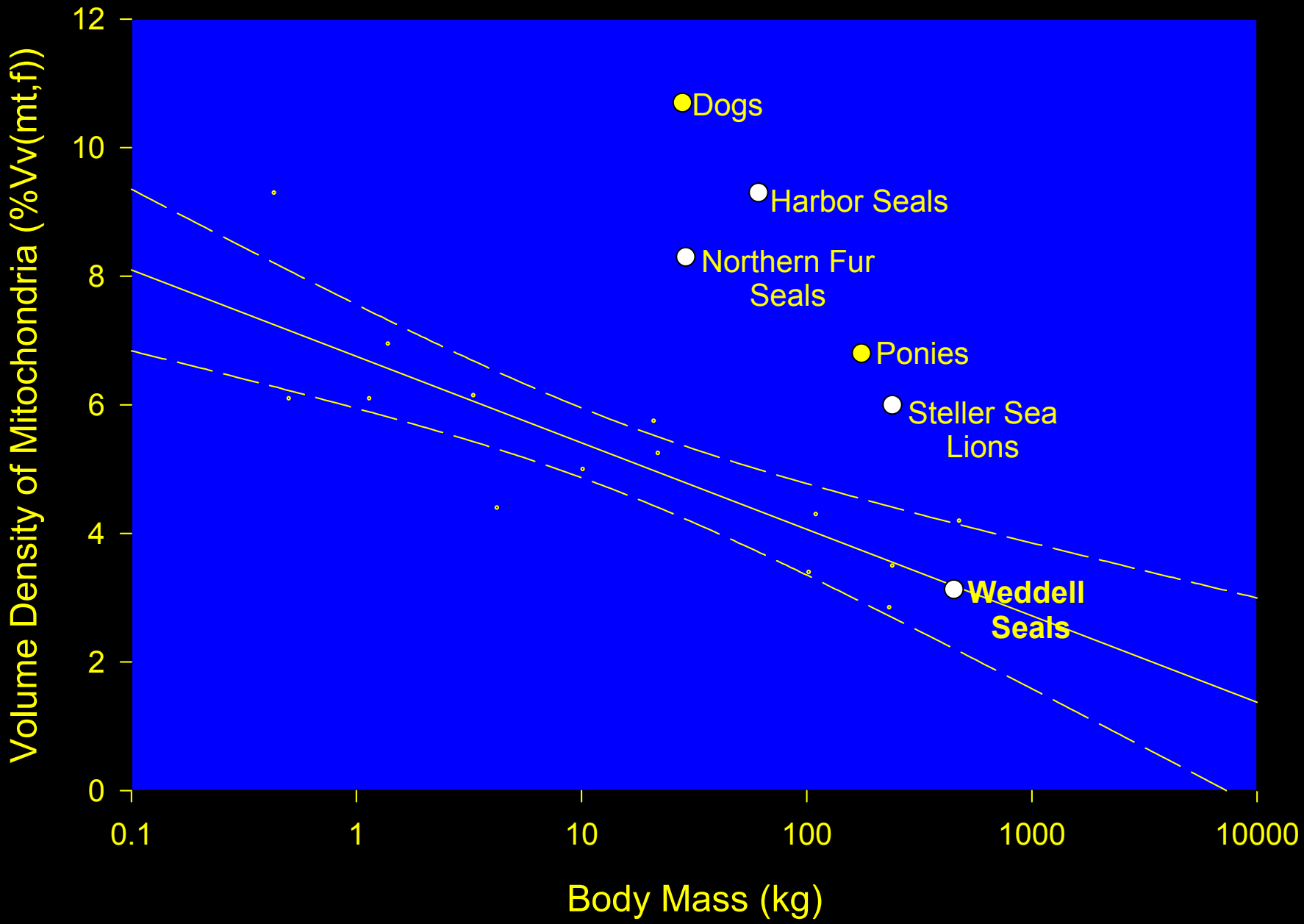
↑ Reliance on fatty acids As the main fuel source for aerobic metabolism

↓Intra-muscular Diffusion Distances

↓ Capillary supply


A. Weddell Seal
B. Elephant Seal
C. Bottlenose Dolphin
D. Blue Whale
Dive Depth (m)
Time (sec)
Time (sec)

Relationship between Volume Density of Mitochondria and Body Mass



Adaptations to Maintain Aerobic Metabolism under Hypoxic Conditions

1) An increased aerobic capacity (or one that is matched to routine levels of exertion)

2) A high reliance on fatty acid catabolism for aerobic ATP production

3) Enhanced oxygen storage in the skeletal muscles

4) A reduced dependency (e.g., decreased capillary density) on blood-borne oxygen and metabolites compared to terrestrial mammals

PHYSIOLOGY AT THE EXTREMES

2002 ANTARCTIC EXPEDITION

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SOUTHWESTERN

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Project Summary

What is the temporal development of aerobic capacity, lipid metabolism and oxygen stores in the skeletal muscles of young Weddell seals, and which aspects of the cellular environment are important in the genetic regulation of myoglobin expression during maturation? We will address this broad question during a two-year study that will collaborate with an ongoing study of the diving and hunting behavior of free-ranging adult and subadult Weddell Seals (NSF Award Number: OPP99-09422). Results from our previous collaboration (NSF Award Number: OPP96-14857) characterized the enzymatic, ultra-structural, and vascular adaptations for diving that occur in the skeletal muscles of adult Weddell seals. The proposed study builds on those results to investigate the ontogeny of these adaptations and the genetic control of their development. Our first objective is to characterize the ontogenetic changes in aerobic capacity, lipid metabolism, fiber type, and myoglobin concentration and distribution using enzymatic, immuno-histochemical and myoglobin assays in newborn, newly weaned, subadult, and adult seals. Our second objective is to determine the molecular controls for changes in the concentration and distribution of myoglobin in skeletal muscles during maturation. Through subtractive hybridization and subsequent analysis, we will determine the differences in mRNA populations in the swimming muscles of the different age classes of Weddell seals. These techniques will allow us to identify the proteins and transcription factors that influence the ontogenetic changes in myoglobin concentration. The results will increase our understanding of both the ontogeny and molecular mechanisms by which young seals acquire the physiological adaptations necessary to become competent divers and marine predators. In addition, this study will advance our knowledge of the molecular regulation of myoglobin in skeletal muscle, which has broader applications for human medicine.

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Shane B. Kanatous

Research Fellow. Department of Internal Medicine, University of Texas Southwestern Medical Center.
· NIH Minority Post-Doctoral Fellow, University of California at San Diego (1998-2000)
· Ph.D., Texas A&M University (1997)
· B. S., Southampton College of Long Island University (1990)

Research Interests and Direction

My research focuses on the adaptations of heart and skeletal muscles to different environmental stresses such as low oxygen levels (hypoxia) and exercise. One of my favorite areas of research has explored the physiological and metabolic adaptations of marine mammals to an aquatic lifestyle. Marine mammals are unique in that they are air-breathing organisms that routinely exercise while holding their breath but exhibit an extraordinary ability to prevent the harmful effects of hypoxia, and low blood flow (ischemia) associated with breath-hold diving. In contrast to terrestrial animals that function under hypoxic conditions but display the typical exercise response of increasing their breathing rate (ventilation) and heart's (cardiac) output, marine mammals exercise under a different form of hypoxic stress. They stop breathing, reduce cardiac output and limit peripheral blood flow during diving. These animals function for

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Rebecca R. Watson

Rebecca is a graduate student at Texas A&M University in Galveston, TX. She is currently working towards completing her Ph.D. on the physiology of harbor seal swimming muscles. Her project involves looking at mitochondrial density in seal muscle with an electron microscope, and analyzing the types of fibers found in the swimming muscles. Rebecca is originally from Orange County, California. She went to high school at Foothill High School in Santa Ana, CA where she was a good (but not great) student academically, and ran enthusiastically for the track and cross-country teams for four years. She received her B.A. from Vassar College in Poughkeepsie, NY in 1992 with a major in Biology. After working for a marine biological consulting firm in Costa Mesa, CA for three years, and attending classes at the California State University at Long Beach, Rebecca entered California State University, Fullerton as a full-time student. She received her M.A. in Biology in 1999. Rebecca's Master's thesis focused on the lipid metabolism of active shark species such as the mako shark and the hammerhead shark. When she is not doing research, Rebecca loves to surf on her longboard, scuba dive, travel, and spend quality time with her two cats. Rebecca's research has taken her to Alaska, Florida, and Hawaii. This is Rebecca's

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Frequently Asked Questions

How can mammals, like seals and whales, stay under water for such long periods of time?

While we still do not have the complete answer to this question, what we do know is that they possess a number of adaptations and behaviors that allow them to be more efficient at using oxygen which prolongs their ability to stay submerged (for a more detailed answer please see our project summary section).

What types of foods will you eat while there?

McMurdo station is a former military station and is still run in a similar fashion. When you are in town you eat in the mess hall, which is cafeteria style dining, and when you are out at camp you prepare your own food. Luckily we have a number of good cooks in our camp so we eat quite well.

What types of clothes do you wear?

For out door work and moving around town, you are issued extreme cold weather clothes, which include parka, pile jackets, thermal underwear, socks, gloves, mittens and hats (a picture of the clothes and geared issued can be seen in the photo archives).

Are poachers a problem in Antarctica?

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Antarctica Photo Archive

Crew on a ...

Bunks from Scott.

Dive Hut

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Lee A. Fuiman

Terrie M. Williams

National Science Foundation

University of Texas Southwestern Medical Center at Dallas