Chapter 25: Diving by Marine Mammals

1. Fig 25.1 Durations of dives by wild Weddell seals (most <20-25 minutes; some > 1hr)
2. Fig 25.2 Depths of dives by wild Weddell seals (most <200 m; up to 600 m)
3. Figure 25.4: Diving by an individual elephant seal (up to 120 min)

Diving Physiology: Challenges of Diving

1. Skeletal muscles, Brain, Heart need the most energy
2. Brain, Heart need the most O_2
3. Hypoxia

Blood O_2 stores in diving mammals

1. Diving mammals have high blood O_2 concentrations,
   A. Carrying capacity
   B. Blood volume:
2. Total Blood O_2 stores:
   A. Carrying capacity X Volume.
   B. Humans: 15 mL of O_2 per kg, Weddell seals: 85 mL O_2 per kg

1. Muscle O_2 :
   A. much higher muscle myoglobin content
   B. higher affinity of myoglobin for O_2
2. Lung O_2 :
   A. air in the lungs of diving mammals is a disadvantage.
   B. Buoyancy
   C. Diving mammals lungs are compressible

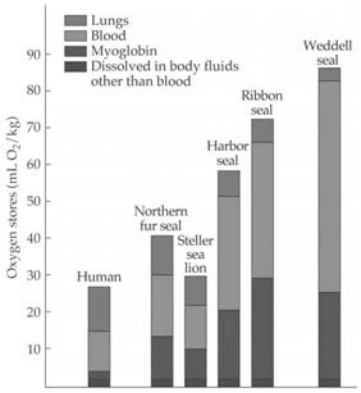


Figure 25.6 A comparison of the total O_2 stores of five species of marine mammals and humans

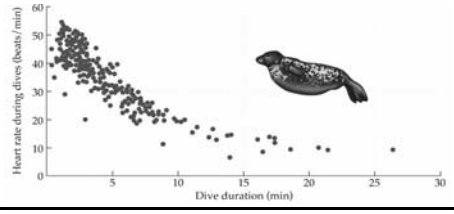
Diving Physiology: Challenges of Diving

1. Brain and heart tissue require aerobic metabolism
2. skeletal muscles can use anaerobic metabolism

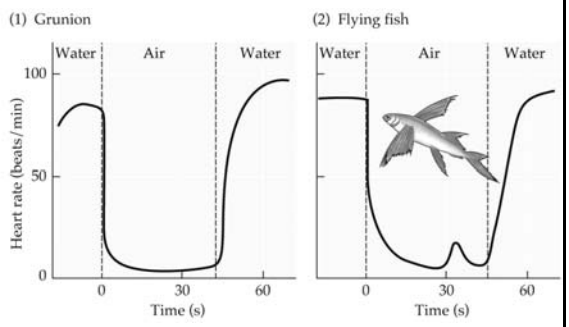
Diving response, 1.
   A. Collapse of the lung: Figure 25.5 The thorax is highly compressible in marine mammals

Diving Response, 2 Bradycardia

1. Figure 25.9 Diving heart rate varies with dive duration in a graded manner in freely diving seals

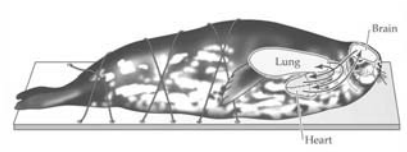


Box 25.1 The heart rates of fish removed from water



Diving Response, 3 Peripheral vasoconstriction

1. Shunting: Figure 25.7 Circulatory patterns are radically changed during forced or prolonged submergence
2. Figure 25.8 The forcibly submerged seal (artificially vasoconstricted) as a "heart-lung-brain machine"



Oxygen Supply During Diving

1. Decreased metabolic rate
   A. Increased anaerobic metabolism
   B. Oxygen debt (from stored lactic acid) must be repaid after diving
2. Figure 25.10 Metabolic subdivision of the body during forced submergence
   A. (25.10a). Oxygen is depleted faster in muscles than the blood

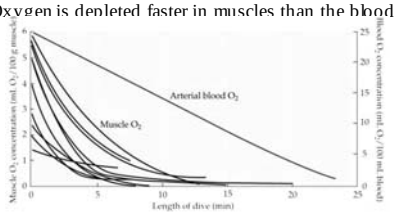
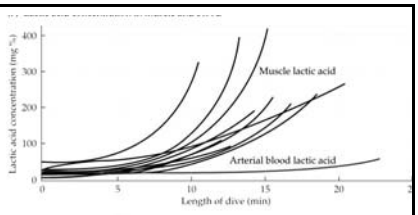


Figure 25.10b Lactic acid in muscle and blood



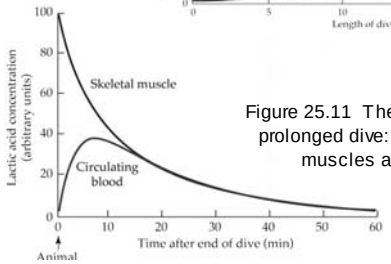
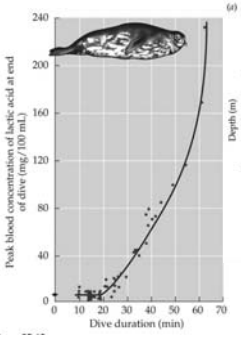
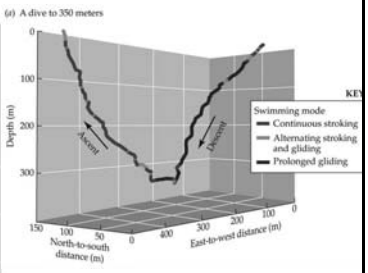


Figure 25.11 The aftermath of a prolonged dive: Lactic acid in muscles and blood

Aerobic capacity and lactic acid build up (Fig. 25.12) limit dive duration





Weddell Seals only swim intermittently at depth (Fig. 25.13)

1. Diving Response, 4
2. Increase in hematocrit (in a few cases): RBCs stored in their spleen.

3. Oxygen supply during diving
4. cutaneous and rectal respiration
   A. not important in birds and mammals
   B. some reptiles (sea snakes)
   C. green turtles can stay dormant underwater

Decompression sickness (the bends)

1. Bubbles of nitrogen in tissue and blood
2. Nitrogen tension > 2 atmospheres
3. No problems with CO_2 or O_2
4. At depth, human diver breathes at high pressure
5. this drives nitrogen into tissue, blood, fat
6. when pressure drops, it bubbles out;
7. use of helium instead of nitrogen
8. Human divers adjust rate of depressurization.

How marine mammals avoid the bends

1. sperm whales can dive to over 1100 m
2. elephant seals can dive to over 1500 m
3. do not super-saturate blood with Nitrogen

Other Problems for Human divers

1. Problem 2: Oxygen Toxicity
2. Problem 3: Narcotic Effects Of Inert Gases
3. Problem 4: Effects Of High Pressure