adapted to moist heat (90° F. and 65 per cent. relative humidity) exhibit a resistance to infection only one quarter as great as do litter mates adapted to a cool environment (65° F.), while mice in a control room at 70–75° F. fall midway between those in the hot and cold environment. This occurs when all other factors of life are held as constant as possible for all groups—same diet (Purina dog chow), similar lighting and ventilation, and the use of divided litters for the different groups to minimize the hereditary factor.

We have previously described the rooms and equipment used in this study[1] as well as the dominance exercised by ease of body heat loss over such basic physiologic functions as rate of growth and development, fertility and longevity. This dominance in man and animals seems to work through the internal combustion level allowed the individual. Energy for most physiologic functions can come only from this combustion, but body efficiency is not high, so that a large part of the combustion energy must be dissipated as waste heat. It is the ease or difficulty with which this waste heat can be dissipated that causes internal combustion rate to be dominated by external temperature levels. Men, as well as animals, show direct evidence of this dominance.[2]

Locke[3] has described a "fitness index" which he bases largely on the rate of oxygen consumption, resistance to infection being proportional to the rate of oxygen uptake. And in certain of man's infectious diseases, ability to survive seems definitely related to prevailing mean temperature level.[4] It therefore seemed important that a close analysis be made of all phases of this dependence on ease of body heat loss, the preliminary findings on resistance to infection being set forth in this brief note.

Using a 10-hour broth culture of hemolytic streptococcus kept at standardized virulence by the necessary mouse passages (so that 0.5 cc intraperitoneally kills healthy control mice within 16 hours), the estimates of M.L.D. given in Table 1 were obtained.

Although the M.L.D. was the same for control and cold-room animals, those from the control room died more quickly than did those from the cold. During the period of these tests, the control room temperature was about 70° F., only 5° above that of the cold room. Hot room mice succumbed with only one fourth the culture dosage needed to kill those of the other two groups.

When mice of all three groups were injected with the same amount of broth culture, 0.5 cc of a 1:20 dilution, then within 26 hours 100 per cent. of the hot room mice were dead, 60 per cent. of those from the control room, but only 30 per cent. of those from the cold. In another series injected with 0.5 cc of a 1:55 dilution of broth culture, 60 per cent. from the hot room were dead within 30 hours, but only 12 per cent. from the cold.

TABLE 1

	Survival time in hours
Cold room mice (kept at 65° F) 0.5 cc of culture diluted 1–10	12, 23, 23, 23, 30, 48, 48, 48 (2 did not die)
Control room mice (kept at 70° F) 0.5 cc of culture diluted 1–10	7½, 11, 12, 12, 12, 23, 23, 23, 23, 23, 132 (1 did not die)
Hot room mice (kept at 90° F) 0.5 cc of culture diluted 1–40	24,24, 30, 36, 50, 108 (1 did not die)

There can be left little doubt, therefore, that difficulty in body heat loss and a lowered tissue combustion rate result in a sharply reduced ability to fight infectious invasion. This depressive effect on resistance to infection (also on growth, developmental rate and fertility) is evident within two weeks after the animals have been placed in the warm environment, and is almost complete by the end of three weeks.

The study is being broadened to include other pathogenic organisms and the appearance of various immune bodies in the blood. Undernutrition from dietary inadequacy, either qualitative or quantitative, has been known to make animals less resistant to infection.[5] It is likely that difficulty in body heat loss works in a similar fashion by making impossible the adequate utilization of even the most perfect diet when offered *ad lib.*

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THE MUSCLE HEMOGLOBIN OF SEALS AS AN OXYGEN STORE IN DIVING

IT is well known that the harbor seal, *Phoca vitulina,* can remain submerged for long periods without breathing. Dives of six minutes are common, while a maximum of 15 minutes has been recorded by Millais.[1] The seal's ability to hold its breath when submerged contrasts so strongly with the slight capabilities of terrestrial mammals that one is led to suspect an extra store of oxygen in the seal's case. The

[1] C. A. Mills and Cordelia Ogle, *Am. Jour. Physiol.,* 125: 36–40, 1939.
[2] C. A. Mills, *Am. Jour. Hygiene,* 29: 147–164, 1939.
[3] Arthur Locke, *Jour. Immunology,* 36: 365–380, 1939.
[4] C. A. Mills, "Medical Climatology," Chapter VII, Charles C Thomas, Springfield, Illinois, 1939.
[5] C. F. Church, *Am. Jour. Pub. Health,* 29: 215, 1939.
[1] J. G. Millais, "The Mammals of Great Britain and Ireland," 3 vols. London, 1906.

extremely dark color of seal meat suggests that the oxygen store exists, at least in part, in the muscle hemoglobin.

The literature on muscle hemoglobin in aquatic mammals is both meager and contradictory. In a review paper on "Respiration in Diving Mammals" Irving[2] estimates the muscle hemoglobin of an aquatic mammal by analogy from Whipple's figures[3] for iron content of dog muscle, and shows that a 70 kg animal could absorb 335 cc of oxygen by this means. He concludes that such a store would, however, be only significant as a store for a fraction of a minute, whereas the endurance of divers requires provision for a number of minutes. But Theorell,[4] who observed that myoglobin occurs in concentrations of 5 to 10 per cent. in the juice pressed from seal meat, states that the necessary oxygen for prolonged diving comes with great likelihood in large part from the exceptionally great myoglobin content of the skeletal muscles, which are so strongly colored that they appear almost blue-black.

I have made some analyses to determine if muscle hemoglobin in the seal is present in concentrations high enough to serve as an oxygen store in diving. The work began with iron analyses of the tissues, as it was thought that the iron content would serve as a rough indication of the relative muscle hemoglobin concentrations. The method of iron determination followed that of Elvehjem and Hart.[5] All tissues analyzed were freed as far as possible from blood hemoglobin by washing in 0.9 per cent. NaCl solution. A single sample of seal meat gave an average of .229 mg Fe per gram of fresh tissue, compared with several analyses of beef muscle by the same method, giving an average of .048 mg Fe per gram of fresh tissue. This experiment indicated that a much larger amount of iron was present in the seal muscle.

In order to determine if the large excess of iron were really present as muscle hemoglobin, samples of tissue from a second seal were washed in 0.9 per cent. NaCl to remove blood hemoglobin, and the muscle hemoglobin was extracted by the dilute NH_4 method of Whipple.[6] The muscle hemoglobin in solution was converted to acid hematin and compared colorimetrically with a blood acid hematin standard. By this method a single sample of seal muscle yielded 7,715 mg of muscle hemoglobin per 100 grams of fresh tissue, compared with an average of 1,084 mg per 100 grams for several samples of beef muscle. In a 70 kg seal, if only 35 per cent. of the body weight represented muscle, there would be 1,890 grams of hemoglobin present, sufficient to combine with 2,530 cc of oxygen. As shown by Table 1, this might amount to 47 per cent. of the total oxygen stores of the animal.

TABLE 1

POSSIBLE OXYGEN STORES OF A 70-KG SEAL

System	Oxygen stored
Lungs	545 cc
Blood	2,055 "
Fluids	245 "
Muscle hemoglobin	2,530 "
Total	5,375 "

SOURCES OF FIGURES IN TABLE 1

Lungs: Average lung capacity of two seals examined after death was 38.9 cc per kg. $38.9 \times 70 \times \frac{1}{5} = 545$.

Blood: Oxygen capacity of seal blood is 29.3 vol. per cent. (Irving, Solandt, Solandt and Fisher[7]). Blood represents 10 per cent. of the seal's body weight (Irving).[8] $70 \times 10 \times 29.3 = 2{,}051$.

Fluids: From Irving.[9]

Muscle hemoglobin: 7,715 mg Hb per 100 gm muscle. If 35 per cent. of the seal's weight is muscle, there are 24.5 kg of muscle. $24.5 \times 10 \times 7{,}715$ mg (7.715 grams) = 1,890 grams Hb. Muscle hemoglobin has the same combining power for oxygen as does blood Hb—1.34 cc per gram hemoglobin. $1{,}890 \times 1.34 = 2{,}532$ cc.

The resting metabolic requirement of a 70 kg seal would be 373 cc of oxygen per minute according to Irving, Solandt, Solandt and Fisher.[10] Assuming 100 per cent. utilization of all oxygen stores, it would be possible for the seal metabolizing oxygen at the basal rate to remain submerged for 14.4 minutes on a store of 5,375 cc of oxygen. This figure compares favorably with the common submersion time, when the animal is active, of about six minutes. But for active 15-minute submersions, such as recorded by Millais, there still seems to be no physiological explanation.

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THE ABSORPTION OF RADIO WAVES IN WATER

IN view of the recent submarine disasters, the question naturally arises as to the possibility of signaling from undersea craft by radio. Some years ago, Mr. Allen Bassett and the author carried out a series of tests in Lake Michigan which have a direct bearing on this problem. We chose for our task the determination of the law of absorption of radio waves in water.

A small transmitter with a loop aerial and an output of about one-tenth watt was set into operation, sealed into a water-tight box and lowered with a rope

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