Carboxyhemoglobin and the Access to Oxygen

An Example of Human Counterevolution

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Carboxyhemoglobin (COHb) alters the oxyhemoglobin dissociation curve in such a manner that oxygen is released to the tissues with great difficulty and at a lower oxygen tension. The known effects on heart and brain of breathing low concentrations of carbon monoxide are primarily related to this leftward shift and perhaps also to combination with myoglobin and certain iron-containing enzymes. Hemoglobin-oxygen equilibria in the presence of COHb resembles the equilibria of more primitive forms of hemoglobin and gives rise to the suggestion that this decrease in the access to oxygen is a form of counterevolution.

Vertebrate and invertebrate evolution is closely tied to the development of specialized systems providing the organism with a supply of oxygen sufficient for its metabolic needs. The phylogeny of such systems was elegantly described by August Krogh in 1939.[1] Summarizing four decades of personal research, he emphasized that the oxygen environment of individual cells was dependent upon the "call for oxygen" and upon the "access to oxygen." Since the major effect of carbon monoxide (CO) inhalation is upon circulating hemoglobin, and since the chemical equilibria of carboxyhemoglobin (COHb) resemble those of more primitive hemoglobins, carboxyhemoglobinemia may be regarded as an acquired variation which is counterevolutionary. Whether the process of natural selection will operate in such a manner as to eliminate this trait from the population is a question of considerable scientific and sociologic interest.

The call for oxygen varies widely among species. A crayfish requires 47 ml of oxygen per kilogram of body weight per hour, a resting butterfly 600, and a flying butterfly 100,000. Resting man requires 200 ml of oxygen per kilogram of body weight but his myocardium requires 1,000 ml or five times more.[1] The access to oxygen is closely balanced to the call for oxygen and the evolution of the iron-containing protein, hemoglobin, is in large part responsible for the delivery of adequate amounts of oxygen to organisms of varying size and complexity.

The respiratory characteristics of hemoglobin may be defined by (1) the oxygen capacity and (2) the shape of the dissociation curve. Since 1 gm of hemoglobin will reversibly bind 1.34 ml of oxygen, the oxygen capacity is closely related to hemoglobin concentration. Invertebrates have oxygen capacities ranging from 1 to 2 ml/100 ml of blood; fishes, amphibia, and reptiles carry between 5 and 15, while mammals carry between 15 and 20. The capacity may be as high as 40 in certain divers.

Equal in importance to the oxygen capacity of hemoglobin is the affinity of hemoglobin for oxygen. Many attempts to mathematically describe the oxyhemoglobin dissociation

Submitted for publication Feb 9, 1972; accepted June 16.

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Read before the AMA Conference on Air Pollution, New Orleans, Oct 7, 1970.

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