sperm in the population. Also, a quantitative method of measuring the lethal effect of U.V. on spermatozoa has been devised. The type of damage for sperm killing is most probably of a different nature than the lesion for a developmental effect.

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1968 #32

WHY VERTEBRATE EXTRACELLULAR AND INTRACELLULAR pH VALUES ARE APPROXIMATELY 7—PHYSICAL-CHEMICAL BASIS OF THE EVOLUTION OF CO_2 TRANSPORT

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Previous work from this laboratory suggests that the general shape of vertebrate CO_2 titration curves is similar among all vertebrates. Edsall and Wyman have analyzed the physicochemical basis of CO_2 titration curves and have derived an expression for the relationship between PCO_2 and H^+ as a function of the pK of the buffer systems available for the buffering of H_2CO_3:

$$PCO_2 = \frac{1}{{}_{\alpha}CO_2} \times \frac{K_B}{K_{H_2CO_3}} \times \frac{(HCO_3^-)\ (HCO_3^- - D)}{C\text{-}HCO_3^- - D}$$

Where PCO_2 = CO_2 tension in mm Hg.
${}_{\alpha}CO_2$ = Solubility Coefficient for CO_2 in M/L/mmHg.
K_B = Dissociation constant of a given buffer.
$K_{H_2CO_3}$ = Dissociation constant of H_2CO_3.
$[HCO_3^-]$ = Concentration of $[HCO_3^-]$ M/L.
D = Difference between fixed cations and anions M/L.
C = Concentration of the buffer M/L.

Using this expression it is possible to calculate CO_2 titration curves that would result from buffers with different dissociation constants. The figure shows 3 such curves with CO_2 titration curves calculated for buffers of pK values of 6.0, 7.0, and 9.0 respectively assuming that all HCO_3^- present in the system arises from buffering of H_2CO_3. The lowermost curve (pK = 6) would present 3 difficulties in terms of vertebrate survival. The animal would be acidotic at any PCO_2. Under conditions associated with hypercapnia there would be limited buffering of H_2CO_3. Because of the small change in total CO_2 with large changes in PCO_2, CO_2 transport from the tissues to the external gas exchanger and from the external gas exchanger to the ambient environment would require huge and unrealistic cardiac outputs. The uppermost curve (pK = 9) would permit adequate tissue and external CO_2 exchange only at low PCO_2s (aquatic vertebrates). However, CO_2 exchange at PCO_2 greater than 5 torr would require huge and presumably unattainable levels of cardiac output. Thus survival during hypercapnia in aquatic forms would be difficult. The transition from aquatic to terresterial vertebrates with attendant high PCO_2 values presumably could not have occurred. It therefore appears that the development of oxidative phosphorylation with substantial CO_2 generation requires the presence of significant concentrations of buffers in body fluids with pK values approximately 7.

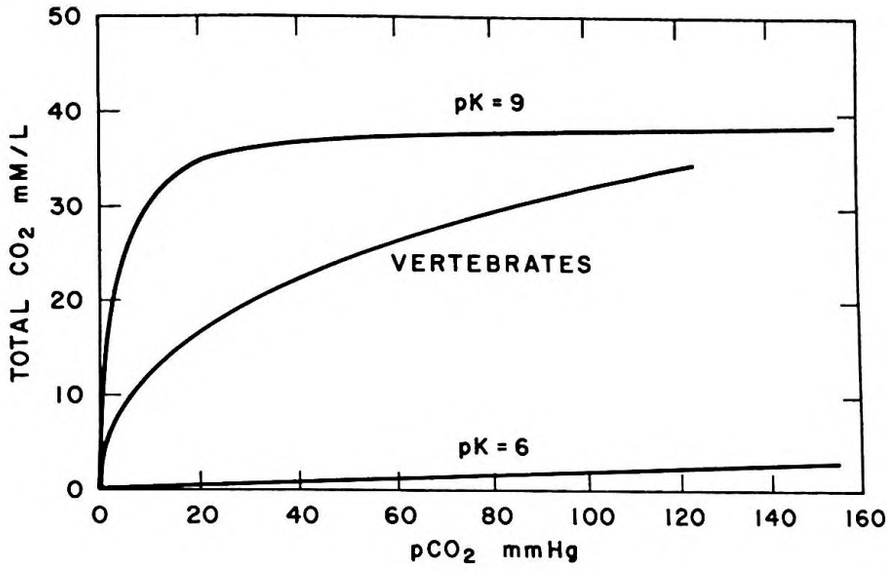

Figure 1

The major compounds with appropriate pK values for subserving CO_2 exchange are proteins containing substantial imidazole residues and αamino groups. Presumably the similarity of CO_2 titration curves among vertebrates reflects a similar protein pattern. Solutions containing substantial concentrations of buffers with pK ~ 7.0 will have a pH around this value. It may be concluded that the fact that vertebrate extracellular and intracellular pH values are generally in the range pH = 7, reflects the operation of the above factors.

1968 #33

ENERGY METABOLISM IN THE ERYTHROCYTES OF THE HARBOR SEAL (Phoca vitulina)

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The erythrocytes of a number of mammalian species (seal, cat, dog) show relatively high intracellular Na^+ and relatively low intracellular K^+ concentrations. The intracellular-extracellular concentration ratios are substantially closer to electro-chemical equilibrium than is true of human, rat, and rabbit erythrocytes. The major source of energy in the mature mammalian erythrocyte is anaerobic glycolysis. Further, calculations of the minimum work required for the active transport of Na^+ and K^+ in low Na^+ cells suggest that a substantial fraction of total energy must be devoted to the work of active cation transport. It seemed of interest to investigate the rate of anaerobic glycolysis; the stoichiometry of glucose to lactate conversion; and the effect of ouabain on glycolytic rate in the high Na^+, low energy requiring erythrocyte of the harbor seal.

Blood was obtained from the extra dural vein of the animal. Erythrocytes were separated by centrifugation and washed 3 times in seal-Ringers containing 5 mM glucose. The red cells were then suspended in seal-Ringers glucose and incubated for 4 hours at 40°C. Glucose consumption and lactate production were measured by the changes in substrate concentrations of