CC/NUMBER 9
MARCH 3,1980

This Week's Citation Classic

Severinghaus I W. Blood gas calculator. J. *Appl. Physiol.* **21:**1108-16, 1966. [Dept. Anesthesia and Cardiovascular Res. Inst., Univ. California Med. Sen. San Francisco, CA]

The paper describes a slide rule for calculating human blood O_2 saturation from Po_2, pH, temperature and base excess, blood gas temperature corrections, the Henderson Hasselbalch equation for blood and CSF, base excess, and BTPS *vs.* STPD factors. However, its primary use by physiologists is the standard O_2 dissociation curve I prepared from 11 publications and new measurements, with a graph of the fall of the temperature coefficient, AlogPo$_2$/AT, at high saturation. [The *SCI*® indicates that this paper has been cited over 645 times since 1966.]

John W. Severinghaus
Department of Anesthesia
and the Cardiovascular Research Institute
School of Medicine
University of California
San Francisco, CA 94143

December 27, 1979

"The idea of devising a slide rule for O_2 dissociation occurred to me while on sabbatical in Copenhagen in 1964. It resulted from talks with Poul Astrup about his proposed, formidable nomogram for calculating O_2 saturation, with four full sets of rectangular and bi-diagonal logarithmic grids. A slide rule multiplies numbers by adding logarithms, and this is needed to correct Po_2 for pH, temperature, BE, and P50. That evening, I constructed the first cardboard rule, adding other scales to it over succeeding weeks by using all the experts around town. Siggaard-Andersen helped with the base excess grid, the most complex calculation Asmussen and I usually had lunch together, and he helped with the gas factors. I was able to join Naeraa's group in Aarhus to finish their studies of the separate roles of pH and Pco_2 on the Bohr coefficient[1] and, with help from Astrup and Xenia Brun, fill in the missing top and bottom of the O_2 dissociation curve. F.J.W. Roughton invited me to Cambridge for final discussions on details, from which grew our subsequent yearly summer dissociation curve studies in San Francisco until his death in 1972.[2] Scale drafting and design required frequent stops at Radiometer Co., halfway from home to work. The coincidence of so many important factors near Copenhagen was the more remarkable since I had chosen my sabbatical there to work on blood brain barrier transport with H.H. Ussing and P. Kruh0ffer and on cerebral circulation with Niels Lassen. Also, I helped teach the WHO 11-month postgraduate course for anesthesiologists from underdeveloped countries. Each of these collaborations and contacts were to continue for many years, and led, on June 1, 1979, to my promotion to Doctor Medicine Honoris Causa on the occasion of the 500th anniversary of the University of Copenhagen (Hafnensis in Latin).

"The article has been widely used as the standard oxygen dissociation curve, and the standard for temperature correction and for calculation of the effects of pH, Pco_2, and base excess on oxygen tension, thus accounting for its frequent citation.

"It is less than 20 years since commercial blood gas analyzers became available. We are still seeing rapid growth in their use. As automated blood gas analyzers, computers, and pocket and desk calculators replace the slide rule, using the equations in this paper, the need for a simple accurate equation for the O_2 dissociation curve has become acute. The Adair and other equations are both complex and not very accurate. I recently modified Hill's too-simple equation enough to compute O_2 saturation from 0-100% to within ±0.5%, and added other simple equations expressing the variations of the temperature and Bohr coefficients with saturation, and an iterative computation of O_2 content from either Po_2 or saturation, thus updating the 1966 papers"[3]

1. **Naeraa N, Strange-Petersen E, Boye E & Severinghaus J W.** pH and molecular components of the Bohr effect in human blood. *Scand. J. Clin. Lab. Invest.* **18:**96-102. 1966.
2. **Roughton F J W & Severinghaus J W. O$_7$** dissociation curve analysis above 98% saturation for human blood. J. *Appl. Physiol.* **35:**861-9, 1973.
3. **Severinghaus I W.** Simple accurate equations for human blood O_2 dissociation computations. *J. Appl. Physiol.* **46:**599-602, 1979.