Fig. 1 illustrates this behavior. We have plotted N_D vs $1/T$, giving the temperature dependence of defects. We have also plotted n' vs. $1/T$, which gives essentially the intrinsic slope and $n'\frac{c^2-1}{c}$, which is parallel to the line representing n'. The concentration of impurities at exhaustion is indicated for various tellurium samples measured by Bottom and others (*8*).

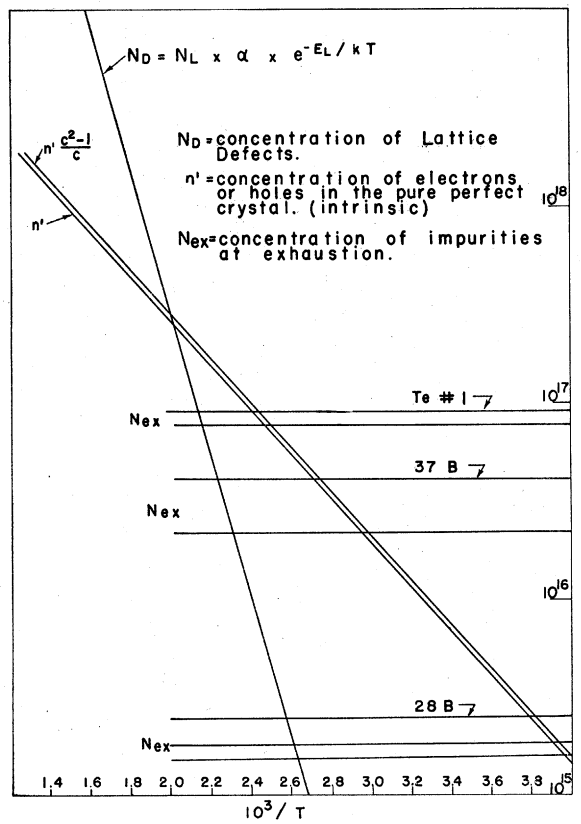

FIG. 1.

The intersection of the lines N_{ex} = constant with $n' \times \frac{c^2-1}{c}$ gives the low temperature reversal. The intersection of N_D with $n'\frac{c^2-1}{c}$ gives the high temperature reversal.

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Red Blood Cell Studies: Ashby Curves[1]

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Important information about the nature and life span of red cells is obtained by the differential agglutination method of Ashby (*1*). All curves at present available can be explained by assuming (*a*) that normal red cells undergo a period of wearing or aging which precedes their eventual breakdown, and (*b*) that the worn or aged red cells are broken down by a random, first order process. The wearing times of individual cells would in general be different, but in the present treatment it is assumed that all the red cells of any one person have the same wearing time. It is also assumed that the rate of breakdown of worn cells is characteristic of their environment.

If it is further assumed that a representative steady state population is transfused, it follows that the number of wearing cells remaining at time t is

$$w = \begin{cases} Y(0)(t_1 - t)/(t_1 + K_1), & 0 \leqq t \leqq t_1 \\ 0, & t_1 \leqq t, \end{cases}$$

if $Y(0)$ = number of transfused erythrocytes, t_1 = their wearing time (which for simplicity is assumed to be the same for all transfused cells), and K_1 = the average lifetime of worn cells *in the donor*.

On letting y = the number of worn cells remaining at time t,

$$K_2 \frac{dy}{dt} = \begin{cases} K_2 Y(0)/(t_1 + K_1) - y, & 0 \leqq t \leqq t_1 \\ -y, & t_1 \leqq t \end{cases}$$

if K_2 = the average lifetime of worn cells *in the recipient*. These K's are therefore the reciprocals of the corresponding turnover rates for the random breakdown. Since $y = K_1 Y(0)/(t_1 + K_1)$ at $t = 0$ and since $Y = y + w$, the final solution of the differential system is

$$Y = \begin{cases} \left(\frac{Y(0)}{t_1 + K_1}\right) \cdot [t_1 - t + K_2 + (K_1 - K_2) \exp(-t/K_2)], & 0 \leqq t \leqq t_1 \\ Y(t_1) \exp(-(t - t_1)/K_2), & t_1 \leqq t \end{cases} \quad (1)$$

where $Y(t_1) = \left(\frac{Y(0)}{t_1 + K_1}\right)[K_2 + (K_2 - K_1) \exp(-t_1/K_2)]$,

so that if $t_1 \gg K_2$, $Y(t_1) \left(\overline{\overline{\text{approx}}}\right) K_2 Y(0)/(t_1 + K_1)$.

For donors in diseased states (such as sickle cell anemia, congenital hemolytic anemia, and acquired hemolytic anemia) in which $\left(\begin{matrix} t_1 = 0 \\ \text{approx} \end{matrix}\right)$, Eq. (1) becomes:

$$Y = Y(0) \exp(-t/K_2). \quad (2)$$

Normal cases are readily interpreted on the basis

[1] Sponsored by the Veterans Administration and published with the approval of the chief medical director. The statements and conclusions published by the authors do not necessarily reflect the opinion and policy of the Veterans Administration.

of Eq. (1), and this is illustrated by the three schematic curves of Fig. 1. The successive steps of curve

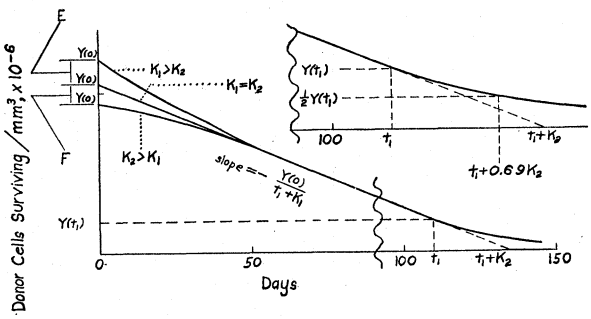

FIG. 1. Three normal schematic Ashby curves of donor red blood cells in the recipient, with magnification × 2 of the tail.

analysis are the determinations of (*a*) time t_1 (at which the curvature starts to increase); (*b*) intercept (t_1+K_2) (and hence K_2 by subtracting the t_1 of $[a]$); (*c*) the linear slope $-Y(0)/(t_1+K_1)$ (and hence K_1 by subtracting t_1 of $[a]$ from $Y(0)$ times the negative reciprocal of this slope); (*d*) the half-life on the tail $(t_1+0.69\,K_2)$ (and hence a check on K_2 by subtracting the t_1 of $[a]$); (*e*) the agreement between Y (t_1) and $\frac{K_2Y(0)}{(t_1+K_1)}$; and, if $K_1 \neq K_2$, (*f*) the agreement between E (or F) and $(K_1-K_2)Y(0)/(t_1+K_1)$. The last three items check the preceding determinations.

Typical experimental curves (*2–5*) yield results of 100–110 days for the wearing time t_1 and of 15–40 days for the average life of worn cells. These results of the present interpretation agree with the conclusions of earlier interpretations in which the curve was linear at the beginning and in which the intercept (t_1+K_2) was said to give the life span of the donor's red cells (since $K_1=K_2$ in these cases). It is to be noted that the survival time of the donor cells, *in the donor,* is $Y(0)$ times the negative reciprocal of the slope of the linear portion of the curve.

The present interpretation also explains why some of the normal curves are not linear near the beginning—in terms of the different rates of random breakdown in the donor and recipient environments (each of which is determined explicitly when $K_1 \neq K_2$).

In case the donor has sickle cell anemia (*6, 7*), congenital hemolytic jaundice (*8*), or acquired hemolytic anemia (*2, 5, 8*), the wearing time t_1 is negligible and the results are expressed by Eq. (2). This expression is linear when it is plotted on semilogarithmic paper because log Y is in this case a linear function of time. On measuring this semilogarithmic plot with a ruler, one finds that K_2 is the number of multiples of 2.30 days corresponding to each power of 10 through which Y changes.

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The Ultracentrifugation of Soluble Cytochromes[1]

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A particulate preparation of mammalian heart muscle dissolved with the aid of sodium desoxycholate has been studied in the ultracentrifuge.[2] The method of preparation and the visible absorption spectra have been previously described (*1*). The designation Preparation O-4 refers to the amount of sodium desoxycholate used to dissolve the proteins. As pointed out previously, there is evidence that the cytochromes *b, c,* and oxidase are present in this preparation.

A concentrated solution of the lyophilized Preparation O-4 was made by dissolving each "ml equivalent"[3] in 1 ml water. It was centrifuged at 260,000 × *g* (59,780 rpm) for 150 min. At this time, the preparation contained one slow-moving boundary. The ultracentrifuge was stopped, using the rapid brake, and the upper two thirds of the contents of the cell were removed for spectral analysis. The solution was transferred to a microcuvette (*2*) of the spectrophotometer,[4] reduced with $Na_2S_2O_4$, and covered with mineral oil for spectral analysis. The curve presented in Fig. 1 indicates that a small amount of cytochrome oxidase is present (the 603-mμ peak), but that the principal component is cytochrome *c* (the 550- and 520-mμ peaks). All the cytochrome *b* and most of the cytochrome oxidase have sedimented. Cytochrome *c,* therefore, is the most slowly sedimenting chromoprotein.

In another experiment the concentrated solution of the enzyme was reduced with $Na_2S_2O_4$ before being introduced into the ultracentrifuge cell. This was accomplished by filling the cell with the oxidized preparation (at which time the last bubble was removed) and by layering the reduced preparation on the bottom of the cell, thus forcing the oxidized preparation

[1] A preliminary centrifugation of a Preparation 2-3 (*1*) was done for us by Lawrence J. Milch, USAF, School of Aviation Medicine, Randolph AFB, San Antonio, Texas. We wish to thank Major Milch for his willing collaboration. This investigation was supported in part by a research grant from the Division of Research Grants and Fellowships of the National Institutes of Health, U. S. Public Health Service.

[2] We thank L. Robinson Hyde for assisting and instructing us in the use of the Spinco instrument.

[3] One "ml equivalent" represents the amount of dry preparation obtained by lyophilizing 1 ml of the original supernatant.

[4] The Beckman spectrophotometer was made available through the courtesy of Arnold Lazarow.