useful work. The condition of maximal stability requires that ΔG be zero between any two altitudes or pressures. Air may freely circulate between any two levels with no change of free energy or performance of work.

If there is a sodium pump or other ion transport mechanism within cells, operating to perform work by increasing the free energy or chemical potential of the ions, then its maximal efficiency must be zero. The reason for this is that it operates in an invariant, isothermal, heterogeneous system. The condition for invariance requires, among other things, that an equivalent quantity of ions must immediately return to the cells. The values of ΔG and $\Delta\mu$ over any cyclical isothermal process in an invariant system may readily be shown to be zero, since they depend on only one fixed state. According to Carnot's principle, the reversible isothermal work is zero. Therefore, the efficiency of any energy-consuming mechanism operating in the reversible cycle must also be zero. Efficiency can be measured only for work-producing processes, such as muscular contraction, which involve both reversible and irreversible steps.

If there is no sodium pump, it is meaningless to calculate its efficiency.

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BIOCHEMISTRY

Structure of α-Keratin

IN a recent publication, Fraser, MacRae and Miller[1] have given a comprehensive interpretation of the X-ray diffraction photograph of α-keratin (porcupine quill tip) and, in particular, considered the quantitative aspects of the small-angle and large-angle equatorial scatter. This problem has also been discussed by Wilson[2], whose approach differs in some important respects from that of Fraser *et al.*, although based on a microfibril model of the same type. Wilson supposes that interference effects between protofibrils within a microfibril, as well as between different microfibrils, affect the X-ray intensity at small scattering angles, whereas Fraser *et al.* consider only the 'between microfibril' interference. According to them, the small-angle scatter can be ascribed solely to a difference in effective mean electron density between the microfibrils and their surrounding matrix, and for a given microfibril-matrix texture the intensity should be simply proportional to this difference. The evidence in favour of this idea is that when heavy metals, such as silver or osmium, are incorporated in the matrix material the main effect on the diffraction is to enhance the small-angle scatter, leaving the maxima of intensity at the same scattering angles as before.

On physical grounds, Wilson's theory is inadequate[3] if only because of his neglect of the side-chain scatter. Fraser *et al.* consider the side-chain scatter, but assume that it completely annuls the protofibril scatter at small angles. We believe that the truth lies somewhere between these extremes, and that the effect of the side-chains and other material between the protofibril main-chains must be to reduce, but not to eliminate, the protofibril intensity at small angles.

This belief is strengthened by our experimental results for the equatorial scatter of Lincoln wool. In a general way these are similar to those quoted by Fraser *et al.* for porcupine quill, with one important exception. This is that the relative intensities of the 45 Å and 27 Å reflexions are quite different in untreated and metal-containing wool (the intensities are roughly equal in untreated fibres, but the 45 Å reflexion is some five times stronger than the other in the silver-wool). The intensity contour, therefore, cannot depend on the relative electron densities of the matrix and microfibril in the way which Fraser *et al.* suppose; some other factor, presumably associated with the arrangement of the protofibrils in the microfibril, must modify the intensity at small angles in untreated wool.

We have examined this possibility in its quantitative implications, and have evolved a model structure which seems to have the correct scattering properties. In this, the microfibril consists of an annular array of protofibrils surrounding a core. The protofibrils have organized and less organized regions along their lengths, the former having diffraction properties like Crick triplet coiled-coils. A maximum of nine such protofibrils could be fitted into the annulus, but they need not all be organized into coiled-coils in any particular cross-section of the microfibril; we suppose, therefore, that there is an effective average number f_a (less than 9) of coiled-coils in the annulus. The microfibril core might also show coiled-coil organization and we suppose that it scatters X-rays as if it contained f_c (less than 2) coiled-coils in the cross-section. The unorganized material in the microfibril is taken to scatter like a uniform electron cloud filling the gaps between, and to some extent within, the coiled-coils. A similar cloud between the microfibrils simulates the scatter from the matrix. The small-angle scatter of such a model consists of (*a*) a part due to microfibril-matrix texture, of the type envisaged by Fraser *et al.*, and (*b*) a part due to protofibril scatter modified by interference between protofibrils in the same microfibril. Both components have maxima near 45 Å and 27 Å; in (*a*) the former is more intense, in (*b*) the latter (to an extent depending on the ratio f_c/f_a). In untreated Lincoln wool component (*a*) must be small (the mean electron densities in the matrix and microfibril being approximately equal) so that the small-angle scatter is mainly due to (*b*). In silver-stained wool only (*a*) is important (electron density of stained matrix being large). In other keratin fibres it may happen that both (*a*) and (*b*) contribute significantly, to give an intermediate type of intensity contour.

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Incorporation of Labelled Lysine into the Desmosine Cross-bridges in Elastin

THE isolation and chemical characterization of two new amino-acids, desmosine and isodesmosine, which form bridge-points between peptide chains in elastin has already been described[1-3]. The isomeric compounds are 1,3,4,5- and 1,2,3,5-tetra-substituted pyridinium salts with the empirical formula $C_{24}H_{40}N_5O_8Cl$ (as the chloride). Consideration of the structure of the two compounds and their location as cross-bridges between peptide chains led Partridge *et al.*[4] to suggest a possible biosynthetic route through ring closure on four lysine residues pre-existing in the peptide chains of a soluble pro-elastin.