short lag period, and finally a steady state was reached. Picrate was transferred from L to R phase against its concentration gradient.

The lag period became shorter or was absent when M phase had been equilibrated with picrate before the experiments. The slope of the linear portion was approximately equal to that obtained without prior equilibration. All experiments described below were performed using pre-equilibrated dichloroethane. The method of preparing the bulk phase (M) is described in Fig. 1 legend. Figure 2 shows the rates of picrate transport in conditions of varying concentrations of ferricyanide, ascorbate and TMPD. The rates increase with increase of the concentrations of these agents and reach approximately the same plateau level.

The membrane potential has been shown to be important in transport across membranes[4–6]. In the case shown in Fig. 1, the electromotive force (e.m.f.) was initially 160 mV, rapidly decreasing to reach a steady value of 120 mV with the polarity being positive in R with respect to L phase. The e.m.f. acts in the same direction as the picrate flux and hence it is possible that it might be responsible for part of the observed flux. To examine the role of the membrane potential, we clamped the potential difference between R and L phases at 0 mV by short-circuiting a pair of calomel electrodes inserted in L and R phases[7]. This made no difference to the observed results; that is, the membrane potential does not contribute to the transport of picrate in this system. This implies that picrate is being transported against its electrochemical potential gradient, that is, that the transport of picrate in this system is 'active'[8].

Our results can be explained by the following mechanism. At the L interface, TMPD is oxidised to a cation[9,10], $TMPD_{ox}^{+}$ which serves as a carrier for picrate anion, $picrate^{-}$. The $TMPD_{ox}^{+}$ and $picrate^{-}$ ion pair migrates down its concentration gradient within M phase. As the ion pair reaches R, picrate is extracted into aqueous phase by virtue of a discharge of $TMPD_{ox}^{+}$ due to the reducing agent. The neutral reduced form of $TMPD_{red}$ diffuses back to the interface and the process is repeated. Structures of $TMPD_{ox}^{+}$ and $TMPD_{red}$ are given in ref. 10. The importance of charging-discharging process of TMPD by the reduction–oxidation reaction is also suggested by the fact that in acidic solutions, the rate of transference slowed down appreciably (data not shown). This may arise from protonation of reduced TMPD, $TMPD_{red}\ H^{+}$ possibly as a result of the lack of the charging–discharging process. The decrease in L phase and the increase in R phase of a negative charge resulting from the transfer of $picrate^{-}$ from L to R are counterbalanced by the production of negative charge of $[Fe(CN)_6]^{4-}$ from $[Fe(CN)_6]^{3-}$ in L phase and by that of H^{+} associated with the oxidation of ascorbate in R phase, respectively.

The transport of cations[1,3] and amino acids[2] against their concentration gradient by coupling to a movement of the other ions in the opposite direction has been reported. It should be noted that no ion is co-transported or counter-transported in the system described here and that the energy for transferring picrate is supplied directly by the free energy associated with the chemical reaction. The substrate to be transported in this system is not restricted to picrate—any lipophilic anions capable of forming lipid soluble in pairs with $TMPD_{ox}^{+}$ may be transported. It may eventually be possible to prepare a membrane system in which a specific substance is transported by coupling of a chemical reaction.

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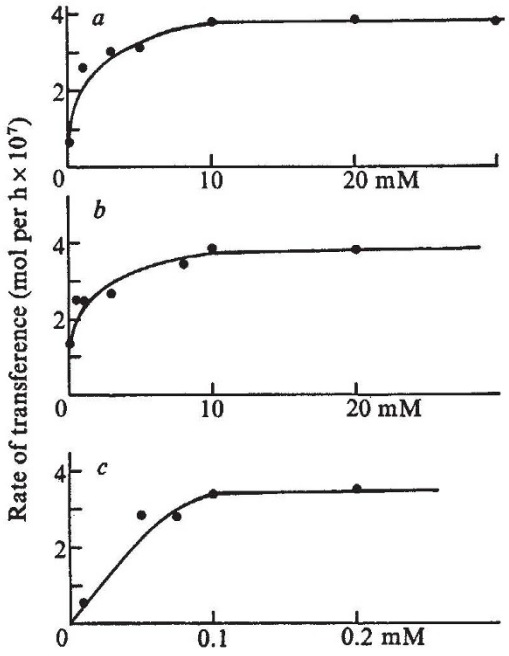
Fig. 2 Rates of transport in conditions of varying concentrations of ascorbate, ferricyanide and TMPD. *a*, Rates plotted against the concentration of ascorbate where the concentrations of ferricyanide and TMPD are kept constant at 10 mM and 0.1 mM, respectively. *b*, Rates against $[Fe(CN)_6]^{3-}$ with ascorbate and TMPD kept constant at 10 mM and 0.1 mM, respectively. *c*, Both ascorbate and $[Fe(CN)_6]^{3-}$ are held constant at 10mM. In all these experiments, the *p*H value is 9.4 buffered with 100 mM $Na_2B_4O_7$–HCl, and the initial concentrations of picrate is 10^{-4} M.



Erratum

In the article 'Mathematical models for the evolution of multigene families by unequal crossing over' by A. S. Perelson & George I. Bell, *Nature* **265,** 304–310 (1977), on p. 304, paragraph 1, line 10, 'randomly' should read 'tandemly': p. 305, paragraph 6, lines 15 and 16 should be replaced by 'crossover there are three possibilities: (1) the number of copies of gene *i* remains the same, (2) increases by one, or (3) decreases by': paragraph 6, lines 17 and 18 '$[1-\lambda_n(t)-\mu_{n_i}(t)]$, $\lambda_{n_i}(t)$ respectively' should read '$[1-\lambda_{ni}(t)-\mu_{n_i}(t)]$, $\lambda_{n_i}(t)$ and $\mu_{n_i}(t)$, respectively'; p. 306, the right side of equation (3a) should read

$$'P\frac{n_i}{N(t)}';$$

p. 306, last line in left column, 'variance' should read 'second moment': p. 306, the summation index should be '*i*' not '*I*' in the equation for $N(t)$ following eqaution (3b): p. 308, line 4, should read '$P_{N0\to 1}(t)$' not '$P_{N\to 1}(t)$': equations (12) and (13), 'P' should read 'P_0': the left side of equation (15) should read

$$p_f(t) = \int_0^t \frac{dp_f(t')}{dt'}\,dt$$

the left side of equation (16) should read

$$\int_0^t t'\frac{dp_f(t')}{dt'}\,dt'$$

paragraph 4, line 18, 'context[38]' should read 'context[39]': p. 309, equation (18) '$1 \leqslant \xi_1 \leqslant m$' should read '$0 \leqslant \xi_1 N_0 \leqslant m$': equation (19) '$0 \leqslant \xi_2 \leqslant m$' should read '$0 \leqslant \xi_2 N_0 \leqslant m$': equation (20), the summation indices 'ξ_1' and 'ξ_2' should read '$\xi_1 N_0$' and '$\xi_2 N_0$'.