Some models for selection in enzyme coupled, selfreproducing, macromolecular systems are considered. The enzyme coupling provides a mechanism for the buildup of systems with large information content. The concept of "selective value" and criteria for selection is discussed.

1. Introduction. In Eigen's theory of selection and evolution of biological molecules (1971), a collection of selfreproducing macromolecular information carriers are considered subject to certain environmental constraints. The reproduction of the macromolecules is described by a set of non-linear rate equations.

In what Eigen has called quasi-linear systems, no internal coupling exists between different macromolecular species so the individual rate parameters are independent of concentration. The non-linearity arises in this case as a result of the environmental constraints imposed on the total population. The equations describing the production of the macromolecules can be solved exactly and selection criteria can be clearly stated (see: Jones, Enns and Rangnekar, 1976; Jones, 1976, 1977; Thompson and McBride, 1974).

In real biological systems reproduction occurs most often as a result of catalytic action of certain enzymes, usually proteins. Since the enzymes are produced via coded instructions provided by the information macromolecules, the catalytic action will in general couple different species of
information carriers together. Such catalytic coupling offers a tremendous selective advantage when it exists and provides a mechanism for the buildup of self-reproducing macromolecular systems with large information content. Thus the problem of how selection arises in such systems is particularly important.

Unfortunately the catalytic coupling introduces further nonlinearities into the problem and as a result analytical solutions of the rate equations are usually not possible. Thus the criteria governing selection is not readily deduced.

In this paper we consider some selection models assuming various types of catalytic coupling between the macromolecular information carriers. Our aim is to gain further insight into the problem of selection in enzyme coupled systems.

**II. Eigen's Equations for Selection.** We consider a collection of self-reproducing macromolecular species (concentrations denoted by $X_k(t), \ k = 1, 2, \ldots, N, \text{for } N \text{ species}$) subject to the selection constraint

$$\sum_{k=1}^{N} X_k(t) = n = \text{constant.} \tag{1}$$

In order to simplify our discussion we shall neglect the effect of reproduction errors, i.e. mutations. Eigen's equations for the production of the various molecular species can then be expressed as

$$\dot{X}_k(t) = (W_k(t) - \bar{E}(t))X_k(t) \tag{2}$$

where $W_k(t)$ describes the net formation rate (production minus decay) of species $k$ and $\bar{E}(t)$ represents a dilution flow rate which is controlled externally and adjusted to maintain the constraint (1), i.e.

$$\bar{E}(t) = \left(\frac{\sum_k W_k(t)X_k(t)}{\sum_k X_k(t)}\right)$$

The parameter $W_k(t)$ has been called the "selective value" by Eigen. In general, if there are catalytic couplings between species, $W_k(t)$ will depend on some subset of the concentration variables. Thus the rate equations (2) are in general highly non-linear.

As we have pointed out previously (Jones et al., 1976) the nonlinearity associated with $\bar{E}(t)$ in (2) can be removed by a transformation to variables