# Séminaires IRIA

## analyse et contrôle de systèmes

# 1974



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### MATHEMATICAL MODELS FOR ENZYME CASCADES

### H.T. Banks

Brown University - U.S.A.

### . INTRODUCTION

In this lecture we report on our current efforts in the area of mathematical modeling of enzyme cascades such as those found in many of the metabolic pathways in mammals. By an "enzyme cascade" we shall mean a finite sequence of enzymatic reactions in which the "product" of the nth-stage reaction acts as stimulus or "enzyme" for the "substrate" in the (n+1)st stage. The importance of such cascades acting as "biochemical amplifiers" by which a change in the level of a catalyst present at extremely low concentrations (small signal) can have major influences (large response) in the body has been recognized for some time. Among well-known cascades are those found in:

- Blood coagulation [10,11,13,14]: Here a minute surface stimulus activates a relatively small number of molecules of Hageman factor which ultimately results in the conversion of millions of molecules of fibrinogen to fibrin.
- (ii) Glycogenolysis [2,7,12,19]: An increase in the cytosol level of cyclic AMP (present at low intracellular concentrations) initiates a sequence of enzymatic reactions which result in an increased rate of activation of glycogen phosphorylase (present at a concentration several orders of magnitude higher) which in turn promotes the breakdown of glycogen to glucose-1-phosphate.
- (iii) The complement system [15]: Antibodies recognize foreign invader cells and activate the so-called complement system, which is an intricately linked set of at least eleven proteins set up in a complex cascade. While the later stages of the cascade are not yet completely understood, it is known that activation of this cascade results in the destruction of invader cells via the Donnan effect.

Other important areas in which it is speculated that cascades are important include the mechanisms for contraction-relaxation in smooth muscle [19].

Previous investigations by others [2,7,10-14,19,20] have led to the recognition of certain features that appear desirable in any mathematical model of an

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