

## 2002 Paper 9 Question 9

### Neural Computing

Explain the mechanisms and computational significance of nerve impulse generation and transmission. Include the following aspects:

- (a) Equivalent electrical circuit for an excitable nerve cell membrane.
- (b) How different ion species flow across the membrane, in terms of currents, capacitance, conductances, and voltage-dependence. (Your answer can be qualitative.)
- (c) Role of positive feedback and voltage-dependent conductances.
- (d) The respect in which a nerve impulse is a mathematical catastrophe.
- (e) Approximate time-scale of events, and the speed of nerve impulse propagation.
- (f) What happens when a propagating nerve impulse reaches an axonal branch.
- (g) What would happen if two impulses approached each other from opposite directions along a single nerve fibre and collided.
- (h) How linear operations like integration in space and time can be combined in dendritic trees with logical or Boolean operations such as AND, OR, NOT, and veto.
- (i) Whether “processing” can be distinguished from “communications” as it is for artificial computing devices.
- (j) Respects in which stochasticity in nerve impulse time-series may offer computational opportunities that are absent in synchronous deterministic logic.

[2 marks each]