A Computer Model
of the Cellular Slime Mould
Dictyostelium discoideum

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Statement of Originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Signed: ....

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Abstract

Excitable media are an important class of systems, examples of which include epidemics, predator-prey interactions, nervous systems, and heart muscle. Aggregating cellular slime moulds are an example of an excitable medium. The species of cellular slime mould *Dictyostelium discoideum* is an important model organism that many science laboratories use. Studying the aggregation of slime moulds increases knowledge about excitable media generally. One method of studying the aggregation of slime mould is to simulate their behaviour on a computer model.

This thesis presents the author's computer model of cellular slime mould *Dictyostelium discoideum* and the results of experiments carried out using the computer model. The experiments investigate the relation between the aggregation patterns and the various parameters of the model. These parameters are the density of artificial slime moulds, the acrasin threshold, the acrasin degradation rate, and the rate of acrasin secretion. Randomness has an effect on the aggregation patterns produced. Results of experiments are presented that examine the effect of randomness. Two forms of randomness are investigated: random secretion of acrasin by the artificial slime moulds; random initial reactivity of the artificial slime moulds.

The computer model describes an artificial environment in which artificial slime mould amoebae interact with each other and their environment. Out of these individual interactions the global patterns that characterize slime mould aggregations emerge. The model facilitates the study of these individual interactions and hence the global patterns that emerge.

The model and the experimental results described in this thesis contribute to the study of the aggregation phase of the life cycle of *Dictyostelium discoideum*. The author proposes mechanism that could underlie certain classes of aggregation patterns. These patterns include net-like aggregations and loop aggregations.

The computer model presented in this thesis is successful in emulating the behaviour of the cellular slime mould *Dictyostelium discoideum*. In its present form the model is a useful tool to biologists. The results of experiments conducted with the model suggest mechanisms that may underlie certain pattern produced by living slime moulds. A result of particular interest is the initiation of the spiral wave pattern from a loop wave, which produces a loop aggregation.

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Notation

C	concentration of a chemical
C_a	concentration of acrasin
$C_\mathrm{threshold}$	threshold concentration of acrasin above which an SM will react
D	diffusion constant
D_a	diffusion constant for the acrasin
d	diameter of an SM
n	the number of triggered wave check field cells
r	a measure of the sensitivity of SM to acrasin, i.e. corresponds to the number of unbound acrasin receptors in living slime mould amoebae, and there for the SM's reactivity
s	the speed of the cAMP wave
t	time variable
Δt_iter	the increment in time for each iteration of the model
v	speed of SM
v_max	maximum speed of SM
α	the angle
β	the angle of maximum chemical gradient
δ	distance between two SM
δ_fc	distance between field cells, ie the length of the side
δ_{field}	the distance from the central SM3 to the wave check field cell
ε	a small random angle added to the direction of maximum rate of change in chemical concentration with respect to distance to give the direction of movement of a SM
ϕ	the angle from direction zero to the direction of maximum rate of change in chemical concentration with respect to distance
σ	the distance a SM moves