Simulating Reaction-Diffusion Textures Using Turing's Partial Differential Equations from Chemical Basis of Morphogenesis

Question: Is it possible to suggest that certain well-known physical laws are sufficient to account for reaction diffusion textures in nature?

Proposal: Referring to a modern version of Alan Turing's continuous PDEs, try to produce textures found in nature:

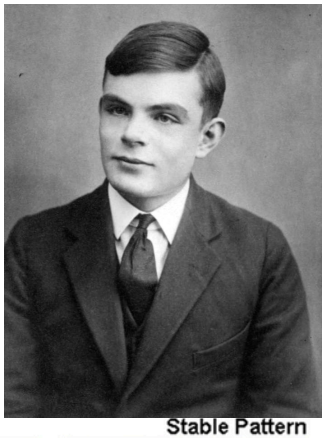
$$\frac{\partial u}{\partial t} = F(u,v) - d_u v + D_u \Delta u$$

$$\frac{\partial v}{\partial t} = G(u,v) - d_v v + D_v \Delta v$$

Rate of concentration change | Production | Degradation | Diffusion

Reaction

Figure 2



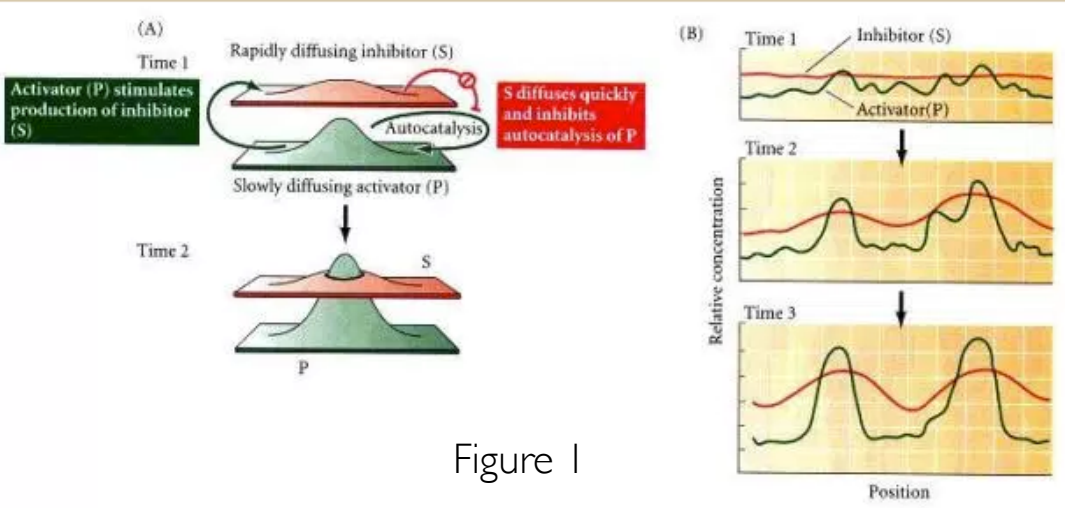


Figure 1

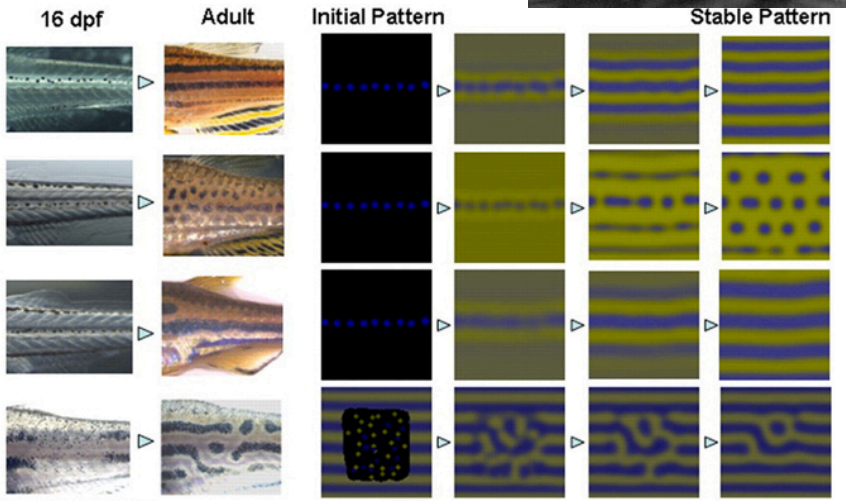
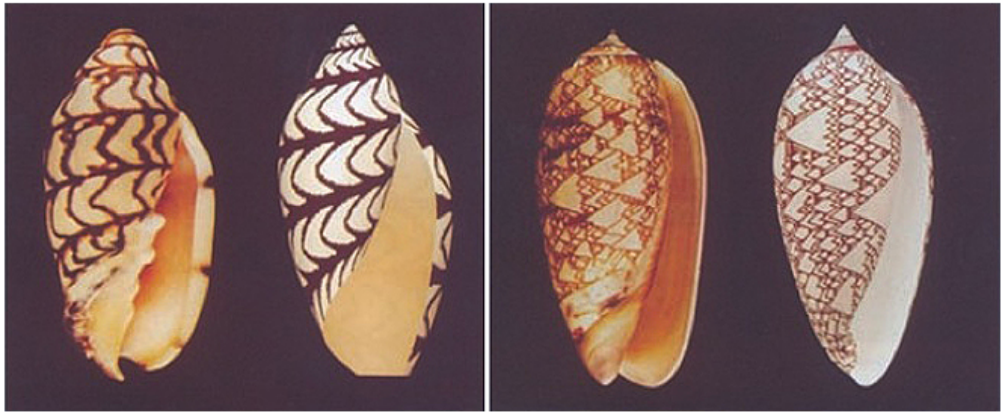
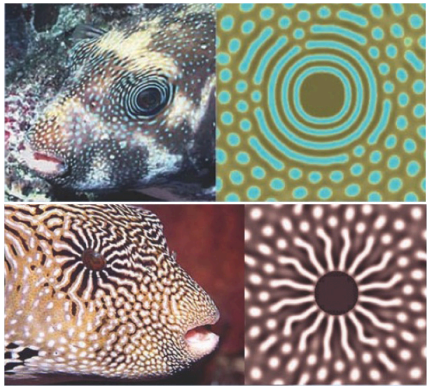
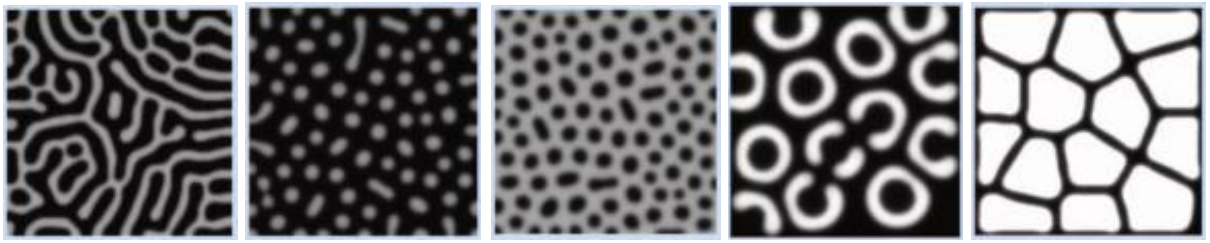


Figure 3



In all of the three pictured cases, the natural pattern is on the left while the Turing simulation/approximation is on the right. Not too shabby.





Methods/Objectives:

1. Determine initial conditions; parameters, scale coefficients, structure of molecules/substance
2. Calculate the four variables per morphogne:
    1. Rate of Production
    2. Rate of Degradation
    3. Rate of Diffusion
    4. Strength of Activating/Inhibiting Interactions
3. Discretize Turing's PDEs using the Crank-Nicolson Method
4. Experiment with the simulation using a grid/multigrid with varying timesteps in order to create an efficient convergence
5. Produce plots that demonstrate the Turing patterns/textures (pictures to the left)