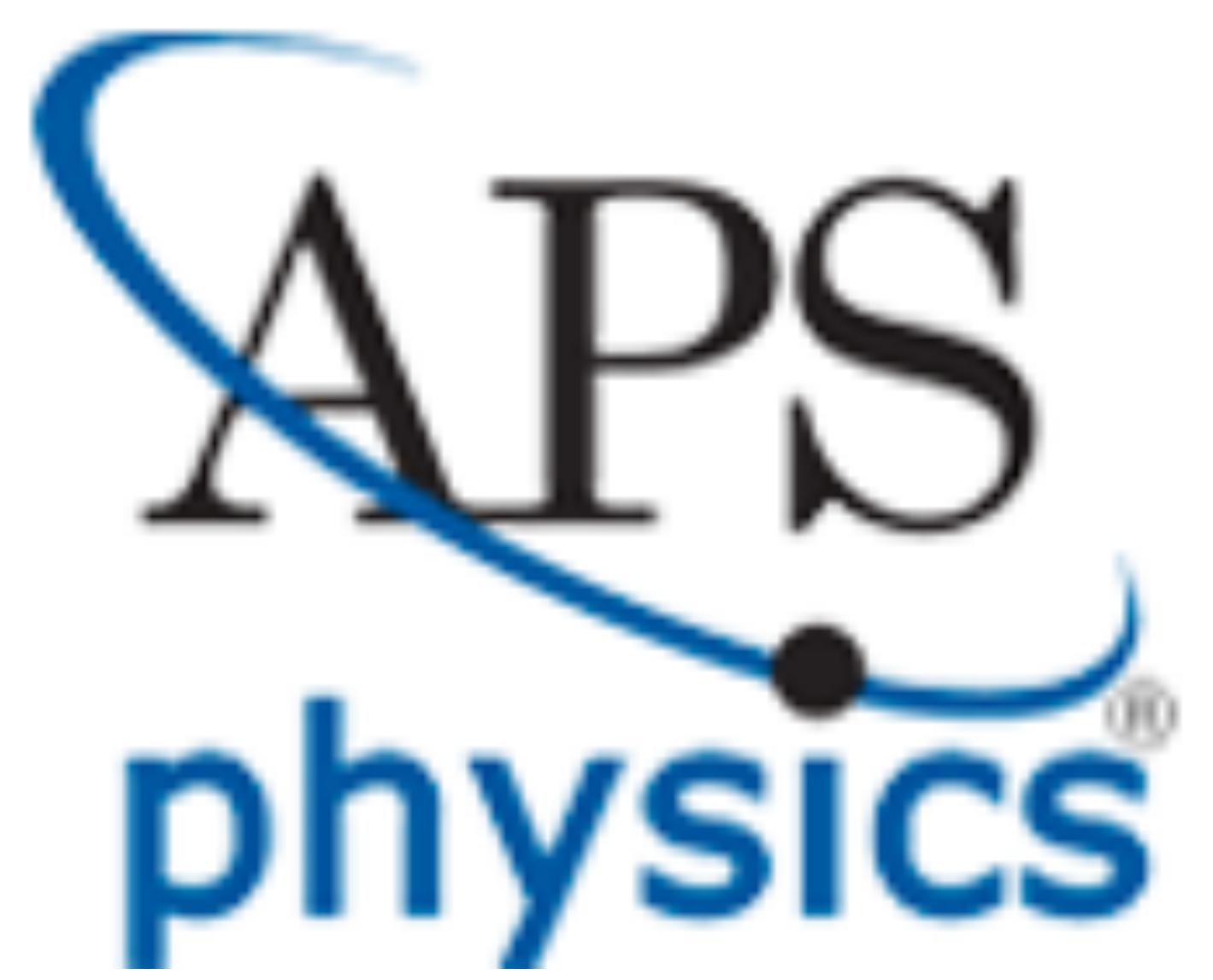


# Dynamic Stomatal Patchiness: Parallel Behavior in Computation and Nature



Matthew Hogan, Utah State University | Dr. David Peak, Utah State University | Dr. Keith Mott, Utah State University

## Nature

All plants **must** solve the problem of regulating the influx and outflow of gas in order to survive. They accomplish this via pores embedded in their leaves called stomata (Figure 1)

Figure 1 – Microscopic view of a leaf's surface



Stomata are made up of two guard cells which form the pore and are surrounded by epidermal cells

Somehow, plants simultaneously regulate the apertures of all of their stomata for optimal gas exchange. How do they do it?

Study conducted with funding from the Peak Summer Research Fellowship Program.

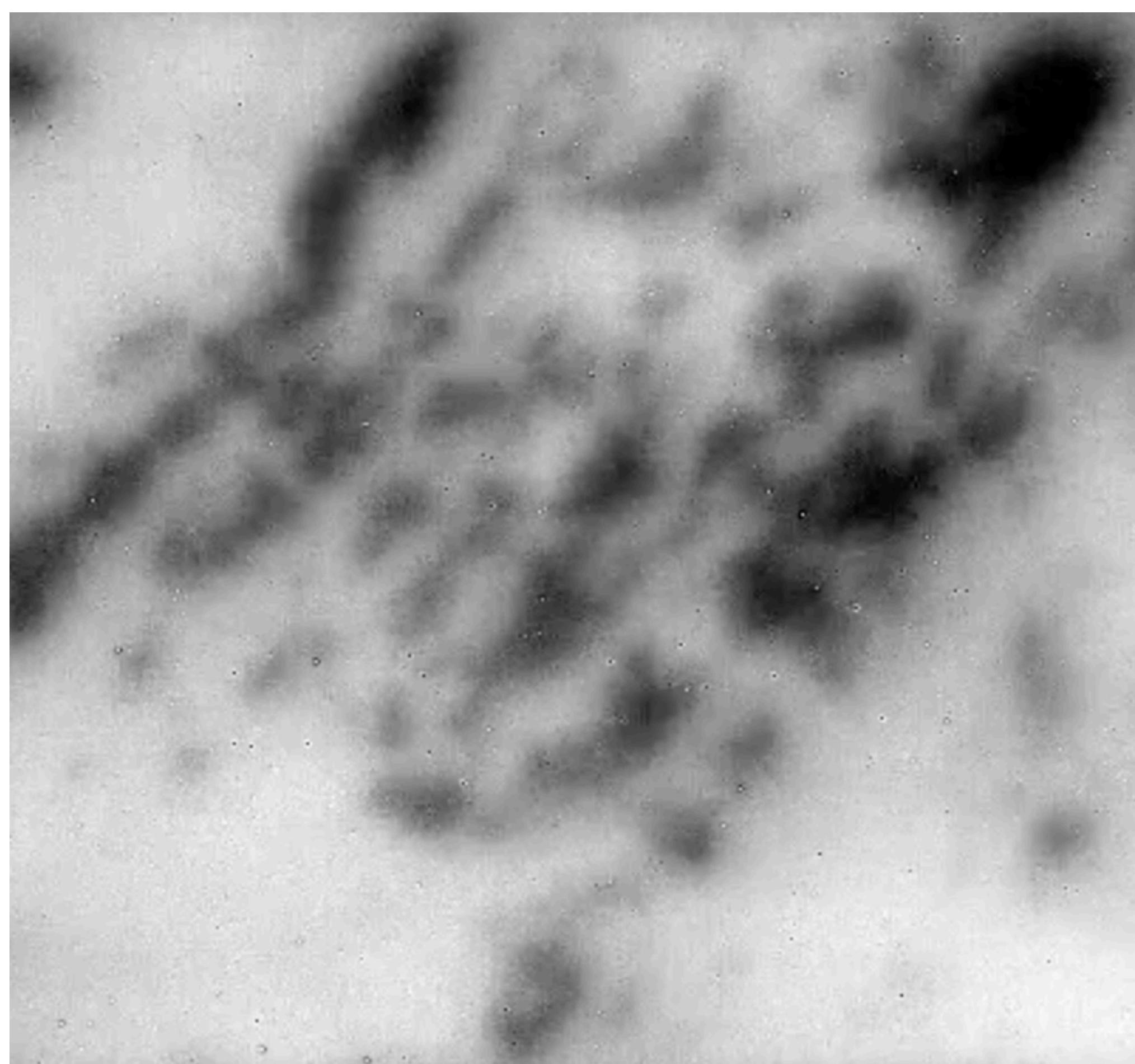
Matthew Hogan  
Utah State University  
Department of Physics  
matthew.hogan@aggiemail.usu.edu

## Observations

When the environment around a leaf suddenly changes, stomata tend to oscillate between open and closed. We observed this by using a FLIR SC7000 thermal imaging system: more open stomata are cooler and more closed stomata are warmer (Figure 2)

Fascinatingly, stomata almost always spontaneously form local groups, called patches, that oscillate in unison across the leaf's surface

Figure 2 – Real (left) and simulated (right) thermal images



While the two images are not necessarily identical, both show the spontaneous formation of patches

## Simulations

Using the computational model, temperature data were simulated in a virtual environment

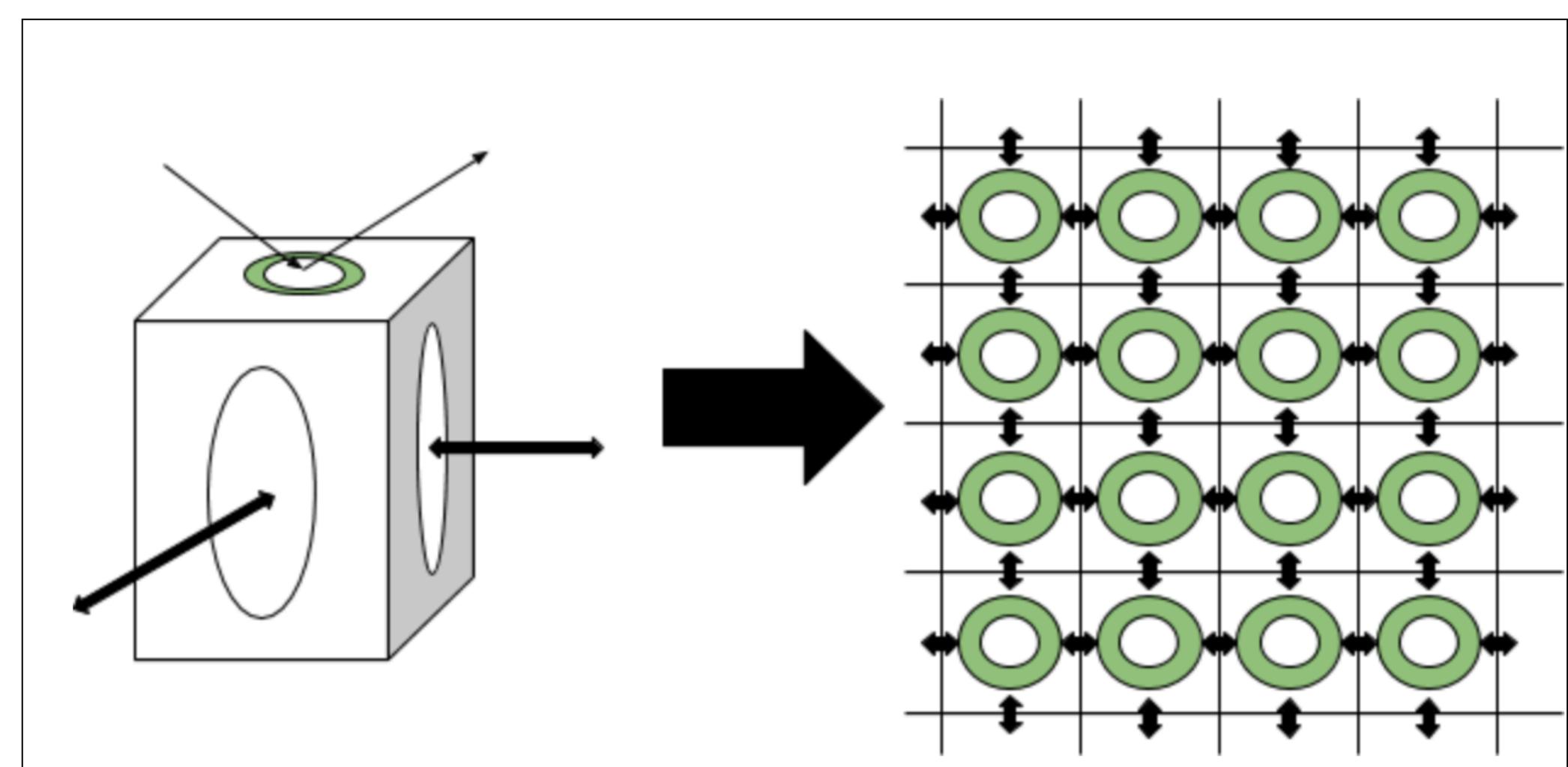
Exactly like what we observed in real leaves, these simulations showed the spontaneous formation of thermal patches (Figure 2)

These patches were **emergent**; that is, they were not directly programmed into the model

## Computational Model

We imagine a leaf may be suitably modeled as an array of autonomous “stomatal units” (Figure 3), each of which independently solves the governing thermodynamic equations

Figure 3 – Theoretical stomatal network



A stomatal unit interacts with the environment and its nearest neighbors only

## Conclusion

This model provides a rational, physical explanation for the formation of patches as well as indicates that patches are a key part in achieving optimal gas exchange in a dynamic environment

**Utah State**  
**U n i v e r s i t y**