A system is considered complex if it is composed of individual parts that abide by their own set of rules while the system, as a whole, exhibits often unexpected properties. The motivation for studying complexity spurs from the fact that it is a fundamental aspect of many systems, including forest fires, earthquakes, stock markets, fish schools, plant root growth, and fly swarms. We are particularly interested in fly swarms and the possible inertial and thermodynamic properties that the swarm exhibits, arising from the individual flies.

Language of Complexity

**Properties of a swarm:**
- Inertia
- Thermodynamic (pressure, temperature, volume)
- Diffusion, distance from center of mass, distance between flies

**Visualization of swarm surface area**
- Black sphere: average distance from center of mass
- Red sphere: average between the black sphere and furthest out fly
- Red sphere typically used in pressure and volume calculation.

**Possible phases of a swarm:**
- Gas: highly dispersed fly system. Non-swarm state
- Liquid: low density swarm state
- Solid: Tightly clustered fly system. High density swarm

**Practical Applications**
- Artificial swarms (drones, etc.)
- Mapping landscapes
- Medical nanobots
- Combat diseases

**The Models**
- Base (random walkers)
- Global (absolute) Center of Mass
- Local (relative) Center of Mass
- Combination Center of Mass
- Desired Separation
- Multi (Global, Local, and Desired Sep.)

**Initialization**

**Results and Analysis**

- High initial density (L = 5):
- Low initial density (L = 15):

**Future Research**

- How is swarming quantitatively defined? Is the definition discrete or continuous?
- Look further into the thermodynamic perspective on fly swarms
- Examine inertia for various swarm sizes
- Compare data with other models and actual fly swarm data
- Improve upon the current models to form the most realistic model
- Do fly swarms exhibit properties associated with self-organized criticality (SOC)?