

# Diffusion Limited Aggregation

Fall Semester

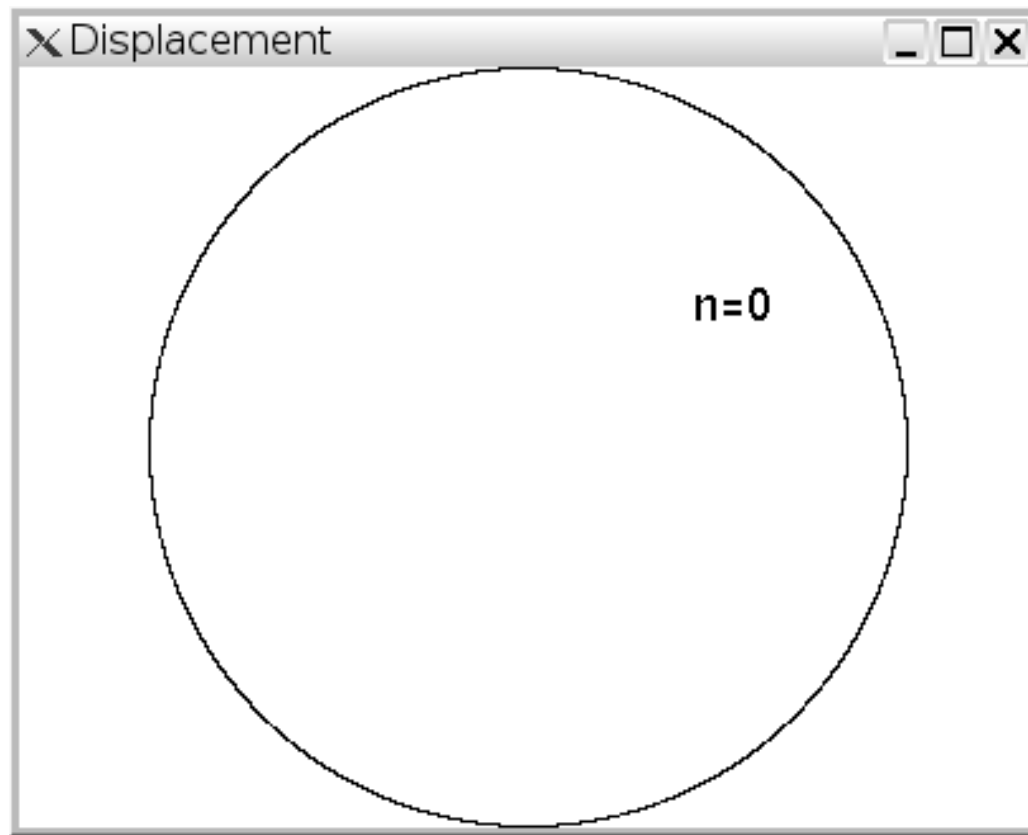
## Topic Outline

- Brownian Motion
  - Random walk
  - Binning
  - Gaussian
- Plotting
  - Particles
  - Statistics
- Two windows?
- Petri Dish
  - Confinement
  - Seed point
  - Clustering
- Parallelization
  - Independence
  - Crystal growth
- Up Next: Game of Life

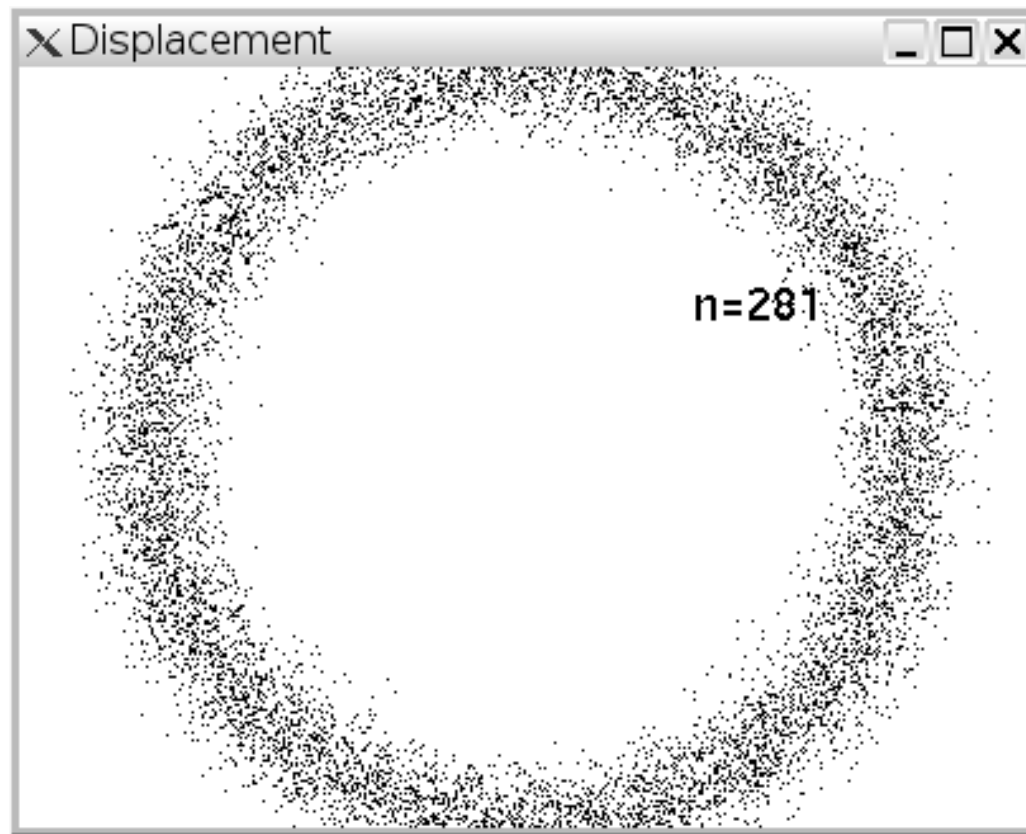
## Brownian Motion

- Randomly initialize  $N$  particles on a circle.
- Each particle moves independently: up, down, left, right.
- Two or more particles may share the same position.
- During each step, each particle makes one move.

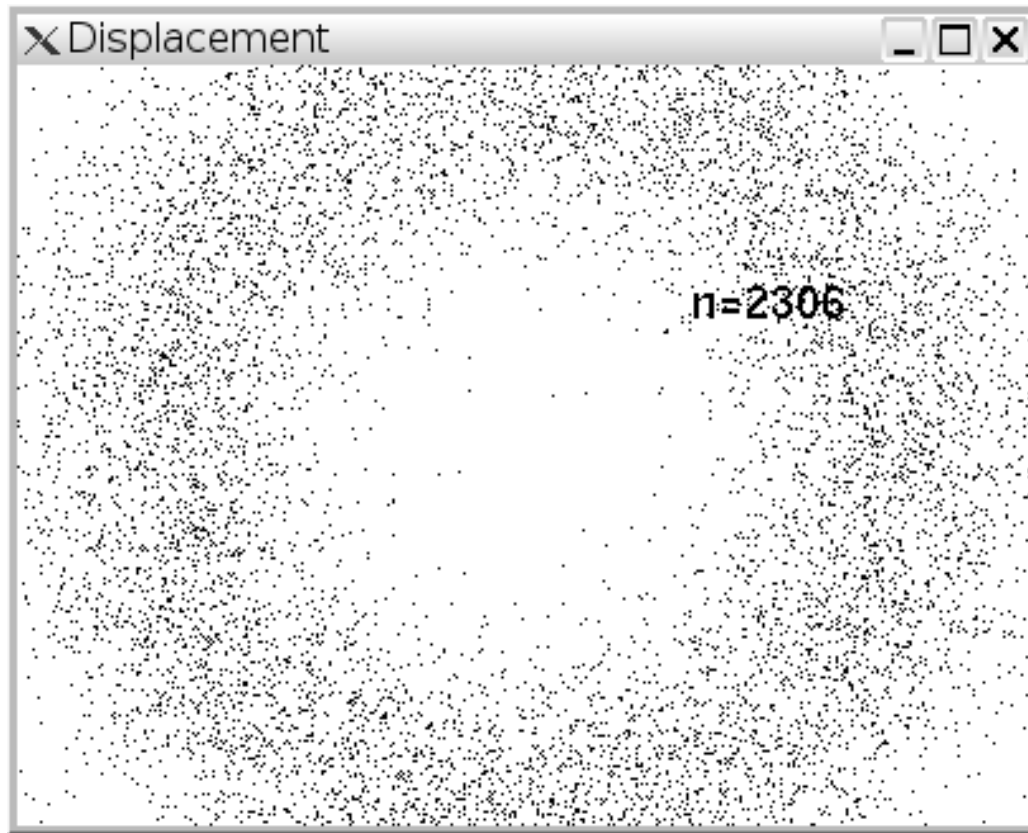
# Screenshot (1)



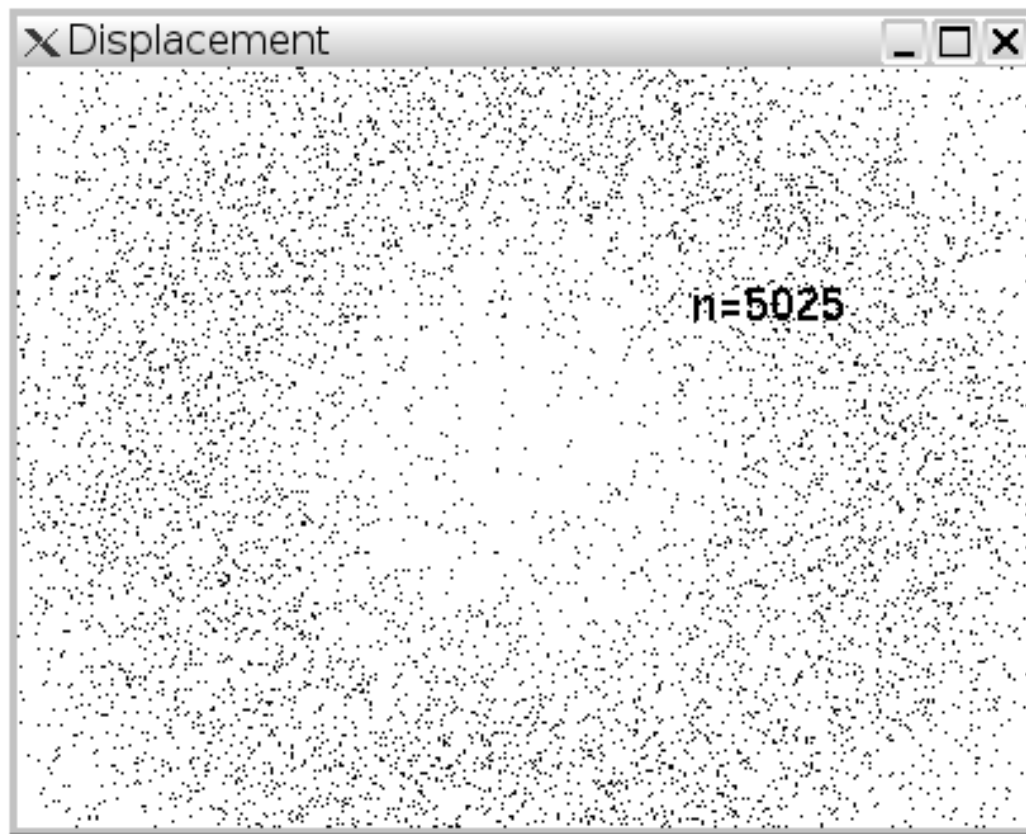
## Screenshot (2)



### Screenshot (3)



# Screenshot (4)

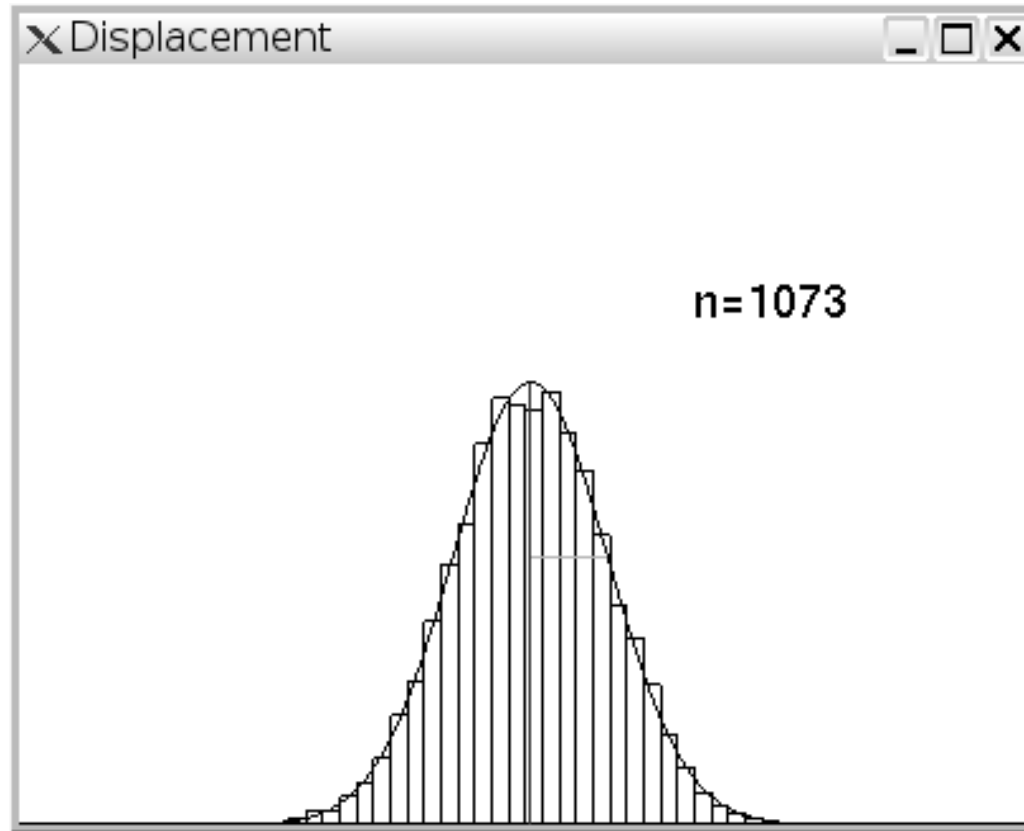


## Statistics

- For each particle, at each step, calculate the distance from the center of the circle. Units? Scale? Axes? Annotation?
- Calculate average distance ( $\mu$ ) and standard deviation ( $\sigma$ ).
- Plot the distribution of distances as a histogram. Hint for scaling the overlay: total area of all buckets should be one.
- Overlay the Gaussian, mark the average and standard deviation.

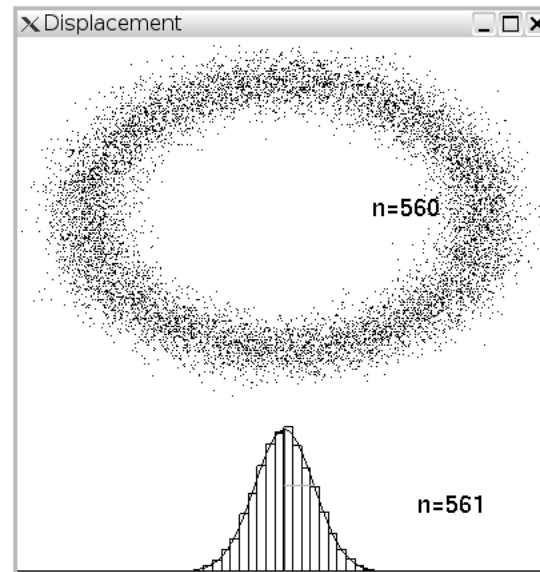
$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

# Screenshot

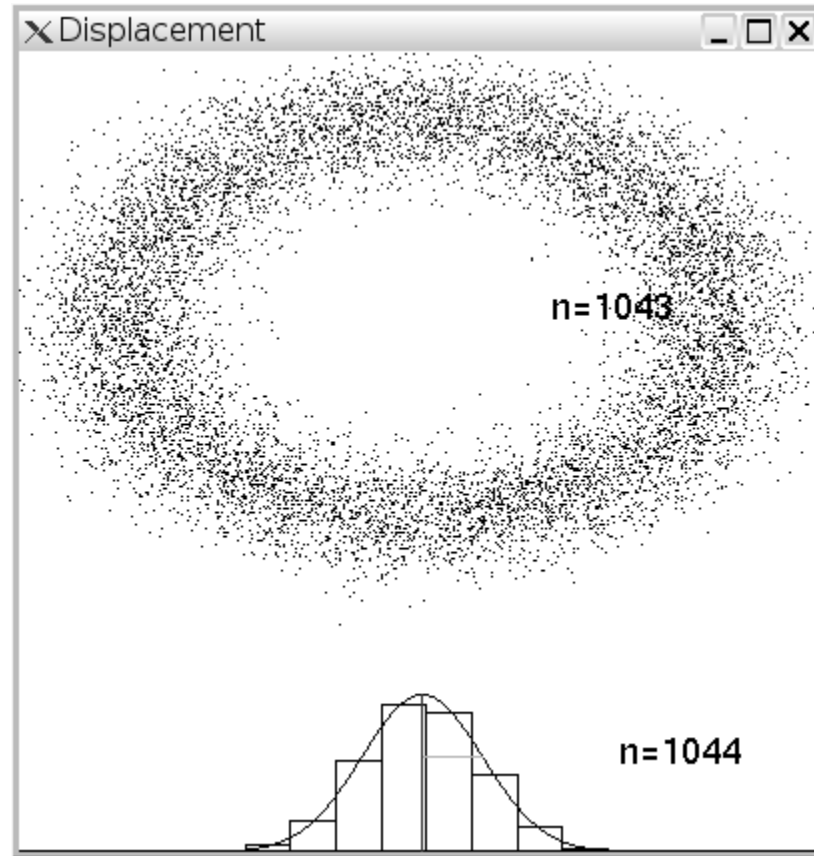


## Lab Assignment: Brownian Motion

- Plot particles and stats over time.
- Allow the user to alter the bin size.



# Screenshot



## Confinement

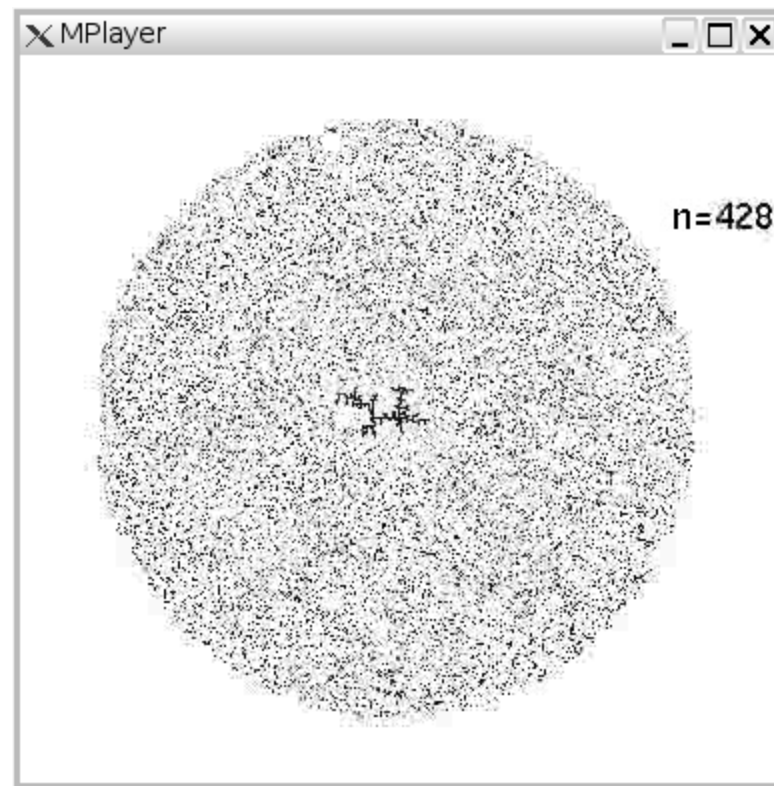
- Instead of initializing the particles along the circle, place them at random within the circle. Then, as they move, prohibit them from leaving the circle (as if it were a petri dish).
- If you choose points at random using polar coordinates then there will be more particles clustered near the center.
- Choose points in a square and discard those not in the circle.

## Seed Point

- Imagine a particle at the center of the circle is stuck. Any particle neighboring a stuck particle also becomes stuck.

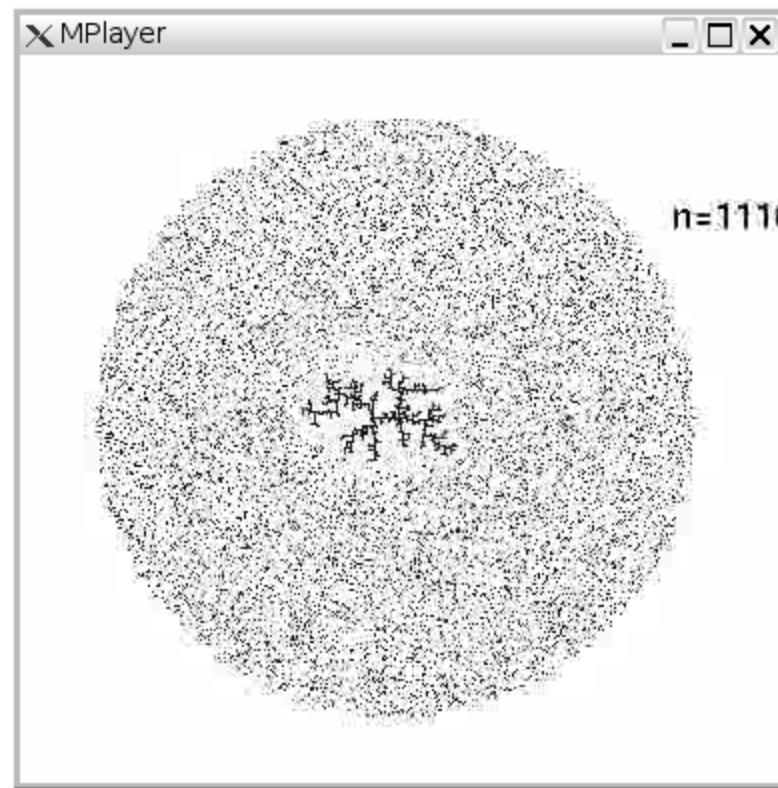
## Crystal Dendrite

- What happens?



## Clustering

- The tendrils continue to grow.



## Parallelization

- If each node is responsible for a certain subset of the points then their movement can be modeled independently of all other points, except the stuck ones.
- At the end of each time step nodes must report to the manager new stuck points and the manager must update all nodes with a list of newly stuck points.
- Collective communication example:  

```
MPI_Bcast(x,n,MPI_INT,0,MPI_COMM_WORLD);  
MPI_Bcast(y,n,MPI_INT,0,MPI_COMM_WORLD);
```
- See also, Lin and Snyder page 214.

## Lab Assignment: Diffusion Limited Aggregation

- Run in parallel.

