AP4 — Modeling Cell Growth Using Delaunay Triangulation and Voronoi Tessellation

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In real biology, cells don't just grow randomly — they push against each other and try to take up as much space as possible. This makes them form nice tight patterns that kinda look like honeycomb or polygons. The shape of each cell mostly depends on how close it is to other cells around it. In this small project, I tried to model this process using geometry, with **Delaunay triangulation** and **Voronoi tessellation**. Each nucleus of a cell is treated as a point in 2D space. The Voronoi tessellation splits the space so every point belongs to the nearest nucleus, while the Delaunay triangulation connects those that are neighbors. Together they show the structure of a tissue and how cells "touch" each other.

First, I created 25 random points to represent where the cell nuclei are located. Then I used `NumPy` and `SciPy` to build both the Voronoi and Delaunay structures:

- The **Voronoi tessellation** defines the borders of each cell.
- The **Delaunay triangulation** shows which cells are connected or adjacent.

I used `matplotlib` to draw everything. Each Voronoi region got a light color to look like a real cell. Delaunay lines were drawn in dashed gray to make the connections visible. The red dots are the nuclei, showing the "center" of every cell.

After drawing the first version, I simulated what happens when a new cell appears (like cell division). I just added one more random point and recomputed everything again. When the new cell appeared, the neighboring cells automatically shrank or changed shape, and some of the Delaunay lines reconnected. This looked really similar to how real cells grow and adjust their space inside a tissue. Basically, adding one new nucleus changes the geometry of the whole structure a little bit, which shows how local growth affects the global pattern.

The first figure shows how 25 cells divide the space. Each polygon fits nicely with others, and no gaps or overlaps appear. The boundaries between cells are right in the middle between neighboring nuclei. The Delaunay edges confirm which cells are directly next to each other. After I added a new cell, some polygons became smaller and the diagram rearranged itself. The change was smooth and organic-looking. It clearly demonstrates how this geometric model captures the natural process of growth. This project also highlights how Delaunay and Voronoi are actually mathematical opposites — Delaunay connects neighbors while Voronoi separates their territories. It's interesting that such abstract geometry can mimic real biological behavior.

By using Delaunay triangulation and Voronoi tessellation, I modeled how cells could grow and divide space based on distance. These diagrams help show both the borders of cells and how they are connected to each other. Even though all points were random, the final result looked surprisingly realistic, like real microscopic tissue. It shows that geometry alone can describe how nature organizes things in an efficient way.