Stare-eo-logical Problem Set

1. Imagine that you were required to cover a floor with tiles exhibiting the same, equal-sided shape. If you were prohibited from leaving gaps, then tile shapes would be limited to equilateral triangles, squares, or regular hexagons. Thin-sections from organs in multicellular animals often show repeated arrangements in which blood vessels and other fluid-filled spaces that service cell assemblages are arranged in compartments much like the tiles on a floor. The mammalian liver typifies this construction: liver cells, or 'hepatocytes,' are assembled in sheets, which appear as strings, or 'cords,' in thin-sections, and the sheets are arranged into polygonal areas, or 'lobules.' Lobules are serviced by capillary blood supplies at the corners (*i.e.*, from the 'portal vein' and 'hepatic artery'). Blood flows past the strings toward the lobule centre, where it is removed by the central vein.

A Computational Biologist might consider which lobule shape provides the most-efficient configuration. Please suppose that hepatocytes were to assume approximately equivalent sizes and shapes; then, hepatocyte numbers within lobules would be determined by lobule areas. Please also assume that capillary blood supplies at corners were shared and, therefore, divided equally among adjacent lobules; then, total blood supply for a lobule would be calculated by summing the fractional supplies from all corners.

Another design consideration concerns the hepatocytes in the cords, which share the blood flow from a capillary blood supply at a corner to the central vein in the centre. This 'cord length' varies. At its shortest, cord length constitutes the straight line from a corner to the centre. At its longest, string length constitutes half the distance between corners (L1) plus the distance from this point to the centre (L2). The 'mean path length' (MPL) is the mean between the shortest and longest cord lengths.

Consider the square that was presented in session 9. Please derive an equation relating the area A and side length l only.

Next, please rewrite the equation using L1 rather than l.

Next, please calculate mean path length MPL (please assume that A = 1 unit area).

Next, please calculate the blood supply per unit area (BS / A; please assume that each corner is supplied by 1 unit blood).

Finally, given that you were informed that MPL and (BS / A) are 1.039 and 0.5 for the triangle that was presented in session 9 and 0.734 and 2 for the hexagon that was presented in session 9, please conclude which shape would provide the most efficient configuration.

2. Please calculate L_L, A_A, S_V, and N_V for the hypothetical sample that was presented in session 9; please show your calculations as concisely as possible (*e*.*g*., for LL, please show calculations for only one horizontal or vertical line).

3. Please state a topic or computational tool that probably will constitute the subject for your report.

4. Please read the first section in Part 1: This World in the book *Flatland* and stop if you can (you may peruse it at the URI

http://www.geom.uiuc.edu/~banchoff/Flatland

or at your local library). Confirm that you did so by quoting the quotation that opens that part.