HW #2 Chi Zhang

Problem 1

1.

Number of histone-like protein per cell ~ 60,000

Number of nuclear pore complexes ~ 2,000

Average rate ~ 60,000/2,000 ~30

2.

Flux of proteins entering the endoplasmic reticulum lumen ~ 460 molecules/s ~ 4* 10^7 /day

Number of outer membrane protein in cell ~ 10^5

Ratio ~ 10^5 * 20/ 4* 10^7 ~ 5%

3.

Carbon:

Dry weight of E. coli cell ~ 300 fg

Glucose mass ~ 180g/mol

Number of glucose ~ 10 ^ 13

Energy:

ATP yield from glucose ~ 3.0

Amount of ATP needed to produce E. coli biomass aerobically on glucose ~ 1.8 * 10^10

Number of glucose ~7 * 10^9

Since the number of glucose cost for carbon mass is much higher than what is needed for energy,

The building material costs is the limiting factor.

4.

Solar power arriving to earth from sun ~ 1.75 * 10^17 W

Fraction of solar energy striking the Earth that is converted to biomass ~ 0.2 %

Converted solar power ~ 3.5 * 10^14 W

Humanity total power usage in 2005 ~ 1.1 * 10^14 w

Humanity power/converted solar energy ~ 0.3

Problem 2.

1.

In Duran's article, the set up the computation model using a particular programming language, which enable simulations of Newtonian physics on groups of interacting particles. Cells are represented as objects having a given position and velocity, and cell-cell interactions are modelled by simple but physically meaningful spring-like interactions.

In David Kirk's article, a genetic modulation of cell number process is done. The studies have revealed the volvocacean inventions rely upon the products of a particular genes that have been adopted.

In Stephen Miller's article, they used an ideal model system, focus on the family of volvocine green algae which is well suited to studying the evolution of multicellularity. The different result from keep unicells in the light for photosynthesize reveals that volvox has multicellularity, because of the somatic cells lost the capacity for reproduction.

In Jacobeen's article, a tractable 'snowflake; yeast model system is built. The approach is mainly about understanding the fracture process and measure the cluster size. The force is applied at fracture of all cluster sizes, the results suggests that bond strength does not vary significantly with cluster size or genotype. The energy input related with cluster size is also measured, suggests the strain accumulation during growth plays a dominant role in determining fracture size.

In Amado's article, the approaches discussed is about assuming the cells performing two tasks, each metabolites brings about a benefit and a cost. The benefit function and the cost function are designed. When a single cell produce both metabolites, namely X and Y, the metabolites are equally shared but the cost of metabolite production is individual.

2.

Ispolatov, Iaroslav, Martin Ackermann, and Michael Doebeli. "Division of labour and the evolution of multicellularity." *Proceedings of the Royal Society B: Biological Sciences* 279.1734 (2012): 1768-1776.

In this article, the consider the simplest possible scenario of aggregation, the formation of a union of two cells. They consider the population of cells, and the cells can be in unicellular or two-cell forms between birth and death states. The population densities of single cells and two-cell aggregates are denoted, the transition between unicellular and two-cellular forms are assumed. The binding constant is controlled by a heritable parameter, also called the cell stickness.

This model focuses mainly on the two metabolities the cells can produce, namely x and y, the fitness of cell is determined by the cost and benefit function.

Finally, they assume a logistic form of the per cell death rate Dp, which is independent of whether a cell is single or a part of an aggregate.