**Appendix 1**

**The mechanism of substrate generation**

When initializing of the substrates-layer, all points in the grid generate substrates at ten times the number of public goods enzymes. In the subsequent time steps, the presence of living cells in the cells-layer will induce the creation of all types of substrates in the substrates-layer. In this way, as long as there are living cells within the community, the public goods enzymes will have a continuous supply of substrates for catalysis. Moreover, the substrates will not exhibit diffusion or decay on the substrates layer. This represents an environment with the substrates similar to chitin. On the timescales I attempt to represent, I expect these physical environments to be largely unchanging with abundant supply of substrate.