

Evolution of complexity in microbial populations

Julian Adams

Department of Biology

University of Michigan Ann Arbor MI 48109

Natural populations of most species appear to be highly variable genetically. It has been argued that such variation provides raw material for the evolutionary process allowing populations to respond to the demands of a never-changing environment. The fuel for this argument has largely consisted in assessing the relative importance of the various mechanisms which can explain maintenance of this variability. Lost in the debate has been the more fundamental issue of how more complex genetic variable populations evolve from simpler ones that are genetically uniform.

Evidence is accumulating that monocultures of asexual microorganisms reproducing in simple unstructured nutrient-limited environments rapidly become genetically variable. Such findings are of particular significance, as they appear to contradict two of the fundamental tenets of evolutionary biology, and ecology: the classical model of the evolution of asexual organisms, and the so-called competitive exclusion principle.

The classical model of the evolution of asexual organisms postulates that in the absence of recombination a population will evolve through a succession of clonal replacements. Except for those periods when the population undergoes adaptive shifts, that is when one clone replaces another, the population will be genetically uniform. The percentage of time that an evolving population will be genetically uniform will depend on the rate of appearance of clones with increased fitness, as well as on the time to fixation of such clones. In its simplest form, the classical model operates under the assumption of the competitive exclusion principle; namely that the number of clones that can exist in a population cannot exceed the number of resources. Thus, in a population with a single limiting resource, the clone possessing the best growth characteristics, defined as a function of the maximum intrinsic rate of increase and yield, will be expected to displace all others.

I present evidence that interactions between newly appearing clones in the evolving populations, allow for their stable coexistence. Certain clones alter the environment by increasing the numbers of resources available, whereas others have evolved to utilize these resources. Evolved clones exhibit mixed strategies, in that both specialist producers and utilizers of resources are seen. As the numbers of clones and resources increase, number of possible interactions between the clones increases geometrically. Thus, we may expect that there is a positive feedback loop, which results in progressive increases in complexity as the population continues to evolve.

Similar patterns of evolution may also occur in the evolution of economic systems. The notion of comparative advantage in international trade can lead to consumers and specialized producers in different trade groups, resulting in the stability of different economic groups or unions. Similarly, analyses of the evolution of the business sector involved in the production of a new and technically elaborate product such as a computer, have shown that specialization of tasks - and the creation of new "niche" industries (such as chip production, software design and service industries), may frequently result.