CHAOS AND FRACTALS IN SELF-ASSEMBLY OF PROTEIN CLUSTER FILMS

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At present, basic experimental investigations of protein properties, self-assembly and morphogenesis, do not seem to be essentially related to recent fundamental theories, such as non-equilibrium thermodynamics and fractal geometry. Most experiments were rather limited to studying more or less thermal-equilibrium crystalline-like structures (e.g., Iwata, 1995). It is well-known, however, that just the theories noted may give rise to understanding self-assembly processes in an open non-equilibrium, biologically functioning system (e.g., Prigogine, 1980). The protein folding is the fundamental process in such a system (Siman, 1992). Thereby, it is hardly possible to conceive that such processes are largely associated with properties of crystalline-like systems. Such considerations were attempted to test experimentally by creating non-equilibrium conditions in a natural protein-water system (Rapis E., 1976-1997). The protein self-assembly process in vitro was studied in the protein-water system (15 different kinds of proteins), far away from thermal equilibrium, at room temperature and ambient pressure. The experimental studies allowed to establish rather unambiguous supramolecular protein structures, containing spontaneously arising three-dimensional films, and to reveal some earlier nonindentified (structural, functional, electric, etc) protein properties not observed in equilibrium crystalline samples (Rapis, 1997). In general, the situation in such films is rather complex, involving non-linear, chaotic dynamics (turbulence, nucleation, etc) and relaxation processes in fractal and dissipative structures (Fig. 1).

Interpretations of the data allows us to assume that the experimentally revealed in vitro non-equilibrium "phase" (Rapis, 1997) consists of protein cluster films resulting from protein folding. The "phase" behavior and structure appear to agree with recent theories of cluster films - (Link et al, 1996), including films of nematic anisotropic liquid crystals and elastic films (e.g., Joanny, 1997; Potera, 1997). Similarities in properties of such protein films in vitro and in vivo rather reflect some autonomy of the protein functioning which does not seem to necessarily require additional energy sources and so goes on in some sense at abiotic conditions. In this connection, an opportunity appears to govern processes in vivo by modeling those in vitro, cluster films of proteins. Probably, this mainly determines the significance of the experimentally revealed occurrence of self-assembling protein cluster films under discussion.