Neal D. Theise

Cell interactions as complex systems: Emergent self-organization and other implications

Neil D. Theise MD, Depts of Pathology and Medicine (Digestive Diseases)
Beth Israel Medical Center-Albert Einstein College of Medicine, New York NY 10003 USA.

Reductionist studies of the functioning of living tissues have been highly successful; much of biology is understood through cell and molecular biologic approaches. However, there is much that arises out of interactions of the individual components of tissue that cannot be predicted from the isolated characteristics identified at the cellular or molecular level. The unpredictability is inherent and not reducible because molecules and cells interact with each other to form complex adaptive systems (CAD). The hallmark of CAD is *emergent* self-organization at the macro-scale from local interactions between individuals at the micro-scale. Emergence is found when interacting individuals (e.g. cells, biomolecules) fulfill four criteria: 1. they are numerous; 2. negative feedback loops predominate in the interactioins (though positive feedback loops may also be present); 3. there is no global sensing, i.e. all individuals only interact in response to their local environment; 4. there is a limited degree of randomness in the system, referred to as *quenched disorder*. This last criterion is most critical and what makes CAD adaptive to a changing environment. Too much randomness in the system and, rather than emergence, one would see chaos (metaphorical or fractal); too little randomness and the system would be rigid and therefore non-adaptive. But with the right level of quenched disorder, the system as a whole can explore new states of organization so that it can suvive in a changing environment. Corollaries to an analysis of cells as members of CAD include the inevitability of mass extinction events and dependence on scale and perspective for appropriate models of the structure of tissues (e.g. cell theory vs. a fluid continuum model). General principles will be presented using ant colonies as readily accessible examples of CAD, with parallels to cell and molecular biology to flesh out (pun intended) the integrated tissue biology where 21st century biology is likely to focus.

References

1. Theise ND. Now you see it, now you don't. Nature 2005; 435: 1165.
2. Theise ND, D'Iverno M. Understanding cell lineages as complex adaptive systems. Blood Cells, Molecules, and Diseases 2004; 32: 17-20.
3. Theise ND. Implications of 'post-modern biology' for pathology: the cell doctrine. Lab Invest 2006; 86: 335-44.