References

Abraham, R. and Shaw, C. (1988) *Dynamics – The Geometry of Behavior*, vols. 1–4 (Aerial Press, Santa Cruz, CA).

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., and Watson, J.D. (1983, 1989, 1994, 2002) *The Molecular Biology of the Cell.*

Alligood, K., Sauer, T., and Yorke, J.A. (1997) *CHAOS: An Introduction to Dynamical Systems* (Springer).

Almaas, E., Kovacs, B., Vicsek, T., Oltvai, Z.N., and Barabási, A.-L. (2004) Global organization of metabolic fluxes in the bacterium *Escherichia coli*. *Nature* **427**, 839–843.

Altmeyer, S. and McCaskill, J.S. (2001) Error threshold for spatially resolved evolution in the Quasispecies Model. *Phys. Rev. Lett.* **86**, 5819–5822.

Alon, U., Barkai, N., Notterman, D.A., Gish, K., Ybarra, S., Mack, D., and Levine, A.J. (1999) Broad Patterns of Gene Expression Revealed by Clustering Analysis of Tumor and Normal Colon Tissues Probed by Oligonucleotide Arrays. *Proc. Natl. Acad. Sci. U.S.A.* **96**, 6745–6750.

Ancel, L.W. (2000) Undermining the Baldwin expediting effect: Does phenotypic plasticity accelerate evolution? *Theor Popul Biol.* **58**, 307–319.

Ancel, L.W. and Fontana, W. (2002) Plasticity, evolvability, and modularity in RNA. *J. Exp. Zool.* **288**, 242–283.

Ariizumi, T. and Asashima, M. (2001) In vitro induction systems for analyses of amphibian organogenesis and body patterning. *Int. J. Dev. Biol.* **45**, 273–279.

Bachman, P.A., Luisi, P.L., and Lang, J. (1992) Autocatalytic self-replicating micelles as models for prebiotic structures. *Nature* **357**, 57–59.

Baguna, J., Salo, E., and Auladell, C. (1989) Regeneration and pattern formation in planarians. *Development* **107**, 77–86.

Baldwin, M. (1896) A new factor in evolution. *Am. Nat.* **30**, 441–451; 536–553.

Barabási, A.-L., and Albert, R. (1999) Emergence of scaling in random networks. *Science* **286**, 509–512.

Banerjee, B., Balasubramanian, S., Ananthakrishna, G., Ramakrishnan, T.V., and Shivashankar, G.V. (2004) Tracking operator state fluctuations in gene expression in single cells. *Biophys. J.* **86**, 3052–3059.

Ben-Jacob, E., Schochet, O., Tenenbaum, A., Cohen, I., Czirok A., and Vicsek, T. (1994) Generic modelling of cooperative growth patterns in bacterial colonies. *Nature* **368**, 46–49.

Benner S.A., and Sismour A.M. (2005) Synthetic biology. *Nat. Rev. Genet.* **6**(7), 533–543.

Bignone, F.A. (1993) Cells–gene interactions simulation on a coupled map lattice. *Theo J. Biol.* **161**, 231.

Bjornson, C.R., Rietze, R.L., Reynolds, B.A., Magli, M.C., and Vescovi A.L. (1999) Turning brain into blood: A hematopoietic fate adopted by adult neural stem cells in vivo. *Science* **283**(5401), 534–537.

Boerlijst, M. and Hogeweg, P. (1991) *Physica 48D* **17**; Spiral wave structure in prebiotic evolution – Hypercycles stable against parasites.

Bonner, J.T. (1980) *The Evolution of Culture in Animals* (Princeton University Press).

Bohr, N. (1958) *Atomic Physics and Human Knowledge* (Wiley).

Braudel, F. *Civilisation Materielle, Economie er Capitalisme XV-XVIII Siecle.*

Brillouin, L. (1969) *Science and Information Theory* (Academic Press).

Buss, L.W. (1987) *The Evolution of Individuality* (Princeton University Press).

Cairns, J., Overbaugh, J., and Miller, S. (1988) The origin of mutants. *Nature* **335**, 142–145.

Cairns-Smith, A.G. (1986) *Clay Minerals and the Origin of Life*

Callahan, H.S., Pigliucci, M., and Schlichting, C.D. (1997) Developmental phenotypic plasticity: Where ecology and evolution meet molecular biology. *Bioessays* **19**, 519–525.

Campbell, K.H.S., McWhir, J., Ritchie, W.A., and Wilmut, I. (1996) Sheep cloned by transfer from a cultured cell line. *Nature* **380**, 64–66.

Chow, M., Yao, A., and Rubin, H. (1994) Cellular epigenesis: Topochronology of progressive spontaneous transformation of cells under growth constraint. *Proc. Nat. Acad. Sci. U.S.A.* **91**, 599–603.

Coyne, J.A. and Orr, H.A. (1998) The evolutionary genetics of speciation. *Phil. Trans. R. Soc. Lond.* **B 353**, 287–305.

David, N.D. and MacWilliams, H. (1978) Regulation of the self-renewal probability in Hydra stem cell clones. *Proc. Nat. Acad. Sci. U.S.A.* **75**(2), 886–890.

Darwin, C. (1859) *On the Origin of Species by Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life* (Murray, London).

Dieckmann, U. and Doebeli, M. (1999) On the origin of species by sympatric speciation. *Nature* **400**, 354–357.

Doebeli, M. (1996) A quantitative genetic competition model for sympatric speciation. *J. Evol. Biol.* **9**, 893–909.

Dobzhansky, T. (1937, 1951) *Genetics and the Origin of Species* (Columbia University Press, New York).

Dolmetsch, R.E., Xu, K., and Lewis, R.S. (1998) Calcium oscillations increase the efficiency and specificity of gene expression. *Nature* **392**, 933–936.

Douarin, N.M., and Dupin, E. (1993) Cell lineage analysis in neural crest ontogeny. *J. Neurobiol.* **24**(2), 146–161.

Driever, W. and N.üsselein-Volhard, C. (1988) A gradient of bicoid protein in Drosophila embryos. *Cell* **54**, 83–93.

Dyson, F. (1985) *Origins of Life* (Cambridge University Press).

Edwards, A.W.F. (2000) *Foundations of Mathematical Genetics* (Cambridge University Press).

Eigen, M. (1992) *Steps Towards Life* (Oxford University Press).

Eigen, M. and Schuster, P. (1979) *The Hypercycle* (Springer).

Eigen, M., McCaskill, J., and Schuster, P. (1989) The Molecular Quasi-species. *Adv. Chem. Phys.* **75**, 149–263.

Einstein, A. (1905) Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhe nden Flüssigkeiten suspendierten Teilchen. *Ann. der Physik*, **17**, 549–560.

Einstein, A. (1906) Zur Theorie der Brownschen Bewegung, *Ann. der Physik*, **19**, 371–381.

Elowitz, M. and Shapiro, J., Time-lapse images of *E. coli* cells expressing GFP, figures provided by James Shapiro, under special courtesy (2003).

Elowitz, M.B., and Leibler, S. (2000) A synthetic oscillatory network of transcriptional regulators. *Nature* **403**, 335–338.

Elowitz, M.B., Levine, A.J., Siggia, E.D., and Swain, P.S. (2002) Stochastic gene expression in a single cell. *Science* **297**, 1183–1186.

Farmer, J.D., Kauffman, S.A., and Packard, N.H. (1986) Autocatalytic replication of polymers. *Physica D* **22D**, 50.

Fischer, E.P. and Lipson, C. (1998) *Thinking about Science: Max Delbruck and the Origins of Molecular Biology* (W.W. Norton & Co.).

Fisher, R.A. (1930, 1958) *The Genetical Theory of Natural Selection* (Oxford University Press).

Felsenstein, J. (1981) Skepticism towards Santa Rosalia, or why are there so few kinds of animals? *Evolution* **35**, 124–138.

Fontana, W., and Buss, L.W. (1994). The arrival of the fittest: Toward a theory of biological organization. *Bull. Math. Biol.* **56**, 1–64.

Forgacs, G., and Newman, S.A. (2005) *Biological Physics of the Developing Embryo* (Cambridge University Press).

Fujimoto, K. and Kaneko, K. (2003) How fast elements can affect slow dynamics. *Physica* **180D**, 1–16.

Furusawa, C. and Kaneko, K. (1998a) Emergence of rules in cell society: Differentiation, hierarchy, and stability. *Bull. Math. Biol.* **60**, 659–687.

Furusawa, C. and Kaneko, K. (1998b) Emergence of multicellular organisms with dynamic differentiation and spatial pattern. *Artif. Life* **4**, 78–89.

Furusawa, C. and Kaneko, K. (2000a) Origin of complexity in multicellular organisms. *Phys. Rev. Lett.* **84**, 6130–6133.

Furusawa, C. and Kaneko, K. (2000b) Complex organization in multicullarity as a necessity in evolution. *Artif. Life* **6**, 265–281.

Furusawa, C. and Kaneko, K. (2001) Theory of robustness of irreversible differentiation in a stem cell system: Chaos hypothesis. *J. Theor. Biol.* **209**, 395–416.

Furusawa, C. and Kaneko, K. (2002) Origin of multicellular organisms as an inevitable consequence of dynamical systems. *Anat. Rec.* **268**, 327–342.

Furusawa, C. and Kaneko, K. (2003a) Zipf's Law in gene expression. *Phys. Rev. Lett.* **90**, 088102.

Furusawa, C. and Kaneko, K. (2003b) Robust development as a consequence of generated positional information. *J. Theor. Biol.* **224**, 413–435.

Furusawa, C. and Kaneko, K. (2006a) Evolutionary origin of power-laws in Biochemical Reaction Network; embedding abundance distribution into topology. *Phys. Rev. E* **73**, 011912.

Furusawa, C. and Kaneko, K. (2006b) Morphogenesis, Plasticity, and Irreversibility. *Int. J. Dev. Biol.*, **50**, 223–232.

Furusawa, C., Suzuki, T., Kashiwagi, A. Yomo, T., and Kaneko, K. (2005) Ubiquity of log-normal distributions in intra-cellular reaction dynamics, *Biophysics*, **1**, 25.

Futuyma, D.J. (1986) *Evolutionary Biology, 2nd edn.*, (Sinauer Associates Inc., Sunderland, MA).

Freeman, W. and Skarda, C.A. (1985) Spatial EEG patterns, nonlinear dynamics and perception: The Neo-Sherringtonian view. *Brain Res. Rev.* **10**, 147.

Ganti, T. (1975) Organization of chemical reactions into dividing and metabolizing units: the chemotons. *Biosystems* **7**, 189.

Gehring, W. (1998) *Master Control Genes in Development and Evolution: The Homeobox Story* (Yale University Press).

Geritz, S.A.H., Kisdi, E., Meszena, G., and Metz, J.A.J. (1998) Evolutionary singular strategies and the adaptive growth and branching of the evolutionary tree. *Evol. Ecol.* **12**, 35–57.

Gilbert, S.F., Opitz, J.M., and Raff, R.A. (1996) Resynthesizing evolutionary and developmental biology. *Dev. Biol.* **173**, 357–372.

Glass, L. and Kauffman, S. (1973) The logical analysis of continuous non!linear biochemical control networks, *J. Theor. Biol.* **39**, 103–129.

Goodsell, D.S. (1998) *The Machinery of Life* (Springer).

Gold, T. (1998) *The Deep Hot Biosphere* (Springer).

Goldbeter, A. (1996) *Biochemical Oscillations and Cellular Rhythms* (Cambridge University Press).

Gould, S.J., and Eldredge, N. (1977) Punctuated equilibria: The tempo and mode of evolution reconsidered, *Paleobiology* **3**, 115–151.

Goodwin, B. (1963) *Temporal Organization in Cells* (Academic Press, London).

Golden, J.W., Robinson, S.J., and Haselkorn, R. (1985) Rearrangement of nitrogen fixation genes during heterocyst differentiation in the cyanobacterium Anabaena, *Nature* **314**, 419–423.

Greenwald, I. and Rubin, G.M. (1992) Making a difference: The role of cell–cell interactions in establishing separate identities for equivalent cells *Cell* **68**, 271–281.

Grey, D., Hutson, V. and Szathmary, E.A. (1995) re-examination of the stochastic corrector model. *Proc. R. Soc. Lond.* **B262**, 29–35.

Goodwin, B. (1963) *Temporal Organization in Cells* (Academic Press, London).

Gurdon, J.B., Laskey, R.A., and Reeves, O.R. (1975) The developmetal capacity of nuclei transplanted from keratinized skin cells of adult frogs. *J. Embriol. Exp. Morphol.* **34**, 93–112.

Gurdon, J.B., Lemaire, P., and Kato, K. (1993) Community effects and related phenomena in development *Cell* **75**, 831–834.

Haken H. (1979) *Synergetics* (Springer).

Haldane, J.B.S. (1949) Suggestion as to quantitative measurement of the rate of evolution, *Evolution* **3**, 51–56.

Hanczyc, M., Fujikawa, S.M., and Szostak, J.W. (2003) Experimental models of primitive cellular compartments: Encapsulation, growth, and division science. *Science* **302**, 618–622.

Hasty, J., Pradines, J., Dolnik, M., and Collins, J.J. (2000) Noise-based switches and amplifiers for gene expression. *Proc. Natl. Acad. Sci. U.S.A.* **97**, 2075–2080.

Hess, B. and Boiteux, A. (1971) Oscillatory phenomena in biochemistry. *Ann. Rev. Biochem.* **40**, 237–258.

Hess, B. and Mikhailov, A. (1994) Self-organization in Living Cells, *Science* **264**, 223.

Hofbauer, J. and Sigmund, K. (1988) *Dynamical Systems and the Theory of Evolution* (Cambrige University Press).

Hogeweg, P. (1994) Multilevel evolution: Replicators and the evolution of diversity. *Physica* **75D**, 275–291.

Hotani, H. and Miyamoto, H. (1990) Dynamic features of microtubles as visualized by dark-field microscopy. *Adv. Biophys.* **26**, 135–156.

Holland, J.H., Escaping brittleness: The possibilities of general purpose learning algorithms applied to parallel rule-based systems. In: *Machine Learning II*, ed by R.S. Mishalski, J.G. Carbonell, and T.M. Mitchell, (Kaufman, 1986).

Holman, E. (1987) Recognizability of sexual and asexual species of Rotifers. *Syst. Zool.* **36**, 381–386.

Holmes, L.B. (1979) Penetrance and expressivity of limb malformations *Birth Defects. Orig. Artic. Ser.* **15**, 321–327.

Houchmandzadeh, B., Wieschaus, E., and Leibler, S. (2002) Establishment of developmental precision and proportions in the early Drosophila embryo. *Nature* **415**, 798–802.

Howard, D.J. and Berlocher, S.H. (eds.) (1988) *Endless Form: Species and Speciation* (Oxford University Press).

Hu, M., et al. (1997) Multilineage gene expression precedes commitment in the hemopoietic system. *Genes & Dev.* **11**, 774–785.

Hubbel S.P. (2001) *The Unified Neutral Theory of Biodiversity and Biogeography*, Princeton Univ. Press.

Ishikawa, K., Sato, K., Shima, Y., Urabe, I., and Yomo, T. (2004) Expression of a cascading genetic network within liposomes, *FEBS Lett.* **576** (3), 387–390.

Ishihara, S. and Kaneko, K. (2005) Magic number 7 ± 2 in networks of threshold dynamics. *Phys. Rev. Lett.* **94**, 058102.

Ishijima, A., Kojima, H., Funatsu T., Tokunaga M., Higuchi H. and Yanagida, T. (1998) Simultaneous observation of individual ATPase and mechanical events by a single myosin molecule during interaction with actin. *Cell* **92**, 161.

Ikeda, K., Otsuka, K., and Matsumoto, K. (1989) *Prog. Theor. Phys. Suppl.* **99**, 295. Maxell–Bloch turbulence.

Ikegami, T. and Hashimoto, T. (1996) Active mutation in self-reproducing networks of machines and tapes. *Artif. Life* **2**, 305–318.

Ito, Y., Kawama, T., Urabe, I., and Yomo, T. (2004) Evolution of an arbitrary sequence in solubility. *J. Mol. Evol.* **58**, 196–202.

Jablonka, E., Marion, J. (1995) *Epigenetic Inheritance and Evolution: The Lamarckian Dimension* (Oxford University Press).

Jain, S. and Krishna, S. (2002) Large extinctions in an evolutionary model: The role of innovation and keystone species. *Poc Nat. Acad. Sci. U.S.A.* **99**, 2055–2060.

Jeon, K.W. (1972) Development of cellular dependence on infective organisms: Micrurgical studies in amoebas. *Science* **176**, 1122–1123.

Jeong, H., Tombor, B., Albert, R., Oltvai, Z.N., and Barabási, A.-L. (2000) The large-scale organization of metabolic networks. *Nature* **407**, 651–654.

Jeong, H., Mason, S.P., Barabási, A.-L. (2001) *Nature* **411**, 41.

Jones, S.J., et al. (2001) *Genome Res.* **11**(8), 1346. SAGE Data is available from *http://elegans.bcgsc.bc.ca/SAGE/*.

Kaneko, K. (1990) Clustering, coding, switching, hierarchical ordering, and control in network of chaotic elements. *Physica* **41D**, 137–172.

Kaneko, K. (1991) Globally coupled circle maps. *Physica* **54D**, 5–19.

Kaneko, K., ed. (1992) CHAOS focus issue on coupled map lattices. *Chaos* **2**, 279–407.

Kaneko, K., ed. (1993) *Theory and Applications of Coupled Map Lattices* Wiley.

Kaneko, K. (1994a) Relevance of clustering to biological networks. *Physica* **75D**, 55.

Kaneko, K. (1994b) Chaos as a source of complexity and diversity in evolution. *Artif. Life* **1**, 163–177.

Kaneko, K. (1997a) Dominance of milnor attractors and noise-induced selection in a multi-attractor system. *Phys. Rev. Lett.* **78**, 2736–2739.

Kaneko, K. (1997b) Coupled maps with growth and death: An approach to cell differentiation. *Physica* **103D**, 505–527.

Kaneko, K. (1998a) On the strength of attractors in a high-dimensional system: Milnor attractor network, robust global attraction, and noise-induced selection. *Physica* D, **124**, 322–344.

Kaneko, K. (1998b) Diversity, stability, recursivity, hierarchy, and rule generation in a biological system studied as intra-inter dynamics. *Int. J. Mod. Phys. B.* **12**, 285–298.

Kaneko, K. (1998c) Life as complex systems: Viewpoint from intra-inter dynamics. *Complexity* **3**, 53–60.

Kaneko, K. (ed.) (2001) Biophysics of Complex Systems, (Kyoritsu Pub.), in Japanese

Kaneko, K. (2002a) Kinetic origin of heredity in a replicating system with a catalytic network. *J Biol. Phys.* **28**, 781–792.

Kaneko, K. (2002b) From coupled dynamical systems to biological irreversibility. *Adv. Chem. Phys.* **122**, 53–73.

Kaneko, K. (2002c) Symbiotic sympatric speciation: compliance with interaction-driven phenotype differentiation from a single genotype. *Populat. Ecol.* **44**, 71–85.

Kaneko, K. (2002d) Dominance of minlnor attractors in globally coupled dynamical systems with more than 7 ± 2 degrees of freedom. *Phys. Rev. E.* **66**, 055201(R).

Kaneko, K. (2003a) *Organization Through Intra–Inter Dynamics in Origination of Organismal Form: Beyond the Gene in Developmental and Evolutionary Biology* (The Vienna Series in Theoretical Biology) (MIT Press).

Kaneko, K. (2003b) Recursiveness, switching, and fluctuations in a replicating catalytic network, *Phys. Rev. E.* **68**, 031909.

Kaneko, K. and Yasutomi, A. (2005) Braudel's viewpoint on hisotory and complex systems in *Perspectives in Economics Theory* (Nippon-Hyoron Pub.) in Japanese.

Kaneko, K. (2005a) On recursive production and evolvabilty of cells: Catalytic reaction network approach. *Adv. Chem. Phys.* **130**, 543–598.

Kaneko, K. (2005b) Inter-intra molecular dynamics as an iterated function system. *J. Phys. Soc. Jpn.* **74**, 2386–2390.

Kaneko, K. and Furusawa, C. (2000) Robust and irreversible development in cell soceity as a general consequence of intra–inter dynamics. *Physica* A **280**, 23–33.

Kaneko, K. and Furusawa, C. (2006) An evolutionary relationship between genetic variation and phenotypic fluctuation. *J. theor. Biol.* **240**, 78–86.

Kaneko, K. and Ikegami, T. (1992) Homeochaos: Dynamics Stability of a symbiotic network with populationdynamics and evolving mutation rates. *Physica* **56**D, 406–429.

Kaneko, K. and Tsuda, I. (1994) Constructive complexity and artificial reality: An introduction. *Physica* **75**D, 1–10.

Kaneko, K. and Tsuda, I. (2000) *Complex Systems: Chaos and Beyond – A Constructive Approach with Applications in Life Sciences* (Springer), pp 1–273.

Kaneko, K. and Tsuda, I., eds. (2003) Chaos focus issue on chaotic itinerancy. *Chaos.*

Kaneko, K. and Yasutomi, A. (2002) *History as Inter-Intra-Dynamics* (in Japanese) (in Perspectives in Social History).

Kaneko, K. and Yomo, T. (1994) Cell division, differentiation, and dynamic clustering, *Physica* **75D**, 89–102.

Kaneko, K. and Yomo, T. (1995) A theory of differentiation with dynamic clustering. In: *Advances in Artificial Life*, ed by E. Moran et al. (Springer) pp 329–340.

Kaneko, K. and Yomo, T. (1997) Isologous diversification: A theory of cell differentiation, *Bull. Math. Biol.* **59**, 139–196.

Kaneko, K. and Yomo, T. (1999) Isologous diversification for robust development of cell society. *J. Theor. Biol.* **199**, 243–256.

Kaneko, K. and Yomo, T. (2000) Symbiotic speciation from a single genotype. *Proc. Roy. Soc.* **B267**, 2367–2373.

Kaneko, K., and Yomo, T. (2002a) On a kinetic origin of heredity: Minority control in replicating molecules. *J. Theor. Biol.* **214**, 563–576.

Kaneko, K. and Yomo, T. (2002b) Symbiotic sympatric speciation through interaction-driven phenotype differentiation. *Evol. Ecol. Res.* **4**, 317–350.

Kaplan, D. and Glass, L. (1995) *Understanding Nonlinear Dynamics* (Springer).

Kashiwagi, A., Kanaya, T., Yomo, T., and Urabe, I. (1998) How small can the difference among competitors be for coexistence to occur, *Res. Populat. Ecol.* **40**, 223.

Kashiwagi, A., Noumachi, W., Katsuno, M., Alam, M.T., Urabe, I., and Yomo, T. (2001) Plasticity of fitness and diversification process during an experimental molecular evolution. *J. Mol. Evol.* **52**, 502–509.

Kashiwagi, A., Urabe, I., Kaneko, K., and Yomo, T. (2005), Adaptive response of a mutually inhibitory gene network to environmental changes by attractor selection. Manuscript submitted for publication.

Kawata M. & Yoshimura J. (2000) *Speciation by sexual selection in hybridizing populations without viability selection. Ev. Ec. Res.* **2**, 897–909.

Kauffman, S.A. (1969) Metabolic stability and epigenesis in randomly constructed genetic nets. *J. Theor. Biol.* **22**, 437.

Kauffman, S.A. (1986) Autocatalytic sets of proteins. *J. Theor. Biol.* **119**, 1–24.

Kauffman, S.A. (1993) *The Origin of Order* (Oxford University Press).

Kenyon, C. (1985) Cell lineage and the control of *Caenorhabditis elegans* development. *Philos. Trans. R. Soc. Lond. (Biol.)* **312**, 21–38.

Kimura, M. (1983) *The Neutral Theory of Molecular Evolution* (Cambridge University Press).

Kirk, D.L. and Harper, J.F. (1986) Genetic, biochemical, and molecular approaches to volvox development and evolution, *Int. Rev. Cytol.*, **99**, 217.

Ko, E., Yomo, and T., Urabe, I. (1994) Dynamic Clustering of bacterial population. *Physica* **75D**, 81–88.

Koch A.L. (1984) Evolution vs the number of gene copies per primitive cell. *J. Mol. Evol.* **20**(1), 71–6 .

Kondrashov, A.S. and Kondrashov, A.F (1999) Interactions among quantitative traits in the course of sympatric speciation, *Nature* **400**, 351–354.

Krishna, S., Banerjee, B., Ramakrishnan, T.V., and Shivashankar, G.V. (2005) Stochastic simulations of the origins and implications of long-tailed distributions in gene expression, *Proc. Nat. Acad. Sci. U.S.A.* **102**, 4771–4776.

Kubo, R., Toda, M., and Hashitsume. N. (1972) *Statistical Physics* in Japanese (English translationi is published from Springer, 1985).

Kuznetsov, V.A., Knott, G.D., and Bonner, R.F. (2002) General statistics of stochastic process of gene expression in eukaryotic cells. *Genetics* **161**, 1321–1332.

Lacalli, T.C. and Harrison, L.G. (1991) From gradient to segments: Models for pattern formation in early Drosophila embryogenesis, *Sems. Dev. Biol.* **2**, 107–117.

Lande, R. (1981) Models of speciation by sexual selection on phylogenic traits, *Proc. Natl. Acad. Sci. U.S.A.* **78**, 3721–3725.

Langer, J.S. (1980) Instabilities and pattern formation in crystal growth. *Rev. Mod. Phys.* **52**, 1–28.

Langton, C., eds. (1989) *Artificial Life* (Adisson Wesley).

Langton, C., eds. (1992) *Artificial Life II* (Adisson Wesley).

Langton, C., eds. (1994) *Artificial Life III* (Adisson Wesley).

Lash, A.E., et al. (2000) *Genome Res.* **10**(7), 1051.

Lee, D.H., Severin K., Yokobayashi Y., and Ghadiri M.R. (1997) Emergence of symbiosis in peptide self-replication through a hypercyclic network. *Nature* **390**, 591–594.

Lev, A.B. and Alexander, N.T. (1994) Biophysical Thermodynamics of Intracellular Processes, (Springer).

Lorenz, E.N. (1963) Deterministic Nonperiodic Flow. *J. Atmos. Sci.* **20**, 130.

Matsuyama, T., and Matsushita, M. (1993) Fractal morphogenesis by a bacterial cell population. *Crit. Rev. Microbiol.* **19**, 117–35.

Matsuyama S., Furusawa C., Todoriki M., Urabe I., and Yomo T. (2004) Global change in Escherichia coli gene expressions in initial stage of symbiosis with Dictyostellium cells. *Biosystems* **73**, 163–171.

Mandelbrot, B.B. (1953) Jeux de communication, Publ. de l'Inst de Statistique de l'Univ de Paris.

Matsuura, T., Yomo, T., Yamaguchi, M., Shibuya, N., Ko-Mitamura, E.P., Shima, Y., and Urabe, I. (2002) Importance of compartment formation for a self-encoding system, *Proc. Nat. Acad. Sci. U.S.A.* **99**, 7514–7517.

Margulis, L. (1981) *Symbiosis in Cell Evolution* (W.H. Freemand and Company).

May, R. (1973) *Stability and Complexity in Model Ecosystems* (Princeton University Press).

May R.M. (1999) Unanswered questions in ecology, Philosophical Transactions of the Royal Society B: Biological Sciences **354**, 1951–1959.

Maynard-Smith, J. (1979) Hypercycles and the origin of life, *Nature* **280**, 445–446.

Maynard -Smith, J. (1989) *Evolutionary Genetics* (Oxford University Press).

Maynard-Smith, J. (1966) Sympatric Speciation, *The American Naturalist* **100**, 637–650.

Maynard-Smith, J. and Szathmary, E. (1995) *The Major Transitions in Evolution* (W.H. Freeman).

Maynard-Smith, J., Burian, R., Kauffman, S., Alberch, P., Campbell, J., Goodwin, B., Lande, R., Raup, D., and Wolpert, L. (1985) Developmental constraints and evolution. *Q. Rev. Biol.* **60**, 265–287.

Meinhardt, H. and Gierer, A. (2000) Pattern formation by local self-activation and lateral inhibition. *Bioessays.* **22**, 753–60.

Mezard, M., Parisi, G., and Virasoro, M.A. eds. (1987) *Spin Glass Theory and Beyond* (World Science Publication).

Mikhailov, A. and Hess, B. (1995) Fluctuations in living cells and itracellular traffic. *J. Theor. Biol.* **176**, 185–192.

Mikhailov, A.S. and Calenbuhr, V. (2002) *From Cells to Societies* (Springer).

Miller, M.B. and Bassler, B.L. (1973) Quorum sensing in bacteria. *Annu. Rev. Microbiol.* **55**, 165–199.

Miller, G.A. (1975) *The Psychology of Communication* Basic Books, New York,.

Mills, D.R., Kramer F.R., and Spiegelman, S. (1973) Complete nucleotide sequence of a replicating RNA molecule, *Science* **180**, 916.

Mills, D.R., Peterson R.L., and Spiegelman, S. (1967) An extracellular Darwinian experiment with a self-duplicating nucleic acid molecule, *Proc. nat. Acad. Sci. U.S.A.* **58**, 217.

Milnor, J. (1985) On definition of an attractor. *Comm. Math. Phys.* **99**, 177 (1985); **102**, 517.

Mjolsness, E., Sharp, D.H., and Reinitz, J. (1991) A connectionist model of development. *J. Theor. Biol.* **152**, 429–453.

Muller, H.J. (1964) Mutat Res. 1; 1–9. The Relation of Recombination to Mutational Advance.

Nakagawa, N. and Kaneko, K. (2004) Autonomous energy transducer: Proposition, example, basic characteristics. *Physica* A **338**, 511–536.

Nakahata, T., Gross, A.J., and Ogawa, M. (1982) A stochastic model of self-renewal and commitment to differentiation of the primitive hemopoietic stem cells in culture. *J. Cell. Phy.* **113**, 455.

von Neumann, J. (1966) *Theory of Self-Reproducing Automata*, ed by A.W. Burks (University of Illinois Press).

Newman, S.A. (1994) Generic physical mechanisms of tissue morphogenesis: A common basis for development and evolution. *J. Evol. Biol.* **7**, 467–488.

Newman, S.A. (2003) From physics to development: The evolution of morphogenetic mechanism to appear in *Origins of Organismal Form* ed by G.B. Müller and S.A. Newman (MIT Press, Cambridge).

Newman, S.A. and Comper, W.D. (1990) Generic physical mechanisms of morphogenesis and pattern formation. *Development* **110**, 1–18.

Nicolis, G. and Prigogine, I. (1977) Self-organization in Nonequilibrium Systems. (Wiley).

Noireaux V. and Libchaber A., A vesicle bioreactor as a step toward an artificial cell assembly. *Proc. Natl. Acad. Sci. U.S.A.* **101**, 17669–17674

Ogawa, M. (1993) Differentiation and proliferation of hematopoietic stem cells. *Blood* **81**, 2844.

Oparin A.I. (1967) The origin of life. In: *Origin of Life*, ed by J.D. Bernal (Wiesenfeld and Nicholson).

Oosawa, F. (2000) The loose coupling mechanism in molecular machines in living cells, *Genes to Cells* **5**, 9–16.

Oosawa, F. (2001) Autonomy, Spontanienty, and individuality. in Biophysics of Complex Systems, (Kyoritsu Pub.) ed. K. Kaneko, in Japanese.

Oosawa, F. Biophysics, Maruzen Pub. (1998), in Japanese.

Oosawa, F. and Hayashi, S. (1986) The loose coupling mechanism in molecular machines in living cells, *Adv. Biophys.* **22**, 151–183 .

Opitz, J.M. (1981) Some comments on penetrance and related subjects, *Am. J. Med. Genet.* **8**, 265–274.

Osawa, M., et al. (1996) Long-term lymphohematopoietic reconstitution by a single CD34-low/negative hematopoietic stem cell. *Science* **273**, 242–245.

Preston F.W. (1962) The Canonical Distribution of Commonness and Rarity: Part II, Ecology, **43**, 410–432.

Roberts, M.S., and Cohan, F.M. (1995) Recombination and migration rates in natural populations of *Bacillus subtilis* and *Bacillus mojavensis, Evolution* **49**, 1081–1094.

Rosen, R. *Dynamical System Theory in Biology*, (Wiley and Sons, 1970).

Ronen, M., Rosenberg, R., Shraiman, B., and Alon, U. (2002) Assigning numbers to the arrows: Parameterizing a gene regulation network by using accurate expression kinetics, *Proc Natl. Acad. Sci. U.S.A.* **99**, 10555–10560.

Rubin, H. (1990) The significance of biological heterogeneity. *Cancer Metastasis Rev.* **9**, 1–20

Rubin, H. (1994a) Cellular epigenetics: Control of the size, shape, and spatial distribution of transformed foci by interactions between the transformed and nontransformed cells. *Proc. Nat. Acad. Sci. U.S.A.* **91**, 1039–1043.

Rubin, H. (1994b) Experimental control of neoplastic progression in cell populations; Fould's rules revisited. *Proc. Nat. Acad. Sci. U.S.A.* **91**, 6619–6623.

Salzar-Ciudad, I., Garcia-Fernandez, J., and Sole, R.V. (2000) Gene networks capable of pattern formation: from induction to reaction-diffusion. *J. Theor. Biol.* **205**, 587–603.

Sato K., Ito Y., Yomo, T., and Kaneko, K. (2003) On the Relation between fluctuation and response in biological systems. *Proc. Natl. Acad. Sci. U.S.A.* **100**, 14086–14090.

Sato, K., Obinata, K., Sugawara, T., Urabe, I., and Yomo, T. (2005). Quantification of structural properties of cell-sized individual liposomes by flow cytometry.

Schrödinger, E. (1946) "*What Is Life* (Cambridge University Press).

Segré, D., Ben-Eli, D., and Lancet, D. (2000) Compositional genomes: prebiotic information transfer in mutually catalytic noncovalent assemblies, *Proc. Natl. Acad. Sci. U.S.A.* **97**, 4112–4117.

Shannon, C. and Weaver, W. (1949) The Mathematical Theory of Communication, (Univ. of llinois Press).

Shapiro, J.A. (1995) Adaptive mutation: Who's really in the garden?, *Science* **268**, 373–374.

Shapiro, J.A., Dworkin M., ed. (1997) *Bacteria As Multicellular Organisms.* Oxford. Oxford University Press.

Shnerb, N.M., Louzoun, Y., Bettelheim, E., and Solomon, S. (2000) The importance of being discrete: Life always wins on the surface. *Proc. Natl. Acad. Sci. U.S.A.* **97**, 10 322.

Simon, H.A. (1955) On a class of skew distribution functions Biometrika **42**, 425–440.

Solari, F. and Ahringer J. (2000) NURD-complex genes antagonise Ras-induced vulval development in *Caenorhabditis elegans*, *Curr. Biol.* **10**, 223–226.

Solé, R.V., Bascompte, J., and Vallis, J. (1992) Nonequilibrium dynamics in lattice ecosystems *Chaos* **2**, 387.

Sprinzak D. and Elowitz M.B. (2005) Reconstruction of genetic circuits. *Nature* **438**, 443–448.

Spitze, K. and Sadler, T.D. (1996) Evolution of a generalist genotype: Multivariate analysis of the adaptiveness of phenotypic plasticity, *Am. Nat.* **148**, 108–123.

Spudich, J.L. and Koshland D.E., Jr. (1976) Non-genetic individuality: Chance in the single cell. *Nature* **262**, 467–471.

Stadler, P.F. and Schuster, P. (1990) Dynamics of small autocatalytic reaction networks–I. Bifurcations, permanence and exclusion. *Bull. Math Biol.* **52**, 485–508.

Stadler, P.F., Fontana, W., and Miller, J.H. (1993) Random catalytic reaction networks, *Physica* **63**D, 378.

Stange, P., Mikhailov, A.S., and Hess, B. (1998) Mutual synchronization of molecular turnover cycles in allosteric enzymes, *J. Phys. Chem.* B **102**, 6273.

Sternberg, P.W. and Han, M. (1988) Genetics of RAS signalling in *C-elegans*, Trends Genet. **14**, 466–472.

Steward, F.C., Mapes, M.O., and Mears, K. (1958) Growth and organized develoment of cultured cells. II. Organization in cultures from freely suspended cells, *Am. J. Bot.* **45**, 705–708.

Strogatz, S. (2001) *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*, (Perseus Books).

Suel, G.M., Garcia-Ojalvo, J., Liberman, L.M., and Elowitz, M.B. (2006) "An excitable gene regulatory circuit induces transient cellular differentiation." *Nature.* **440**, 545–50.

Sunami, T., Sato, K., Tsukada, K., Matsuura, T., Urabe, I., and Yomo, T. (2005) Population analysis of liposomes with protein synthesis and a cascading genetic network. In: *Protocells*, ed by Pacakrd et al. (MIT Press).

Szostak, J.W., Bartel, D., and Luisi, P.L. (2001) Synthesizing life, *Nature* **409**, 387–390.

Szathmary, E., and Demeter, L. (1987) Group selection of early replicators and the origin of life. *J. Theor. Biol.* **128**, 463–86.

Szathmary, E. and Maynard-Smith, J. (1995) The major evolutionary transitions. *Nature* **374**, 227.

Szathmary E. and Maynard-Smith J. (1997) From replicators to reproducers: The first major transitions leading to life, *J. Theor. Biol.* **187**, 555–571.

Takagi, H., and Kaneko, K. (2001) Differentiation and replication of spots in a reaction diffusion system with many chemicals. *Europhys. Lett.* **56**, 145–151.

Takagi, H., and Kaneko, K. (2002) Dynamic relationship between diversity and plasticity of cell types in multi-cellular state. In: *Proceedings of the Eighth International Conference of Artificial Life.*

Takagi, H. and Kaneko, K. (2005) Dynamical systems basis of metamorphosis: Diversity and plasticity of cellular states in reaction diffusion network. *J. Theor. Biol.* **234**, 173–186.

Takagi, H., Kaneko, K., and Yomo, T. (2000) Evolution of genetic code through isologous diversification of cellular states, *Artif. Life* **6**, 283–305.

Takakura K. and Sugawara, T. (2004) Membrane dynamics of a myelin-like giant multiamellar vesicle applicable to a self-reproducing system. *Langmuir* **20**, 3832–3834.

Takakura, K., Toyota, T., and Sugawara, T. (2003) A novel system of self-reproducing giant vesicles. *J. Am. Chem. Soc.* **125**, 8134.

Tam, L. and Kirk, D.L. (1991) The program for cellular differentiation in Volvox carteri as revealed by molecular analysis of development in a gonidialess/somatic regenerator mutant, *Development*, **112**, 571.

Till, J.E., McCulloch, E.A., and Siminovitch, L. (1964) A stochastic model of stem cell proliferation, based on the growth of spleen colony-forming cells. *Proc. Natl. Acad. Sci. U.S.A.* **51**, 29.

Tilman, D. (1976) Ecological competition between algae: Experimental confirmation of resource-based competition theory, *Science* **192**, 463–465.

Tilman, D. (1981) Test of resource competition theory using four species of lake Michigan algae, *Ecology* **62**, 802–815.

Todoriki, M., Oki, S., Matsuyama, S.-I., Urabe, I., and Yomo, T. (2002a) Uniqe colony housing the coexisting *Escherichia coli* and *Dictyostelium discoideum*. *J. Biol. Phys.* **28**(4), 793–797.

Todoriki, M., Oki, S., Matsuyama, S., Ko-Mitamura, E.P., Urabe, I., and Yomo, T. (2002b) An observation of the initial stage towards a symbiotic relationship. *BioSystems.* **65**, 105–112

Togashi, Y. and Kaneko, K. (2001) Transitions induced by the discreteness of molecules in a small autocatalytic system. *Phys. Rev. Lett.* **86**, 2459.

Togashi, Y. and Kaneko, K. (2003) Alteration of chemical concentrations through discreteness-induced transitions in small autocatalytic systems. *J. Phys. Soc. Jpn.* **72**, 62–68.

Togashi, Y. and Kaneko, K. (2004). Discreteness of molecules in reaction-diffusion systems can induce a novel steady state, *Phys. Rev. E* **70**, 020901(R).

Togashi,Y. and Kaneko, K. (2005) Discreteness-induced stochastic steady state in reaction diffusion systems: Self-consistent analysis and stochastic simulations. *Physica* D **205**, 87–99.

Tsuda, I. (1991a) In: *Neurocomputers and Attention* (Manchester university press) pp 430.

Tsuda, I. (1991b) Chaotic itinerancy as a dynamical basis of Hermeneutics in brain and mind. *World Futures* **32**, 167.

Tsuda, I. (1992) Dynamic link of memory–chaotic memory map in nonequilibrium neural networks. *Neural Networks* **5**, 313.

Turner, G.F. and Burrows M.T. (1995) A model for sympatric speciation by sexual selection. *Proc. R. Soc. Lond.* **B 260**, 287–292.

Tyson, J.J., Novak B., Odell G.M., Chen K., and Thron C.D. (1996) Chemical kinetic theory: Understanding cell-cycle regulation. *Trends Biochem. Sci.* **21**(3), 89–96.

Turing, A.M. (1952) The chemical basis of morphogenesis *Phil. Trans. Roy. Soc.* **B 237**, 37–72.

Ueda, H.R., et al. (2004) Universality and flexibility in gene expression from bacteria to human. *Proc. Natl. Acad. Sci. U.S.A.* **101**(11), 3765–3769.

Ueda, M., Sako, Y., Tanaka, T., Devreotes, P., and Yanagida, T. (2001) Single-molecule analysis of chemotactic signaling in Dictyostelium cells. *Science* **294**, 864–867.

Uochi, T. and Asashima, M. (1996) Sequential gene expression during pronephric tubule formation in vitro in Xenopus ectoderm. *Dev. Growth Diff.* **38**, 625–634.

de Visser, J.A.G.M., et al. (2003) Evolution and detection of genetic robustness. *Evolution* **57**, 1959–1972.

Veening, J.W., Hamoen, L.W., and Kuipers, O.P. (2005) Phosphatases modulate the bistable sporulation gene expression pattern in Bacillus subtilis. *Mol. Microbiol.* **56**, 1481–1494.

Velculescu V.E., Zhang L., Zhou W., Vogelstein J., Basrai M.A., Bassett D.E. Jr., Hieter P., Vogelstein B., Kinzler K.W. (1997) Characterization

of the yeast transcriptome. *Cell* **88**, 243: SAGE Data is available from http://www.sagenet.org/.

Velculescu, V.E., Zhang L., Vogelstein B., Kinzler K.W. (1995) Serial analysis of gene expression. *Science* **270**, 484.

Volkov, E.L., Stolyarov M.N., and Brooks, R.F. (1992) The modelling of heterogeneity in proliferative capacity during clonal growth. In: *Proceedings of the Lebededv Physics Institute Biophysical Approach to Complex Biological Phenomena*, Vol. **194**, ed. by E. Volkov (Nova Publishers).

Wachtershäuser, G. (1990) Evolution of the first metabolic cycles. *Proc. Natl. Acad. Sci. U.S.A.* **87**, 200–204.

Watson, J.D. (1965) *Molecular Biology of the Gene* Benjamin (Revised 1970, 1975).

Waddington, C.H. (1957) *The Strategy of the Genes* (George Allen and Unwin L.D., Bristol).

Weinig, C. (2000) Plasticity versus canalization: Population differences in the timing of shade-avoidance responses., *Evolution* **54**, 441–451.

Weismann, A. (1893) *The Germ-plasm; A Theory of Heredity* (Charles Scribner's Sons, New York).

West-Eberhard, M.J. (2003) *Developmental Plasticity and Evolution* (Oxford University Press).

Wiener, N. (1948) *Cybernetics, or Control and Communication in the Animal and the Machine* (John Wiley).

Wilson, A.B., Noack-Kunnmann, K., and Meyer, A. (2000) Incipient speciation in sympatric Nicaraguan crater lake cichlid fishes: Sexual selection versus ecological diversification *Proc. Roy. Soc. Lond.* **B 267**, 2133–2141.

Wilson, E.O. (1992) *The Diversity of Life* (W.W. Norton and Company Inc.).

Wolpert, L. (1969) Positional information and the spatial pattern of cellular formation. *J. Theor. Biol.* **25**, 1–47.

Xu, W.Z., Kashiwagi, A.T. Yomo, and Urabe, I. (1996) Fate of a mutant emerging at the initial stage of evolution, *Res. Popul. Ecol.* **38**, 231–237.

Yamauchi, A., Nakashima, T., Tokuriki, N., Hosokawa, M., Nogami, H., Arioka S., Urabe I., and Yomo, T. (2002) Evolvability of random polypeptides through functional selection within a small library, *Protein Eng.* **15**, 619–26.

Yanagida, T., Arata, T., and Oosawa, F. (1985) Sliding distance of actin filament induced by a myosin cross-bridge during one ATP hydrolysis cycle. *Nature* **316**, 366–369.

Yoshida, H., Furusawa, C., and Kaneko, K. (2005) Selection of initial condition for recursive production of multicellular organisms *J. Theor. Biol.* **233**, 501–514.

Yoshimura, J., and Shields, W.M. (1987) Probablistic optimization of phenotypic distributions: A general solution for the effects of uncertainty on natural selection? *Evol. Ecol.* **1**, 125–138.

Yoon, H.-S. and Golden, J.W. (1998) Hereocyst pattern formation controlled by a diffusible peptide, *Science* **282**, 935–938.

You, L., Cox, R.S., Weiss, R., and Arnold, F.H. (2004) Ppopulation control by cell–cell communication and regulated killing. *Nature* **42**, 8868–8871.

Yates, F.E. (1980) Physical Causality and brain theories. *Am. J. Physiol.* **238**, 277.

Yu,W., Sato, K., Wakabayashi, M., Nakaishi, T., Ko-Mitamura, E.P., Shima, Y., Urabe, I., and Yomo, T. (2001) Synthesis of functional protein in liposome. *J. Biosci. Bioeng.* **92**(6), 590–593.

Zandstra, P. and Nagy, A. (2001) Stem cell bioengineering, *Annu. Rev. Biomed. Eng.* **3**, 275–305.

Zaug, A.J. and Cech, T.R. (1986) The intervening sequence RNA of *Tetrahymena* is an enzyme. *Science* **231**, 470–475.

Zipf, G.K. (1949) *Human Behavior and the Principle of Least Effort* (Addison-Wesley, Cambridge.)