Cell Dynamics and Complex Systems

An overview of case studies

Samuel Bernard 01.02.2023

DYNAMICS OF TUMOR GROWTH

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Gompertz equation of the following form:

$$W/W_0 = e^{\frac{A}{\alpha}(1-e^{-\alpha t})}$$

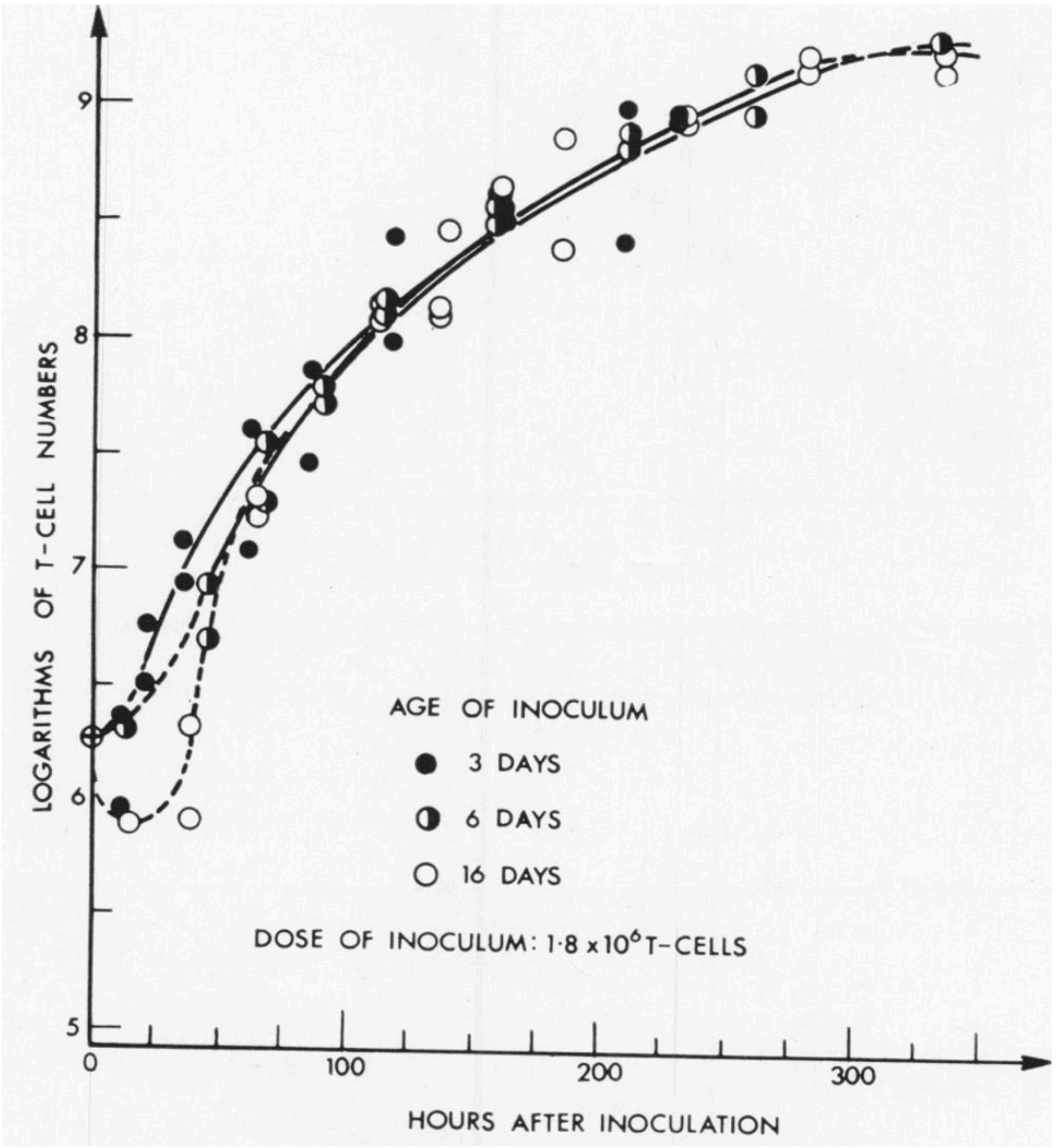


TABLE II.—*Analysis of Theoretical Gompertz Functions in Terms of Doublings*

Gompertz curve Corresponding to :	Duration, initial doubling,	Ratio, second to first doubling time	Approx. No. doublings to upper limit
Krebs	3·26 hours	1·06	18
Ehrlich	9·26 hours	1·10	12
MC_1M, low dose	6·09 hours	1·11	11
$6C_3HED$, high dose	19·6 hours	1·44	4·5
$6C_3HED$, low dose	11·9 hours	1·19	7·5
DBA lymphoma	2·59 hours	1·07	16
El_4, low dose	3·46 hours	1·08	15
El_4, high dose	4·23 hours	1·12	10
EO771	1·08 days	1·09	15
Osteosarcomas	5·03 days	1·15	9
Walker, W26b1	3·26 days	1·08	14
Walker, W12a7	2·07 days	1·05	23
Walker, W10a6	1·99 days	1·09	13
Walker, W10b4	5·29 days	1·02	62
R39, R3a7	0·56 days	1·08	14
R39, R4c4	1·35 days	1·13	9·5
R39, a7R3	0·97 days	1·07	16
Flexner-Jobling	1·84 days	1·11	11
Brown-Pearce	0·576 days	1·12	10

J. gen. Microbiol. (1967), **48**, 155–159
Printed in Great Britain

Inequality of Mean Interdivision Time and Doubling Time

By P. R. PAINTER AND A. G. MARR
Department of Bacteriology, University of California, Davis, California 95616, U.S.A.

The mean interdivision time $\bar{\tau}$ is then

$$\int_0^\infty \tau f(\tau)\, d\tau.$$

$$\bar{\tau} = \ln 2/k, \qquad \bar{\tau} \approx \ln 2/k + k\sigma^2/2,$$

Organism	Standard deviation, σ (min.)	Specific growth rate, k (min.$^{-1}$)	$\ln 2/k$ (min.)	$\bar{\tau}$, observed (min.)	$\bar{\tau}$, estimated (min.)
Pseudomonas aeruginosa	5·37	0·01831*	37·85	38·1	38·11
Bacillus megaterium	7·76	0·03259†	21·27	22·3	22·25
Bacillus mycoides	14·2	0·02637*	26·29	28·7	28·95

JOURNAL OF MATHEMATICAL ANALYSIS AND APPLICATIONS **178**, 344–362 (1993)

Global Geometry of the Stable Regions for Two Delay Differential Equations

JACK K. HALE* AND WENZHANG HUANG

Center for Dynamical Systems and Nonlinear Studies, Georgia Institute of Technology, Atlanta, Georgia 30332

$$\dot{x}(t)+ax(t)+bx(t-r)+cx(t-\sigma)=0, \qquad r\geqslant 0,\ \sigma\geqslant 0,\ t\geqslant 0$$

$$p(\lambda, r, \sigma) \overset{\text{def}}{=} \lambda+a+be^{-\lambda r}+ce^{-\lambda\sigma}=0.$$

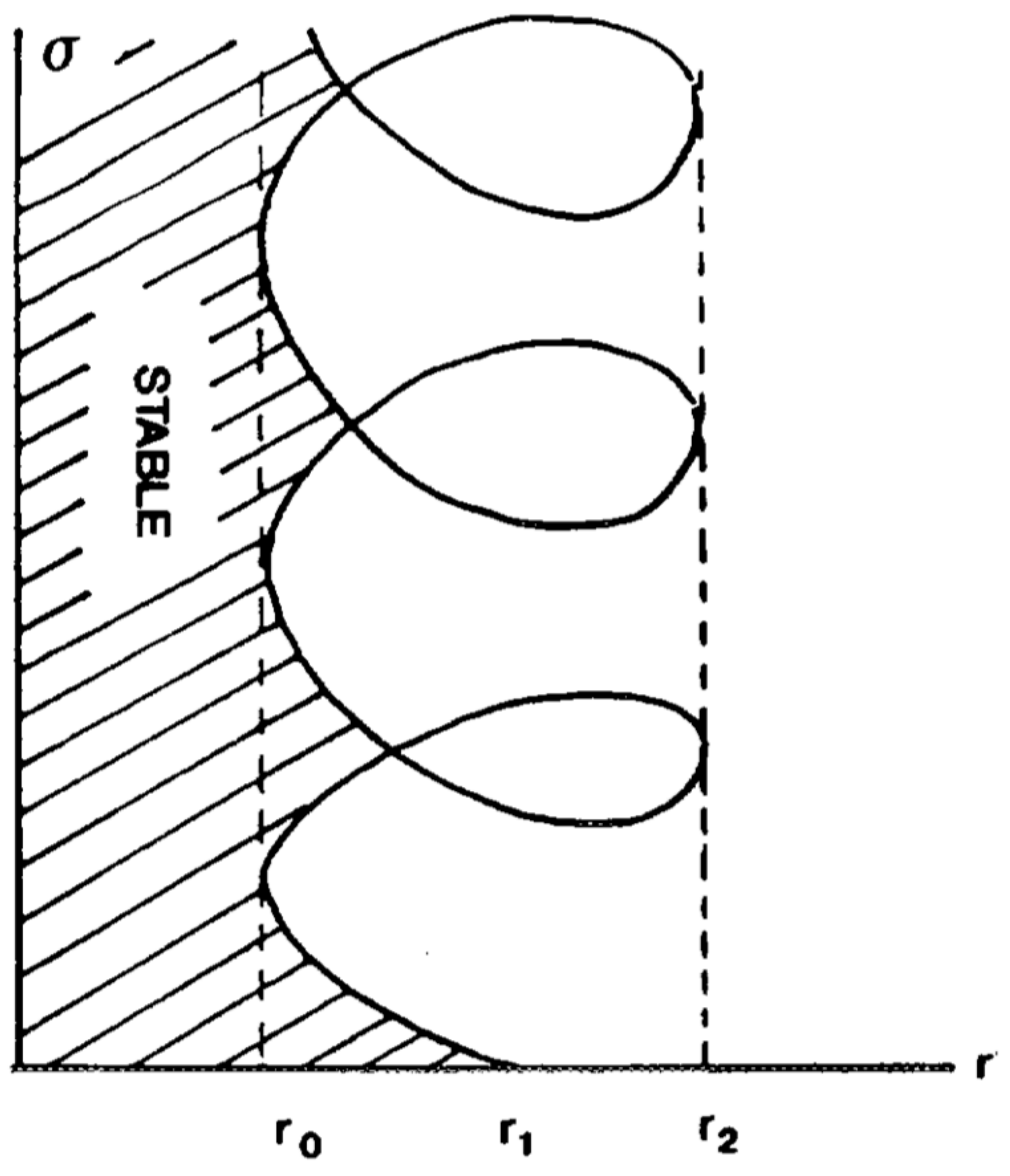


FIGURE 3.7

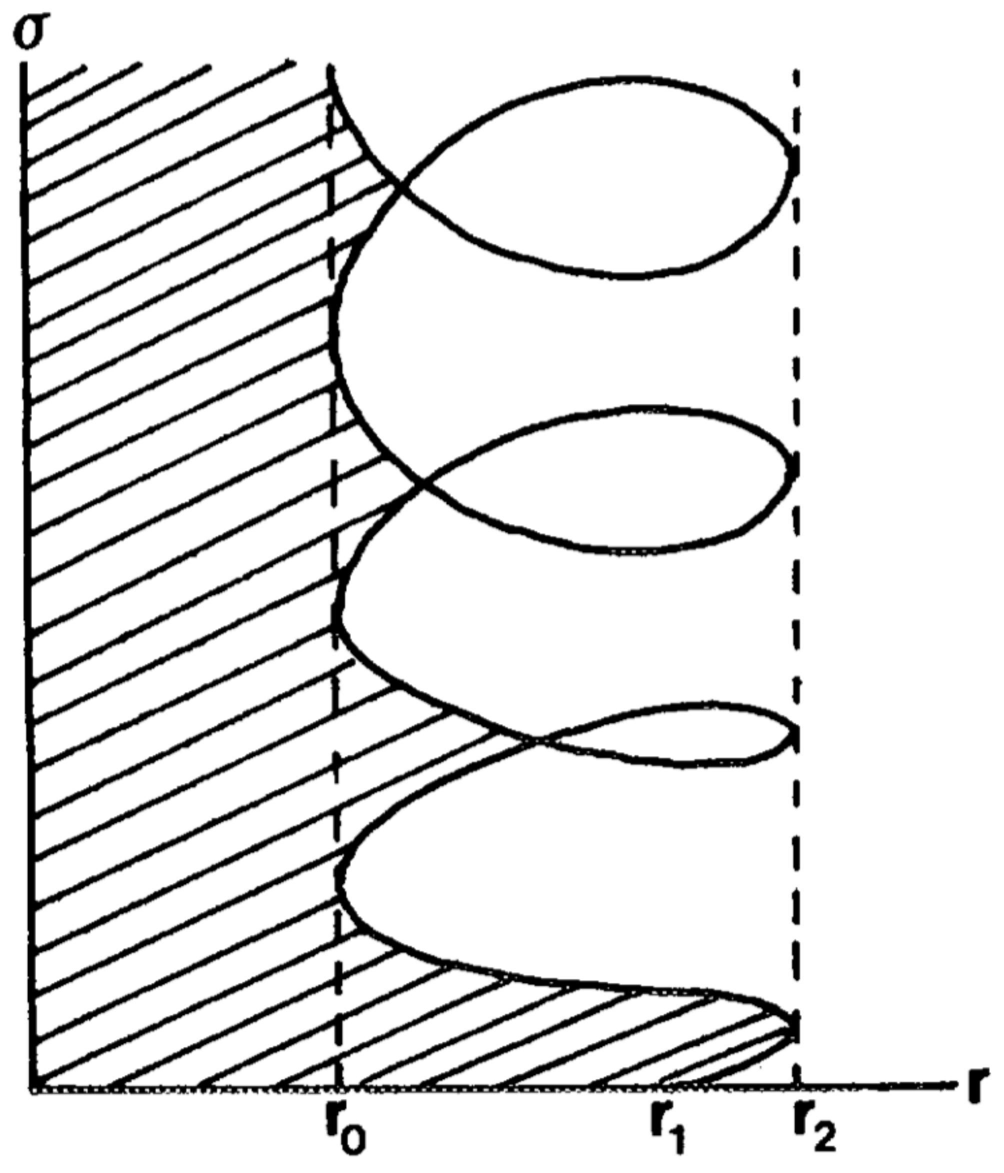
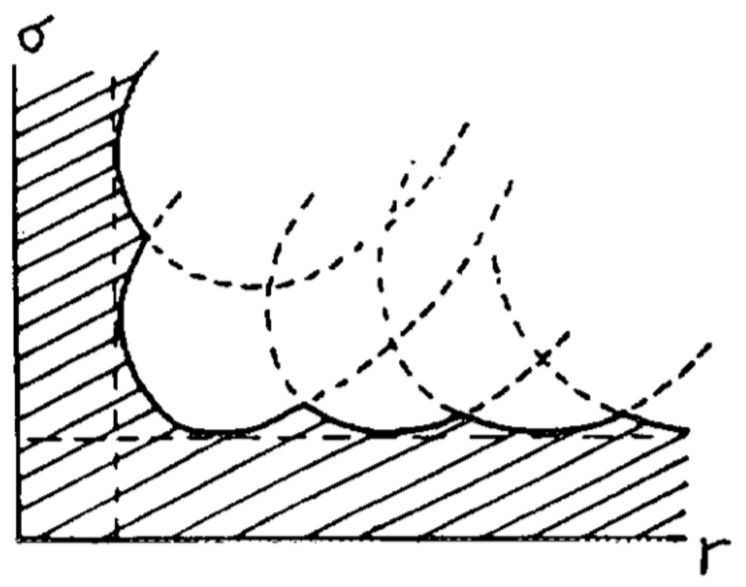
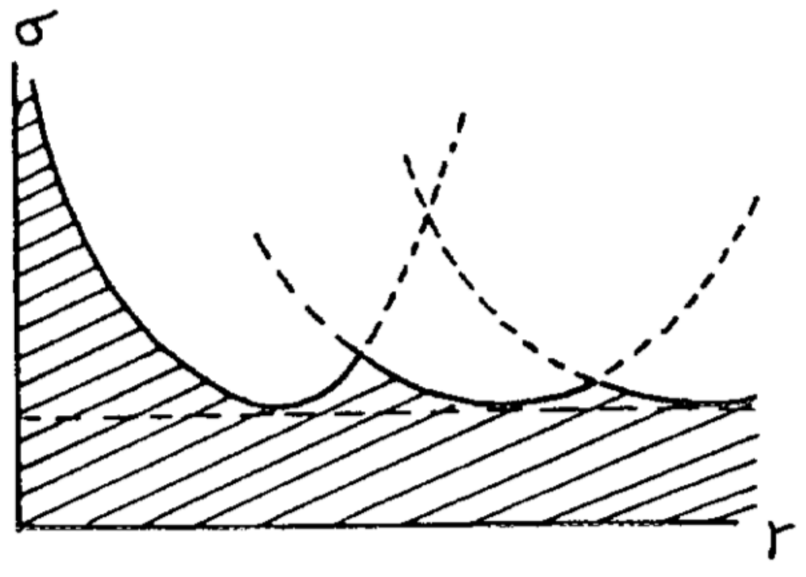


FIGURE 3.8





J. Math. Biol. (1990) 28: 671–694

Journal of Mathematical Biology

A nonlinear structured population model of tumor growth with quiescence

M. Gyllenberg[1] and G. F. Webb[2,*]

[1] Department of Applied Mathematics, Luleå University of Technology, S-95187 Luleå, Sweden

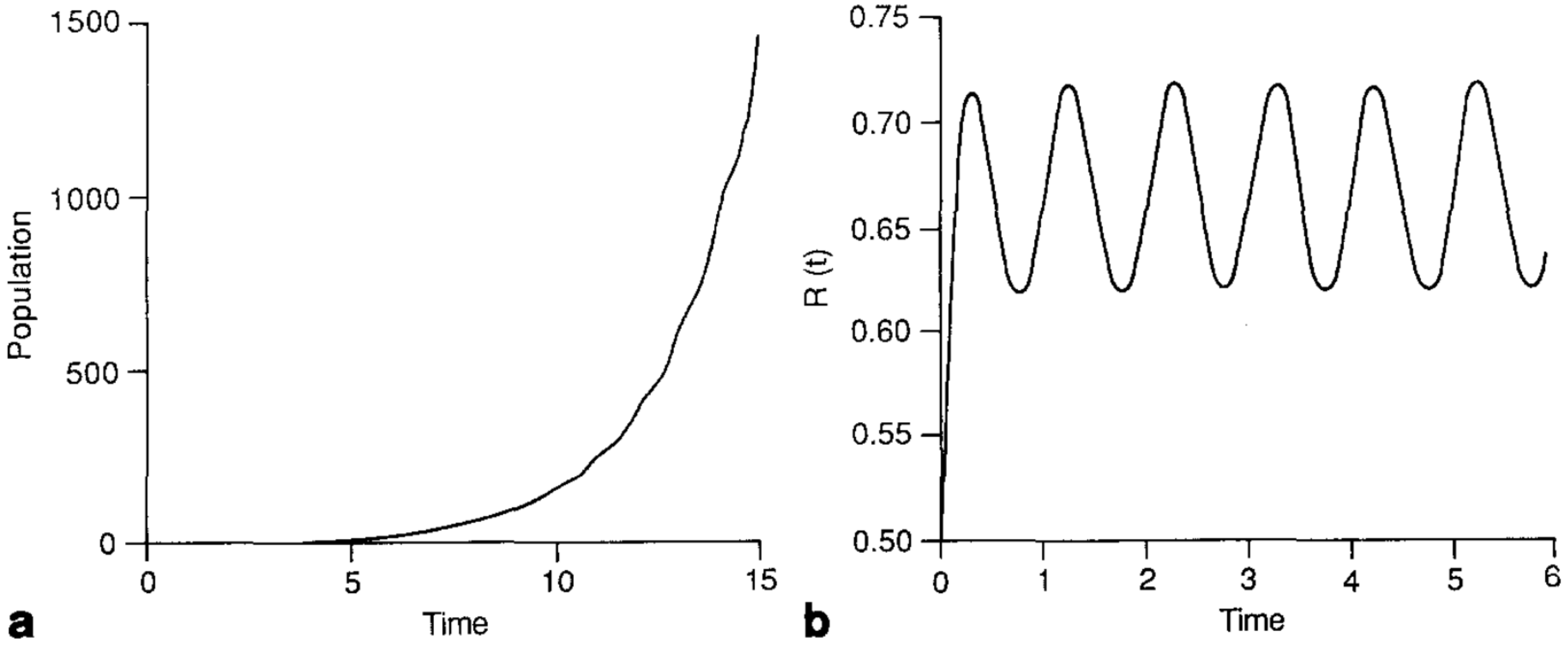
[2] Vanderbilt University, Department of Mathematics, Nashville, TN 37235, USA

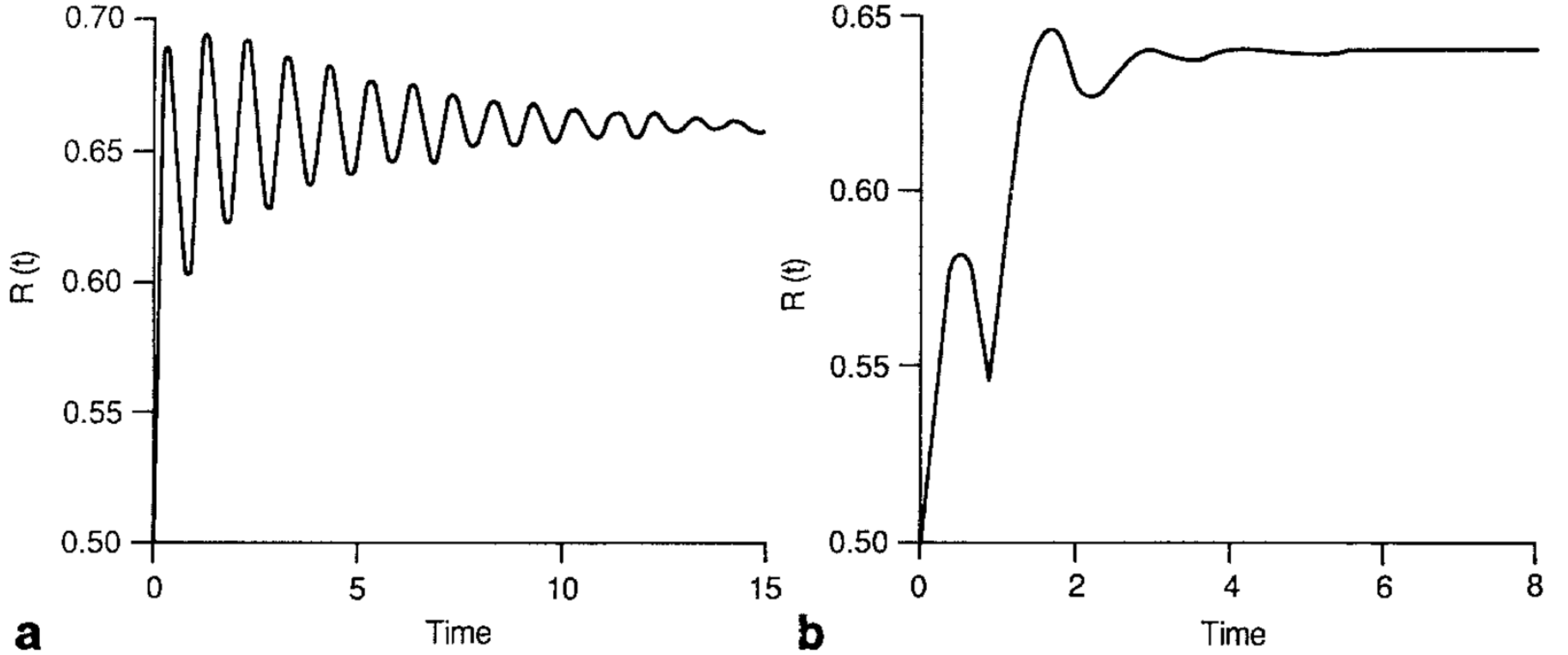
(2.1) $$\frac{\partial}{\partial t}p(x,t)+\frac{\partial}{\partial x}(g(x)p(x,t))=2(2-r(x,N(t)))b(2x)p(2x,t)-b(x)p(x,t)$$
$$-\mu_P(x)p(x,t)+\varrho(x,N(t))q(x,t),$$
$$t>0,\quad \frac{x_0}{2}<x<x_1,$$

(2.2) $$\frac{\partial}{\partial t}q(x,t)=2r(x,N(t))b(2x)p(2x,t)-\mu_Q(x)q(x,t)$$
$$-\varrho(x,N(t))q(x,t),\ t>0,\quad \frac{x_0}{2}<x<\frac{x_1}{2},$$

(2.3) $$p\left(\frac{x_0}{2},t\right)=0,\quad t>0,$$

(2.4) $$p(x,0)=\phi(x),\quad \frac{x_0}{2}<x<x_1,\quad q(x,0)=\psi(x),\quad \frac{x_0}{2}<x<\frac{x_1}{2}.$$





DISCRETE AND CONTINUOUS
DYNAMICAL SYSTEMS SERIES B

doi:10.3934/dcdsb.2020263

CHAOTIC DYNAMICS IN A SIMPLE PREDATOR-PREY MODEL WITH DISCRETE DELAY

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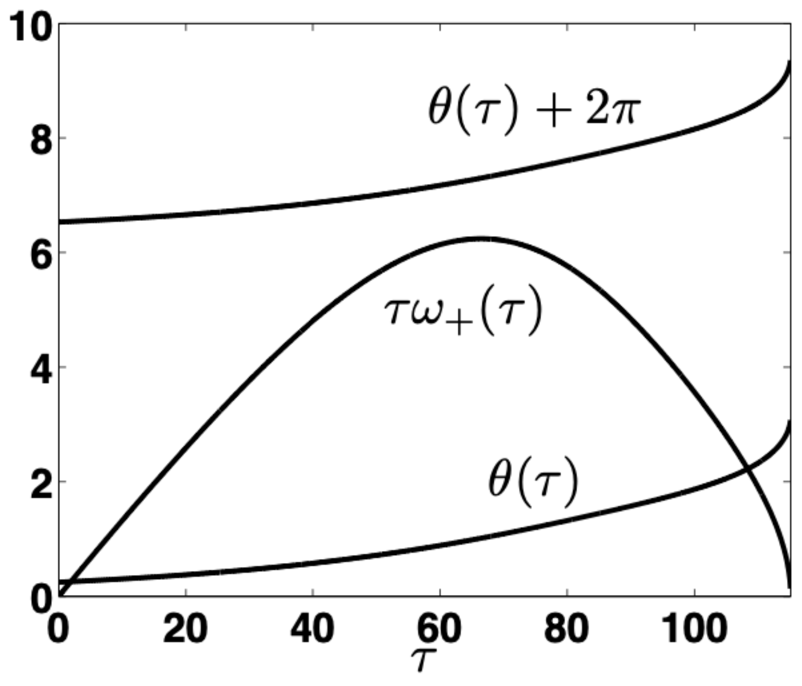
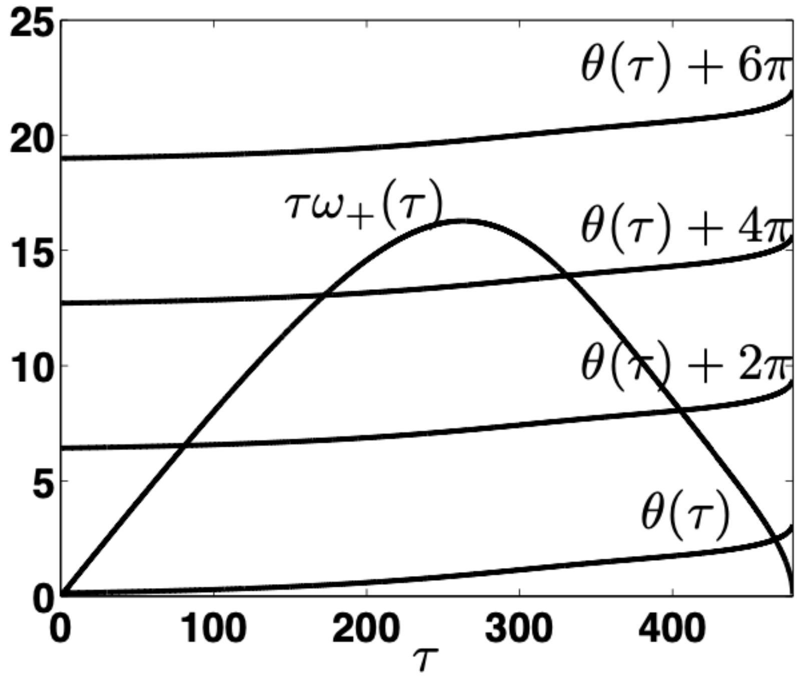
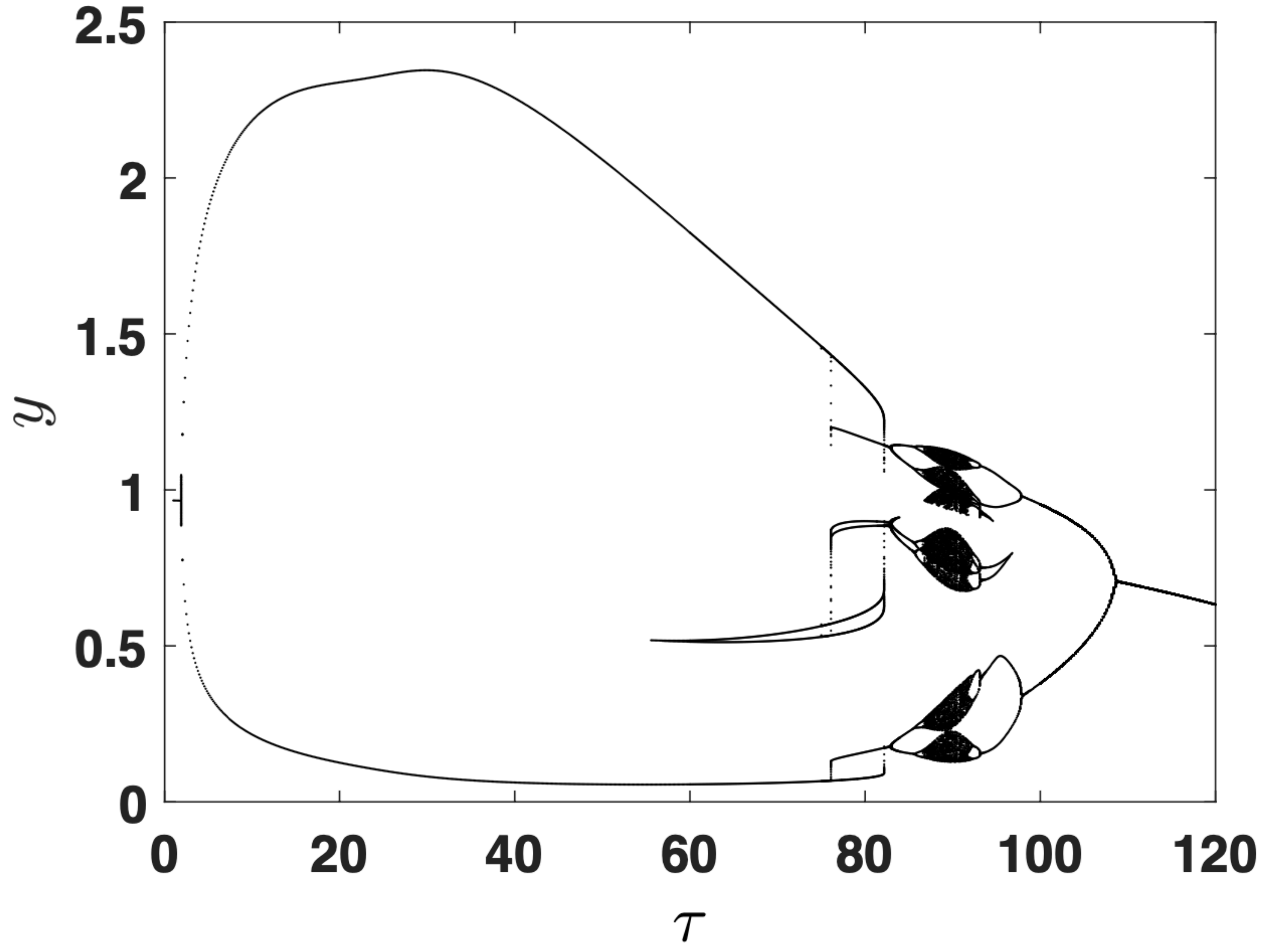
Hamilton, Ontario, Canada L8S 4K1, Canda

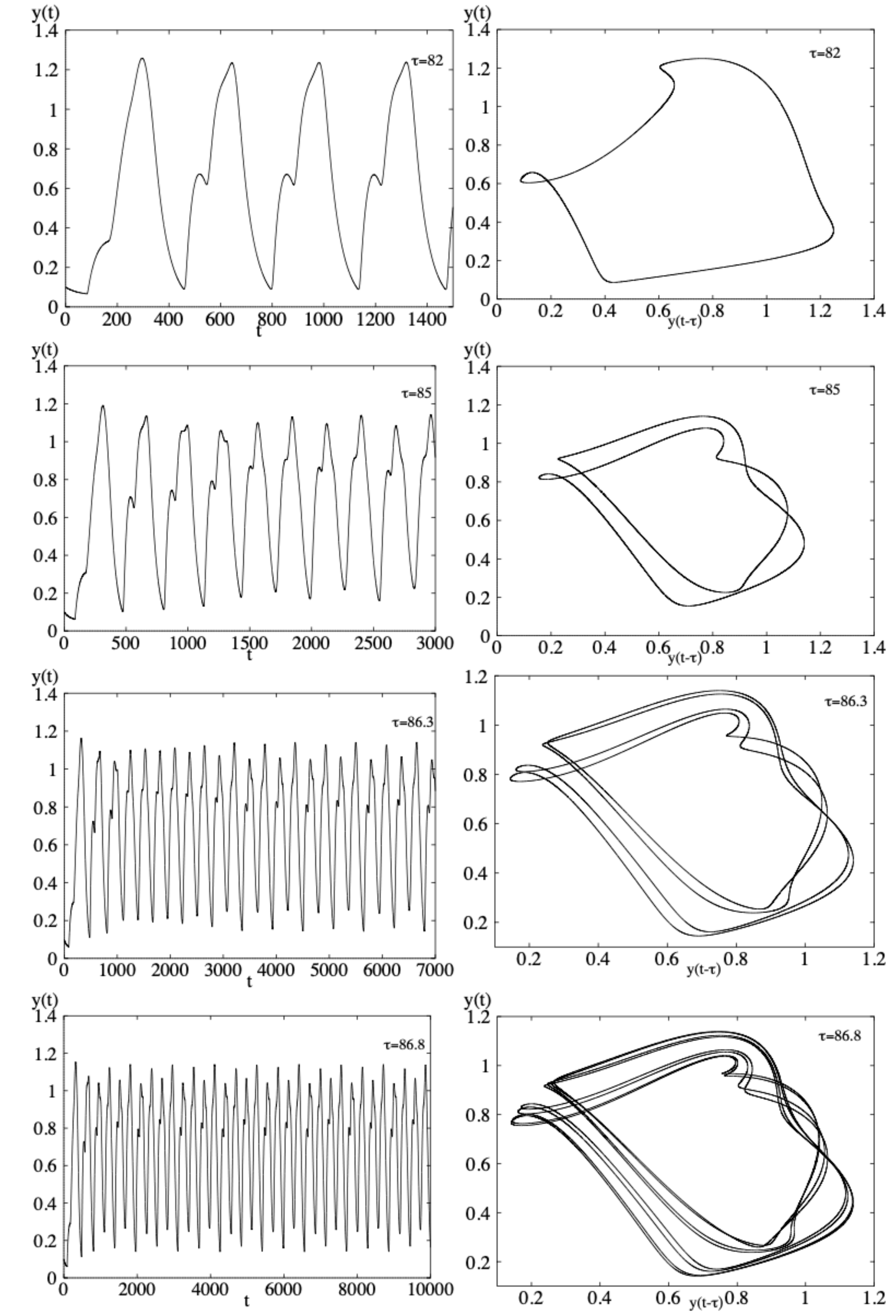


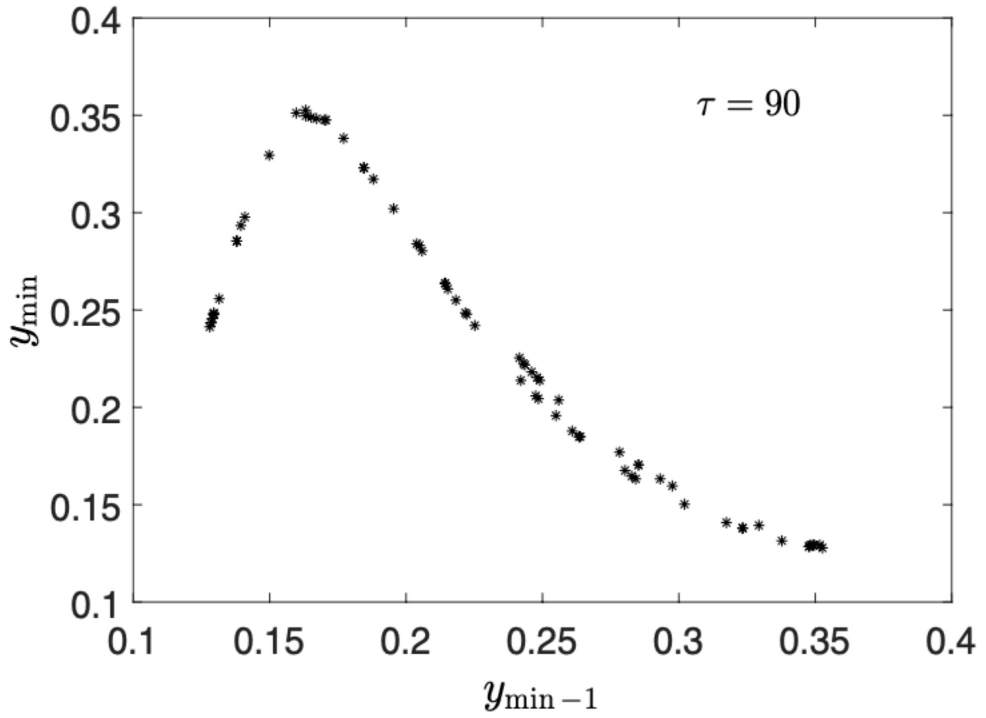


$$\begin{cases} \dot{x}(t) = rx(t)\left(1-\dfrac{x(t)}{K}\right) - my(t)x(t), \\ \dot{y}(t) = -sy(t) + Ye^{-s\tau}my(t-\tau)x(t-\tau). \end{cases}$$

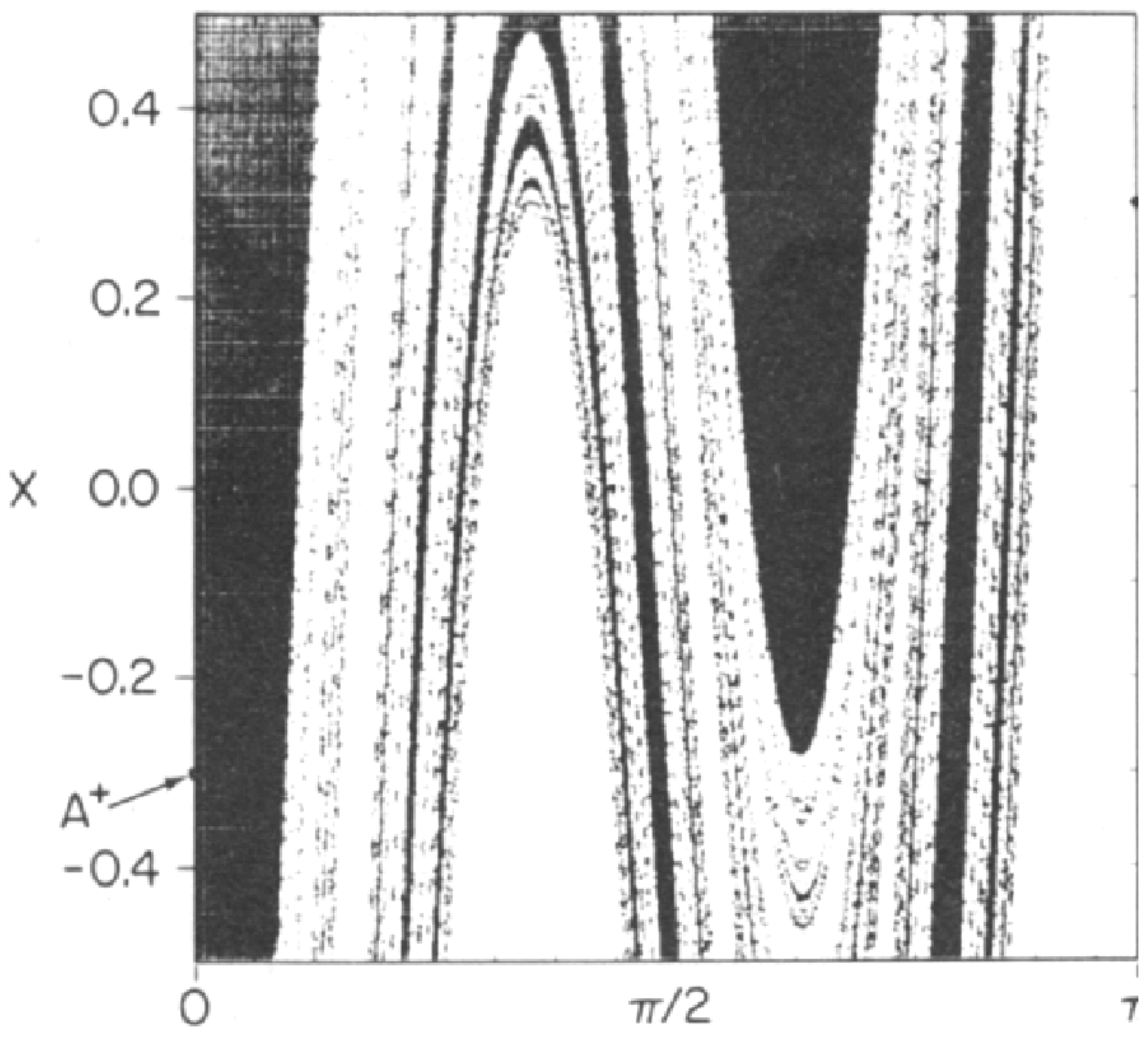
$$(\lambda+s)(\lambda+y^\star-(1-2x^\star)) + Ye^{-(s+\lambda)\tau}x^\star(1-2x^\star) - \lambda Ye^{-(s+\lambda)\tau}x^\star = 0.$$

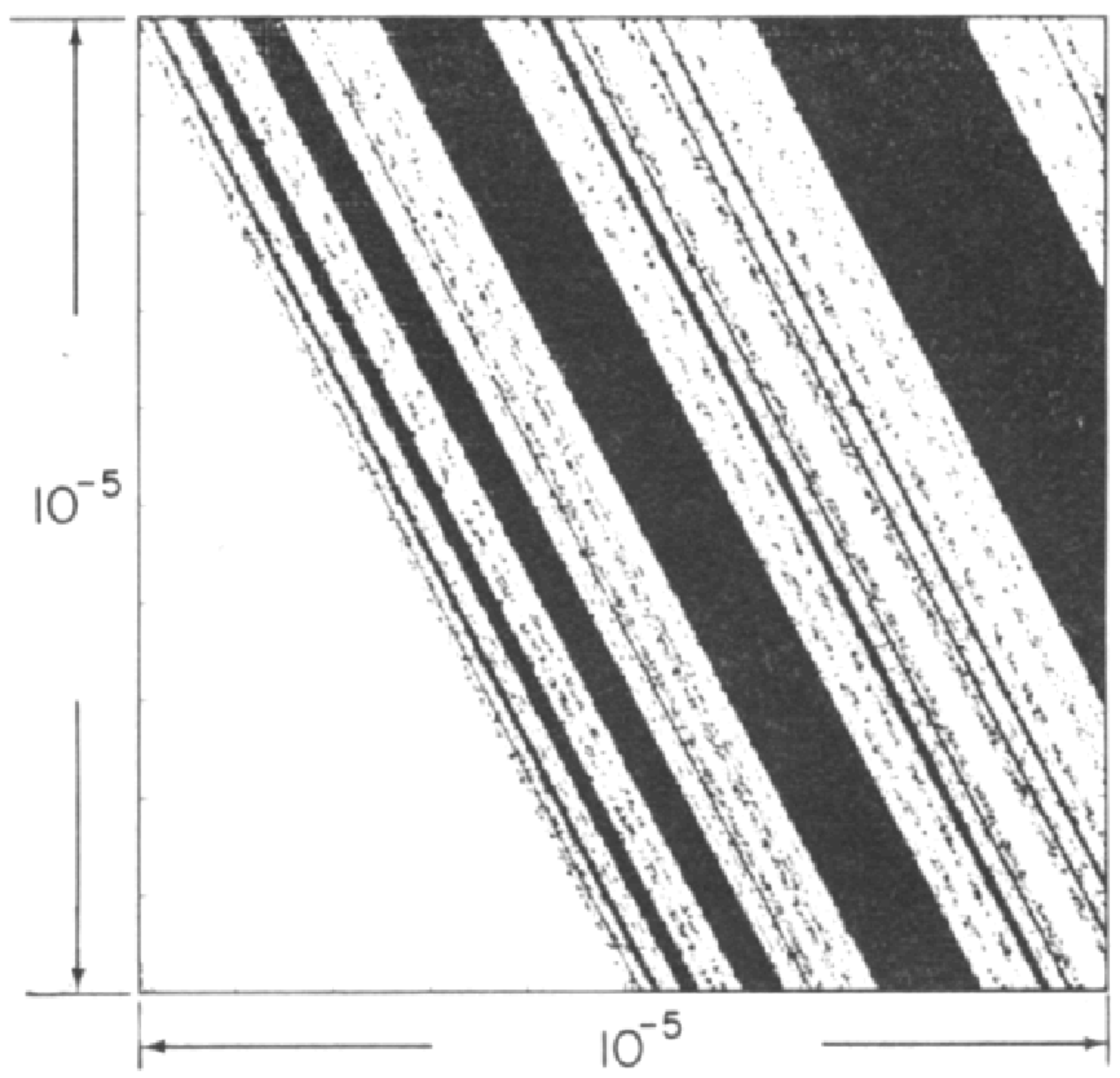






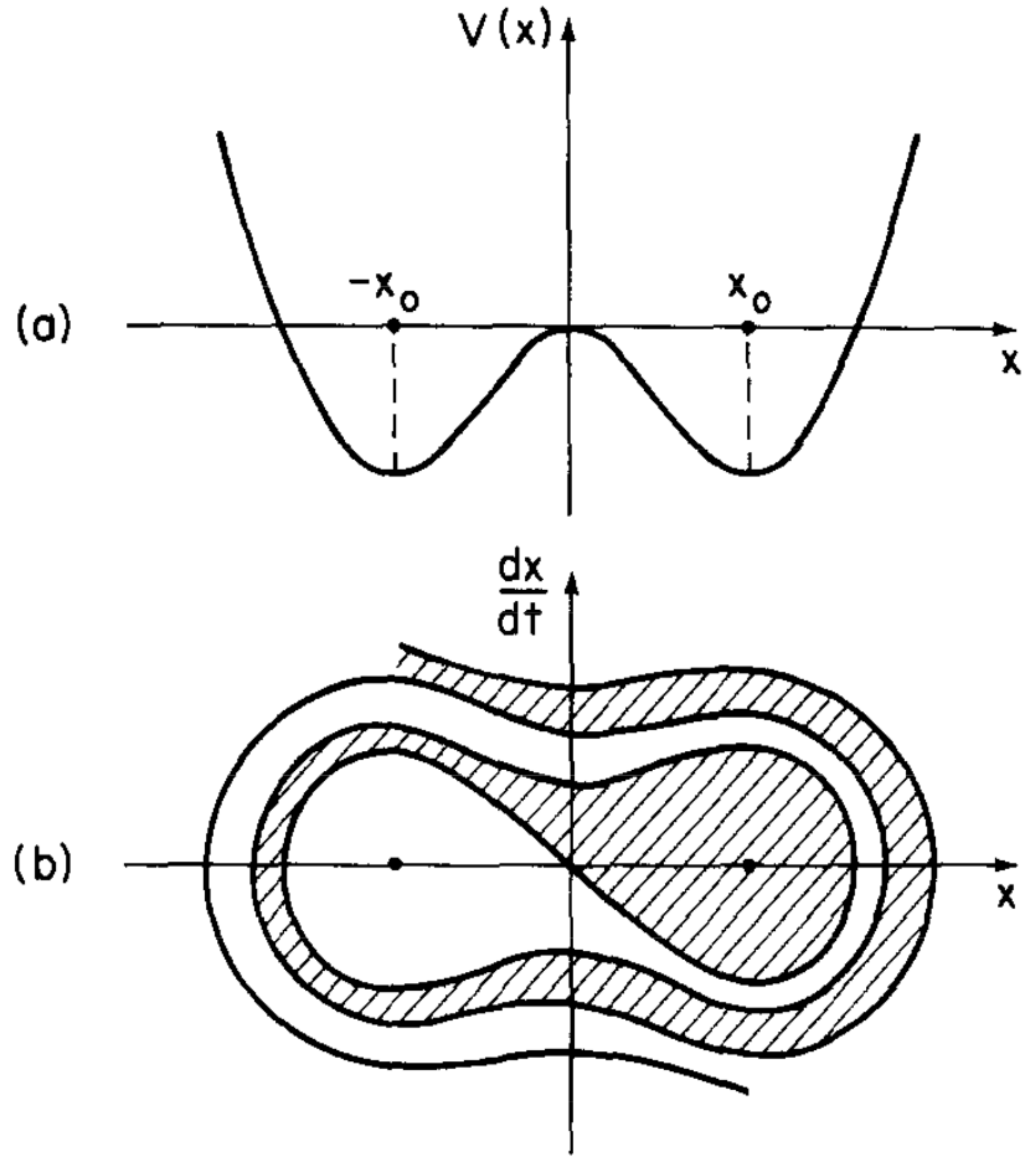
Physica 17D (1985) 125–153
North-Holland, Amsterdam

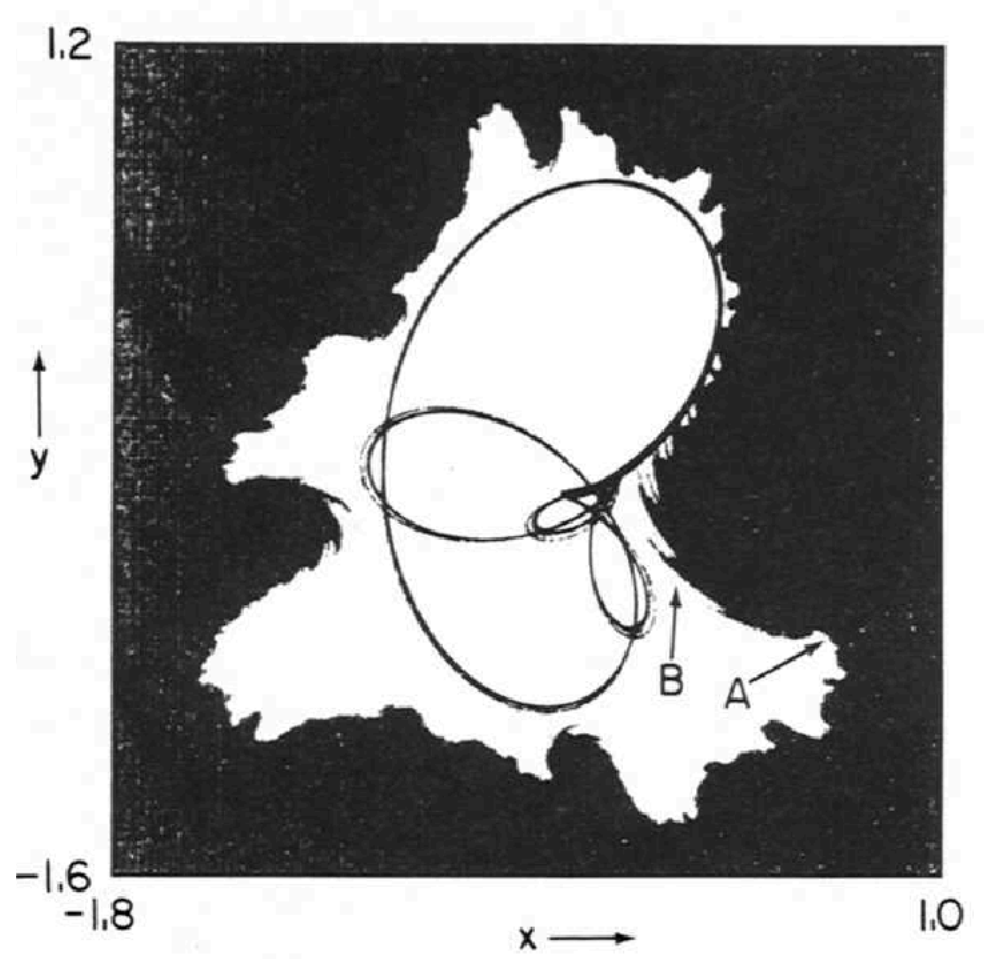


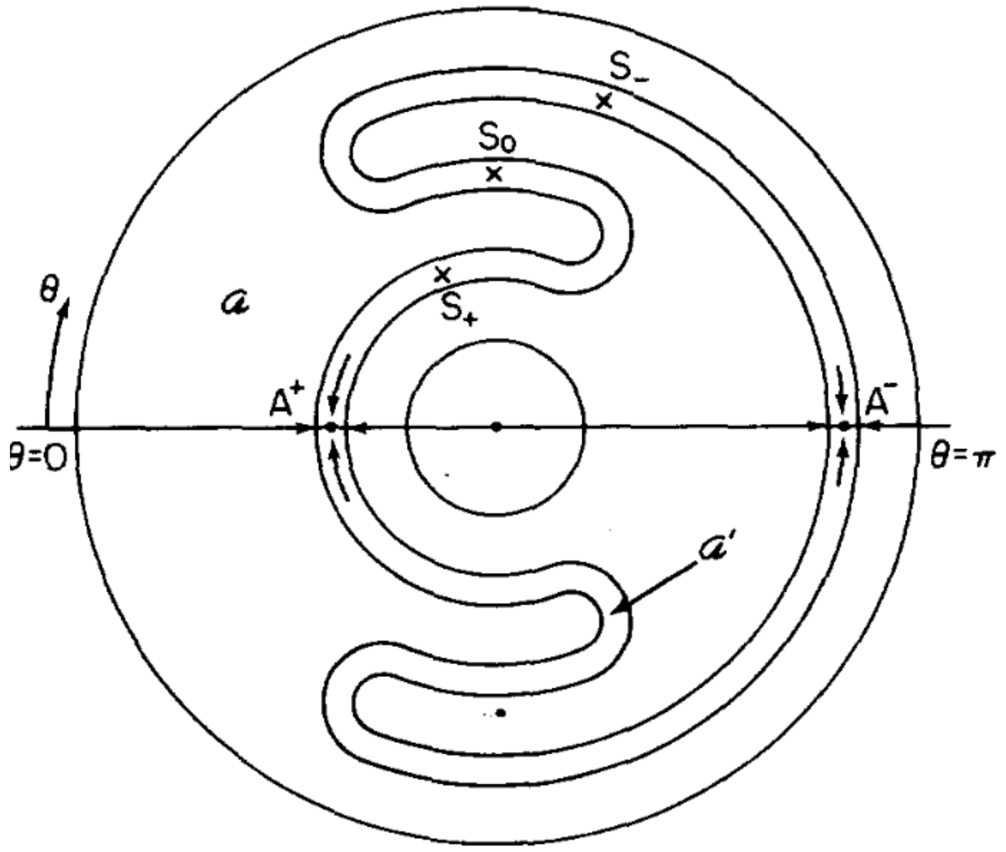


FRACTAL BASIN BOUNDARIES

Steven W. McDONALD,[a] Celso GREBOGI,[a] Edward OTT[a,b] and James A. YORKE[c]







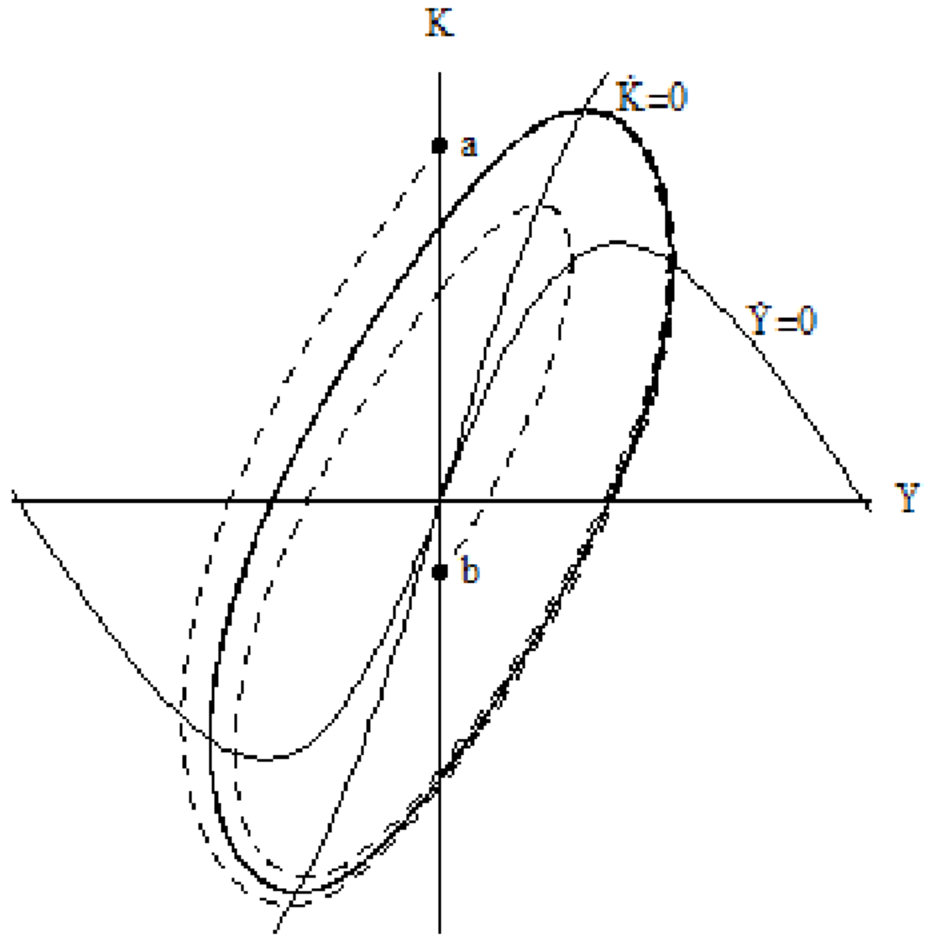
Delay Differential Nonlinear Economic Models*

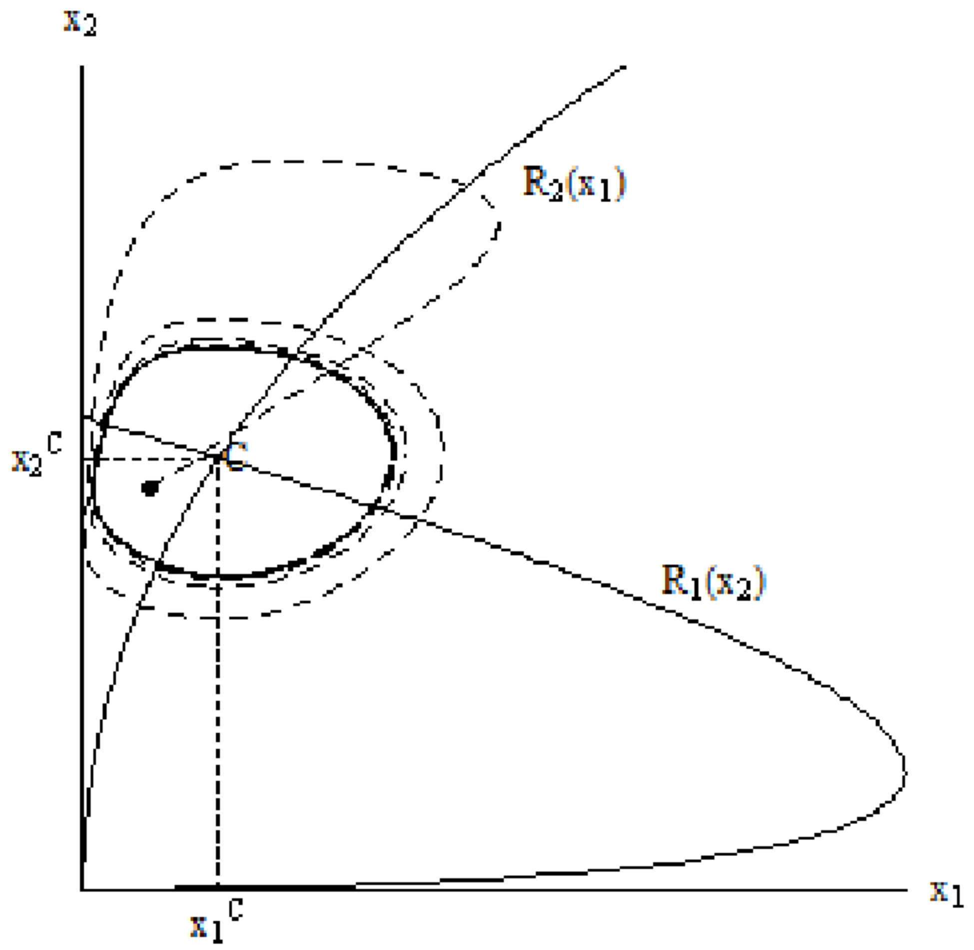
Akio Matsumoto† Chuo University

Ferenc Szidarovszky‡ University of Arizona

$$\begin{cases} \dot{Y}(t) = \alpha \left[I(Y(t), K(t)) - S(Y(t)) \right], \\ \dot{K}(t) = I(Y(t-\theta), K(t)) - \delta K(t), \end{cases}$$

$$\begin{cases} \dot{x}_1(t) = k_1 \left\{ R_1(x_2(t-\theta_1)) - x_1(t) \right\}, \\ \dot{x}_2(t) = k_2 \left\{ R_2(x_1(t-\theta_2)) - x_2(t) \right\}, \end{cases}$$

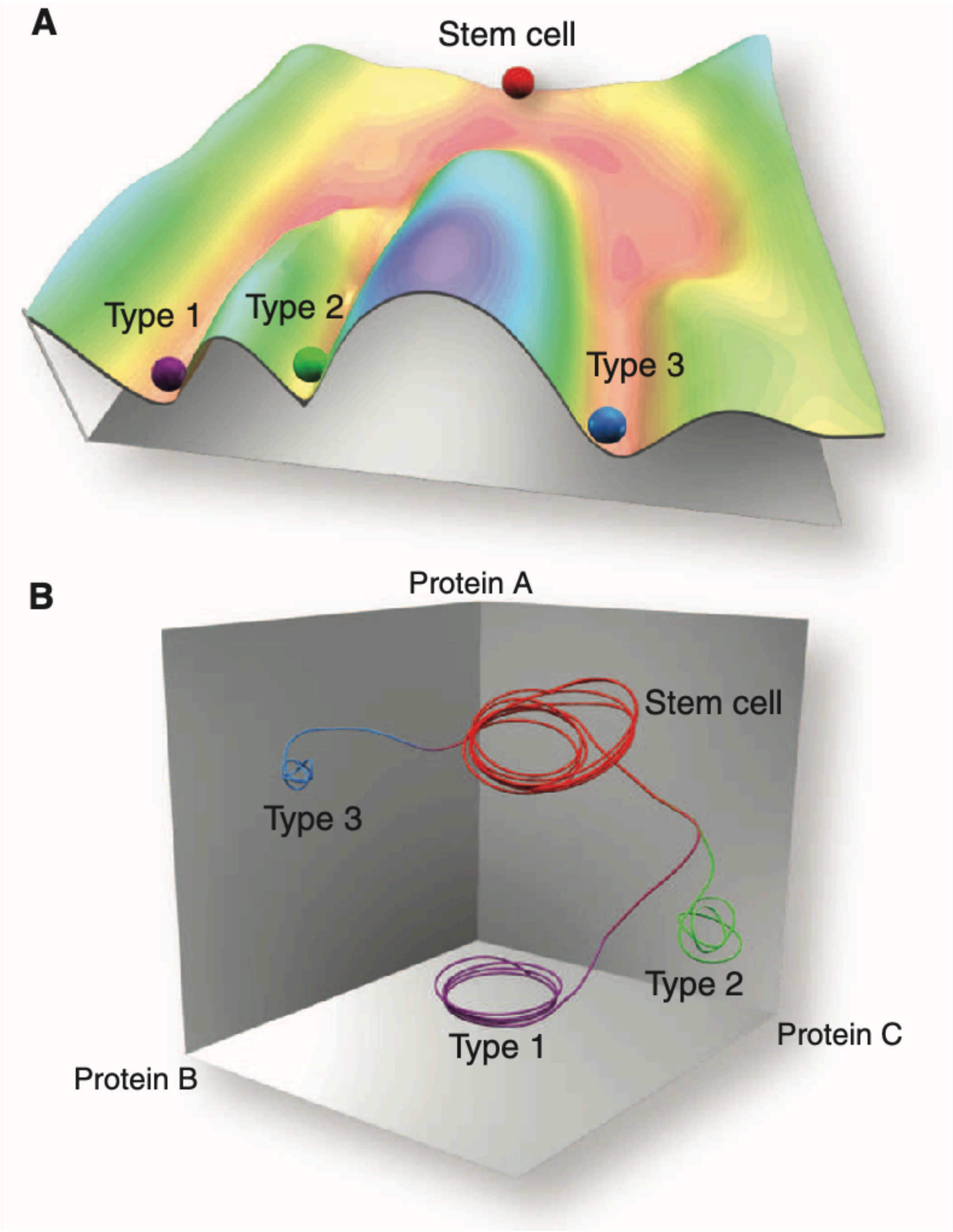


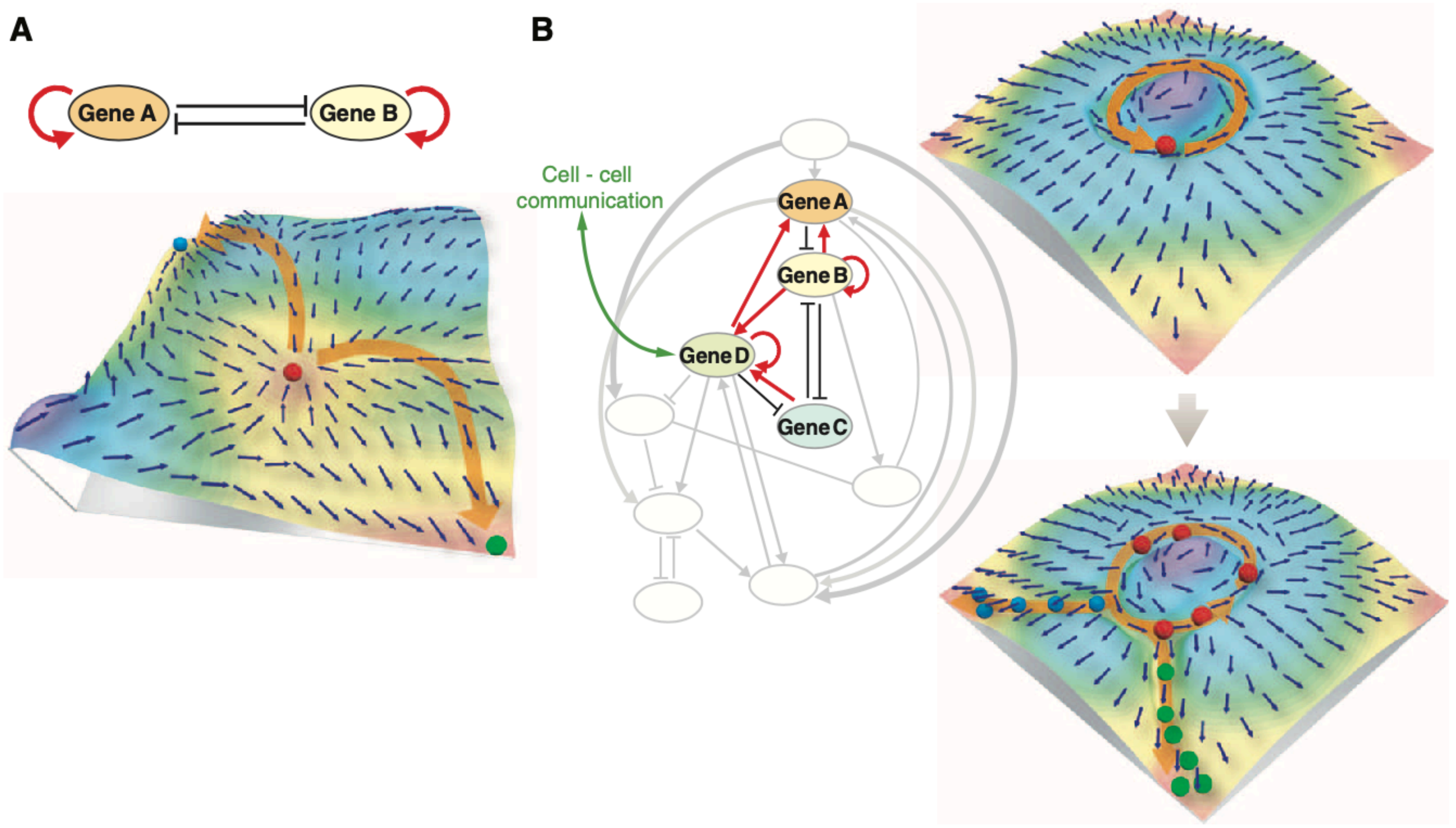


PERSPECTIVE

A Dynamical-Systems View of Stem Cell Biology

Chikara Furusawa[1] and Kunihiko Kaneko[2]*

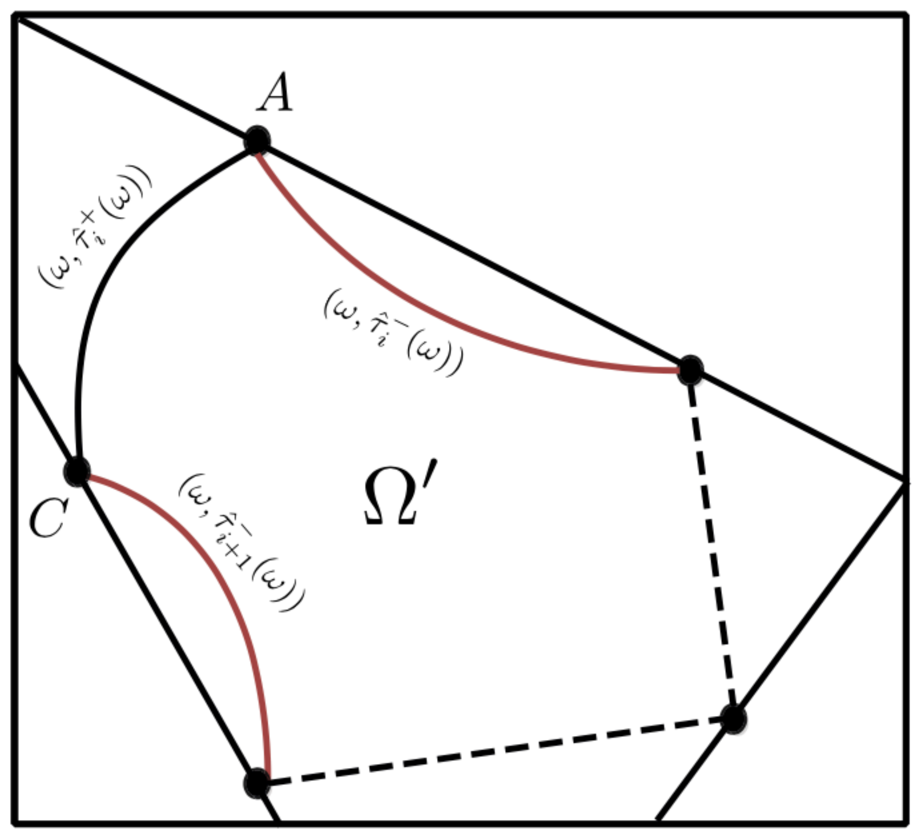


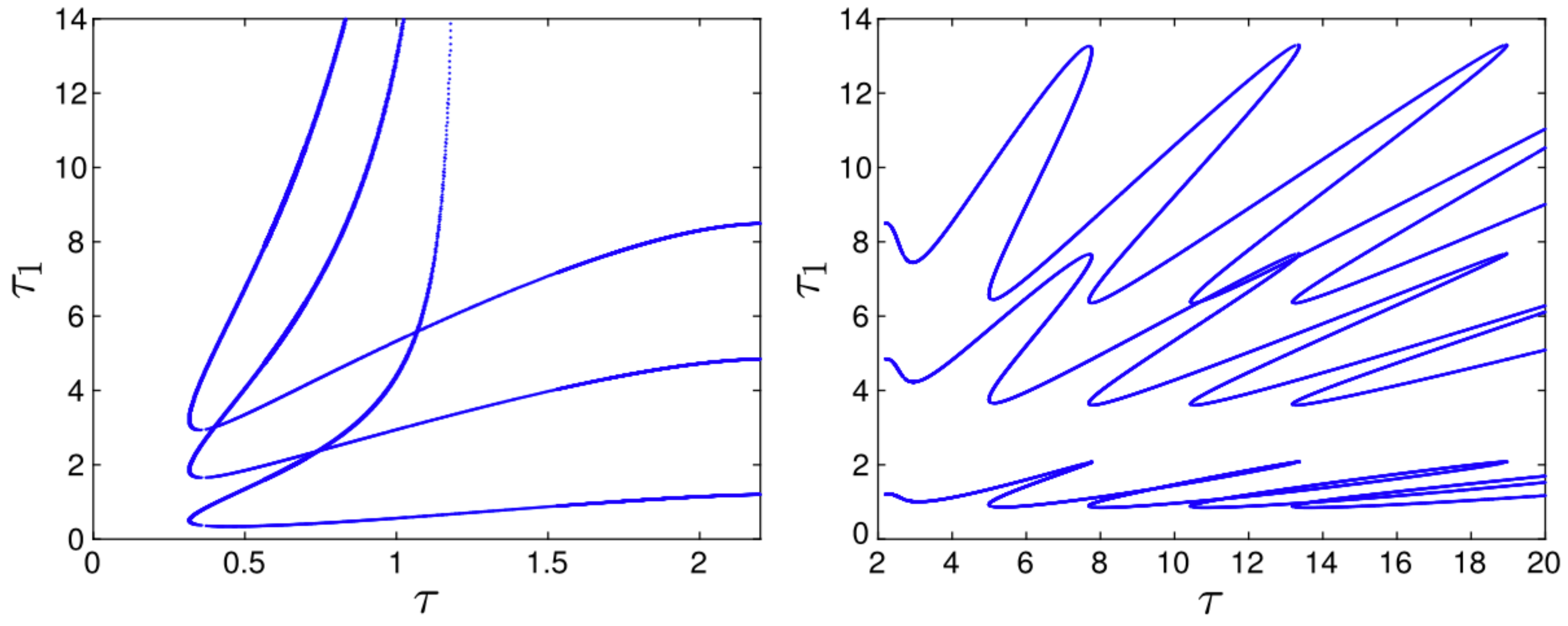


Geometric stability switch criteria in delay differential equations with two delays and delay dependent parameters ☆

Qi An [a], Edoardo Beretta [b], Yang Kuang [c], Chuncheng Wang [a], Hao Wang [d,*]

$$D(\lambda, \tau, \tau_1) := P_0(\lambda, \tau) + P_1(\lambda, \tau)e^{-\lambda\tau} + P_2(\lambda, \tau)e^{-\lambda\tau_1} = 0,$$





Theoretical Biology and Medical Modelling

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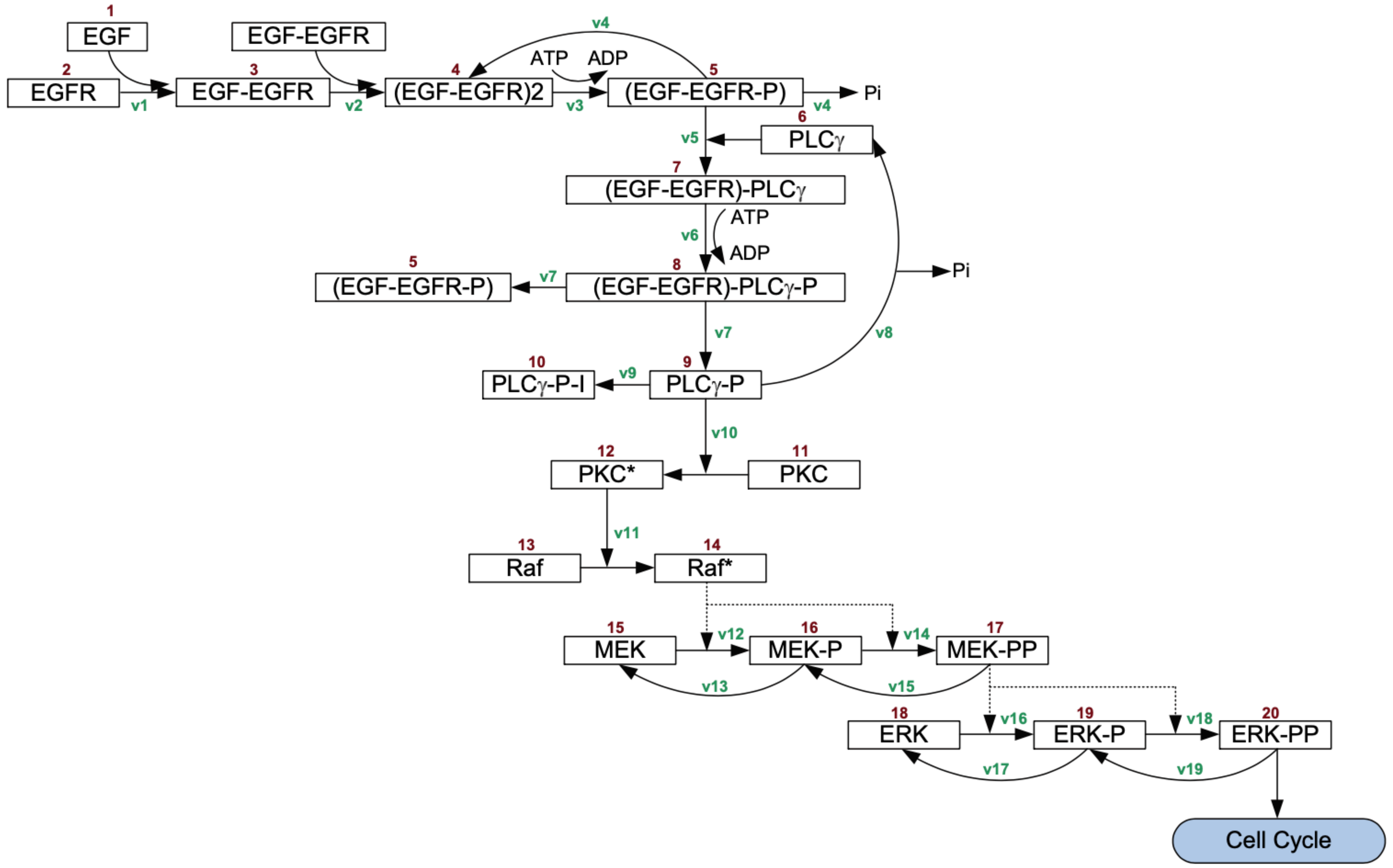
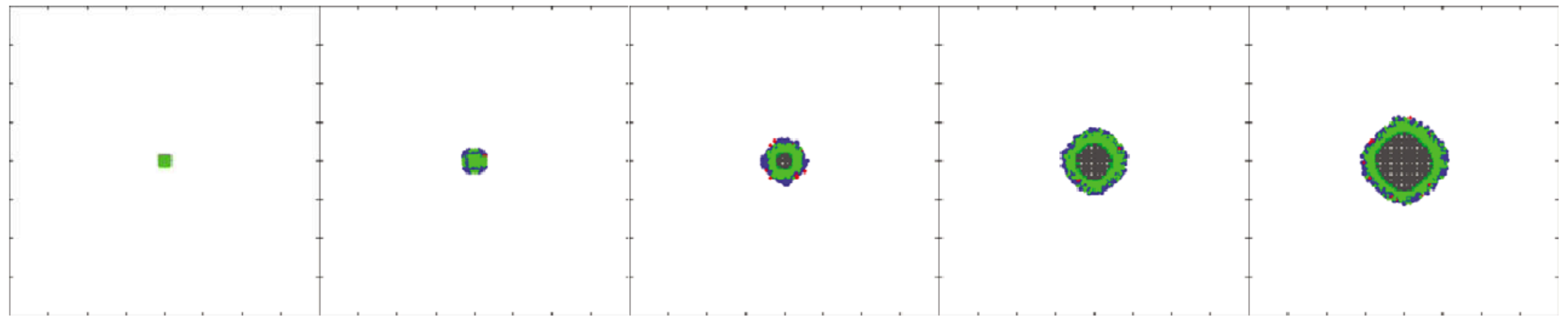
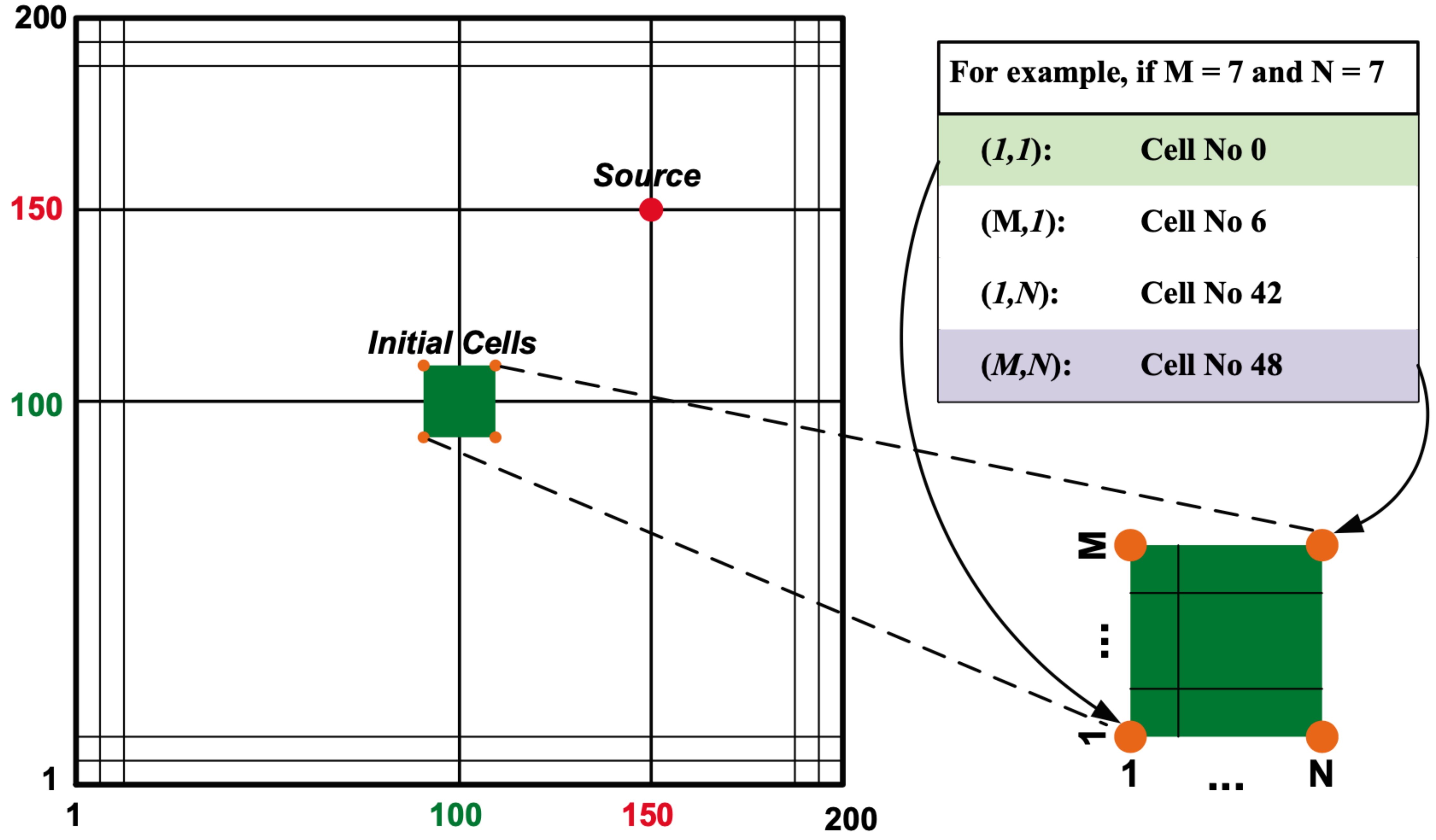
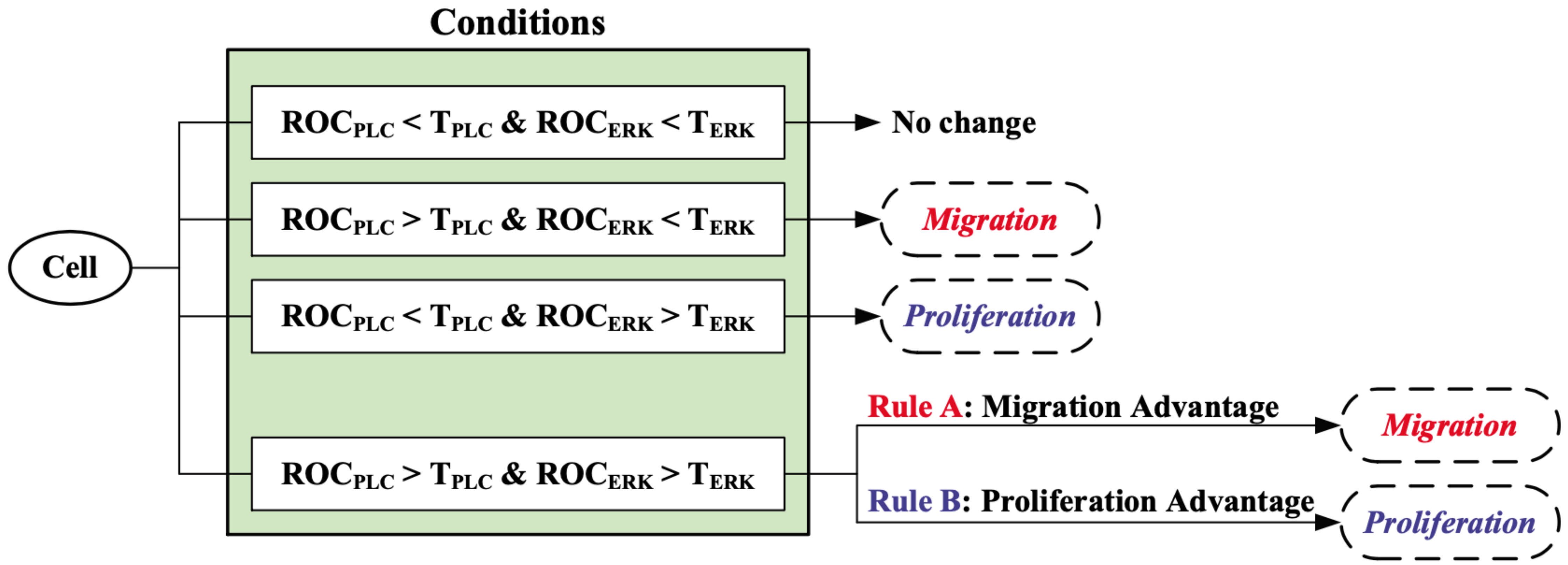
Simulating non-small cell lung cancer with a multiscale agent-based model

Zhihui Wang, Le Zhang, Jonathan Sagotsky and Thomas S Deisboeck*





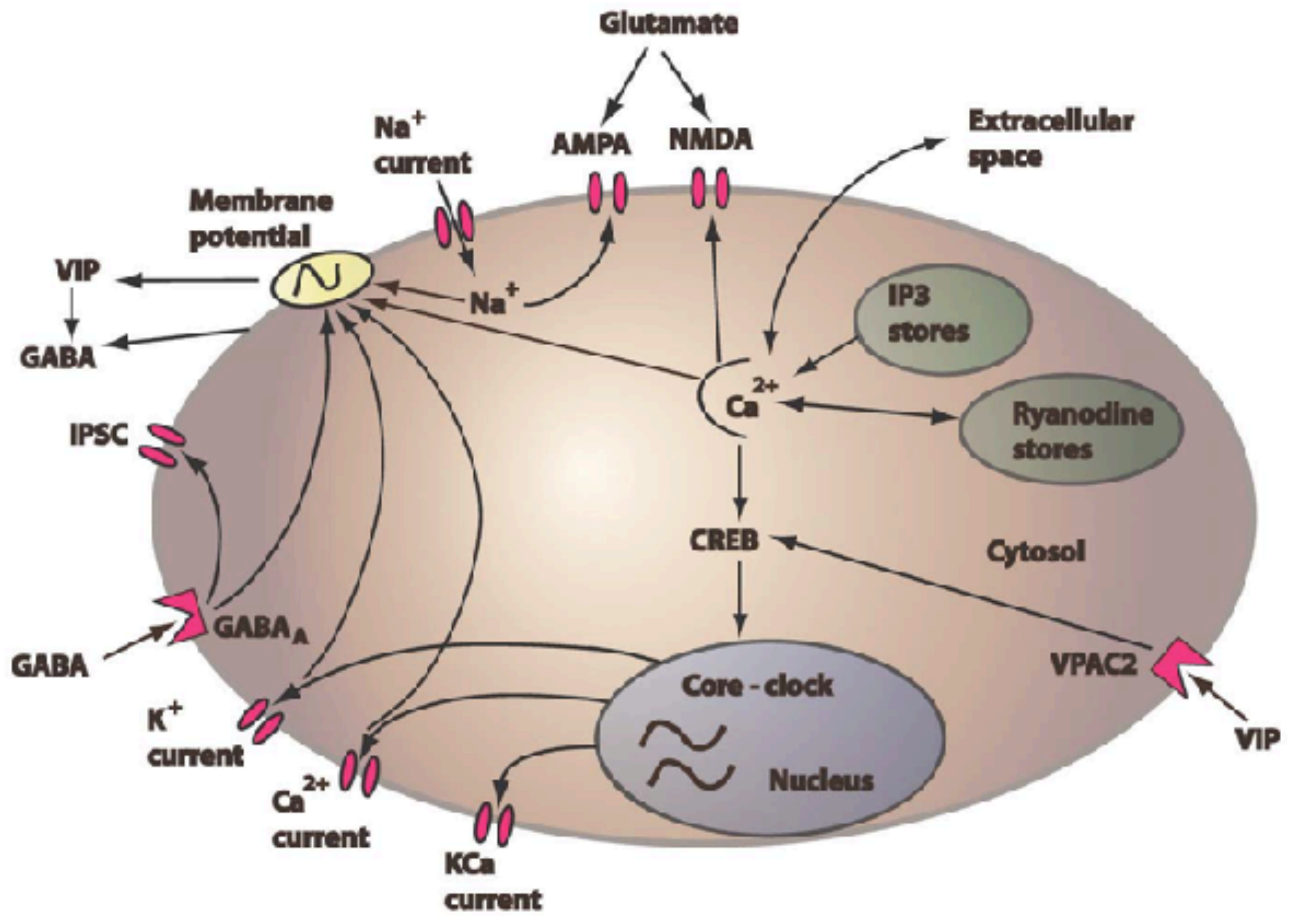


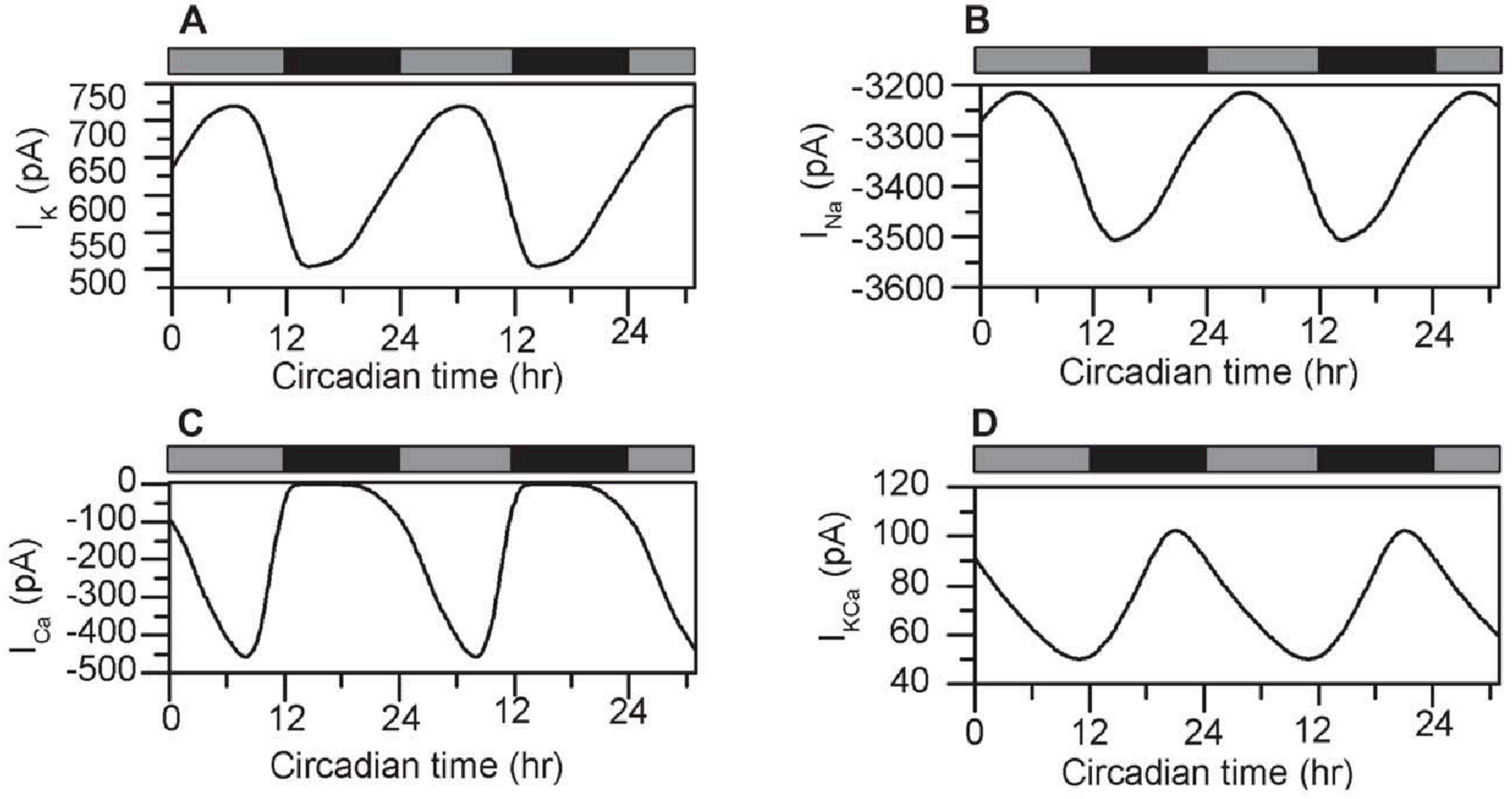


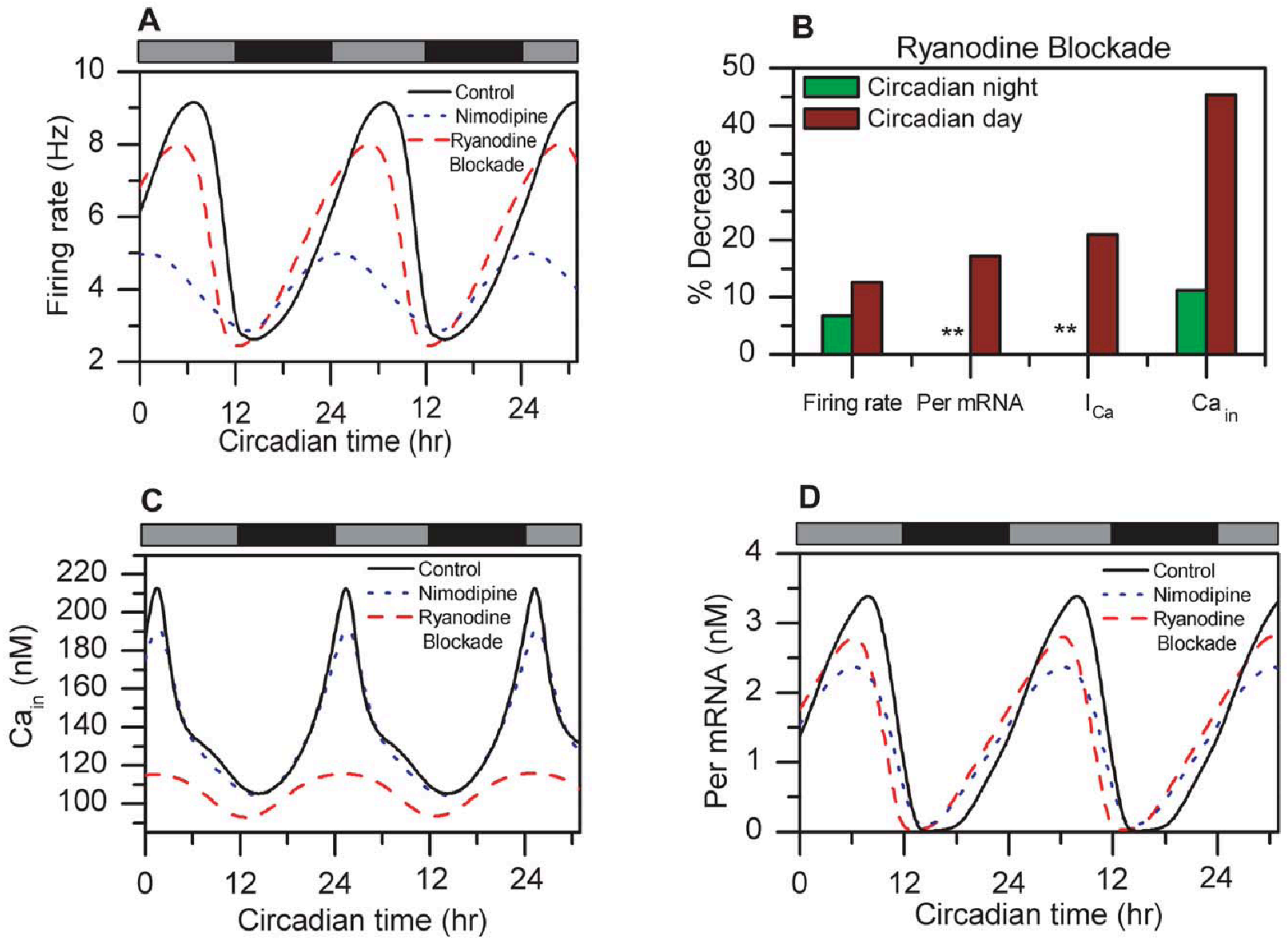
PLoS COMPUTATIONAL BIOLOGY

A Multiscale Model to Investigate Circadian Rhythmicity of Pacemaker Neurons in the Suprachiasmatic Nucleus

Christina Vasalou, Michael A. Henson*







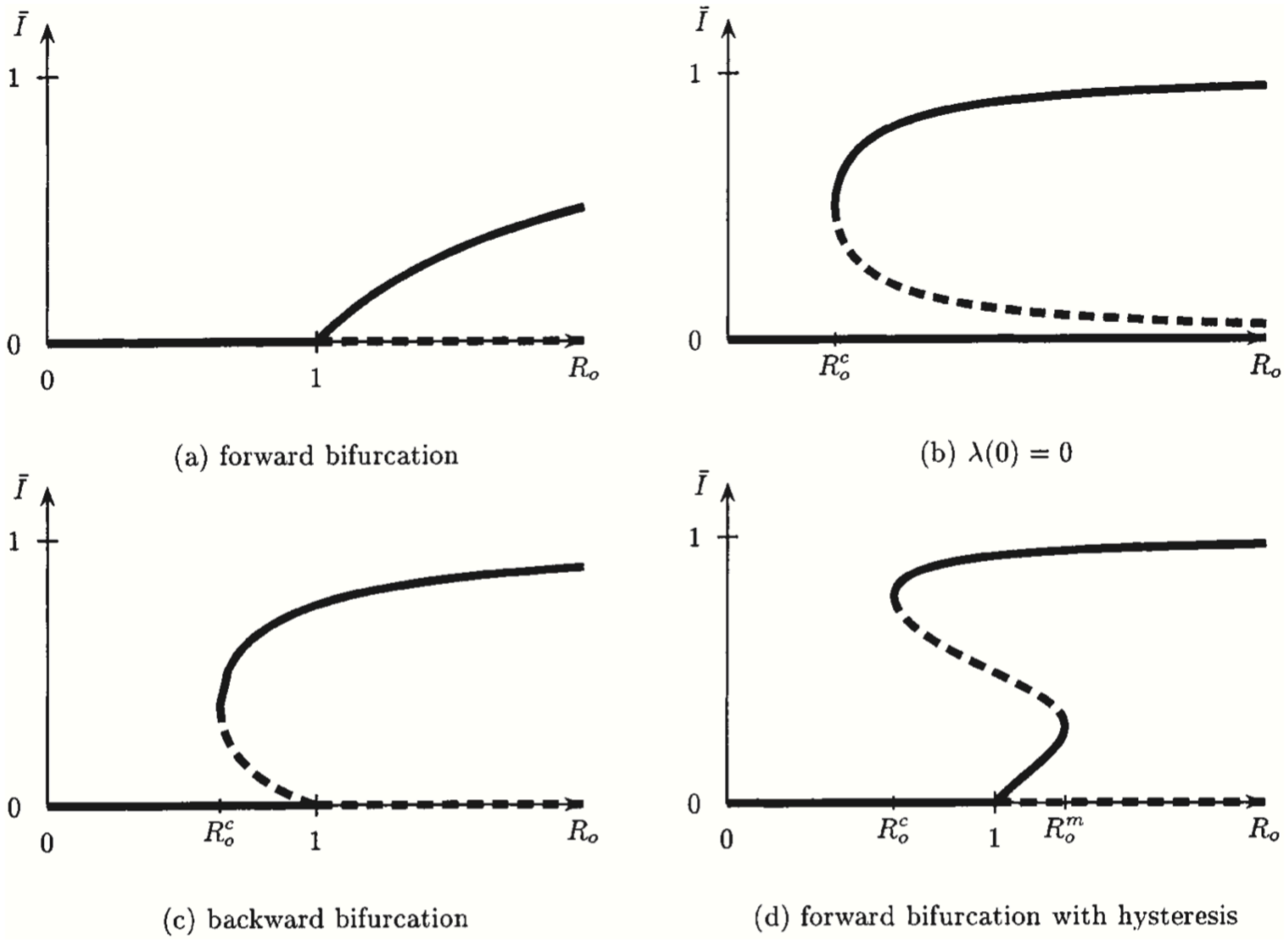
J. Math. Biol. 40, 525–540 (2000)
Digital Object Identifier (DOI):
10.1007/s002850000032

Mathematical Biology

P. van den Driessche · James Watmough

A simple SIS epidemic model with a backward bifurcation

$$I(t) = I_o(t) + \int_0^t \lambda(I(u))I(u)(1 - I(u))P(t-u)e^{-b(t-u)}\,du,$$



Biophysical Journal Volume 89 July 2005 120–129

Spontaneous Synchronization of Coupled Circadian Oscillators

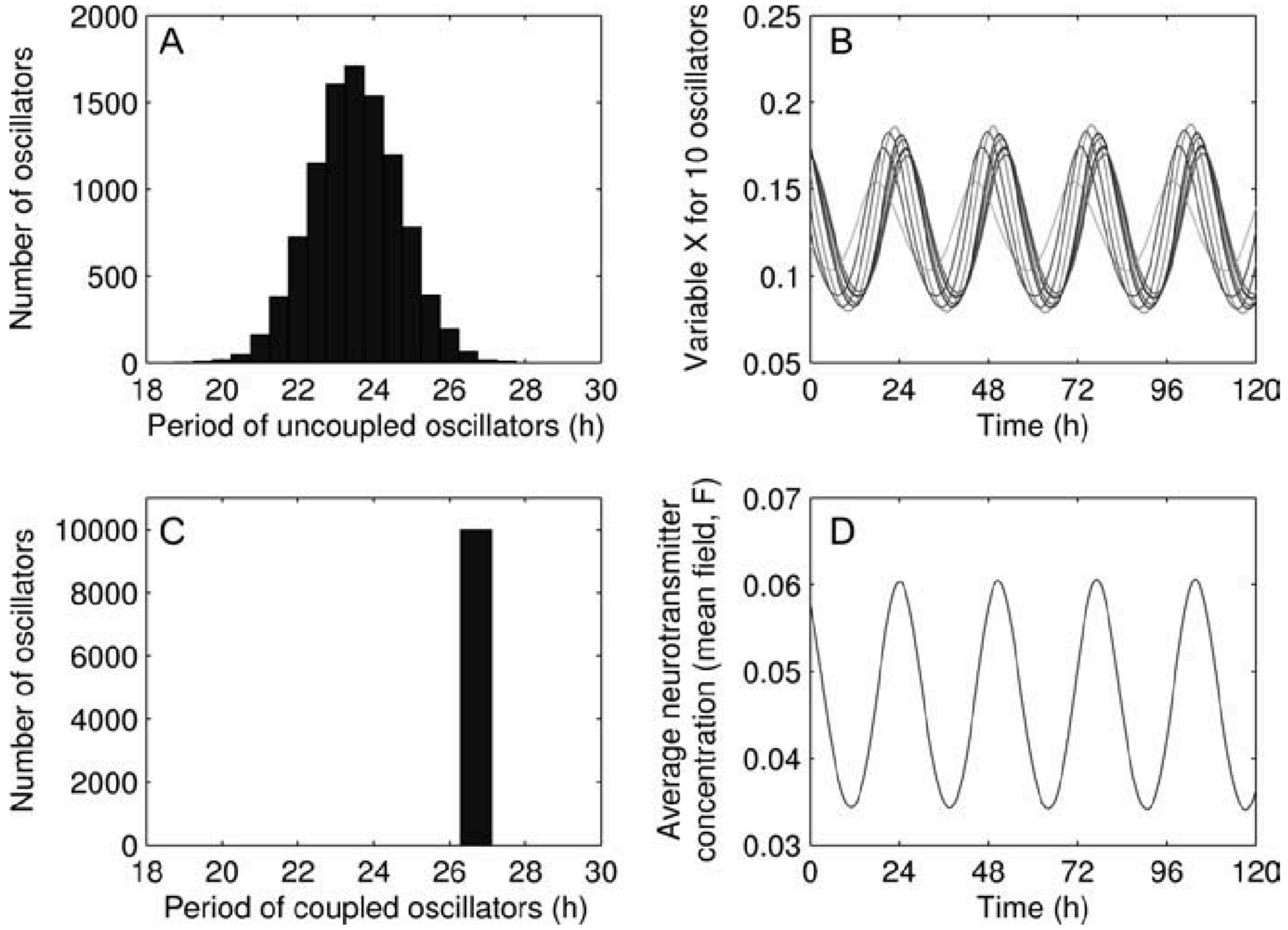
Didier Gonze,*† Samuel Bernard,* Christian Waltermann,* Achim Kramer,‡ and Hanspeter Herzel*
*Institute for Theoretical Biology, Humboldt Universität zu Berlin, Berlin, Germany; †Unité de Chronobiologie Théorique, Université Libre de Bruxelles, Brussels, Belgium; and ‡Laboratory of Chronobiology, Institute of Medical Immunology, Charité-Universitätsmedizin Berlin, Berlin, Germany

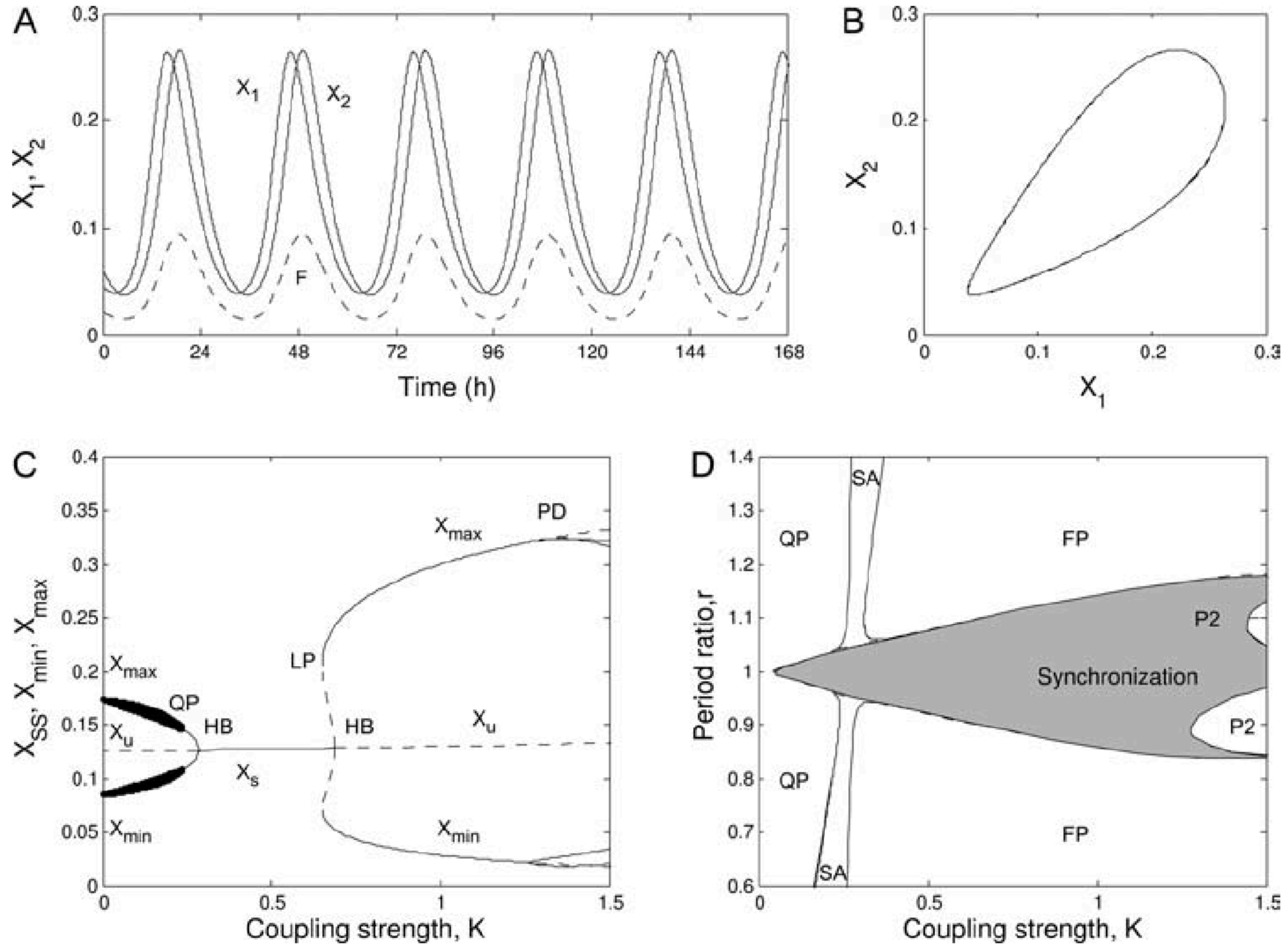
$$\frac{\mathrm{d}X_{\mathrm{i}}}{\mathrm{d}t} = v_1\frac{K_1^{\mathrm{n}}}{K_1^{\mathrm{n}}+Z_{\mathrm{i}}^{\mathrm{n}}} - v_2\frac{X_{\mathrm{i}}}{K_2+X_{\mathrm{i}}} + v_{\mathrm{c}}\frac{KF}{K_{\mathrm{c}}+KF} + L, \quad (1)$$

$$\frac{\mathrm{d}Y_{\mathrm{i}}}{\mathrm{d}t} = k_3X_{\mathrm{i}} - v_4\frac{Y_{\mathrm{i}}}{K_4+Y_{\mathrm{i}}}, \quad (2)$$

$$\frac{\mathrm{d}Z_{\mathrm{i}}}{\mathrm{d}t} = k_5Y_{\mathrm{i}} - v_6\frac{Z_{\mathrm{i}}}{K_6+Z_{\mathrm{i}}}. \quad (3)$$

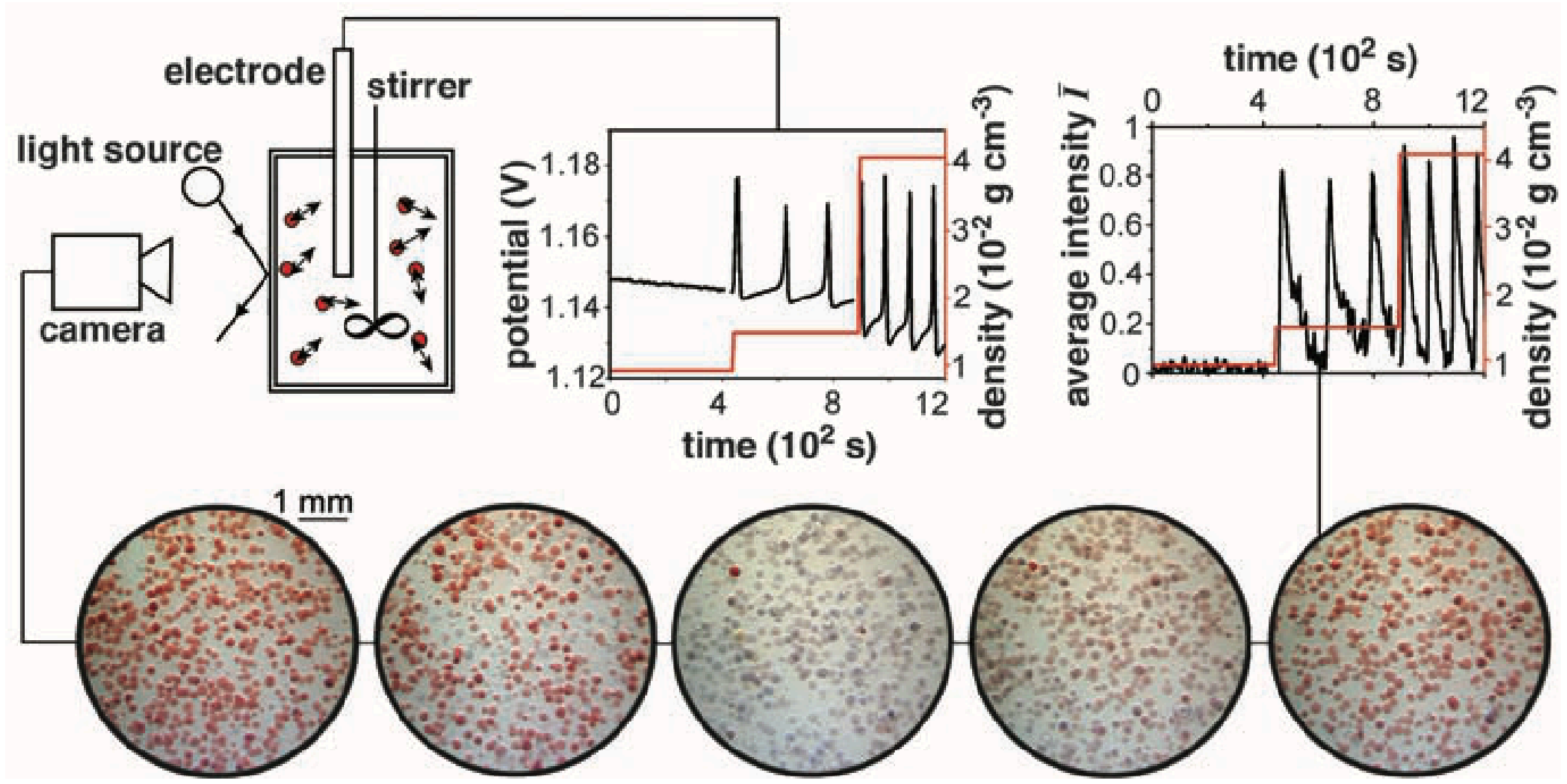
$$\frac{dV_{\mathrm{i}}}{dt} = k_7X_{\mathrm{i}} - v_8\frac{V_{\mathrm{i}}}{K_8+V_{\mathrm{i}}}. \quad (4)$$





Dynamical Quorum Sensing and Synchronization in Large Populations of Chemical Oscillators

Annette F. Taylor,[1] Mark R. Tinsley,[2] Fang Wang,[2] Zhaoyang Huang,[2] Kenneth Showalter[2]*



$$\frac{dX_i}{dt} = -k_{ex}(X_i - X_s) + f(X_i, Y_i, Z_i) \qquad (1)$$

$$\frac{dX_s}{dt} = \frac{\overline{V}}{V_s}\sum_i N k_{ex}(X_i - X_s) + g(X_s, Y_s)$$