NONLINEAR DYNAMICS, MATHEMATICAL BIOLOGY, AND SOCIAL SCIENCE

Joshua M. Epstein

Senior Fellow, Economic Studies Program, The Brookings Institution, and Member, External Faculty, Santa Fe Institute

Lecture Notes Volume IV

Santa Fe Institute Studies in the Sciences of Complexity



Addison-Wesley Publishing Company, Inc. *The Advanced Book Program*

Reading, Massachusetts Menlo Park, California New York Don Mills, Ontario Harlow, England Amsterdam Bonn Sydney Singapore Tokyo Madrid San Juan Paris Seoul Milan Mexico City Taipei Publisher: David Goehring Editor-in-Chief: Jeff Robbins

Production Manager: Pat Jalbert-Levine

Director of Publications, Santa Fe Institute: Ronda K. Butler-Villa

Production Manager, Santa Fe Institute: Della L. Ulibarri Publication Assistant, Santa Fe Institute: Marylee Thomson

This volume was typeset using T_EX tures on a Macintosh IIsi computer. Camera-ready output from a Hewlett Packard Laser Jet 4M Printer.

Copyright © 1997 by Addison-Wesley Publishing Company, The Advanced Book Program, Jacob Way, Reading, MA 01867

All rights reserved. No part of this publication may be reproduced, stored in a retrieval sytem, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher. Printed in the United States of America. Published simultaneously in Canada.

ISBN 0-201-95989-5 Hardback ISBN 0-201-41988-2 Paperback

1 2 3 4 5 6 7 8 9-MA-0100999897 First printing, April 1997

Contents

| Introduction | 1 |
|---|-----|
| LECTURE 1: On The Mathematical Biology of Arms Races, Wars, and Revolutions | 7 |
| LECTURE 2: An Adaptive Dynamic Model of Combat | 19 |
| LECTURE 3: Imperfect Collective Security and Arms Race Dynamics: Why a Little Cooperation Can Make a Big Difference | 41 |
| LECTURE 4: Revolutions, Epidemics, and Ecosystems: Some Dynamical Analogies | 69 |
| LECTURE 5: A Theoretical Perspective on The Spread of Drugs | 89 |
| LECTURE 6: An Introduction to Nonlinear Dynamical Systems | 107 |
| References | 151 |
| Index | 159 |