Sexual Interactions in Eukaryotic Microbes

edited by Danton H. O'Day/Paul A. Horgen

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Preface

We decided to compile a book dedicated to the sexual processes of eukaryotic microorganisms because previously no complete, up-to-date volume existed on this subject. Although there have been many individual recent reviews on various aspects of microbial mating, both specific and general, these works do little to provide the reader with a detailed understanding of the individual organisms and their real and potential value as research tools.

Essentially all of the microbes whose sexual cycles have been detailed to a significant extent in the past are examined in this book. In keeping with our intent to impart some special knowledge to our readers, each chapter has been written according to a more-or-less specific organizational plan. Each begins with a summary of aspects of the lifestyles, life cycles, and availability of the organism under analysis. After a subsequent brief review of previous work done on the sexual processes of the specific organisms and its relatives, the authors describe in detail the current research of their laboratories. Finally, they discuss what they consider to be important areas for future work.

Because of its design, this book should be of value on a multitude of levels: from a general reference text to a source of research ideas. We feel it should appeal to a wide spectrum of readers in a large number of disciplines, but will be particularly valuable to cell biologists, microbiologists, protozoologists, and mycologists interested in the study of cellular communication.

We thank Elinor Foden for her exceptional secretarial assistance and editorial comments. We also thank the staff of Academic Press for their assistance in the compilation of this work. We sincerely hope that it will fill the existing void.

Danton H. O'Day
Paul A. Horgen

Part I
INTRODUCTION

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1

Modes of Cellular Communication and Sexual Interactions in Eukaryotic Microbes

DANTON H. O'DAY

I. INTRODUCTION

Although the topic under consideration in this book is sexual interactions in eukaryotic microbes, the essential problem under analysis is the ways in which eukaryotic cells communicate with one another. The survival of cells as individuals and as integral parts of multicellular organisms requires that they be able to communicate with other cells. Cell communication is important in the regulation of cell movement, morphogenesis, cellular differentiation, cell division, and cellular adhesivensss. Whether cells interact over long distances or short, two essential components must comprise their communications systems: (1) a signaler, which produces and transmits the message, and (2) a responder, which receives the message and translates it into an action.

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There appear to be a limited number of ways in which eukaryotic cells communicate. These are diagrammatically represented in Fig. 1 and each system is outlined in the following section. Rather than provide an exhaustive review, the aim of this chapter is to set the stage for the chapters that follow by giving an overview of what we understand about intercellular communication. One should keep in mind that a cell may, at a point in time or throughout its life, utilize several and possibly all methods of communication. The use of one communication system does not exclude another.

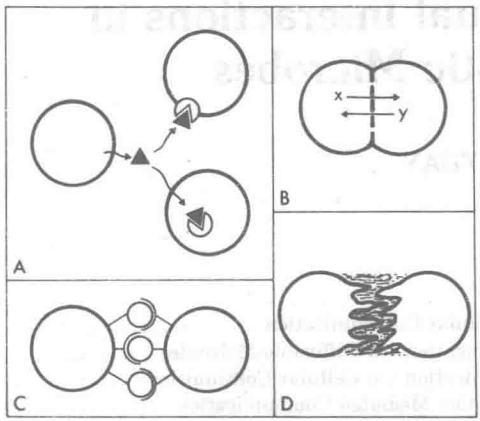

Fig. 1. A diagrammatic representation of the modes of communication used by eukaryotic cells. (A) Communication via diffusible molecules. One cell or a group of cells synthesizes and secretes a message molecule which travels in the extracellular environment. The message is received by a target cell which has surface receptors (upper cell) and/or intracellular receptors (below) that are specific for the molecule. (B) Communication via cellular continuities. In this system direct cytoplasmic coupling exists between cells. These vary in size and may be large enough to permit penetration of entire organelles or small enough to restrict the flow of all but specific ions. They may or may not reveal special structural differentiations. Gap junctions are special structures which allow cells to be metabolically and/or ionically coupled. (C) Cell contact-mediated communication. Cell contact regulates many biological phenomena. The example shown represents the most widely accepted concept of cell-cell contact which involves complementary molecules bound to the surface of the adjacent cells. Generally, the molecular interaction is believed to be a molecule-receptor or an enzyme-substrate (glycosyltransferase) interaction. Other types of contact-mediated communication may also exist. (D) Extracellular matrix-mediated communication. This is similar in some ways to the situation discussed in (C) except that extracellular components are interposed between and essential for the communication between adjacent cells. The similarity lies in models that propose adhesive molecular interactions between the cells and the extracellular matrix. The difference lies in models that propose that the matrix provides other functions such as collecting and concentrating extracellular factors of communication. In all of these models the message that is received by the target cell(s) must be interpreted and transduced into a subsequent biological response.

II. MODES OF CELLULAR COMMUNICATION

A. Communication via Diffusible Molecules

1. Hormones versus Pheromones

Distance alone should not be a priori a means of inferring that a specific method of communication is employed. However, if cells are to communicate over long distances they must employ chemicals which diffuse in the extracellular environment. The messages that are sent can be received either by the cell surface or by an internal receptor of the target or responder cell (Fig. 1A). Subsequently the message–receptor complex will dictate a specific cellular response.

Specific molecules of communication that are produced and secreted within one part of an organism which influence other parts of that same organism are termed hormones. Although the microbial literature is full of references to hormones, it is clear that the term is not being correctly used since these molecules are released from one organism to influence others. Karlson and Luscher (1959) proposed the term pheromone for such interorganismic molecules of communication and this is the term which is employed throughout this volume regardless of historical usage. Part II of this book focuses on pheromonal communication during sexual development in eukaryotic microbes. While most hormones that serve the same function in different multicellular organisms are very similar in structure and often cross-immunoreactive, pheromones do not necessarily show such molecular relatedness even in closely related species. In his chapter, Kochert expresses the view that this reflects the role of pheromones "which serve as a vital communication mechanism through an external medium between individuals of the same species." It would be disadvantageous to an organism's survival to respond to the pheromones of other species. Thus, although all *Volvox* sex pheromones appear to be glycoproteins they are species specific (see Chapter 4 by Kochert). Similarly, species-specific sex pheromones are produced by *Dictyostelium* (see Chapter 9 by O'Day and Lewis). In *Blepharisma,* Miyake shows that the glycoprotein gamones (gamone 1) which control the mating interactions are also species specific. In contrast, several species of *Achlya* all seem to use identical female (antheridiol) and male (oogoniol) sterol sex pheromones (see Chapter 7 by Horgen). The most unusual situation occurs in the Mucorales where all genera appear to use trisporic acid as their sex pheromone. However, as is detailed by Jones *et al.,* the control in this sexual system resides at the