

Meeting preview

Microbial signalling and communication

A preview of the topics to be discussed at the SGM Main Symposium at Edinburgh, 13–14 April 1999

An inspection of the primary research journals or a search of the publication databases reveals a healthy interest in microbial signalling and communication. Suffice it to say that we felt it timely for the SGM to pay attention to this area by producing a symposium to explore our current understanding of this topic. The forthcoming meeting in Edinburgh, and associated symposium volume, covers a cross-section of material from groups throughout the world who are, and continue to be, leaders in their field. By way of introduction to the subject we should perhaps start with literal definitions.

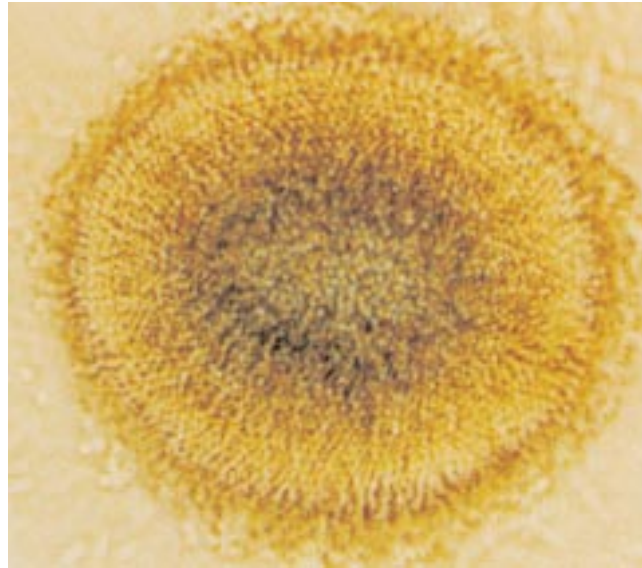
● The terminology

The word signal is defined as 'to send, notify, announce, communicate by means of signals', whereas, communication is defined as 'that which is communicated, a letter, a message, information imparted by speech, writing, etc.' Taking these two interrelated dictionary definitions as they stand would suggest that fundamental to each is an absolute requirement that there is a 'language' based upon a set of symbols, by which the signaller can communicate and be understood by the signalled. As human beings we are constantly signalling and communicating in the form of words, gestures, symbols, etc., to ourselves and each other. These communications allow us to carry out many diverse functions in a 'social' environment with relative speed and efficiency, enabling us to hopefully enjoy and survive another day. At a simpler level, it is known that for successful cell division to occur within a culture of mammalian cells there is a requirement for extracellular growth factors called cytokines, which act as chemical signals. It is becoming clear that similar chemicals also occur in higher plants, multicellular invertebrates and ciliates. Within the world of micro-organisms signalling, communication, and hence information flow, also occur.

Language is the common factor between all methods of communication used by biological organisms. This symposium will attempt to decode and translate the different languages and, by definition, vocabularies (chemical signal molecules) utilized by a wide range of different micro-organisms within various environmental situations. For some micro-organisms we know the chemical structure of the signal molecule(s) utilized; however, in others the structures are far less clear. Perhaps the most exciting feature of the symposium is that we will hear how, and under what conditions, micro-organisms communicate with each other and also other biological cells, and how in some instances we can exploit this knowledge.

● Microbial communication

One area of microbial communication that has advanced considerably in recent years is that of bacterial cell-cell communication. This has been facilitated by the discovery of the chemical nature of the signal molecules involved. In most cases they have been shown to be small peptides or a modified form of homoserine lactone. These types of signal



molecules have often been referred to as 'pheromones' or 'autoinducers'. Where's the dictionary? If we accept the definition of a pheromone, as 'substances which are secreted to the outside by an individual and received by a second individual of the same species, in which they release a specific action, for example, a definite behaviour or a developmental process', then their *raison d'être* becomes clearer. In most cases this can be viewed as a density-dependent or quorum sensing process, by which a signal molecule is released into the local environment that cannot be detected by an individual bacterium or even low numbers of bacteria. Only when bacteria are at relatively high numbers, or within a confined environment, will a threshold level of signal molecule be reached that can then initiate specific gene expression required for the 'survival' mechanisms peculiar to the genus of bacterium involved. Thus we have the captivating situation of intercellular communication, by signalling, from bacteria that may not be in close physical contact. Examples that we will hear about at the meeting are: antibiotic production and regulation in *Streptomyces* and *Erwinia*; multiplication of prokaryotes and a role in viable-but-non-culturable (VBNC) cells; gene transfer mechanisms in *Enterococcus*; biofilm formation; multicellular differentiation of *Myxococcus* (Fig. 1); and quorum sensing in Gram-negative pathogenic bacteria. Not only will the types and role of signal molecules in all of these diverse processes in prokaryotes be described, but there will also be plenty of

Fig. 1. Fruiting body of *Myxococcus xanthus* viewed from below in bright field optics.
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discussion about the exploitation of the knowledge available to us, either in terms of increasing production of a particular natural product, or conversely, as a target for controlling cellular proliferation, or as a means to help detect otherwise undetectable bacteria.

"What about the eukaryotes?!" we hear you exclaim.

Pheromones are not only produced by bacteria. Events in pheromone pathways of yeasts are similar to those found in higher eukaryotes. The fission yeast, *Schizosaccharomyces pombe*, has proved to be an excellent organism for studying the communication processes. The audience will hear about the production and action of peptide hormones on target cells, also how the cell recovers from the effects of stimulation and returns to a resting state. Continuing the eukaryotic theme, chemical communication between fungal hyphae will be discussed. The pheromones involved in the cross-talk between hyphae are very diverse and range from oxygen to peptides, which interact with specific chemoreceptors, coupled to signal transduction pathways within the hyphae.

The life cycle of the slime mould *Dictyostelium discoideum* incorporates key features of morphogenesis found in higher organisms, e.g. chemotaxis, cellular differentiation and multicellular organization. The audience at the symposium will hear about quorum sensing and cAMP in signalling mechanisms and mathematical modelling of cell streams in *D. discoideum*. The accurate prediction of cellular behaviour with models provides reassuring evidence that we do now understand signal mechanisms. The models afford the opportunity to test new hypotheses.

Another group of organisms that will be discussed, and many people will be new to them, are the dinoflagellates. These organisms dominate the plankton of the subtropics in the world's oceans and subsequently are important ecologically and economically. However, very little is known about their signalling mechanisms that have been proposed to mediate cellular processes including encystment, cell division and bioluminescence. Cell-to-cell recognition of endosymbiotic relationships between the coral-dinoflagellate associations is only just beginning to be understood. We will be fortunate to hear the latest information on this fascinating topic.

If your scientific appetite is still not quite whetted and you haven't tried accessing the web for the rail network timetable to Edinburgh, then read on.

● Microbes and plant cells

Continuing with cell-cell communication, let us talk plant cells for a moment. Microbial-plant cell communication will be discussed from both pathogenic and symbiotic aspects. The signalling molecules involved in bacterial-plant cell communication can be broadly classified as: synthesized metabolites, e.g. syringolides produced by *Pseudomonas syringae* that infects soybean; secreted proteins, e.g. non-specific plant-degrading enzymes that in some bacteria are regulated via quorum sensing; proteins that

are delivered into plant cells causing a hypersensitive response, which eventually kills the invasive bacteria; and nodulation signalling proteins produced by the symbiont *Rhizobium* spp.

Taking up the plant pathogen baton, we will hear about the signalling interactions between the eukaryotes *Phytophthora* and *Pythium* and their host-plant cells. The hallmark of these organisms is their ability to form zoospores that are required for the dispersal of the organism through films of water within wet soils. The signalling systems involve chemical and electrical signals generated by the host plant to guide zoospores to the plant which eventually leads to invasion of the plant cells. Much of the work described will deal with zoospore-root and zoospore-zoospore interactions.

Understanding the mechanisms by which plant-associated pathogens/symbionts produce/regulate synthesis of signalling molecules or respond to plant-induced signals will be of immense benefit to the agricultural industry. It could lead to the development of blocking or enhancing agents, either *ex planta* or *in planta*, depending on the particular requirement.

● Microbes and animal cells

Moving on from plant-associated micro-organisms, another extremely important topic that will be addressed is bacterial-animal cell communication. It is recognized that infective bacteria are able to alter eukaryotic signal transduction pathways and thus host-cell functions. As a consequence, invasive pathogenic bacteria are able to overcome the defence mechanisms of their animal host and to reproduce in the tissues. Within the last few years there have been considerable advances in the molecular detail of communication and signalling between pathogenic bacteria and animal host cells. In particular, the mammalian cell targets of some of the bacterial effector proteins have been investigated. To help illustrate the advances made in this important area, work will be presented on the interaction of enteropathogenic *Escherichia coli* (EPEC) (Fig. 2) and enterohaemorrhagic *E. coli* (EHEC) with mammalian intestinal enterocytes and the Yop system of

Yersinia spp. that obstructs a cellular immune response. Clearly, a better understanding of pathogenic bacteria-host cell communication would allow the rational design/development of drugs that could block bacterial effector protein action and/or synthesis.

Concluding this outline of the Main Symposium in Edinburgh, we would like to first apologize to any speaker who feels we have misrepresented their contribution. Second, we encourage scientists from widely diverse disciplines (academic, medical and industrial) to come along, signal and communicate, as there is something for everyone in what should prove to be a very stimulating and thought-provoking session. Third, if you cannot get to Edinburgh then the book will be available from Cambridge University Press.

We hope to see you in Scotland.

Symposium organizers

● **Dr Reg England**
Department of Biological Sciences, University of Central Lancashire, Preston

● **Dr Glyn Hobbs**
School of Biomolecular Sciences, Liverpool John Moores University, Liverpool

● **Dr Nigel Bainton**
School of Biological Sciences, University of Surrey, Guildford

● **Dr Dave Roberts**
Natural History Museum, London

Further details of this meeting together with a booking form are given in the enclosed Programme Booklet. The symposium will be published as a book. A review and order form will be available in the May issue of 'Microbiology Today'.

Who did invent the Petri dish? The mystery deepens... Milton Wainwright

Oh the problems of assigning credit to discoveries! Just when I thought I had pinned down the discoverer of the 'Petri' dish as the English scientist, Percy Frankland (*SGM Quarterly* 25, 98-99) I receive news of a counter claim. This comes from Dr Philip P. Mortimer of the Central Public Health Laboratory, Colindale, who wrote a fascinating article (*PHLS Microbiology Digest* 14, 242), almost identical in style to my own, in which he gives credit for the 'Petri' dish to Emanuel Klein.

Klein (1844-1925) was a histologist and microbiologist who, although born in Slavonia, worked in England from 1872 until his death. He made important, and largely overlooked, contributions to microbiology and also wrote an influential textbook called *Micro-organisms and Disease* which, by 1886, had reached its third edition. As Dr Mortimer points out, Klein (on p. 43 of the book), provides a line drawing of his dish and details its use to isolate bacteria. His description of a 'Petri' dish appeared in 1886, the same year as Frankland's. Both descriptions predate Petri's paper by at least a year. Did Klein then beat Frankland to the 'Petri' dish?

The preface to Klein's book is dated November 1885, so it would seem that he was using his dish in the year before the appearance of the third edition of his book. This would give him priority on the invention over Frankland, whose paper appeared in the *Proceedings of the Royal Society* dated June 1886. However, we do not know how long Frankland, or Klein (or, for that matter, Petri), were using their dishes before they published. In the absence of their notebooks it is therefore impossible to assign priority accurately.

In the fourth edition of his book, published in 1889, Klein refers disparagingly to the fact that Petri's name is associated with the famous dish, claiming that he had used his identical dish some years before Petri's paper appeared. Yet, as far as I can tell, Klein fails to mention his dish in any of his papers published prior to 1886. However, in one that appeared in the *Practitioner* of 1887 (i.e. in the same year as Petri's paper appeared) Klein describes how he used his dish to isolate air-borne micro-organisms. This paper is clearly influenced by Frankland's earlier Royal Society contribution on the same subject.

It is also worth noting that Klein, unlike Frankland, suggested that his dishes be covered with a large glass bell jar, thereby making his approach somewhat cumbersome. Petri also used a bell jar in the same way and his description of this dish is almost identical to that given by Klein. The fact that Klein was annoyed when Petri received the recognition for what he considered to be his dish, suggests that Petri, either directly or indirectly, was not the source of his inspiration.

Who then invented the 'Petri' dish? As I stated above, we do not know how long the individual contenders used their dishes before they announced their inventions; as a result, we must rely upon publication dates. At the moment (there may yet be other contenders!), the race is clearly between

Frankland and Klein. Since it is such a close run thing, it would be fair to talk about Frankland-Klein (or FK) dishes. However, if on pain of death I had to choose between the two competing claims I would give the result to Frankland, simply because he published details of his invention in a refereed scientific journal, while Klein's description appeared in a book. When assigning authority for a discovery or invention, the former usually has priority over the latter. My result then - Frankland by a nose, with Klein second and Petri nowhere in the frame!

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