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AXENIC CULTURE OF RUST FUNGI: CURRENT STATUS AND FUTURE CHALLENGES

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For some of the most innovative studies now undertaken in agriculture, biology and medicine, it is very useful, and often absolutely necessary, to be able to culture a micro-organism in the laboratory under aseptic conditions. In agriculture, there is a constant need to culture the most harmful parasites of crop plants in the laboratory, so that they can be examined and studied experimentally and be better understood; it is a case of 'know your microbial enemy'. It is no accident that as early as the middle of the last century, the journal *Nature* published a leading article entitled 'The future of parasitology', which stressed the importance of culturing pathogens free from their hosts and other micro-organisms, stating that, *'when we know how the parasite breathes, feeds, excretes, and uses, within its host and at its host's expense, whatever biochemical processes link it to that host, we may learn to control it'* (Anonymous, 1951). However, it is no easy matter to grow a biotrophic micro-organism in the laboratory, as is shown by the scant number of rust agents that have so far been cultured in this way. Both the lifestyle of the micro-organism itself, and extrinsic factors such as the culture conditions may prevent growth. Failure to grow can be overcome by an attentive study of the parasite and its nutritional requirements (or, failing that, by relying on what is known about some related organism) and by determining the optimal conditions for culturing the organism *in vitro*. At present, new opportunities have opened up to grow microbial agents axenically. Much more than in the past, thanks also to the powerful research tools now available, axenic cultures can be profitably used to study the biology of these biotrophs. The advantages to be reaped from these advances are immense and there is no time to list them all here. To mention only a few, axenic cultures are ideally suited to study the metabolic processes and nutrition of rust agents separately from their hosts. Mycelium obtained from culture can serve as inoculum, available at any time of year and for any kind of experiment, ranging from DNA-based studies to artificial infection tests. Axenic cultures can thus also have an important practical role in the control of rust diseases. They can be employed to study the host-parasite interaction, shedding light on what makes a plant resistant or susceptible, and help in screening host pedigrees to evaluate complementary gene action in rust disease, facilitating the identification of resistant host plants. Axenic cultures further have important applications in research on rust physiology, diversity, and on research aimed at deciphering the signal exchanges at the host-parasite interface. Modern experimental techniques, such as those involved in transcriptomics and proteomics, which depend on the availability of extractions of uncontaminated RNA or proteins, would be impossible without the availability of 'cell-free' (i.e. uncontaminated) rust coltures. Lastly, I should like to point out that the notable advances on *in vitro* rust cultivation have not prevented the rust agents from still continuing to play the leading role that they have always played in the study of plant pathology in general. If the pioneering studies of Biffen on the inheritance of resistance, and Flor on the gene-for-gene hypothesis, were instrumental in the development of the plant pathology discipline, these later advances have made the concepts of this field more precise. Since it has been shown that the rusts can be cultured *in vitro*, they are now no longer viewed as being entirely dependent on the living tissues of their hosts, and this has led to a reconsideration of some of the basic concepts of plant pathology such as obligate parasitism, biotrophism, host specificity and fungal nutrition.