polysaccharides from the vegetable materials ingested to the tissues of the animal. No mention has been made in this communication of the protein syntheses integral to the maintenance of a microbial population in the cæcum or rumen; nor of the initial nitrogen sources from which they may be able to proceed. A detailed study of some microbiological aspects of the problem is, however, now being made in close collaboration with the biochemical investigation of *in vitro* incubations of rumen contents in progress at the Hannah Dairy Research Institute[3,8].

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Spore Dispersal in the Mucorales

THE problem of spore dispersal presented in my last communication[1] is now partially solved, as a result of spore-blowing experiments and the observation of cultures grown in cemented glass cells with coverslip surfaces.

The chief fact which emerges is that the Mucor sporangium is primarily a water dispersal mechanism, and that Mucor spores, for the most part, become air-borne only after preliminary separation in water, and then chiefly on the surface of soil dust particles and hyphal fragments.

The sporangial membrane in Mucors breaks up and eventually disappears in contact with water. In Mucors with thin walls, usually described as 'diffluent' (for example, *M. hiemalis*), this process is rapid, and if the sporangium remains untouched in moist air it gives place to a conspicuous sporangial drop. The stalk on losing turgidity collapses and usually brings the drop against a solid surface, whereupon it spreads out rapidly owing to surface tension. The word 'burst' is inappropriate to describe this process. On drying down the spore masses remain firmly stuck together with mucilage which, however, is readily dissolved and the spores separated in water.

Growing on organic matter in soil the sporangiophores can be seen to form a network linking the soil particles, against which the sporangia are inevitably brought into contact at some stage, with the presumed result that the spores are dispersed by the soil water when present.

Spore-blowing experiments on this type of Mucor show them to be complete *spore retainers* in air. The function of the sporangiophore is thus seen to be that of ensuring some preliminary dispersal of the spore masses, rather than that of raising the sporangium into the air. Its sensitiveness to light in the early stages of growth may also have the effect of counteracting the down-washing of water, and raising the spore masses so as to keep them in the upper layers of the soil, where both aeration and organic matter provide more favourable conditions for the growth of Mucors.

However, when air-dried soil, which has been sterilized and then soaked in a suspension of spores of *Mucor hiemalis*, is subjected to gentle blowing, many colonies are obtained, some of which arise from visibly single spores, but the majority from soil particles, and natural soils also yield scattered colonies of diffluent-walled Mucors. The occurrence of air-borne infections by Mucors of this type is thus explained, and also their frequent presence in dust.

Some species, however, notably *M. rouxianus*, exhibit a subsidiary form of air dispersal, in that the old dry mycelial network is extremely brittle, and when blown upon fragments, yielding scattered colonies each of which is found to arise from a spore mass, or even a single spore, attached to a hyphal fragment. This is referred to as *hyphal spore dispersal*.

Mucor racemosus also fragments in this way, dispersing chlamydospores as well as attached sporangiospores. A few spore masses, without hyphæ, are also dispersed, and the stalks do not collapse so completely, so that some direct air dispersal is possible. Here the wall survives longer in contact with water, and the spores have been seen to pass out into a superficial drop. The sporangial drops are less conspicuous, as surviving pieces of wall may render them relatively opaque. Probably most of the Mucors with thick ('fragmenting') walls are of this type, which remains chiefly water-dispersed.

Absidia glauca is a *spore-mass-shedder* with relatively little hyphal dispersal. Despite such adaptations to air dispersal as stoloniferous growth, rigid sporangiophores, and a columella which collapses into a cup, liberating the whole spore mass, it forms sporangial drops, scatters no single spores in air, and seems to be readily water-dispersed. It is thus intermediate in type.

Rhizopus nigricans, however, exhibits advanced adaptation to air dispersal. The sporangiophores, borne aloft on 'stolons' and firmly 'rooted' on their substrate, remain rigid when dry, and the collapse of the columella into a bell-shaped cap exposes the spores to air movements for long periods. Such sporangiophores, grown in a glass cell in 1939, are still erect and capable of shedding viable spores after three years. The rough angular spores are not easily wetted, and do not 'clump' closely in water, so that they dry out rapidly, and are not stuck together in mucilage. This type, however, sheds no spores when moist, but broadcasts spore masses of varying size, and single spores, when quite dry. It is therefore called a *dried-spore-shedder*.

Finally, in conidial types such as Cunninghamella we have *spore shedders* which scatter spore masses from the fresh, moist colony, and vast numbers of single spores from the dry, and are comparable in efficiency of air dispersal with many Hyphomycetes.

The Mucorales are thus brought into closer relationship with the other groups from which they have been somewhat isolated. Once it is realized that the Mucor sporangium is a water-dispersal mechanism, it can bear some comparison with that of the soil Oomycetes, especially in those species which liberate akinetes, and at the same time the various conidial forms, some of them approaching those of the Plectomycetes, become intelligible as adaptations to air dispersal.

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[1] NATURE, **143**, 286 (1939).