MOLDS

INTRODUCTION TO MOLDS

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Molds are microscopically small plant-like organisms, composed of long filaments that grow over the surface and inside nearly all substances of plant, food, dry leaf, or animal origin. They are enabled by their filamentous construction. They can be nearly any color—e.g., white, orange, green, or black. Biologists consider them to be separate from the plant kingdom and members of the kingdom of fungi. They are related to the familiar mushrooms, differing only in not having their filaments united into large fruiting substances. Molds are vital part of the environment and are needed to break down dead materials. Very tiny and lightweight, mold spores travel easily through the air. Most building surfaces can provide adequate nutrients to support the growth of mold. When mold spores land on material that is damp—e.g., walls, floors appliances (such as humidifiers or air conditioners), carpets, or furniture—they can begin to multiply. When molds are present in large numbers, they may cause allergic symptoms similar to those caused by plant pollen. Molds are those dusty little spots that spread over bread, cheese, books, and other things in the home, cause the loss of millions of Naira and dollars to our economy every year. To deal successfully with this menace, we must understand what molds are and exactly what they are doing.

DESCRIPTION OF MOLDS

The filaments of the mold fungi are called hyphae. When the hyphae are numerous enough to be seen by the naked eye they form what is called a Mycelium. It is the hyphae and resulting mycelium that invade things in our homes and cause them to decay. Molds reproduce by spores. Spores are like seeds and germinate to produce a new mold colony when they land in a suitable place. Unlike seeds, they are very simple in structure and never contain an embryo or any sort of preformed offspring. Spores are produced in a variety of ways and occur in a bewildering array of shapes and sizes. In spite of this diversity, the form of spores is quite constant for any given mold, making it one of the most useful features for identification (see diagram). The most basic difference between spores lies in their method of initiation, which can be either sexual or asexual. Sexually initiated spores result from a mating between two different organisms or hyphae whereas asexual spores result from a simple internal division or external modifications of an individual hypha. The recognition of a mating and subsequent spore formation is often difficult for an observer, and is usually reserved for patient specialists. However, for practical purposes one can learn to recognize certain indications of the sexual process, namely, the four kinds of sexually determined spores that appear in mold fungi:

1. Oospores

2. Zygospores

3. Ascospores

4. Basidiospores

6.2.1 Oospores

They are produced when male gametes (reproductive nucleic) enter a large spherical cell (oogonium) and fertilize the eggs within. The result, as seen in routine examination, is numerous oogonia containing one to several spherical and often brownish eggs. The oogorus are usually penetrated by one or more hyphae (antheridia) that give rise to the male nucleus Fig. 6.1.

6.2.2 Zygospores

They do not occur inside any kind of enclosing structure, but are produced by the direct fusion of two hyphal protrusious (suspensors) from neighboring filaments. Usually zygospores are recognized as large, nearly spherical, often dark brown or black, rough-walled spores with two connecting hyphae, representing the two maturing gametangia. Sometimes the zygospores may be surrounded by several finger-like extensions from the two gametangia Fig. 6.2.

Ascospores

They are produced within spherical to cylindrical cells called “asci,” most often in groups of four or eight. Usually the asci are produced within some kind of enclosing structure and thus are not found exposed on the hyphae. In a few cases the oogonia with eggs, will never be penetrated by any sort of fertilizing hyphs. Fertilization occurs early in the life cycle and is not evident at the time ascospores are produced Fig. 6.3.

6.2.4 Basidiospore

They are always produced externally on a structure called basidium. Basidia come in a variety of forms, but those commonly encountered on molds will be club-shaped and bear four or eight spores on a sharp protrusion at the apex. At first, it may be difficult to distinguish between a basidiospore and one of the asexually initiated spore types, but one should always suspect the presence of basidia when externally produced spores consistently occur in groups of four or eight. As with ascospores, basidiospores are the result of an early fertilization that is not easily observed Fig. 6.4.

Asexual: spores usually occur either in sporangia or as conidia. Sporangia are modified hyphae or cells containing numerous spores (sporangios pores). They never have more than a single connecting hyphae and the spores do not constantly occur in groups of four or eight, as do ascospores.

6.2.5 Conidia

They are the most difficult group to characterize because of their great diversity of form. The only feature that most conidia have in common is that they occur externally on the cells that produce them.

6.3 TYPES OF MOLD

The Centers for Disease Control and Prevention (CDC, United States) states that all molds should be treated the same in terms of health risk and removal. Some Common Types of Mold

 Stachybotrys chartarum (also known as stachybotrysatra) Aspergillus sp. Penicillium sp. Fusarium sp. Trichoderma sp. Memnoniella sp. Alternaria sp.

All fungi strictly speaking should be classified according to their method of sexual reproduction. In many cases this is possible, allowing us to recognize several groups of fungi, of which the following four are of interest as molds.

Oomycetes

These members of the group all reproduce by oogonia and eggs. The hyphae have few or no cross-walls (septa) and these appear as long, clear tubes. If a hypha is broken, most of the contents run out. Many oomycetes reproduce asexually by zoospores, which are motile and can swim quite rapidly. Because of their motile zoospores, oomycetes commonly require water for reproduction and are often encountered in water or wet soil (Fig. 6.5).

6.3.2 Zygomycetes

As their name implies, these fungi all produce zygospores. They resemble the oomycetes in having hyphae that usually lack cross-walls or septa, but differ in lacking white spores. Asexual reproduction is by sporangia or conidia. The members of this group are usually terrestrial and will be encountered only occasionally in aquatic conditions (Fig. 6.6).

6.3.3 Ascomycetes

All ascomycetes have ascospores borne inside asci. The hyphae always bear numerous septa. Asexual reproduction is by conidia that always lack motility. Although most ascomycetes are terrestrial some occur in fresh water or marine habitat (Fig. 6.7).

6.3.4 Basidiomycetes

This large group, which includes mushrooms and puff-balls, is characterized by the presence of basidia and basidiospores. Like ascomycetes, to which

FIGURE 6.5 Examples of (A) zoosporangia of Sapralegnis sp. and (B) zoosporangia of Pythium sp.

they are related, basidiomycetes have hyphae with septa and lack motile spores. The hyphae of many basidiomycetes bear characterization swellings—called clamp connections—that play a specialized role in nuclear migration. Asexual spores when formed are produced as conidia. Most basidiomycetes are terrestrial.

6.3.5 Some Mold-Like Organisms

Often in routine work we encounter organisms that are similar to molds but which do not fit a strict definition of the term. Either the organism is not filamentous or it is filamentous but not strictly a fungus. Four groups of organisms can be put into this category: bacteria, actinomycetes, yeast, and slime molds.

FIGURE 6.6 Examples of zygomycetes. A sporangia of Mucor sp.

FIGURE 6.7 Examples of ascomycetes asci (cylindrical, clavate, and spherical).

6.3.5.1 Bacteria They represent a very ancient group of organisms, perhaps as old as four billion years. Colonies of bacteria are composed of minute spore-like cells that together form a slimy mass. Such colonies never contain hyphae and are thus easily distinguished from those of true molds. Bacterial cells, rarely more than 1 um in diameter, are difficult to examine, even with a good microscope, and are best seen when stained. Many bacteria are motile and swim vigorously.

6.3.5.2 Actinomycetes These organisms are usually classified as bacteria but have filaments like fungi. The filaments are seldom more than 1 μm in diameter, however, and are thus considerably narrower than those of molds. Streptomyces, the only actinomycetes genus commonly encountered as a "mold," produces gray to brightly colored powdery colonies, usually with a soil-like odor.

6.3.5.3 Yeasts These are true fungi, but in lacking hyphae cannot be classed as molds. They resemble bacteria in forming pasty or slimy colonies of spore-like cells, but differ in having these cells much larger, usually 2 μm or more in breadth. Reproduction of yeasts is usually by budding, a process where a smaller cell appears to bubble slowly out of the parent cell.

6.3.5.4 Slime Molds Slime molds normally occur on dead or nearly dead materials and other natural materials but many occasionally occur in the laboratory as "molds." Cellular slime molds, the most likely to appear in the laboratory, have creeping amoeba-like cells during one part of the life cycle and sporangium-like structures in another. They most closely resemble members of the zygomycete genus mucor, but differ in their complete lack of hyphae.

6.4 ENVIRONMENTAL OCCURRENCE

Every natural material one can name, no matter how small, will support an indigenous population of molds. Molds are part of the economy of nature, quickly occupying dead or nearly dead materials and returning them to the basic building components of new organisms. They are essential to what biologists cell nutrient cycling, the process whereby nutrients never leave the realm of living things, but simply get used again and again (forming the basis of the passage, "earth to earth, ashes to ashes, dust to dust"). Molds are known to be everywhere; it is useful to classify their habitats under a number of categories based on nutritional characteristics. Molds have specialized nutritional requirements and are not likely to range very far

from their usual habitats. The completion among molds having similar nutritional requirements is intense and leaves no room for a mold adapted to another habitat. Fungi that naturally decay seaweed on the beach will not be expected to occur on moldy bread in the kitchen. Some factors encourage habitat restriction among molds from nutritional and competitive barriers. Most influential is spore dispersal. Although most molds seem to produce astronomical numbers of spores they are, in fact, practicing a strict economy. There can be little waste, in their highly competitive life every minute bit of energy must be put to good use or a more efficient organism will prevail. Thus mold will produce only enough spores to ensure reproduction of their species from year to year. If a mold were to put a disproportionate amount of energy into spore production, it would have to be at the expense of other activities, such as rapid growth. Economy in spore production is best ensured by the existence of mechanisms of spore dispersal that confer a high probability that spores will encounter suitable places to germinate and grow. Many different mechanisms exist and account for the great variety of spores and spore-producing structures found in molds. Occasionally, molds living together in particular habitats have similar methods of spore dispersal even when the molds themselves are not closely related, illustrating the idea that many structures in organisms are similar because of common ecological pressures rather than common ancestry.

6.4.1 Dead Plant Materials That Support the Growth of Molds 6.4.1.1 Plants The molds that occur on dead herbaceous plants are often the same species that attack dying ones. Thus, we can again list Alternaria, Cladosporium, and others, as well as a few new ones such as Epicoccum, and Candida. In temperate climates, where many plants die in the fall, there is a tremendous flush of mold activity in autumn because the dead plant materials simply release their spores in the wind. The likelihood that a spore of Cladosporium, e.g., will hit a dead plant in the fall is very great. Nutritional specialization dictates that different plants will support different fungi and we find that, e.g., dead grasses will yield a different flora of molds than dead milkweeds or mustard, at least to a partial extent.

6.4.1.2 Wood Dead wood is a good source of molds and provides two distinct habitats, depending on whether it is covered with bark or not. Molds that occur under the bark of fallen and standing trees cannot disperse their spores into the air and most often utilize insects for their transmission. Although as we might expect, many have wet and sticky spores, some have dry spores, and we can speculate that these can become trapped among the insects' bodies for hours.

The surface of wood that is not covered with bark often has a distinct mold flora. Although air dispersal of spores is possible in this situation and apparently often occurs, wet-spored molds are still abundant. Again standing and fallen trees support different fungi. Freshly cut wood is a good source of molds causing a phenomenon called blue stain. These molds, common in lumber-yards as bluish to black discoloration on the wood, produce tall sporulating structures bearing wet drops of insect-transmitted spores.

6.4.1.3 Leaves Dead or dying leaves of trees support molds that are similar to those from herbaceous plants, with some notable exceptions, however. Tree leaves appear to support fewer Alternaria and Cladosporium colonies and this often allows a better chance to observe the more slowly growing or rarer fungi. Leaves that become submerged in water support a number of molds with unusual spore forms. The spores may be needle-like, coiled like a watch spring, or coiled into barred-shaped structures that bob to the surface of the water and float away. Others have three or four narrow arms and look something like jacks with two or three of the arms missing. These molds may be examined by submerging leaves in a bowl of water and stirring them vigorously. After a few minutes the spores will float to the surface, where they can be skimmed off in a drop of water.

6.4.1.4 Animals and Humans A number of diseases of humans and other animals are caused by mold and yeast-like fungi. Many are known only in this habitat and are quite specialized. Notable are the molds called dermatophytes, the cause of a number of skin diseases such as ringworm and athletes foot. The fungus grows on the outermost layer of skin, causing reddening of the surrounding tissues (zoophilic types) and sometimes scaliness (anthropophilic types). Dermatophytes do not normally attack deeper tissues; the symptoms are usually due to an allergic reaction.

6.4.1.5 Soil Soil is one of the most commonly studied mold habitats. It is a source of plant disease fungi, some human disease fungi, predacious fungi, and a host of forms that bring about the transformation of dead plant and animal material into soil. Fungi, because they are highly specialized users of organic substances, vary from one soil to another and with depth in the same soil. They are entirely dependent upon the kind of material that falls into the soil; a fungus that specializes in oak leaves will probably not colonize a pure needle. This factor alone will account for many differences between the mold populations of two soils. In addition fungi may be sensitive to moisture levels, pH, competition from other organisms, and many other influences.

As a leaf falls into the soil it gradually becomes buried under newer generations of leaves and thus moves down into the lower layers of soil. At the same time, it undergoes continuous decay by molds and other organisms until it finally disappears (somewhere in the B layer; a mineral layer in the soil containing little organic matter). The fungi that first invade the leaf, often while it is still on the, will grow on it until the particular nutrient they need is exhausted and then die back from the leaf. In this way, a leaf moving down through the layers of soil will have a series of molds on it, each replacing a previous population. This transition of populations as the habitat alters and is modified is called succession and is the object of much study and discussion among ecologists. Although we tend to think of soil fungi as decomposers of litter, they play a number of other roles as well. Many are specialized for animals and animal products and may trap eel worms and other soil animals, or decay the dead bodies of insects and earth worms. Some invade cast-off feathers and hair, and at least one group specializes in old hooves and horns. Through their roots, living plants offer an attractive habitat for soilinhabiting fungi. Some live around the root and decay away the dead root layers or substances exuded by the root, others invade the living root tissues and either cause plant disease or live in harmony with them. The latter situation involves a form of symbiosis called mycorrhizae, where the root and fungi within each benefit the other. Most mycorrhizal fungi and plants cannot live apart. Only a few species of plants are consistently free of this association.

6.4.1.6 Air Air is not habitat for molds, though many disperse their spores by air currents and are encountered in routine work. Fungi have a variety of mechanisms for getting their spores into the air. Simplest is that of exposing dry spore masses to air currents. Many molds use this method, especially those that colonize exposed leaves and stems. Species of Alternaria, Cladosporium, and some of the basidiomycetes called smuts are well known for this kind of dispersal. These species usually produce large numbers of spores, a necessary expenditure if at least a few randomly dispersed spores are to land on a suitable place to grow. Ascomycetes and basidiomycetes are usually capable of actually shooting their spores away into the air. Asci are like popguns: the water pressure inside the ascus builds up more and more until the spores are fired out the end with considerable velocity. With such a mechanism, ascomycetes need not be exposed directly to the wind but may grow in sheltered places which allow entry to the air of their discharged spores. Thus, ascomycetes can often be found growing closer to the ground than other air-dispersal organisms. Some spores become airborne by a mechanism known as droplet adhesion, a process dependent upon the presence of tiny water droplets in the air.

When one of these droplets, as on a foggy day, encounters a mold spore attached to a leaf e.g., the spore adheres to the droplet by surface tension and is carried off on it. It is then either deposited when the drop comes to earth, or becomes truly airborne when the drop dries out.

6.4.1.7 Dung People although expect dung to be a rather disgusting material to study, many become so intrigued with the molds and other organisms found there that they soon overcome their initial objections. Many fungi found on dung are highly specialized for growth there and never occur anywhere else. They do not produce large numbers of spores and these require a high probability of success in getting their spores from one dung pile to another. Other Coprophilous molds present their spores to the environment in wet drops at the ends of a stalk. When one of the many insects (especially flies) that visit dung brushes against these stalked spore-drops they carry with them a few of the sticky spores. Later, perhaps on a new dung pile, the spores rub off and germinate to produce a new colony. Most insect-transmitted fungi lack dormancy mechanisms in their spores and are unlikely to be away from dung for more than a few hours.

6.5 IMPORTANCE OF MOLDS—HUMAN-MADE HABITATS

Aside from their role in plant, animal, and human disease, many molds enter directly into the affairs of humans, in either a harmful or beneficial way. On the plus side is the involvement of molds in the greatest contribution to medicine of all time, that of antibiotics. The discovery of penicillin by Sir Alexander Fleming in 1928 probably resulted in the saving of more lives than all other medical discoveries combined. Penicillin, a product of the common mold Penicillium chrysogenum, is still one of the safest and most widely used antibiotics in spite of a nearly 40-year search for others. The foods we eat are as nutritional to many molds as they are to us, a fact often put to use in the preparation of food products, e.g., several types of cheese, such Roquefort, Danish Blue, Camembert, and Brie, owe their distinctive flavor to the presence of mold growing on them. If the mold were absent, these cheeses would not ripen properly. Yeast, although not strictly molds are among the most important fungi in food preparation. Their value, at least for some Saccharomyces species, lies in their ability to produce carbon dioxide and grain alcohol. In wine-making, where the production of alcohol is valued, yeast is added to the grape juice to bring this about. In bread-making, the important product is carbon dioxide, which is necessary in the rising process, and, again yeast is added to the dough. In the production of beer, both alcohol and carbon dioxide, to produce carbonation, may be necessary, although today the carbon dioxide may be added later, artificially.