Taken from *Slayers, Saviors, Servants, and Sex: An Exposé of Kingdom Fungi* by David Moore; published by *Springer-Verlag, New York: 2001,* ISBN 0387950982.

Chapter 8 The old Kingdom in time and space

Call me Ishmael. Well, you can call me anything, really, just don't call me a monkey - my opinion of your general knowledge and level of education will be greatly reduced if you do. I'm a hominid primate and proud of it. Monkeys have tails and questionable habits and are only very distantly related to me because their evolutionary line launched off on its own about 40 million years ago. But then, thanks to TV and printed media, we all know about that now. Chances are that we've seen or read about Jane Goodall and her chimpanzees, about the plight of mountain gorillas in the interminable civil wars in Africa, and about the sad predicament of orang-utans in the dwindling forests of Sumatra and Borneo. We know about Lucy - that three million year old fossil from Ethiopia - and, indeed, most people probably have quite a sophisticated understanding of animal relationships and evolution. It's likely that this is centred on relationships to, and evolution of, the human animal but it's none the worse for that, and there are other bits of general knowledge which are equally impressive.

In the same TV programs and the same magazines we have watched whales migrating from Arctic to Antarctic; been amazed by the aquabatic feats and communication skills of dolphins and appreciated the family structure of killer whales (and happily chat about Orca families called pods). Hell, we even freed Willy! So when Herman Melville has the Mate Starbuck ask of Captain Ahab '...what more wouldst thou have? Shall we keep chasing this murderous fish till he swamps the last man?' when talking about Moby Dick, the great White Whale, I think most people today would stop and say that there's something wrong with that '...murderous fish...' bit.

You might think the mistake is excusable in the context of a nineteenth century writer putting words into the mouths of nineteenth century fishermen. After all, the King James edition of the Bible tells that '..the Lord had prepared a great fish to swallow up Jonah. And Jonah was in the Belly of the fish three days and three nights.' But to think that the 'whale = fish' equation in *Moby Dick* is an ignorant mistake would be doing Melville an injustice. Melville, through his spokesman Ishmael, explains it like this: '... There are some preliminaries to settle. First: the uncertain, unsettled condition of this science of Cetology ... that in some quarters it still remains a moot point whether a whale be a fish. In his *System of Nature*, A. D. 1758, Linnaeus declares, "I hereby separate the whales from the fish." ... The grounds upon which Linnaeus would fain have banished the whales from the waters, he states as follows: "On account of their warm bilocular heart, their lungs, their movable eyelids, their hollow ears, penem intrantem feminam mammis lactantem, and finally, ex lege naturae jure meritoque." I submitted all this to my friends Simeon Macey and Charley Coffin, of Nantucket, both messmates of mine in a certain voyage, and they united in the opinion that the reasons set forth were altogether insufficient. Charley profanely hinted they were humbug. Be it known that, waiving all argument, I take the good old fashioned ground that the whale is a fish, and call upon holy Jonah to back me.'

Well, we've all seen so much on TV and film, books and magazines that most people these days would think it uneducated and unsophisticated to hear someone describe a whale as a fish. I'm sure that even Simeon Macey and, especially, Charley Coffin, of Nantucket, would be convinced. In these enlightened times, then, why do so many people think fungi are plants?

They're not plants. They never have been and they never will be plants. Fungi form a group of organisms entirely distinct from both animals and plants. Unfortunately, fungi have been damned by history to be lumped in with plants at almost every turn. Historically, the study of fungi, a science that is called mycology, has origins in two activities; both strongly associated with plants. The first emerged from the ancient habit of collecting the larger fungi, that is mushrooms and toadstools, for food and for medicine. This has been done for thousands of years by most human societies around the world, and as they collected the mushrooms and toadstools they were also collecting berries, fruits and plants from the same locations. And so the fungi became identified with vegetables and plants. The second activity was the scientific study of fungi. This developed in a systematic way in the nineteenth century and the first academic mycologists, aside from collecting and cataloguing, were mainly interested in understanding the role of fungi in causing plant diseases. And so fungi inevitably fell within the orbit of the botanists and mycology never developed an identity of its own. Mycologists have aided and abetted in this. Sitting comfortably in Departments of Botany for most of this century until today when they are more than likely to be thrown out on their ears! Unfortunately, the management have heard that fungi are not plants and when downsizing becomes necessary guess, who's shown the door. The only alternative home that mycologists seen able to find is in something called microbiology. The bothersome aspect of this, is that the biggest organism on the planet is a fungus. *Micro*biology?

There are still a large number of people around whose education was completed before the mid-1960s, when a revolution occurred in our understanding of relationships between organisms, and who are firmly convinced that fungi are plants - peculiar plants, maybe, but plants nevertheless. This idea is now accepted as completely wrong, and plants, animals and fungi are assigned to three quite distinct Kingdoms of higher organisms. Arranging organisms into Kingdoms is a matter of what is called systematics - an agreed scheme of naming things. It really is only a matter of looking, comparing and making categories - but the arrangement we have reached now does seem to square with current ideas about the early evolution of these organisms. So it seems to be a natural, meaningful systematics in which the fungi have been allocated a kingdom, the so-called Fifth Kingdom, all of their own (the other four Kingdoms being bacteria, plants, animals, and primitive single-celled creatures called protists).

Ideas about categorizing things change as more information comes to light so some people believe there should be seven, or nine, or even more Kingdoms. But these are minor adjustments which still leave most of the fungi in a Kingdom of their own and there are probably more people who know it as 'the Fifth Kingdom' than by any other number. A major aspect of the original 1960s definition of the Kingdoms was their nutrition: plants use the direct radiant energy from the sun to make their food. Animals, from amoeba to killer whales, engulf their food. And fungi? Well, fungi degrade food externally and absorb the nutrients which are released. Once this apparently simple basis for making the grand separation between Kingdoms has been used, numerous other differences in structure and life style become evident. One thing worth emphasizing is that the three Kingdoms are very different from one another in ways that are crucial to determining shape and form. A key feature during the embryology of even lower animals is the movement of cells and cell populations, so cell migration (and everything that controls it) plays a central role in animal development. Being encased in walls, plant cells have little scope for movement and their changes in shape and form are achieved by regulating the orientation and position of the wall which forms when a plant cell divides. Fungi are also encased in walls; but their basic structural unit is a tubular, thread-like cell (called a hypha), has two peculiarities which result in fungal development being totally different from that in plants. These are that the hypha grows only at its tip and that new walls form only at right angles to the growth axis of the hypha.

This is a nice bit of fine detail, which pleases the academic in me, but it has a significance beyond that because it raises an important consequence for arguments about the evolution of these organisms. The evolutionary separation between the major Kingdoms must have occurred at a stage when the most highly evolved things were single cells. The consequence is that each Kingdom must have 'learned' independently how to organize populations of cells in order to make the multicellular organisms we now know as mushrooms, mice or marigolds. So studying *how* a mushroom *makes* a mushroom is an investigation every bit as deep and meaningful (and difficult!) as studying how a human embryo develops or how a tree is shaped and sculptured in the forest. Sadly, in the popular imagination mushrooms don't have the same status as human animals or forest trees.

The man who is usually thought of as the 'Father of Mycology', Elias Fries, and his contemporaries in the early nineteenth century put far too much emphasis on shape in their attempt to understand mushrooms, toadstools and their relatives. This fundamental mistake is still with us. Academic mycologists may have moved well away from this position now, but they have taken a long time to do so and external shape is still the guiding light in the minds of many non-academic mycologists. With plants and animals, shape was important in ancient herbals and bestiaries but it has not been a dominant factor in 20th century science. Indeed, as my quotation from *Moby Dick* shows, the 'Father of Classification', Linnaeus, distinguished the shape of whales from the shape of fish (sufficiently strongly for a novelist to pick up on it) on the basis of comparisons of their structure, anatomy and development. Not so for fungi. Most of the early workers were content to rely solely on current shape and form - the most simplistic sort of study. Detailed studies of development, structure and anatomy did not start until the middle of the twentieth century and even today their practitioners have to fight to be heard and deep ignorance abounds.

Remember that classification of organisms is an exercise in arranging them into groups to make it easy to study them and, more importantly, to make it easy to interpret the results of the studies. It's a clerical exercise, like arranging all the papers in an office in files and then into filing cabinets. The arrangement that Fries produced used the shape and form of the fruit body and especially the nature of the tissue on which the spores were made. So he had a group called *agarics* which have plates (or gills) beneath an umbrella-shaped cap, just like the ordinary cultivated mushroom. And 'mushrooms with gills' were 'filed' into that group whatever their other characters were like. This agaric group was contrasted with fruit bodies which had tubes (or pores) in a spongy layer beneath the cap (called *polypores*). Toadstools in this group were called *boletes* but *bracket fungi* whose fruit bodies grow directly on the trunks of trees were also included. Then there were those with teeth or spines hanging down below their cap or bracket, and these were called *hydnoids*. Other major groups included some with spores formed over the outside of a club-shaped (called *clavarioid*) or coral-like (called *coralloid*) fruit body, and then there were the completely enclosed fruit bodies (called *gasteroid*) which had their spores inside the fruit body like puff-balls.

On the face of it, this is a nice simple scheme. Just the sort of thing you could apply as you trek through a forest. Sadly it was applied too rigidly. It was as if the 'experts' insisted that everything that flew should be called 'bird' whether they were actually fruit bats, bumble bees or buzzards. Look closer and you can see the limitations of the scheme; but very few mycologists looked closely enough. Even though some studies done soon after Fries published his work indicated that his groupings were artificial, his views were s fervently believed that at the end of the nineteenth century such suggestions were considered heresies.

In fact it's taken over a hundred years to break the stultifying grip of the Friesian system of classification of larger fungi. The biggest changes have come from work done in the last twenty-five years of the twentieth century. Work that has used developmental features and detailed comparisons of anatomy, chemistry and microscopic characters to reveal natural groupings and evolutionary relationships. Ironically, the zoologists battled through this sort of argument in the development of evolutionary ideas in the first quarter of the twentieth century. Initially, animal evolution was thought of as resulting mainly from modification of adult form and development was seen as a recapitulation of previous mature stages. This was encapsulated in 'the individual in its development recapitulates the development of the race' in MacBride's *Textbook of Embryology* in 1914. Progressive views were diametrically opposed and by the mid-1920s it was widely agreed that animal embryology does not recapitulate evolution, but contributes to it. Reproduction - or rather *success* in reproduction - is the winning ticket in the evolutionary lottery. So all features which influence that success are subject to evolutionary selection. For an animal, that might mean efficiency in finding a mate; efficiency in egg-laying; efficiency in dispersal of larvae; efficiency in care of the young; or any of a host of other factors which contribute to one set of genes being distributed to the next generation in preference to some other, competing, set of genes. If the cosmic watchmaker is blind, then that set of evolutionary principles apply just as much to fungi as to animals and plants. Only the details change.

The function of the fungal fruit body is to distribute as large a number of spores as the structure will allow. The familiar mushroom shape has evolved to give protection to the developing spores. It really is an umbrella protecting the spores from rain. The first step in improving the basic mushroom shape is to expand spore-production capacity. Making gills (plate-like downward extensions of the cap) and pores (tubular 'excavations' into the cap) are both strategies to increase the surface area available for spore production. If that has positive evolutionary advantage is it any wonder that careful observation of developing fruit bodies shows that there are at least ten different ways by which the mushroom shape can be constructed? It's relatively easy to show that geometrical constraints make pores a less efficient way of expanding spore production than gills. So, don't be surprised to find that there are some gilled-mushrooms which are closely related to polypores and only distantly related to 'real' agarics. Oyster mushrooms and the shiitake mushroom are like this. Presumably, at some stage in their evolution they found advantage in folding their spore-forming tissue into gills and they have now converged onto the agaric shape. It's *convergent evolution* just like swimming mammals evolving towards efficient swimming in water and finishing up fish-shaped, like dolphins, because fish *also but quite independently* evolved towards efficient swimming in water.

Look closely at the tissue structure for more wonders of evolutionary architecture. There are different ways of constructing gills. Not all dinner plates are the same, so why should all mushroom gill-plates be the same? All mushrooms must increase in size as they develop. Some hold the *number* of cells unchanged but pump fluids into what they've got to increase their size by ten, twenty or fifty times. Others hold the *size* of cells unchanged and just make more of them to increase the volume of the tissue. Both strategies, though, seem to use the same simple management system whereby one cell organizes and controls a rosette of cells immediately surrounding it. These little families of hyphae orchestrated by a central *inducer* hypha are called Reijnders' knots after the man who first described them.

Look closely at the lifestyle strategies of fungi and you will find some interesting behavior patterns. Bracket fungi achieve massive spore production by increasing the lifetime of the fruit body. At the extreme the fruit body is adapted to be perennial. These fruit bodies are often described as 'woody' but, clearly, as fungi are not plants they cannot use the plant-like wood components and in another example of convergent evolution have developed their own solutions to the same challenges solved by woody plants. The need for mechanically strong structures which must be resistant to attacks by pests and microbes as well as adverse weather conditions if they are to last several growing seasons.

At the other extreme of the lifetime strategy spectrum there are some fungi whose fruit bodies last barely more than a day. They may mature overnight and be dead and gone by the next night. These mushrooms are stripped down for athletic action. They tend to be small and delicate and adapted to get maximum spore yield from minimum mass of fruit body.

Stink horns are interesting because they parallel mushrooms in gross morphology - having recognizable caps and stems. But the whole structure is adapted to insect dispersal as opposed to wind dispersal of the spores. Like insect-attracting flowering plants these fungal fruit bodies sport bizarre shapes, colours and penetrating smells to attract flies and other insects. A distinctive odour is also important for fruit bodies formed under the soil surface. Truffles are the obvious examples but other fungi use the same strategy of attracting animals (some produce an odour resembling the male sex hormone of pigs) to dig them up and help disperse their spores.

Fungal systematics is now coming of age. Almost a century behind its sister sciences of botany and zoology, mycology is now appreciating that fruit body shape should not hold such a central position as it once did. This is a matter of interpretation of the value of particular features in establishing relationships between groups of organisms. One reason why the belief is growing that fruit body shape is less useful in fungi is that it's become clear that it is a more flexible feature than previously thought. Variation in shape and form of mushrooms occurs at different levels and for different reasons. Many mutants or variants in shape have been induced in the laboratory or isolated from nature. These mutants have been very instructive in establishing developmental pathways and future molecular analysis will be even more revealing. But there are also several instances where, for some reason, the development of a normal fruit body becomes disturbed without change to its genes. This sort of variability seems to be a strategy to cope with environmental stress. If there is a prime rule in fungal fruit body development then it seems to be '*distribute spores*'. If the environmental conditions are so damaging that only a monstrous distorted fruit body can be produced then it is counted as a success if it disperses some spores. The fungi really take this tactic to extremes. An agaric fungus that normally produces a mushroom fruit body can, if the atmosphere gets too dry or the temperature too high, form coralloid or gasteroid fruit bodies alongside the normal agaric fruit bodies; and all functional as spore production and dispersal structures. To compare this with an approximate animal counterpart, the parallel would be for cats to be able, quite normally, to give birth to litters containing the odd kitten looking like an aardvark, dog or even iguana.

Abnormal mushrooms like this indicate that normal fruit body development is made up of separate routines, each of which controls the structure and shape of a different component of the fruit body. So development of fungal fruit bodies in general depends on organized expression of these routines. The sequence and location in which routines are put into effect determines the shape of the fruiting structure and the progress of its development. It's similar to the way different component production lines contribute to the manufacture of a product like a car. Change the way the components are assembled and you change the product. In fungi, essentially the same routines can give rise to very different fruit body shapes, depending on other circumstances.

For example, the agaric gill subroutine is expressed with the rule 'where there is space, make gill'. When this is combined with a routine providing mechanical anchorages the gills are stretched along the lines of mechanical stress as the fruit body expands and end up straight and radial. If the anchorages are left out (because of some mutation, say), then the gills are formed but are never pulled straight and remain tangled and contorted.

A highly flexible developmental process like this allows the fungus to adapt to a wider range of conditions. The criterion for successful adaptation is successful production of spores and even the most monstrously abnormal mushroom can do that. This is not true for animals and plants, where even mild abnormalities can reduce their ability to reproduce quite drastically. Fungi differ from animals and plants, therefore, by having much less selection pressure against developmental abnormality.

Development of a structure like a mushroom fruit body, flowering plant or furry little animal involves individual cells undergoing different sorts of specialization to carry out different functions in the final structure. Generally speaking, this sort of cell differentiation involves successive steps that steadily reduce the options the cell can follow. Eventually, the cell has only one option - it is fully specialized for a particular function. Early in this differentiation pathway the cell retains the ability to revert back to the unspecialized 'embryonic' state, but as it progresses through its differentiation pathway it becomes committed to that pathway and can turn back no more. This is another respect in which fungi differ from animals and plants. The only committed cells we've been able to find in mushroom are those that make spores. All other cells, no matter how specialized they become, are able to revert to the simple original state if they are removed from the fruit body and put onto some nutritive artificial medium.

This is another evolutionary adaptation that permits flexibility. It allows the fungus to start over again if conditions really turn so nasty that continued development of the fruit body is not feasible. But this feeble grasp on their specialization also tells us something else unexpected about fungal developmental biology. This is that since undisturbed cells in the fruit body do not revert to hyphal growth, then it follows that their specialized state is somehow continually reinforced whilst they are inside the fruit body. Rather than rigidly following a prescribed sequence of steps, developmental pathways in fungi allow application of rules that allow great variability in expression. A sort of 'fuzzy logic' in which decisions between possible pathways are made with a degree of uncertainty, being based on balancing probabilities rather than all-or-none switches.

Fungal cell differentiation is no less sophisticated or complex than is found in animals and plants, but it is very different. Fungi can vary the timing, extent, and mode of differentiation in response to external signals. They can swap growth forms and procreative phases of their life cycle. It all contributes to making them supremely able to adapt to challenging conditions. This results in a flexibility which surpasses that of other organisms and provides the mycologist with an enormous intellectual challenge.

Nutrition has always been a major characteristic in schemes of classification. Photosynthetic plants have always been clearly distinguishable from ingesting animals and recognizing the fundamentally different sort of nutrition fungi employ was one of the features which placed them in an entirely separate Kingdom Fungi. One of the original papers on this topic emphasized this point like this: '..nutritive mode and way of life of the fungi differ from those of the plants...Fungi characteristically live embedded in a food source or medium, in many cases excreting enzymes for external digestion, but in all cases feeding by absorption of organic food from the medium. Their organization ... is adapted to this mode of nutrition.'

Fungi have evolved to grow effectively embedded in a substrate which they digest by the excretion of appropriate enzymes. The smaller molecules produced by the activity of those enzymes are the nutrients which can be absorbed by the fungal cells. Among higher organisms only the fungi must digest their food externally prior to absorption of the smaller molecules of which the food is composed (though this is a character they share with bacteria). There are ecological and structural, and biochemical, consequences of this. An animal, even the simplest ones can capture morsels of food by engulfing them so the food immediately goes inside the body where it can be digested without fear of loss to competing organisms. A fungus may be capable of digesting the same food, but must perform most of that digestion externally with the valuable results of the digestion being open to absorption by competitors until the fungus can take them in. This may have influenced the evolution of cell walls and digestive enzymes in ways that enable the fungus to improve its competitive effort by controlling the environment in the immediate vicinity of the fungal surface.

The evolution of fungi can't be established from a good collection of fossils. There isn't one. There are some fossils, but they are relatively few and scattered across evolutionary time. This has meant that we have to use evolutionary trees constructed from analysis of molecular (protein and nucleic acid) structures. This approach has been validated by comparisons in organisms (like many animal groups) for which a good fossil record does exist. The approach works well provided you don't try to extract too much detail from it. So in what follows I will restrict myself to the major messages that come out of this work.

The solar system formed about four and a half billion years ago. There is evidence for the activities of living organisms (as microbial fossils) in terrestrial rocks that are three and a half billion years old. Life may have evolved before that (it certainly arose very quickly on the embryonic Earth) but calculations from study of the craters on the Moon suggest that up to about 3.8 billion years ago the Earth-Moon system was subjected to gigantic asteroid impacts. These would have been large enough to release sufficient energy to re-sterilize the Earth's surface if any life had evolved. These cataclysmic impacts stopped (we hope!) about 3.8 billion years ago and the Earth's surface stabilized sufficiently for life to evolve and for the fist bacterial-product fossils to be laid down three and a half billion years ago. Bacteria themselves don't make good fossils but photosynthetic bacteria precipitate calcium salts into big characteristic mounds that *do* make good fossils.

After this there was a period of one and a half billion years during which early bacteria continued to evolve before the higher organisms (called *eukaryotes*) emerged from their bacterial ancestors about two billion years ago. This critical event was followed by a billion years of eukaryote evolution (as single-celled creatures) before plants, animals and fungi began to diverge from each other. So, finally, the major Kingdoms of higher organisms have been separate from each other for the past billion years. There is still uncertainty about the exact sequence of emergence of the major kingdoms, probably because of the effect of variable rates of evolution between the different groups (and, indeed, between the different molecules analyzed). The best available calculations indicate that plants, animals, and fungi last shared a common ancestor about a billion years ago; that recognizable animals originated about eight hundred million years ago; and that animals and fungi are each others closest relatives. Put that lot together and the sequence that emerges is that plants arose from the common eukaryote ancestor a billion years ago, then a joint fungal/animal line continued for another two hundred million years until the animals left home eight hundred million years ago.

It's been argued that the oldest fossils so far found (which are about six hundred and fifty million years old) are actually lichens rather than worms or jellyfish, but this is a hotly disputed interpretation. Fungi must have been around at that distance in time because from rocks about five hundred and seventy million years old we begin to get evidence (mostly in the form of spores because these seem to make good fossils) for all the major groups of fungi that exist today. Very early in evolution intimate associations between fungi and plants occurred. Almost all land plants of today form cooperative associations with fungi. Plant roots are infected with fungi that contribute to the mineral nutrition of the plant and can benefit plants in a variety of other ways. This association is the mutually-beneficial mycorrhiza ('fungus-root') which is described in Chapter 4. This cooperation would have eased, if not solved, some of the most difficult problems the first land plants faced as they emerged from the primeval oceans. Some of the oldest (about four hundred million year old) plant fossils contain mycorrhiza structures almost identical to those which an be seen today. It's now generally thought that the initial exploitation of dry land by plants about four hundred and thirty million years ago depended on the establishment of cooperative associations; between fungi and algae (lichens) on the one hand, and between fungi and emerging higher plants (mycorrhizas) on the other. Fungi were crucially important in the shaping the ancient ecosystem.

Amber is good at preserving soft-bodied organisms like fungi. Fungal spores, have been found in amber which is about two hundred and twenty million years old. Several of these spores are almost identical to fungi existing in the present day. This is pretty remarkable. When they were trapped in the resin which hardened into amber, all of Earth's land masses were combined into one supercontinent (called Pangaea), birds were only just beginning to evolve, and flowering plants would not appear for another hundred million years! Fossils like this (and others) show that the characteristic fungal structures seen today arose long, long ago and have been maintained for enormous periods of time. One of the experts put it this way: '... the history of fungi is not marked by change and extinctions but by conservatism and continuity.'

Probably the most remarkable find reported so far is amber containing the remains of two mushrooms which can actually be identified because they are so similar to existing mushrooms. But the amber is ninety to ninety-four million years old. Before the age of mammals, when dinosaurs still ruled the Earth, there existed mushrooms almost the same as those existing today. Mushroom fungi first evolved about two hundred million years ago, but the mushrooms we see around us when we trek through the forests now are pretty well identical to mushrooms in the undergrowth through which dinosaurs trekked fifty or a hundred million years ago. They survived whatever cataclysm brought extinction to the terrible reptiles. They've seen the mammals evolve to a monkey-like primate that calls himself '*sapiens*'. And there's no reason to doubt that they'll still be around when all the monkey-things are dead and gone.

If a final reckoning of *Life on Earth* is ever written the fungi will figure from first to last. Arguably, the first 'higher' organisms to evolve, in a sense they 'gave rise' to plants and animals, maybe two billion years ago. Later, they enabled plants to invade the land to start terrestrial development of planet Earth, helping the plants to shape nature as we know it today. We would not be here without fungi because their interventions and contributions have been crucial in the development of life on land to the point where it could support larger animals. And all the while, the fungi themselves were so well adapted to even dramatically changing environments that their own evolution was slow and relaxed.

Today fungi range from amongst the smallest to the largest individuals on Earth. The yeasts are amongst the smallest, yet we use them to make enough alcohol every year to refloat the Titanic! In a hardwood forest in northern Michigan, where there is little more than a curious mycologist and the breeze to disturb the leaves, a monster dwells. It is eating the forest. The monster covers an area of fifteen hectares, weighs in at around one hundred metric tonnes and is at least fifteen hundred years old. This makes the monster amongst the largest, heaviest and oldest living things known on this planet, but it's no alien creature. The monster is a fungus, a clone of a tree root pathogen known as *Armillaria bulbosa*. But you must have guessed that by now!