Growing Gourmet Mushrooms from A to Z!

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Definitions you need to understand before beginning:

Fungus (plural fungi): Fungi are unique organisms made up of cells that have no chlorophyll. They digest their food (decomposing organic matter) outside of their bodies and reproduce by way of microscopic seed-like particles called "spores". Some fungi cause diseases of plants and animals, but most are valuable recyclers of minerals and nutrients for plants and animals and some produce tasty food.

Mushroom: The fruiting body or reproductive structure of a fungus. Some mushrooms are poisonous, some are delicious! All mushrooms produce spores**.** **Figure 1** shows a typical mushroom. Most mushroom spores fall from gills, which are located on the underside of the cap. However, not all mushrooms have gills. Some have pores on the underside of the cap and others have pits on the sides of the cap for spore dispersal.

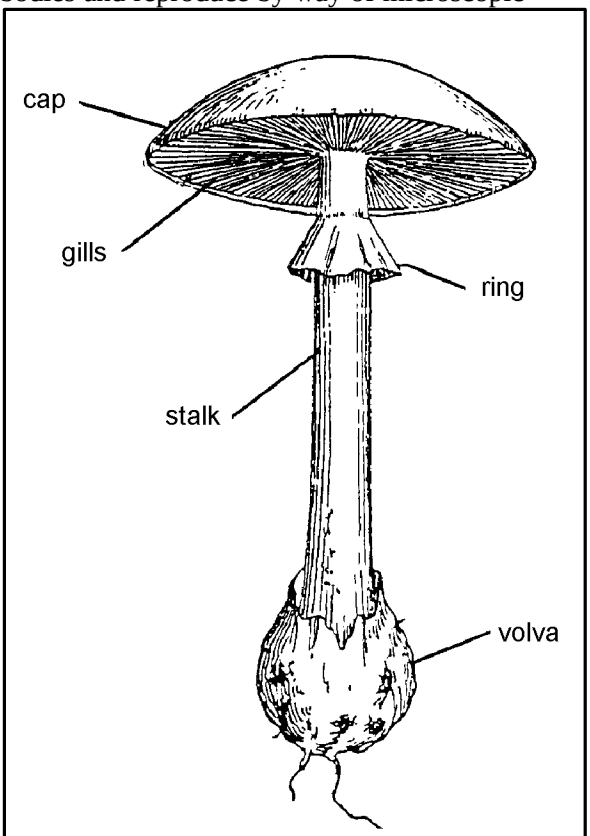

Figure 1

Mycelium: The vegetative part of a fungus, which grows on and absorbs water and food from organic matter. The organic matter that fungi grow on is called a substrate. Mycelium is often white in color and may appear mold-like or string-like. Mycelium will produce mushrooms when conditions are right. **Figure 2** shows typical mushroom mycelium with young mushrooms "called pinheads" beginning to form. **Figure 3** shows a pinhead next to a mature mushroom.

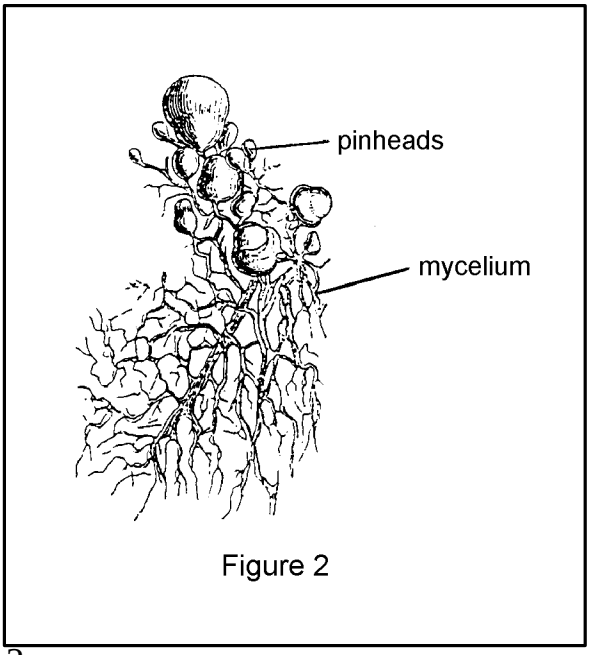

Figure 2

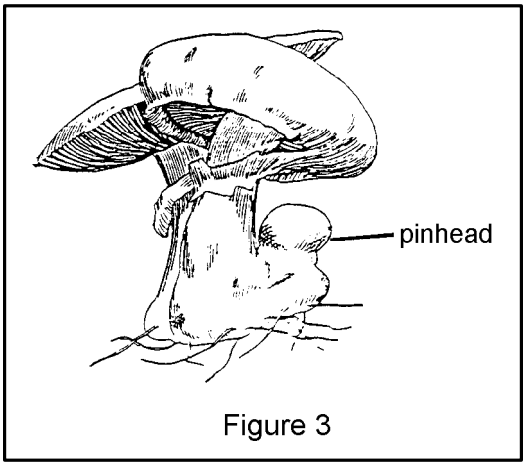

Figure 3

S**pawn:** Often the cereal grains rye (not ryegrass) or barley seed, which has a specific type of mycelium growing on it. Spawn is used to multiply mycelium or to inoculate a different substrate.

Tissue Culture: Vegetative propagation of non-reproductive tissue also called "cloning".

Agar: A sterile growth medium made from a specific type of algae. Agar is usually purchased as a powder and is mixed with water and cooked for a period of time. As it cools it hardens somewhat and has the consistency of gelatin. Various types of nutrients are added to agar to feed whatever type of mycelium is placed on it. The most common types of nutrient enriched agar used for mushroom growth are potato, dog food and blood. Hot, liquid agar is poured into petri dishes or test tubes before it hardens.

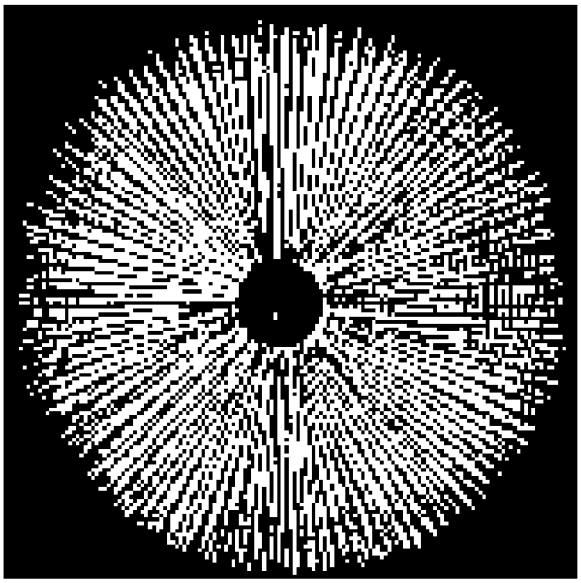

Figure 4

Spore print: Produced when a fresh mushroom cap is placed on a piece of paper with the gill side facing down. Within a few hours the microscopic spores fall out of the gills and leave a characteristic deposit on the paper. Individual spores are too tiny to see, but a spore print is readily visible. Spore print color is an important characteristic used for identifying mushrooms. Spores come in many different colors from white to black and all colors in-between. **Figure 4** shows a white spore print on a black background made from a mushroom with gills.

The Four Stages of Mushroom Growth:

Stage 1. Growing Mycelium.

Mycelium starts to grow when mushroom spores germinate. Unlike seeds, which have diploid cells and fully formed embryos, mushroom spores are haploid cells, either + or - . You can't tell one strain from the other and either type will grow into mycelium. However, in order for mushrooms to form, + and – mycelium must grow together and fuse. This happens in nature largely by chance, but mushroom growers can force the issue by growing spores of the two strains together in the same culture dish. Once the fusion occurs, the "new" culture can be maintained by way of tissue culture. Typically, a tiny piece of tissue is removed from the upper stalk of a mushroom where the stalk meets the gills. The tissue fragment is placed on a nutrient agar medium in a petri dish. The same agar media is used that would be used to grow mycelium from spores. Within a few days to two weeks the mycelium will grow and cover the agar in a petri dish.

The tricky part of growing mycelium is avoiding contamination. The air is full of many types of fungal spores that may contaminate petri dishes. It is often necessary to take smaller sections from the agar in the dish to isolate the desired mycelium. Contaminants also produce mycelium, which may look exactly like the desired mycelium, or they may be a different color or have a different appearance. This procedure of removing small sections from the petri dish and transferring them to other dishes may have to be repeated several times before a truly pure culture of the desired mycelium is obtained. Pure cultures of many different types of mushroom mycelium are available from the sources listed on the last page. Cultures of mycelium growing on agar in petri dishes or in test tubes may be stored for months in a refrigerator.

Stage 2. Growing Mycelium on Spawn.

In order to produce sufficient mycelium to inoculate bulk substrate, it must be multiplied and grown on a material that is easier to handle than petri dishes or test tubes. Typically, the cereal grain rye (also called winter rye, readily available from farm and home stores) is used to multiply mycelium. Before rye can be inoculated with mycelium, it must be sterilized. One quart, canning type, jars are used for spawn production. Each clean jar is partially filled with approximately one cup of rye grain, three quarters of a cup of water and one-eighth teaspoon of gypsum. The jars are sealed with a typical metal canning lid and ring with one minor modification. A small hole, approximately three eighths of an inch in diameter is drilled through the metal lid to admit air. The mushroom mycelium, which will be transferred to the jar after the jar is sterilized, needs air.

In order to prevent air borne fungal spores from contaminating the rye grain, several layers of filter paper are placed under the tin lid. A few drops of iodine are sometimes dripped into the hole onto the filter paper beneath to kill any contaminant spores that might squeeze through the filter paper. The next step is to sterilize the rye grain by placing the filled canning jars in a pressure cooker and processing at 15 pounds of pressure for 45 minutes. After the jars cool completely, the mycelium is transferred from the petri dishes to the jars. This is accomplished by cutting the agar inside the petri dish into eight wedges, much like cutting an apple pie. Approximately three or four wedges are dropped quickly and carefully into each jar and then the jar is quickly capped again. The jar is then shaken to distribute the agar wedges into the rye grain.

Figure 5

Within a few days the mycelium will grow all over and through the rye grain, turning the entire contents of the jar white. **Figure 5** shows jars of rye grain spawn that are partially covered with mycelium. The jars need to be shaken every few days to evenly distribute the rye grain in order to insure that all of the grain is fully covered with mycelium. It takes a week to ten days to completely colonize all the grain in a jar.

Stage 3. Multiplying Grain Spawn.

The grain spawn produced after this initial process is often referred to as G1 for grain spawn stage one. Each one-quart jar of G1 may be used to inoculate up to ten more jars of sterilized rye grain by transferring a small portion of the fully colonized grain into other jars, which have been prepared exactly as noted above. This second generation of grain spawn would be called G2. Each of these ten jars of G2 may, in turn, be used to inoculate ten more jars, which would be called G3. Therefore, each jar of G1 can produce up to 100 more jars of grain spawn. It is very hard to avoid contamination beyond G2 however. Very few growers can successfully produce G3 consistently without any contamination. Sometimes mushrooms can be grown directly from G1 or G2 spawn. **Figure 6** shows mushrooms growing directly from the G1 jars, which have had their lids removed.

Figure 6

Stage 4. Using Grain Spawn To Inoculate Bulk Substrates.

After they are fully colonized by the mycelium, jars of grain spawn must be transferred to bulk substrate within a few days to two weeks. Otherwise the spawn will harden into an unusable, solid mass of fungal mycelium. For this fact sheet two types of bulk substrate will be discussed.

First-time mushroom growers typically use one of two types of bulk substrate. The first type is fresh, hardwood wood chips. Hardwood chips are often readily available after a road has had trees cut along the shoulders for widening or routine maintenance. Most highway departments shred the branches and brush after such procedures and leave them at the site. Wood chips are also available from most sawmills. Tree care companies, arborists and utility companies are also possible sources of wood chips. For mushroom production, the fresher the chips, the better!

The point is to inoculate the chips with the mushroom spawn you wish to grow before other, airborne fungi start to grow. There is no hard and fast rule as to how much grain spawn is required to inoculate a given quantity of chips or which species of trees work best for each particular species of mushroom. In general, the softer hardwoods such as willow or alder or basswood will grow mushrooms the fastest since these woods are quick to break down but any hardwood will do. A cubic yard of wood chips will occupy an area approximately ten feet square by three inches deep. **Figure 7** shows a bed of freshly prepared wood chips. At least five or six quarts of grain spawn would be required to inoculate a cubic yard of chips.

Figure 7

Figure 8 shows a plastic bag, which contains approximately 8 quarts of grain spawn. The more grain spawn that is used, the quicker the colonization process and the more likely chance of success. It is not necessary to sterilize or pasteurize the wood chips if they are fresh. If the chips are dry the bed should be wet with a garden hose prior to inoculation. The jars of grain spawn or the larger bag of spawn is shaken to break up the individual rye seeds and the spawn is simply broadcast or raked into the wood chips. The best time to do this operation is when temperatures remain above freezing, such as late May or early June.

Figure 8

If all goes well the mycelium on the grain spawn will grow through the wood chips within a few weeks. **Figure 9** shows wood chips from a bed that has mycelium beginning to grow. Once the mycelium has grown throughout the wood chips, normal changes in weather conditions will trigger the mycelium to produce mushrooms within a few months. If no rain occurs the beds will need to be watered approximately every week. Some beds of wood chips will continue to produce mushrooms for several seasons after the initial inoculation.

The second type of bulk substrate to consider is pasteurized straw. Wheat, oat, barley or rye straw is shredded into pieces about three or four inches long. Immersing the shredded straw in a hot water bath (165 to 185 degrees Fahrenheit) for approximately one hour pasteurizes it. A container made from hardware cloth is used to hold the straw while it is cooking. **Figure 10** shows an outdoor fireplace set up with a 55-gallon drum filled with water for pasteurizing straw. After allowing the straw to cool, the mushroom spawn is mixed with it. The inoculated straw is stuffed into plastic bags and the bags are sealed with a twist tie. **Figure 11** shows bags of pasteurized straw with mushrooms beginning to emerge. Within two to three weeks the mycelium will grow throughout the straw. When the straw is fully colonized, slits are made in the plastic bag to admit air. Soon pinheads should appear on the surface of the straw. The slit bags are misted with water to maintain high humidity and mushrooms should appear a few days later. Sometimes bales of straw are directly inoculated with grain spawn without being pasteurized first. **Figure 12** shows mushrooms growing directly from a bale of unpasteurized straw.

Figure 9

Figure 10

Figure 11

Harvesting Mushrooms:

Mushrooms may be harvested as soon as they are big enough to eat. **Figure 13** shows mushrooms in the "button" stage. "Button"sized mushrooms are bigger than pinheads but smaller then mature mushrooms. Most of the common mushrooms we buy in supermarkets are harvested in the button stage. **Figure 14** shows the same species of mushroom as illustrated in **Figure 13** approximately three days later. Some mushrooms taste best when harvested in the young stage while others taste better if allowed to mature somewhat. Several species of insects quickly lay eggs in mushrooms growing outdoors causing them to be riddled with "worms" within a week to two weeks after they first appear. Very few mushrooms require more then one week from pinhead formation to harvest.

Freshly harvested mushrooms should never be washed with water. They may be wiped clean with a paper towel or lightly brushed with a soft brush to remove any soil or wood or straw debris. Mushrooms should be stored in a cool dry place in paper or cloth bags, not in plastic.

Figure 12

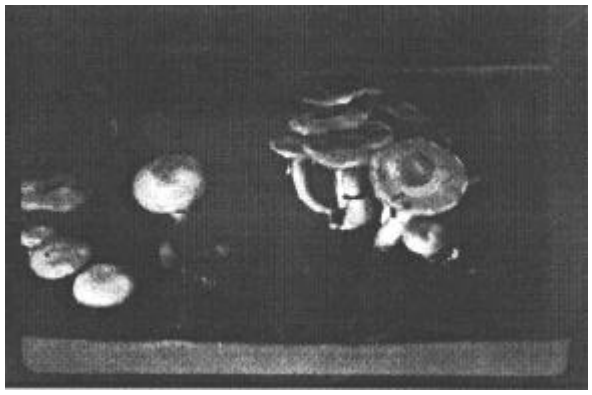

Figure 13

Marketing Mushrooms:

Mushrooms are a specialty or "gourmet item" and should be handled and packaged accordingly. They need to be sold quickly in a ready to use state. Any mushrooms that cannot be sold within a few days of harvest should be dried in a food dryer. They should be completely free of dirt and packaged attractively. It is very difficult to predict yields from any given mushroom planting, however, over a period of time and several crops, growers will learn how much to expect to harvest. Prospective growers are encouraged to keep accurate records of costs incurred in order to estimate appropriate prices to charge. Typical buyers of fresh mushrooms include restaurants, farm stands, and small retail markets. Today, large supermarkets offer several species of fresh and dried mushrooms at prices ranging from two or three dollars per pound for the cultivated "button" mushroom to more than $100 per pound for dried morels.

The following prices were observed at a large supermarket in Ithaca NY in April 1999.

- Common "button" mushroom (*Agaricus bisporus)* fresh $1.99 per pound
- Portabello mushrooms *(Agaricus sp.)* fresh $4.65 per pound
- Crimini mushrooms, which are immature Portabellas, sold for $3.99 per pound
- Fresh oyster mushrooms (*Pleurotus ostreatus)* cost $6.99 per pound
- Fresh shiitake mushrooms sold for $7.99 per pound
- Dried chanterelle mushrooms sold for $55.00 per pound
- Dried morel mushrooms sold for $113.00 per pound

It should be noted that both morel and chanterelle mushrooms are usually gathered from the wild and not cultivated. The other species listed above are not grown in exactly the same manner as outlined in this fact sheet.

Resources: Suppliers of pure cultures, spawn, pre-inoculated kits and equipment.

Fungi Perfecti P.O. Box 7634 Olympia, WA 98507 Phone (800)780-9126. (This outfit sells everything!).

Home and Forest Mushrooms, South Street, Durham NY 12422, contact John Boyle, (518) 239-8039. (John also does classes and consulting).

Books: *The Mushroom Cultivator* by Paul Stamets and J.S. Chilton, 415 pages, $29.95 (this book tells you all you need to know and much more) available from Fungi Perfecti directly and many book stores. THE textbook for mushroom growers.

Growing Gourmet and Medicinal Mushrooms by Paul Stamets, 586 pages. $39.95 This book picks up where the previous one ends.

Photo credits:

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Photographs for Figures 5 through 13 were taken by Bob Beyfuss.

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