



# CULTIVATING MUSHROOMS on SMALL FARMS



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# Commonly Cultivated Edible Fungi

- ★ Button Mushrooms *Agaricus spp.*
- ★ Oyster Mushrooms *Pleurotus spp.*
- ★ Shiitake *Lentinula edodes*
- ★ Reishi or Ling Chi *Ganoderma lucidum*
- ★ Lion's Mane *Hericium erinaceus*
- ★ Nameko *Pholiota nameko*
- ★ Ears *Auricularia spp.*
- ★ Chicken-of-the-Woods *Polyporus sulphureus*



# More Cultivated Edible Fungi

★ White Jelly

★ Shaggy Mane

★ Garden Giant

★ Paddy Straw

★ Velvet-Stemmed or  
Enokitake

★ Maitake or  
Hen-of-the-Woods

*Tremella spp.*

*Coprinus comatus*

*Stropharia rugoso-annulata*

*Volvariella volvacea*

*Flammulina velutipes*

*Grifola frondosa*



# Limited Cultivation Edible Fungi

- ★ Morel
- ★ Black Morel
- ★ Summer White Truffle
- ★ White Italian Truffle
- ★ Black Perigord Truffle
- ★ Chanterelles
- ★ Maize Mushroom

*Morchella esculenta*  
*Morchella angusticeps*  
*Tuber aestivum*  
*Tuber magnatum*  
*Tuber melanosporum*  
*Cantharellus spp.*  
*Ustilago maydis*



# Commonly Cultivated *Agaricus* Mushrooms

★ *Agaricus augustus*

Prince Button Mushroom

★ *Agaricus bisporus*  
"portobello"

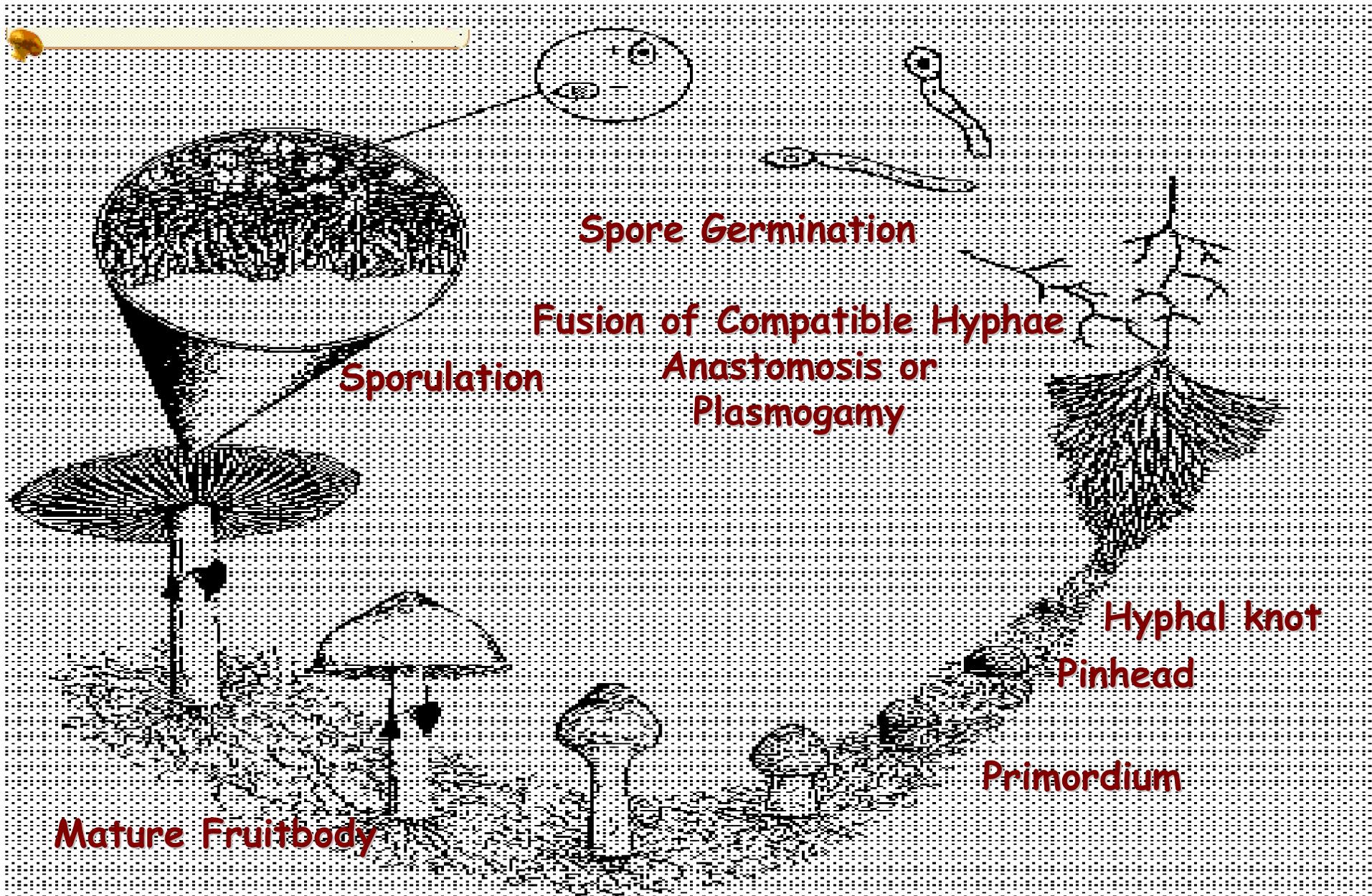
Italian *Agaricus*,  
Portabella, Portabellini

★ *Agaricus bitorquis*

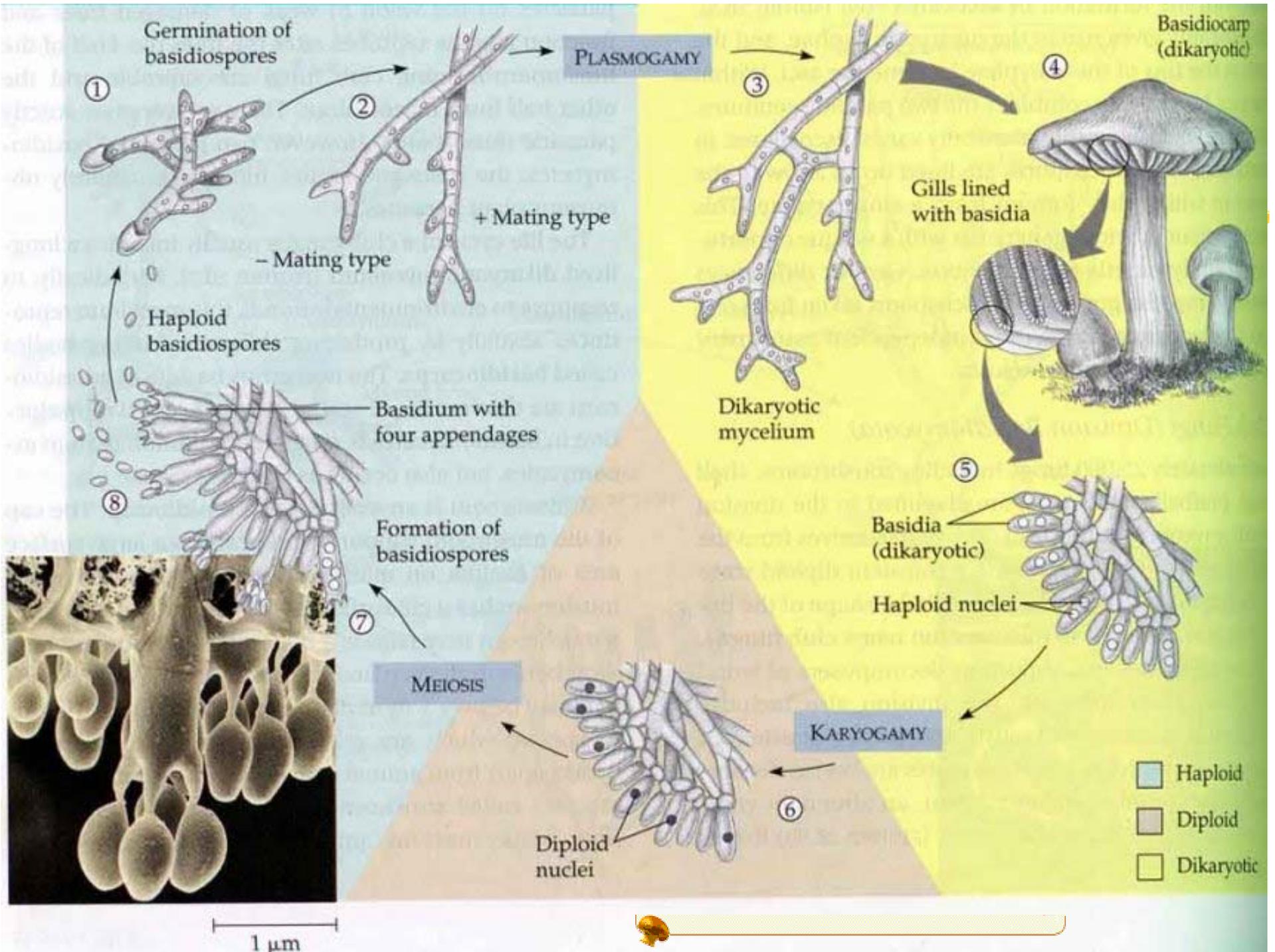
Warm-Weather Button

★ *Agaricus bisporus*  
(= *A. brunnescens*)

White Button Mushroom,  
Cremini

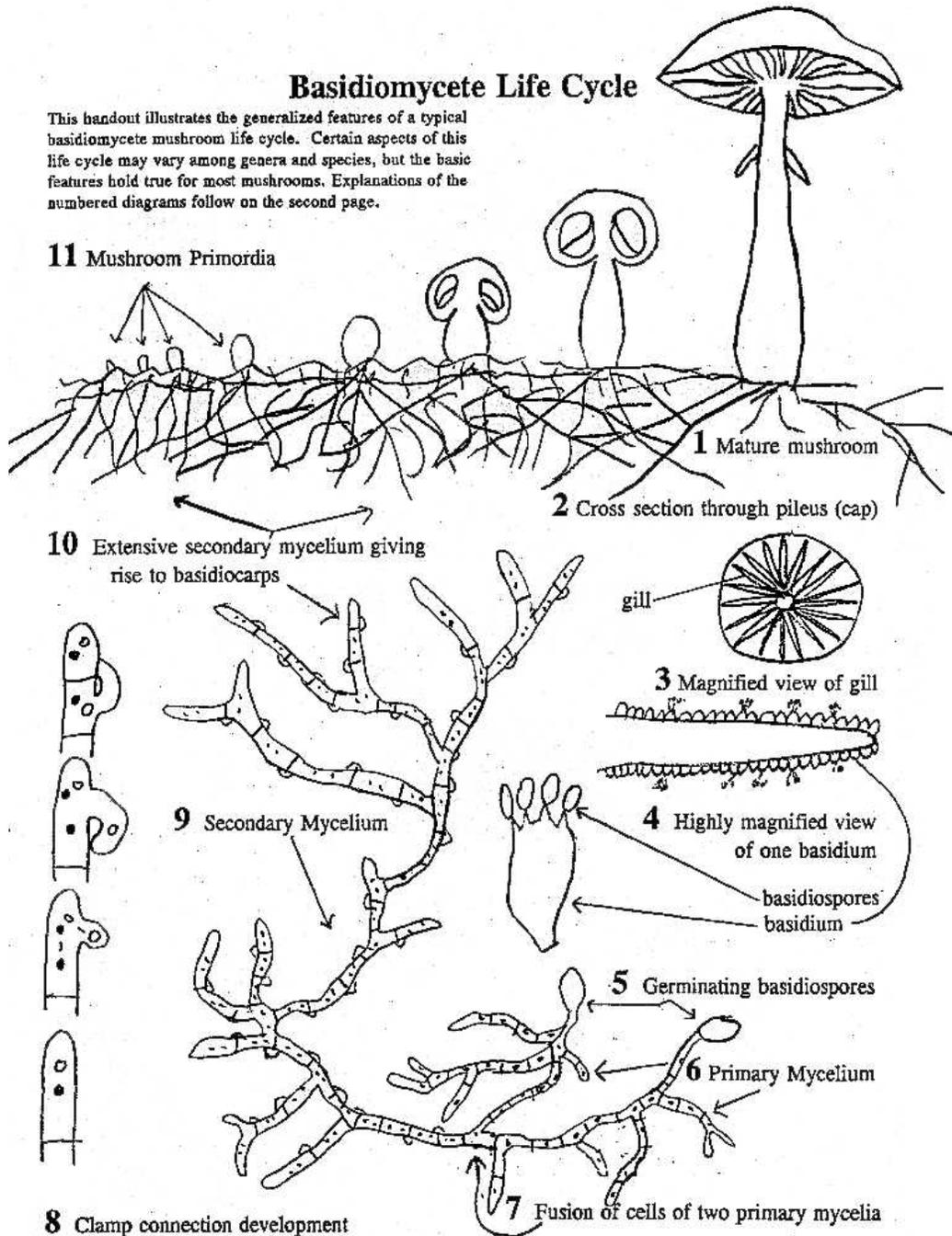


# The Mushroom Life Cycle



## Basidiomycete Life Cycle

This handout illustrates the generalized features of a typical basidiomycete mushroom life cycle. Certain aspects of this life cycle may vary among genera and species, but the basic features hold true for most mushrooms. Explanations of the numbered diagrams follow on the second page.



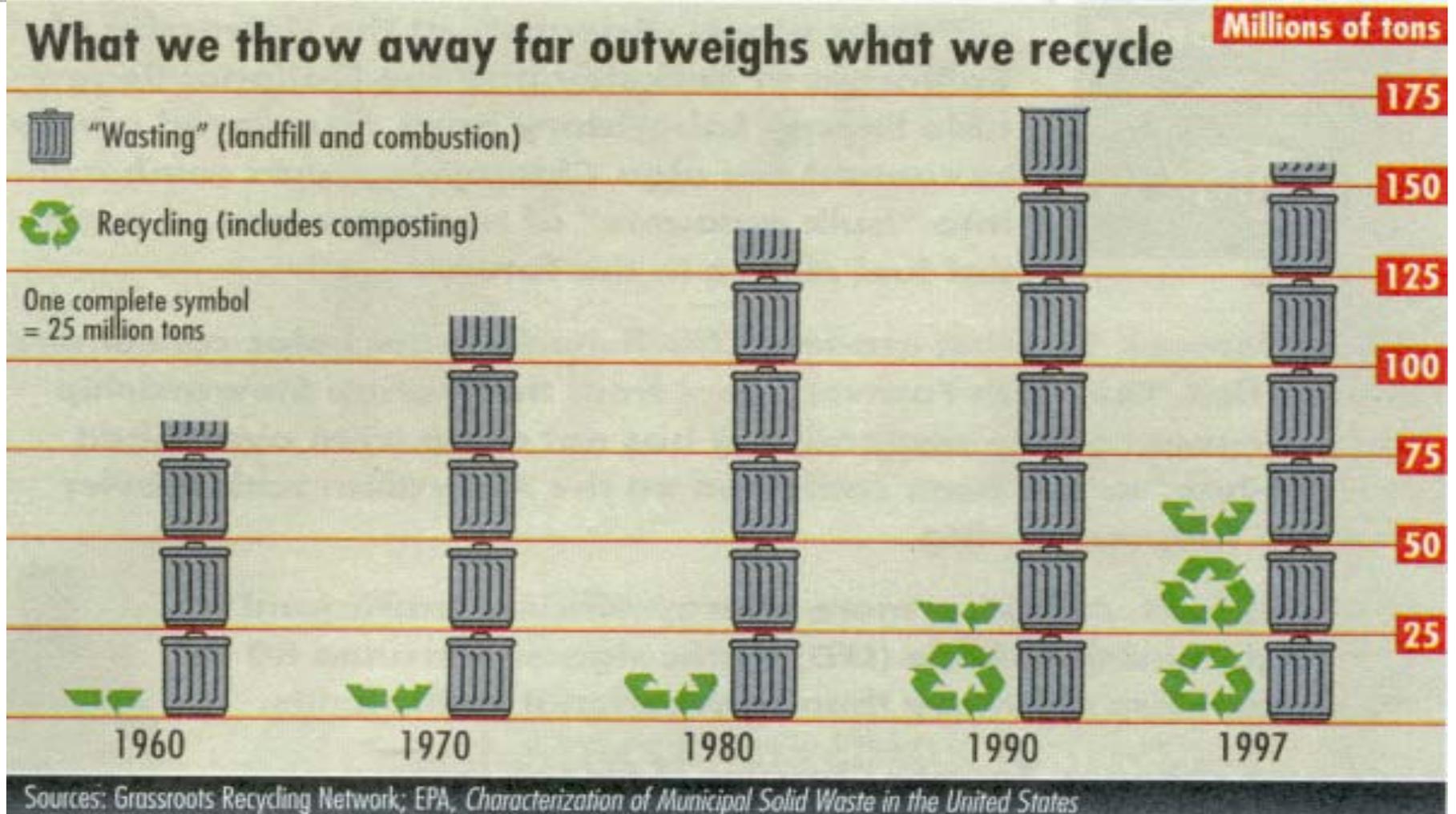
## Major stages Basidiomycota Life Cycle

- 1) Mature Sporocarp
- 2) Gilled Hymenophore
- 3) Gill
- 4) Basidium
- 5) Basidiospore
- 6) Monokaryon
- 7) Fusion of Monokaryons
- 8) Clamp connections
- 9) Dikaryon
- 10) Mycelium
- 11) Young sporocarp



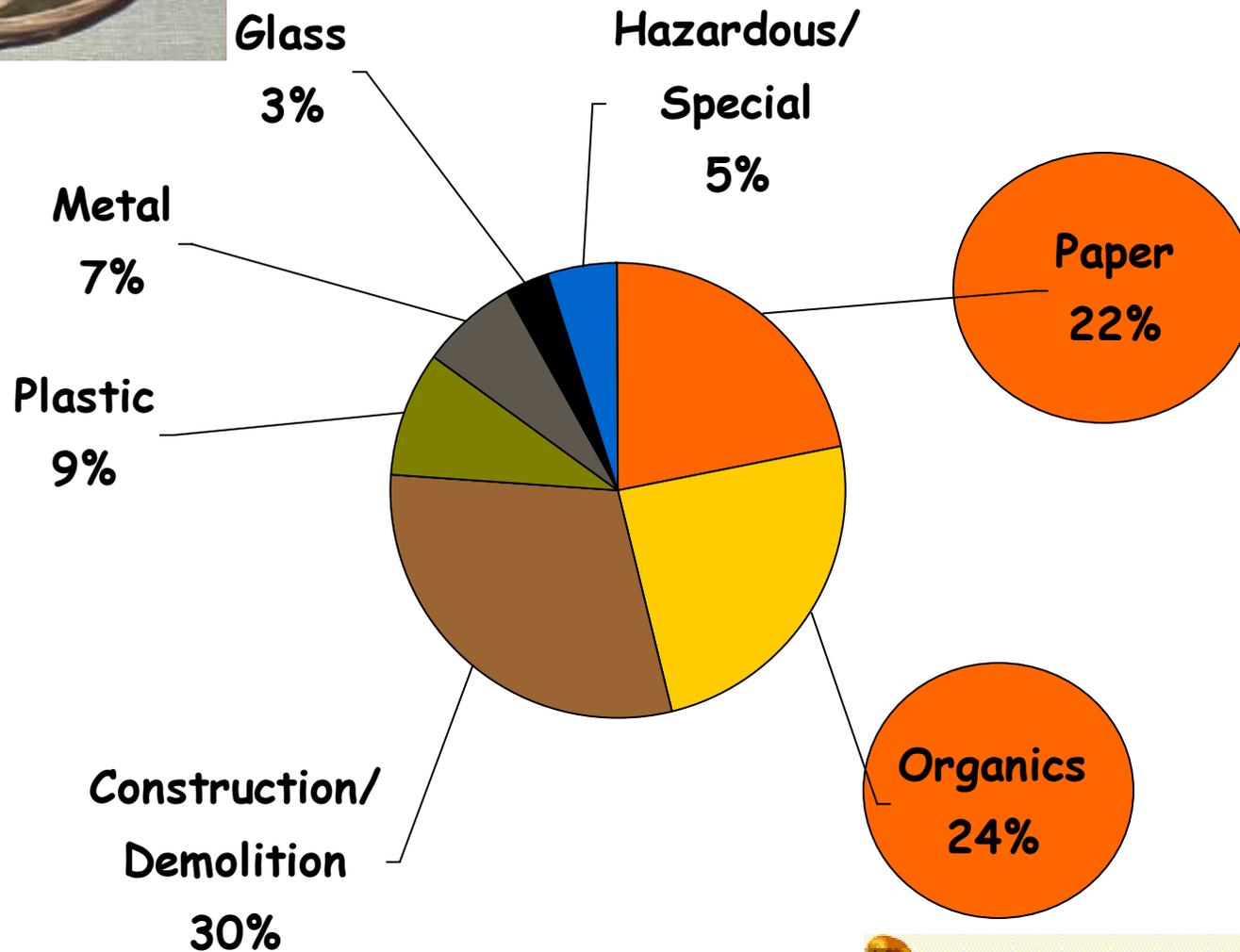


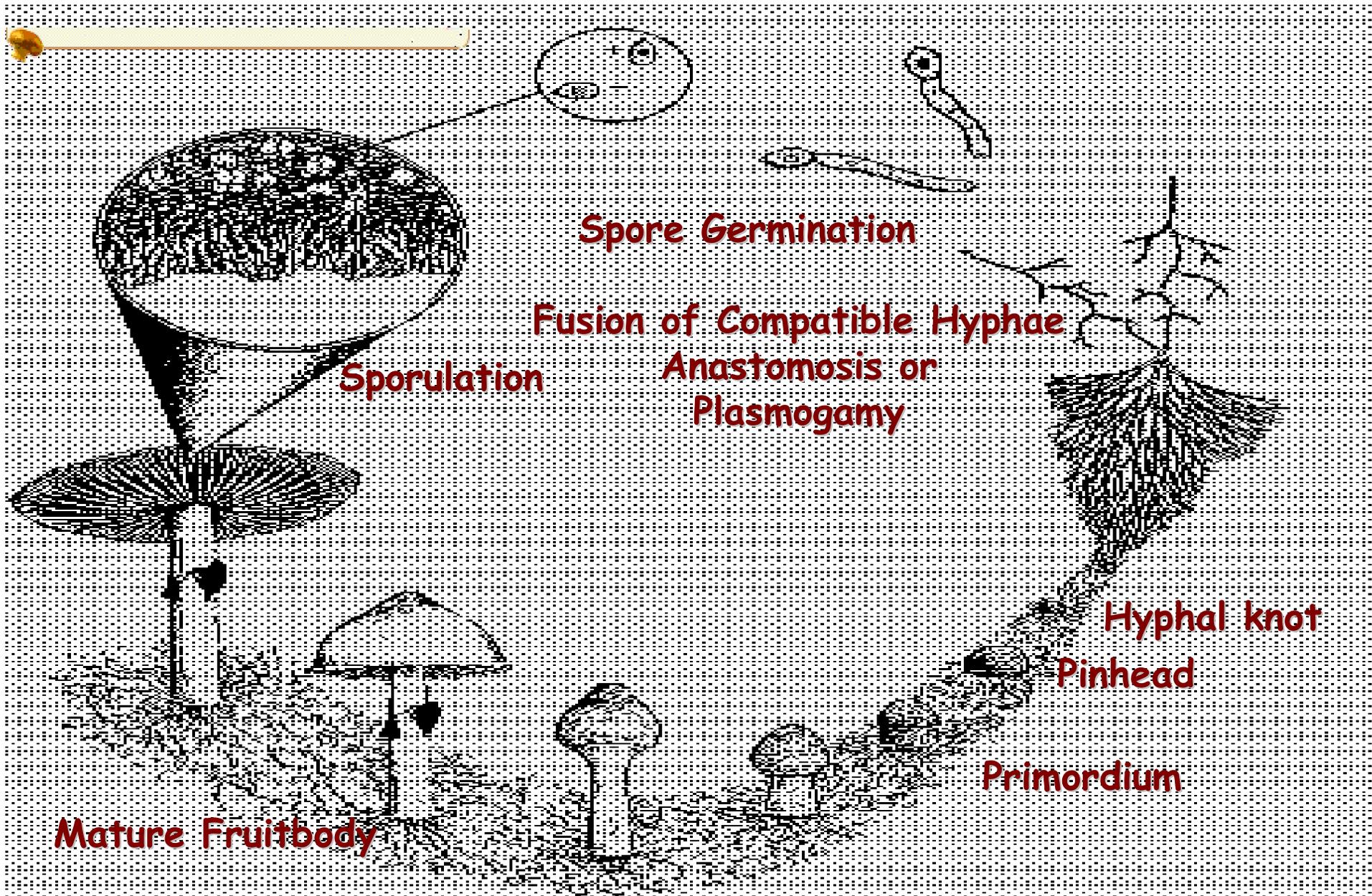
# Waste and Recycling





# Waste Characterization Study Composition of Materials going to Landfill





# The Mushroom Life Cycle

Spawn Production

Spawning

Commercial Spawn Producers

Mushroom Growers

Harvesting

Spawn Run

Mature Fruitbody

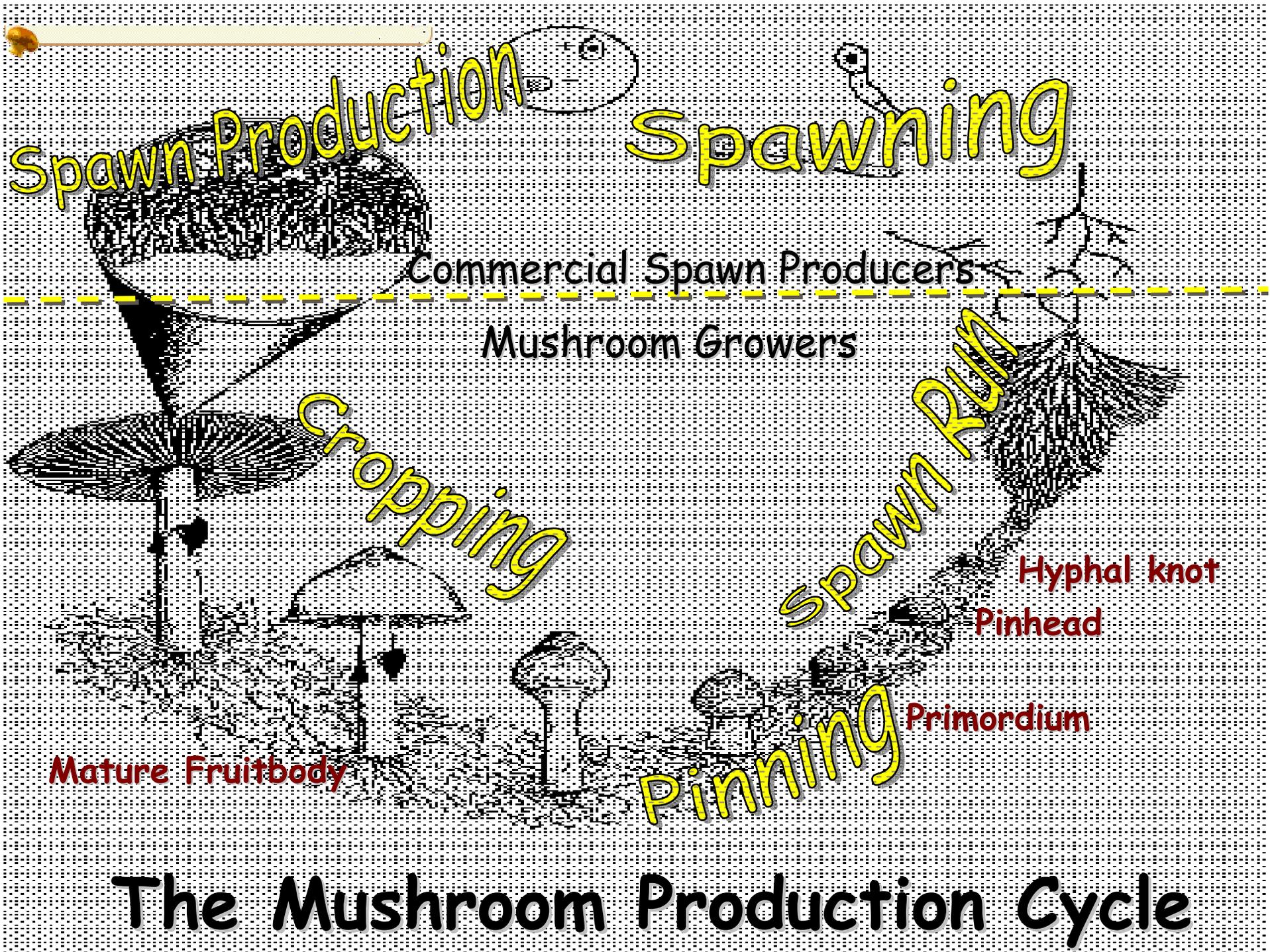
Hyphal knot

Pinhead

Primordium

Pinning

# The Mushroom Production Cycle





# Culture Parameters at Every Production Stage

- **Spawn Run Parameters** or conditions during mycelial colonization of the substrate.
- **Pinhead Initiation Parameters** or conditions for fructification to occur.
- **Cropping Parameters** or conditions needed to sustain the cyclic production of mushrooms or flushing.



# Culture Parameters or Conditions to Monitor

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- Relative Humidity:
- Air T:
- Duration of Stage:
- $CO_2$ :
- Fresh Air Exchanges:
- Light:
- Intervals:
- Watering:





# Semi-Controlled Conditions

- Temperature of substrate: pocket thermometers (metal 1-inch dial and 5-inch stem)
- Air temperature and relative humidity: battery operated LCD digital thermometer/hygrometer (Thermo-Hygro<sup>®</sup>), which also shows temperature maximums and minimums.
- Relative Humidity: time-set semi-automated misting system (Raindial - Irritrol Systems<sup>®</sup> Model RD 600 Ext).
- PVC pipes: along the production areas on the ceiling, with Turbo-Flo<sup>®</sup> Mistlers, extremely low flow (1/2 gph) and very small droplet size.



# Insulation Material

- External walls and ceiling insulated with insulation boards, Tuff-R Blackore<sup>®</sup>, an insulating sheathing made by Celofex<sup>®</sup>, consistent of semi-rigid carbon black-filled polyisocyanurate-foam with aluminum foil faces on both sides of about  $\frac{3}{4}$  inch thickness. This gives an insulation coefficient of R=7.5.

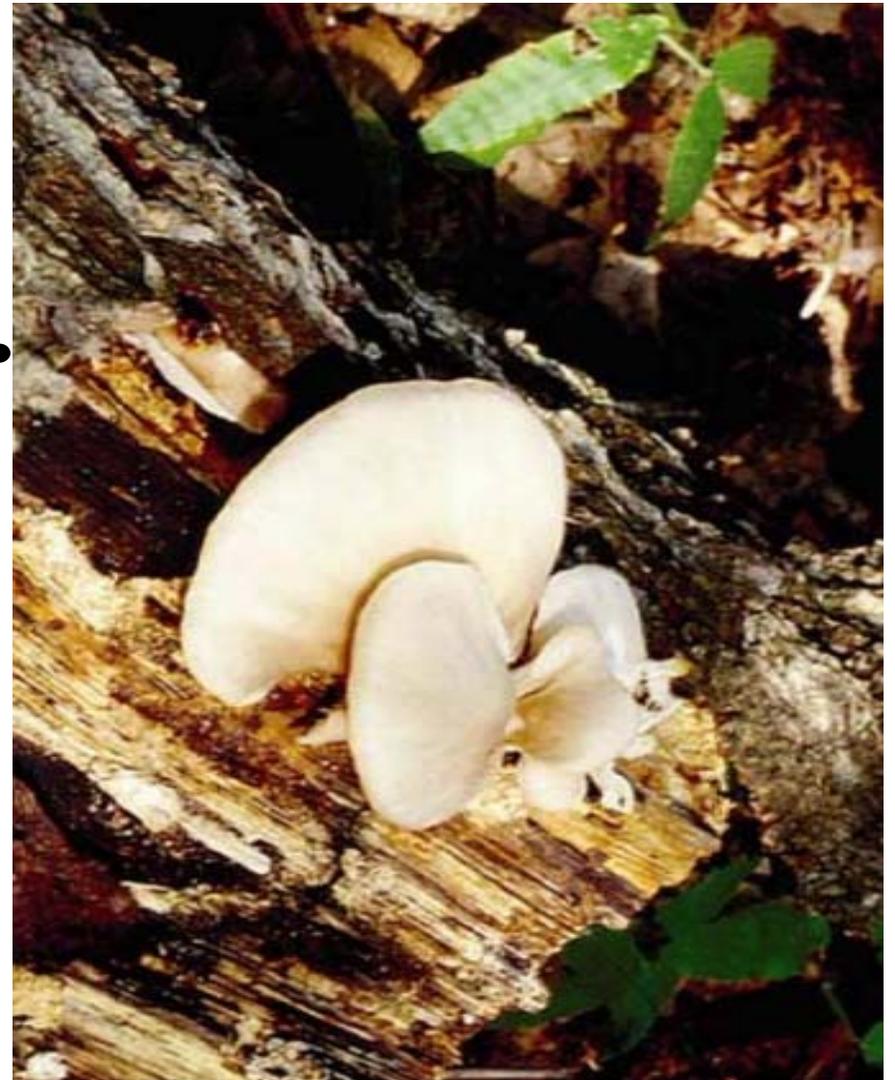




# Oyster Mushroom Production



*Pleurotus* spp.





Natural



И 89.1-18+





# Biology

- *Pleurotus spp.* efficiently utilizes its substrate. Its ability to fruit on a single component substrate, to permeate the straw rapidly while tolerating high carbon dioxide levels and to produce abundant crops within a short time period, makes it ideal for small scale cultivation.



# Commonly Cultivated Oyster Mushrooms

- ★ *Pleurotus citrinopileatus* (= *P. cornucopiae*)  
Golden Oyster Mushroom, Tamogitake
- ★ *Pleurotus cystidiosus*  
Abalone Mushroom, Maple Oyster, Miller's Oyster
- ★ *Pleurotus columbinus*  
Blue Oyster Mushroom
- ★ *Pleurotus djamor* (= *P. salmoneo-stramineus*)  
Pink Oyster, Salmon Oyster, Strawberry Oyster, Flamingo Mushroom, Albino Oyster Mushroom, Takihiro Hiratake



# Commonly Cultivated Oyster Mushrooms

- ★ *Pleurotus eryngii*  
King Oyster Mushroom
- ★ *Pleurotus euosmus*  
Tarragon Oyster Mushroom
- ★ *Pleurotus flabellatus*  
Strawberry Oyster Mushroom
- ★ *Pleurotus ostreatus*  
Old World European Blue Oyster, New World  
American Beige Oyster, Tree Oyster, Oyster  
Shelf, Espresso Oyster, Pearl Oyster, Hiratake



# Commonly Cultivated Oyster Mushrooms

- ★ *Pleurotus ostreatus-florida* (= *P. floridanus*)  
Tropical Oyster, Florida Oyster
- ★ *Pleurotus pulmonarius*  
Phoenix Oyster, Indian Oyster Mushroom
- ★ *Pleurotus sajor-caju*  
Tropical Phoenix Oyster, Tropical Indian Oyster  
Mushroom
- ★ *Pleurotus tuberregium*  
King Tuber Oyster Mushroom, Tiger Milk  
Mushroom, Omon's Oyster



# *Pleurotus* different types



# *Pleurotus* spp. Production Systems





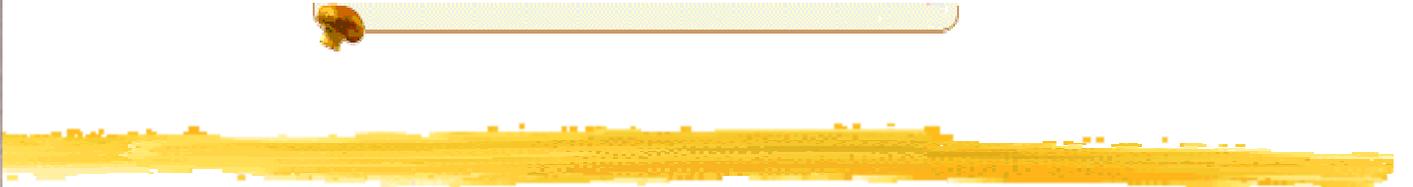


# *Pleurotus* spp.

## Spawn Run Parameters

(Substrate Colonization)

- **Relative Humidity:** 90-100%.
- **Substrate T:** Fastest growth 78-84°F.  
Thermal death occurs above 104°F /48 hr.
- **Duration:** 10-14 days for colonization.
- **CO<sub>2</sub>:** 20,000 ppm or 20% by volume. Growth is stimulated up to 28,000 ppm.
- **Fresh Air Exchanges:** None (0/hr).
- **Light:** Incubation in total darkness.





## *Pleurotus* spp. Pinhead Initiation Parameters

- **Relative Humidity:** 95%.     **Air T:** 55-60°F
- **Duration:** 7-14 days.     **CO<sub>2</sub>:** less than 600 ppm.
- **Fresh Air Exchanges:** 4/hr.
- **Light:** Phototropic, most responsive to an exposure of 2,000 lux/hr for 12 hr/day. Grow-lux type fluorescent lighting recommended. Diffuse natural light is sufficient.
- **Watering:** Regular misting once to twice daily until fruit bodies are 30-40% harvest size.



# Primordia or Pinheads





# Fruiting Clusters









## *Pleurotus* spp. Cropping Parameters

- **Relative Humidity:** 85-92%.    **Air T:** 60-64°F
- **Duration:** 5-7 weeks.    **CO<sub>2</sub>:** less than 600 ppm.
- **Fresh Air Exchanges:** 4-6/hr.
- **Light:** Same as for pinhead initiation.
- **Harvest Stage:** Directly before incurved margins elevates to plane.
- **Flush Intervals:** ~10 days.
- **Watering:** Regular misting to prevent caps from cracking and to keep resting pinheads viable.











## *Pleurotus* spp. @ Harvest

- **Moisture Content:** 91% water, which means that for every 100 g of fresh weight of mushrooms, we get only 52.36 g of dry matter after dehydration, losing 47.64 g of water.
- **Nutritional Content:** Crude Protein has been reported at 30.4% of dry weight.
- **Yield Potential:** Average commercial yield are 1 kilogram fresh weight of mushrooms per kilogram of dry weight of substrate.
- **Biological Efficiency:** 100% or more.



# How to Calculate Moisture Content

- 100 g of Mushrooms (or any matter) dry in oven (@60°F) until constant weight.
- Moisture Content = Weigh of lost water (100 g - dry weight) /dry weigh x 100



# Shiitake Production



*Lentinula*  
*(Lentinus)*  
*edodes*





Natural



И 89.-+ 8+



# Biology

- *Lentinula (Lentinus) edodes*. A wood decomposer, typically saprophytic growing on dead tissue of deciduous trees mainly Fagaceae (oak, shiia (*Pasania*), chestnut, alder and beech), and fruiting in the fall, early winter and spring.



# Shiitake Production Systems





# Shiitake

## Spawn Run Parameters

(Substrate Colonization)

- **Relative Humidity:** 60-75% for logs; 90% for sawdust blocks or artificial logs.
- **Substrate T:** Fastest growth 77°F. Below 41°F and above 95°F mycelial growth halts.
- **Duration:** 6-12 months for logs; 30-60 days for sawdust blocks.
- **CO<sub>2</sub>:** None established.    **pH:** 5-6
- **Fresh Air Exchanges:** None (0/hr).
- **Light:** None required.







# Shiitake Pinhead Initiation Parameters

- **Initiation:** Submerge logs and blocks in cold water for 24-72 hr.
- **Relative Humidity:** 95%.     **Air T:** 59-68°F
- **Duration:** 7-14 days after soaking.
- **CO<sub>2</sub>:** None
- **Fresh Air Exchanges:** 2 - 4/hr.
- **Light:** Ambiantal natural light or optimally 10 lux in the 370-420 nanometer range.



# Primordia or Pinheads











# Shiitake Cropping Parameters

- **Relative Humidity:** 85-90%.     **Air T:** 59-68°F
- **CO<sub>2</sub>:** less than 1000 ppm.
- **Fresh Air Exchanges:** 2-4/hr (cooling).
- **Duration:** 3-5 years on oak logs; 2-3 years on alder.
- **Light:** Same as for pinhead initiation.
- **Harvest Stage:** Directly before incurved margins straightens and the cap expands to plane.
- **Flush Intervals:** Outdoor fall and spring; indoor up to 4 flushes depending on soaking schedule.





## Shiitake @ Harvest

- **Moisture Content:** 85% water (54.05 g dry matter / 100 g of mushroom).
- **Nutritional Content:** Crude Protein 10-17.5% and 55 mg niacin/100 g of dry weight.
- **Yield Potential:** Average commercial yield are 2-3 lb fresh weight of mushrooms per log.
- **Biological Efficiency:** 50-145%.





# Biological Efficiency

- Biological Efficiency is the ability of converting dry matter into fresh weight, expressed as percentage.
- To produce one pound of beef, a cow needs 15 lb of dry matter = 6.7%
- To produce one pound of chicken, a chicken needs 5 lb of dry matter = 20%
- To produce 1 lb of mushrooms, substrate needs 1 lb or less of dry matter  $\geq$  100%



# Examples of Biological Efficiency

- Oyster Mushrooms = 100 - 200%
- White Button Mushrooms = 70 - 100%
- Shiitake = 50 - 145%
- Maitake = 5 - 35%



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