II

II-1.- Mushroom Poisoning (Mycetism)

1.- Poisoning involving cell death
- Cyclopeptides (*Amanita* species)
- Monomethylhydrazine (*Gyromitra*)

2.- Coprine poisoning (*Coprinus atramentarius*)
3.- Muscarine poisoning
*4.- Ibotenic acid/muscimol poisoning (*Amanita muscaria*)
*5.- Psilocybin/Psilocin poisoning (*Psilocybe* species)
6.- Gastrointestinal poisoning (various species)
7.- Miscellaneous poisoning
*Hallucinogenic effects

II-2.- *Amanita* (Cyclopeptide) Poisoning

*Poisonous species of *Amanita* produce a variety of toxic cyclopeptides including phallotoxins (the source of phalloidin), virotoxins and amatoxins; most of damage is done by the amatoxins.
*Amatoxins attack the nucleoli in the nuclei of liver cells. They are filtered out of the blood by the kidneys but attack the convoluted tubules and are then reabsorbed into the bloodstream.
*Stages of poisoning

1. First latent period--no symptoms for 6-24 hrs. (usually 8-12 hrs.); the shorter the period, the more toxin consumed.
2. Gastrointestinal phase--sudden onset of nausea, vomiting, abdominal plain and diarrhea; may last for 12-24 hr to 4 days; leads to loss of electrolytes that contributes to:
    a. Lowering of blood pressure
    b. Accelerated pulse
    c. Shock
    d. Dehydration
    e. Leg cramps
3. Second latent period--12-24 hr to four days; liver and kidneys are being damaged
4. Serious phase--enlarged and pressure sensitive liver, jaundice, stomach and intestinal bleeding, loss of consciousness and death in hepatic coma some 4-7 days after consumption.

II-3.- Coprine Poisoning

- Due to combining alcohol and the inky cap mushroom *Coprinus atramentarius*.
- This mushroom contains coprine, an antabuse-like chemical that interferes with the metabolism of alcohol.
-Symptoms appear 30 min to 1 hour after consumption and may last for 4-5 days.
-Symptoms include

1. Flushing of face
2. Throbbing of neck
3. Swelling of hands and feet
4. Difficulty in breathing
5. Strong metallic taste in mouth.

II-4.- Miscellaneous Mushroom Poisoning
1. Food poisoning due to bacteria growth
2. Allergic responses
3. Intolerance
4. Contamination with heavy metals
5. Imaginary poisoning (panic attacks).

II-5.- Mushrooms as Food
---Good Source of protein
---Low in cholesterol & saturated fat
---Good sources of various vitamins
---Various medical benefits (???)
Agaricus bisporus (= *A. campestris*, *A. brunnescens*)
Nutritional index = Essential amino acid index X % protein divided by 100
Chicken = 59
Beef = 43
Soybean = 31
Spinach = 26
Milk = 25
Agaricus = 22
Carrots = 6

II-6.- Examples of Fungi Commonly Grown for Food/Medicine
*All are referred to as "mushrooms," but not all are true mushrooms (Agaricales)
1. *Agaricus bisporus* = button, cremini, portobella mushrooms
2. *Lentinula edodes* = shiitake mushroom ("shii" tree + "take"= Mushroom)
3. *Pleurotus ostreatus* = oyster mushroom
4. *Volvariella volvacea* = padi straw mushroom
5. *Flamulina velutipes* = enokitake or enoki mushroom
6. *Auricularia auricula* = ear fungus or wood ear
7. *Tremella fuciformis* = white jelly fungus
8. *Hericium erinaceus* = bear's head fungus
9. *Ganoderma lucidum* = Reishi (Japan) or Ling Zhi (China)
10. *Grifola frondosa* = Maitake mushroom hen of the woods
11. *Ustilago maydis* = the corn smut fungus (cuitalacoche)
12. *Morchella esculenta* = morel fungus.

II-7.- Substrates for Mushroom Growth
-Logs, sawdust, woodchips, wheat straw, leaves, sugar cane bagasse; pomace (apple waste), wastes from sugar beets, coffee, tea and cotton, horse manure and chicken manure
-Materials either used directly or composted
-Anything that yields a C/N ratio of 80:1 to 10:1 can be composted

-Ideal end product should have 1.5-1.7% N, 70% water content and 30:1 C/N ratio.

II-8.- Commercial Production of *Agaricus bisporus*

*Appears to have begun in the 1650's near Paris, France where melon growers noticed that mushrooms routinely developed on wheat straw and manure that they applied to their crops
*By 1770 individuals in France were growing *Agaricus* outdoors on piles of straw and manure covered with soil.
*By 1780 production of mushrooms was moved into caves; commercial production soon spread to England.
*From England production soon spread to the U.S., principally the Philadelphia area.

II-9.- Production of *Agaricus bisporus*

*Involves approximately 7 steps
1. Spore germination (requires heat shock; discovered in 1890; allowed growers to develop improved strains)
2. Spawn growing (the production of mycelium on winter rye or tobacco stems + calcium carbonate)
3. Composting of substrate (horse manure and wheat straw historically used)
4. Filling and sweating out (finishing); sweating out involves pasteurization at 58-60 degrees C
5. Spawning (spawn is added to compose); mycelium allowed to grow 15-20 days; 25 degrees C is ideal; must have good ventilation; moisture level is critical
6. Casing (a thin layer of soil is placed on the compose; this induces sporulation; mushrooms develop in “flushes” or “breaks” in a few weeks
7. Harvesting and marketing.

II-10.- Composting

--- 2 week long process that produces a substrate that meets the nutritional needs of *Agaricus* and which provides the physical and chemical environment that favors the growth of *Agaricus* over other microorganisms

Start with

--- 6-8 tons of wheat straw and horse manure
--- 300 pounds of dried poultry manure
--- 300 pounds of dried brewer’s grain
--- 300 pounds gypsum (a white mineral containing Calcium)

Phase 1.- Large piles of materials are mixed and watered. Piles are turned and mixed on days 3, 5, & 7 to keep aerobic; air may be injected

Phase 2.- Composed material placed in beds, trays or bags and pasteurized at 58-60 degrees C; this kills nematodes, fly eggs/larvae, mites, fungi and some bacteria. Spawning done at 25 degrees C.

II-11.- Problems related to growth of *Agaricus*

1. Bad odors associated with composting
2. Disease problems
    **Trichoderma harzianum*
    *Viruses

*Nematodes / fly contamination
3. Disposal of spent (waste) compost
*500,000 tons per year in U.S.
- Soil amendments
- Potting soil
- Strip mine reclamation
4. Competition from foreign growers

II-12.-
Agaricus blazei

-although new to the U.S. and Europe, cultivation of this mushroom is well-established in Brazil and China

-grows well at warm temperatures; can be grown outdoors during the summer

-contains up to 14% beta-glucans that can be used to boost immune system; also appears to selectively kill tumor cells

-primary market now is in Japan where *A. blazei* is known as Himenatsutake; dried mushrooms are used to produce medicinal compounds or consumed as food; has a pronounced almond taste

-however, *A. blazei* belongs to a group of *Agaricus* species that are notorious for the ability to accumulate heavy metals, particularly cadmium which is very toxic

-also contains agaritine, a potentially carcinogenic compound

Note: the popular Portobella mushroom also has been shown to contain agaritine; probably not a good idea to eat this mushroom raw; however, cooking destroys agaritine

II.13.- Production figures for all species
---1982....440 U.S. growers
---1998....153 U.S. growers
---1997-1998 Production = 878 million pounds valued at over $800 million (Pennsylvania produced 379 million pounds valued at over 279 million)
*Per-capita consumption in U.S. is near 2.17 pounds per year and increasing.
II. 14.- ***Lentinula edodes***
---The shiitake mushroom
* Is indigenous to Japan, China and other Asian countries. Is renowned in Orient as food and medicine. Reports of its use as early as 200 AD.
---Good taste
---Good nutritional value
*Protein

*Carbohydrates
*Minerals (especially calcium)
*Ergosterol (converted to vitamin D by sunlight)

---Medicinal uses

*Lentinan (extracted from basidiocarps and mycelium)
*LEM (*Lentinula edodes* mycelium extract)
*Both compounds reported to have anti-tumor and anti-viral activity. Are thought to enhance the immune system. Also reported to lower blood pressure and reduce cholesterol levels.

II-15.-

Commercial production of Shiitake Mushrooms

-*Lentinula edodes* is a true saprobe and in nature grows on dead trees/stumps or on dead portions of living trees

-there are two principal ways of growing shiitake on a commercial basis

1. Outdoors on hardwood logs; used mostly by small growers; not extremely profitable; takes 6-12 months to get a crop; involves cutting, drilling and sawing of logs; logs are then placed outdoors in a shady area and watered periodically; once mycelium has permeated the logs they are soaked for 24-36 hours in water and then stacked; mushroom development begins in a few days to weeks; mushroom development may continue for several weeks but becomes sporadic.

2. Indoor growth on hardwood sawdust amended with nitrogen rich supplement such as bran from rice, wheat, rye, oats or soybeans; substrate is moistened, mixed and placed in heat tolerant plastic bags equipped with a "breathing filter." Following sterilization, bags are inoculated iwth spawn and placed in climate controlled rooms; contents of bags are kept moist until mycelium has permeated the substrate and mushroom promordia become visible (usually 70-90 days); "shiitake blocks" are removed from bags and mushrooms mature; blocks can be dried and soaked to induce more flushes.

II-16.- Examples of fungi collected in nature on a commercial basis

1. *Morchella* species = morels
2. *Cantharellus cibarius* = chantarelles
3. *Tuber* species = truffles
4. *Tricholoma magnivelare* = Matsutake or pine mushroom
5. Various species of *Boletus*

II.17.- Truffles

*Belong to the genus *Tuber*, Phylum Ascomycota
*About 60 species are known worldwide; only a few are prized as food
*Are the most expensive fungi used as food
*All are mycorrhizal and produce their hypogeous (underground), tuber-like spore producing structures near plant roots

*Two most highly prized species are *Tuber melanosporum* and *Tuber magnatum*
*There are some truffles found in south Georgia in pecan orchards; other species are fairly common in the Pacific Northwest.
1. *Tuber melanosporum* = The "black winter" or "melano" truffle; is preferred by most people; is found in southern France and parts of Italy and Spain; Collected December through March near oak and hazlewood trees growing in chalky soils; prefers areas where summers are hot with scattered rain storms and winters that lack harsh freezes.
2.- *Tuber magnatum* = The "white" or "magnatum" truffle is found primarily in Italy; costs 4 times more than the melano; is eaten raw (flavor is lost when cooked) over pasta or rice; collected from October to January.
*The term for truffle hunting is "cavage"; best cavage partners are dogs; pigs once were used but present special problems; in a small scale search one can look for where flies lite on bare ground under oak trees; some flies lay their eggs in soil just above truffles.
*Yearly truffle production is now only 3% of what is was in 1900's
-Truffieres were not kept up
-New oak trees were not planted
-Less land is available
-Interest and knowledge were not transmitted to younger generations.

II-18.- Most Common Claims for Medical Benefits of Mushroom
- Lower blood pressure
- Lower cholesterol
- Lower blood sugar (glucose)
- Reduce stress
- Anti-viral and anti-bacterial effects
- Anti-tumor effects
- Boost immune response
- Increase sex drive.

-Medicinal compounds from mushrooms are often described as "adaptogens"

-an adaptogen is a compound that performs broad-based, non-specific actions in the body that support the functions of all the body's major systems. They are said to aid in the body's natural resistance to toxins, noise, emotional stress and pathogens. They are especially noted for their ability to rebuild endurance and reduce fatigue.

II-19.- Medicinal Value of Mushroom
* A variety of claims have been made for the medicinal values of various mushrooms; many claims may be true but few have been proved by controlled experiments or tests
* Some of the most notable species are:
1. *Ganoderma lucidum* = Reishi mushroom (Ganoderm)
2. *Cordyceps sinensis* = caterpillar fungus
3. *Lentinula edodes* = shiitake mushroom (Lem, Lentinan)

4. *Grifola frondosa* = hen of the woods or Maitake mushroom. (β-glucans)
5. *Trametes versicolor* (Krestin)

Historically, the appearance of a fungus was thought to provide hints as to its value as medicine; this idea was referred to as "The Doctrine of Signatures"; examples include;
1. *Phallus*
2. *Daldinia*
3. *Elaphomyces*

II - 19A - PREVENTION/TREATMENT OF MULTIPLE SCLEROSIS WITH CERTAIN MUSHROOMS

There is some evidence that the consumption of certain mushrooms or mushroom products may help prevent as well as ameliorate MS. Examples include the following:

Hericium erinaceus - the lion's mane or bear's head fungus

various species of *Cordyceps* including *C. sinensis*, the caterpillar fungus

Ganoderm lucidum (Reishi) and *G. tsugae*

Wolfiporia cocos - (Indian bread or tuckahoe)

* However, there is some evidence to suggest that certain mushrooms or mushroom products that overstimulate the immune system may be detrimental to MS patients

II-20.- Examples of Agarics
Agaricus - The meadow mushroom.
A. brunnescens - Is principal commercial mushroom.
Chlorophyllum - Only green-spored mushroom, common in yards, open areas.
Amanita caesarea - Good edible mushroom, commonly known as Caesar's mushroom
A. muscaria - fly agaric, madman's mushroom, hallucinogenic.
A. virosa - The destroying angel.
A. phalloides - The death cap, the most poisonous mushroom.
Psilocybe - Principle hallucinogenic mushroom, "shrooms".
Corpinus atramentarius - An inky cap mushroom, good to eat unless consumed with alcohol.
Armillaria mellea - Serious root rot pathogen of trees, the honey mushroom, good to eat.
Pleurotus - The oyster mushroom, good to eat, some grow on living trees, grown commercially.
Lentinula edodes - The shiitake, growth commercially, various medicinal claims made for this species.
II-21.- Notable Non-agarics Sometimes Referred to as "Mushrooms"
Auricularia - The ear fungus, grown commercially, popular in Chinese food
Tremella - The jelly fungi, grown commercially, popular in Chinese food.

Cantharellus - Chanterelles, grow wild, good to eat.
Morchella - Morels or sponge mushrooms, grow wild, are mycorrhizal.
Tuber - Truffles, fruiting structures look like small potatoes (tubers), are produced underground, mycorrhizal with oaks.
Phallus, Dictyophora - Stinkhorns, one or two species are grown commercially for food in the Orient.
Ganoderma lucidum - A bracket or shelf fungus that is grown commercially in Orient for medicinal uses. commonly known as "Ling Chi" in China and "Reishi" in Japan.
Ustilago maydis - The corn smut fungus, is edible, commonly known as cuitlacoche or maize mushroom.

II-22.- Examples of Mutualistic Relationships Involving Fungi
1. Mycorrhizae - Relationships between the hyphae of fungi and the roots of plants; almost all plants form mycorrhizae.
2. Lichens - Relationships between fungi and blue green algae or algae.
3. Endophytes - Relationships in which fungi live inside the leaves and stems of plants without causing disease.
4. Leaf-Cutting Ants - Relationships in which ants maintain and care for fungi growing on leaf pieces in underground chambers.
5. Rumen fungi - Relationship in which fungi live inside the digestive tracts of cows, sheep, goats and horses.

II-23.- Lichen
Lichen = a mutualistic association between fungus (called the mycobiont) and an alga or Cyanobacterium (called the photobiont).

Importance of Lichens:
1. Nitrogen fixation (done by cyanobacteria)
2. Food for animals (reindeer moss)
3. Medicines and perfumes
4. Weathering of rocks (lichen acids)
5. Biomonitors of air quality (Some actually accumulate heavy metals and radioactive materials)
6. Dating of objects up to 500 years old.

Basic types
1. Foliose = Leaf-like appearance
2. Crustose = Scale-like or crust-like
3. Fruticose = Erect or pendant (Usually cylindrical in appearance).

II-24.- Leaf cutting Ants
*Mutualistic relationship in which neither ants nor fungus partner is found separately in nature
*Very common in Central and South America; also found in Southeast U.S.
*Are serious pests in tropics where they defoliate trees and crop plants (have caused damage to citrus crops in Louisiana and Florida)
*Important in soiling building; may carry out 88 tons of soil in an average mound. Mounds are up to 3 feet under ground and may consist of over 2000 chambers measuring 8-12 inches in

diameter.
Workers search for leaves, cut leaves and bring to mounds ....give to other workers who chew and mix them with saliva to form a paste-like material. Inoculate with fungus then monitor and clean gardens. Add secretions to eliminate unwanted fungi.

II-25.- Fungi and mutualistic relationships

1. Mycorrhizae (plant roots + fungi)
2. Lichens (fungi + algae)
3. Rumen fungi (fungi + horses, cows, goats, sheep)
4. Endophytes (fungi and plant leaves)
5. Leaf cutting ants and fungi.

II-26.- Two basic types of Mycorrhizae

1. Ectomycorrhizae
    *About 2000 species of vascular plants (mostly woody species)
    *About 5000 species of fungi (mostly Basidiomycetes & Ascomycetes)
    **Pisolithus tinctorius, Thelephora terrestris, Russula* species*, Amanita* species*, Boletus* species.
    ---In ectomycorrhizae, roots are physically altered. Roots are short, thickened and dichotomously branched. Are covered by a mantle of hyphae.
    Intercellular spaces of cortex are filled with hyphae (Hartig network).
2. Endomycorrhizae
    *About 300,000 species of vascular plants including grasses, shrubs, vegetable crops and fruit trees (90% of all vascular plants)
    *About 150 species of fungi all in order Glomales of Zygomycetes.
    ---Roots appear normal but cells of cortex are filled with vesicles and arbuscules (V.A. Mycorrhizae)

In a 5 acre Southern pine plantation there may be as many as 150 species of ectomycorrhizal fungi; a single 20 year-old pine tree may have formed relationship with as many as 30 different species of fungi.

**Pisolithus tinctorius* (=Mycorhiz, a product of Abbott Laboratory)

Mycorrhizae(e) = A mutually beneficial relationship between plant roots and hyphae of fungi
    ---Benefit to fungus
        *Food source
    ---Benefits to plant
        *Increased absorption of N, Ca, P, K
        *Drought tolerance
        *Tolerance to heavy metals & pH extremes
        *Tolerance to temperature extremes
        *Protection against root pathogens
        *Growth hormones

II-27.- Endophytes

-Fungi that grow inside plant leaves or stems without causing disease. The presence of the fungus

benefits the plant.

*Benefits include insect resistance and drought tolerance; fungus partner gets food

-Endophytes have been reported in various types of plants ranging from trees to grasses; studied most extensively in grasses due to problems caused when grasses are eaten by animals; problems are caused by toxic alkaloid chemicals produced in plants by these fungi.

-Example of problems related to consumption of grasses containing endophytes by animals.

1. Fescue toxicosis, fescue foot and bovine fat necrosis ..... USA/principally in cattle
2. Agalactia .....USA/horses; mares do not produce milk after giving birth
3. Rye grass staggers ..... New Zealand and Australia/sheep
4. Sleepy grass ..... China/cattle; go to sleep, do not eat, often starve
5. Dag and fly strike ..... New Zealand and Australia/sheep; can not void feces completely.

II-28.- Fescue Toxicosis, Fescue foot and Bovine Fat necrosis

*Fescue toxicosis symptoms include poor weight gain, low milk production, low fertility, animals can not regulate body temperature

*Fescue foot symptoms include loss of holfs, tails and ears dues to constriction of blood vessel and poor circulation.

*Bovine fat necrosis - causes intestinal strangulation (related to high nitrogen levels).

-All three conditions are caused by cattle eating a type of tall fescue known as Kentucky 31; this forage grass is very common in the Southeast; grown on 35 million acres; estimated losses in cattle due to low fertility and poor weight gain are $500 million to $1 billion per year

- Kentucky 31 was discovered in Kentucky in 1930; because of its excellent insect resistance and drought tolerance it became very popular; problems with animals increased over the years; cause was discovered in 1970 by researchers here in Athens

- Discovered that leaves of Kentucky 31 contain the endophyte *Neotyphodium coenophialum*, a close relative of the ergot fungus *Claviceps purpurea*.

- Chemicals that poison cattle provide insect resistance; the endophyte also causes plants to produce finer and more fibrous roots that are more effective in absorbing water and nutrients.