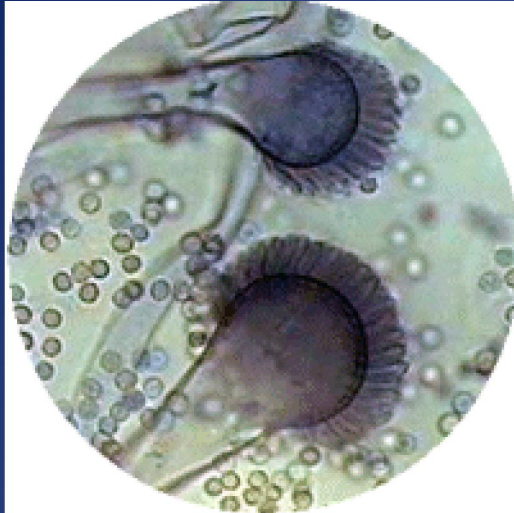


<http://www.ptccmold.com/images/mycotoxins.jpg>



<http://cropmonitor.co.uk/images/fusariumImages/Image344.jpg>

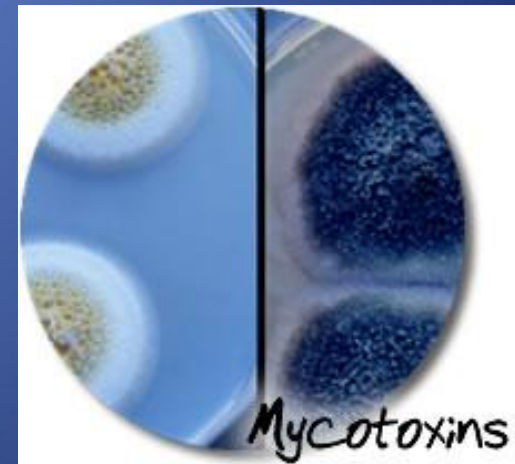


Mycotoxins

A Biological Perspective



http://www.knowmycotoxins.com/cn/assets/maninfieldcropped_000.jpg



<http://www.ptccmold.com/images/mycotoxins.jpg>



What is a Mycotoxin?



- Secondary metabolites (chemicals) of a fungus that produce toxic results in another organism.
- Cytotoxic: disrupt cell structures such as membranes, and processes such as protein, DNA, and RNA synthesis.
- Lack of visible appearance of fungus does not negate presence of mycotoxins. Toxins can remain in the organism after fungus has been removed.
- Less selective in organism selection, can cross plant species barrier.
- Can be heat stable, not destroyed by canning or other processes.

Information About Fungus

- Range from single cells to fruiting bodies that form molds, mushrooms, smuts, and yeasts.
- Absorb nutrients from living or deceased organisms, contain no chlorophyll.
- If multicellular, they have tubular filaments called hyphae that branch out.
- Reproduce using spores.



Modes of Spore Transmission

- Airborne, wind or indoor ventilation systems.
- Attachment to insects or birds, thus transmitted from plant to plant, or animal to animal, etc.
- Via transportation mechanisms such as trucks, crop machinery, etc.



Fungal Infection

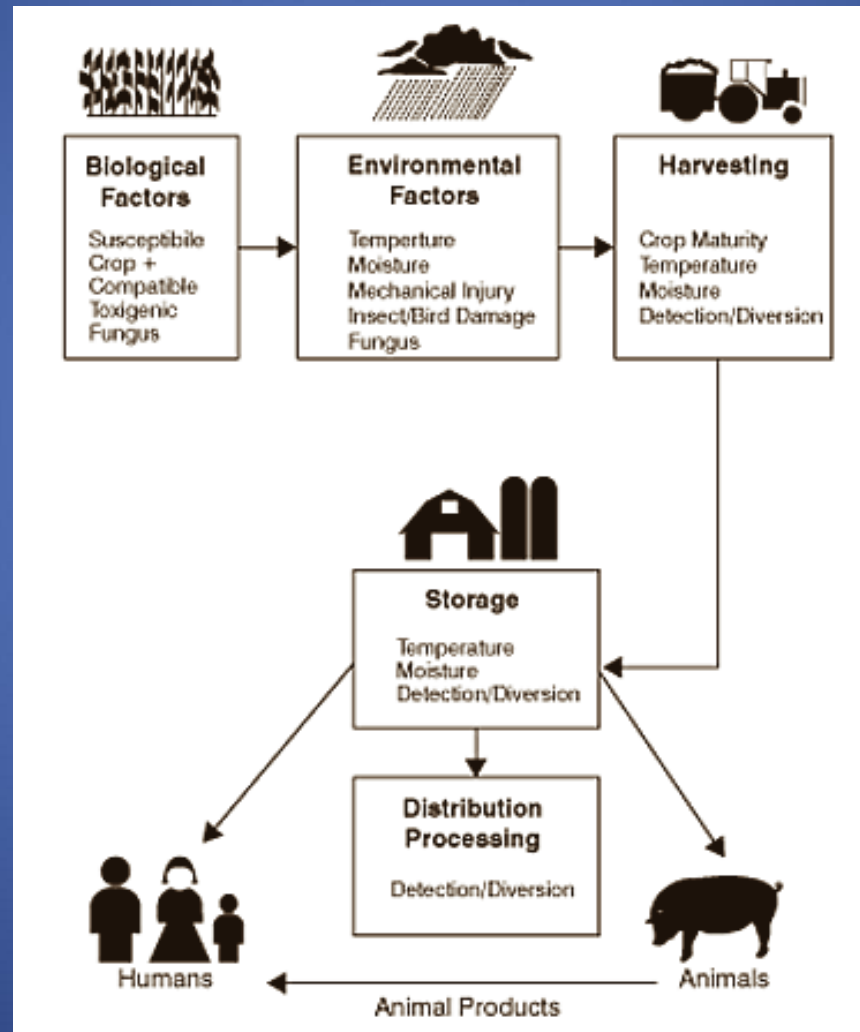
- Can occur at any stage in crop production.
- While in the field.
- During harvesting.
- While in silage and storage.
- Spores can lay dormant for months to years, waiting for positive conditions for germination.



Conditions to Encourage Fungal Growth

- Relative humidity over 70%.
- Temperatures over 30 degrees Celsius for a period of a few days to a week.
- Stress to the affected plant, such as drought, flood, or insect infestation.
- High moisture content of crop (20% or higher).
- Must occur in conjunction, or fungal growth cycle will cease.

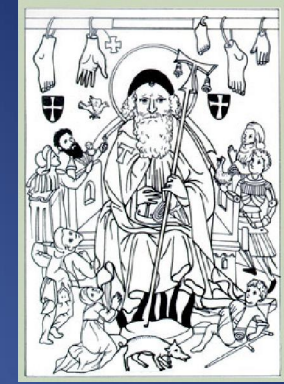
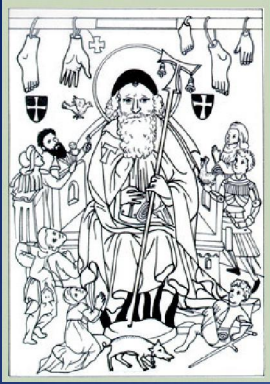
Mycotoxin Chain of Events



Locales of Mycotoxins

- In North America, grain producing areas spread from central Canada to the southern parts of the US.
- These grains are then exported to Asia, the Pacific Islands, South and Central America, Europe, the Middle East, India and Africa.





Brief History of Mycotoxins

- Mycotoxin contamination has affected humans for thousands of years.
- In 7th and 8th century, festival for Roman God Robigus, protector of grain and trees was celebrated to stave off rust and mold.
- Middle Ages had outbreaks of ergotism.
- Only in last 30-40 years have scientists been able to isolate specific toxins from their fungal source.
- Research ideas and methodologies, in this field, change frequently, and data from 20 years ago are considered questionable.

Mycotoxin Statistics

- 300-400 mycotoxins presently identified, with more becoming evident as new isolation techniques are used.
- Most frequent toxins present are aflatoxin, DON, ZEN, fumonisin, and T-2 toxin, to name a few.



Mycotoxin Health Hazards

- Generally lower risk in well developed countries due to improved standards of living.
- High intake of affected product, usually in conjunction with limited amounts of other food sources.
- Greatest threat comes from long term exposure due to eating spoiled food or meat from animals fed contaminated feed.



Symptoms of Mycotoxicosis

1. Drugs and antibiotics are not effective in treatment.
2. The symptoms can be traced to foodstuffs or feed.
3. Testing of said foodstuffs or feed reveals fungal contamination.
4. The symptoms are not transmissible person to person.
5. The degree of toxicity is subject to persons age (more often in very young and very old), sex (more often in females than males)and nutritional status.
6. Outbreaks of symptoms appear seasonally.

Mycotoxin Effects on Humans

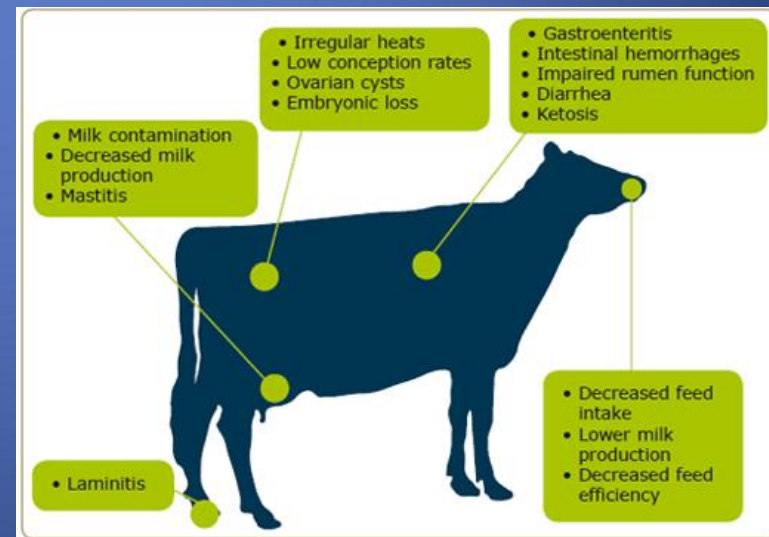
- Economic loss due to impaired health of stock animals.
- Illness: symptoms can include cold/flu-like symptoms, sore throats, headaches, nose bleeds, fatigue, diarrhea, dermatitis, and immune suppression, and vary by species.
- Death.



<http://toxicblackmold.info/images/moldsickenschildren.jpg>

Mycotoxin Effects on Animals

- Feed refusal.
- Impaired animal health, resulting in reduced production of eggs, milk, weight gain, etc.
- Metabolites are passed through the milk in cheese, dry milk, and yogurt.
- Disease.
- Death in animals.





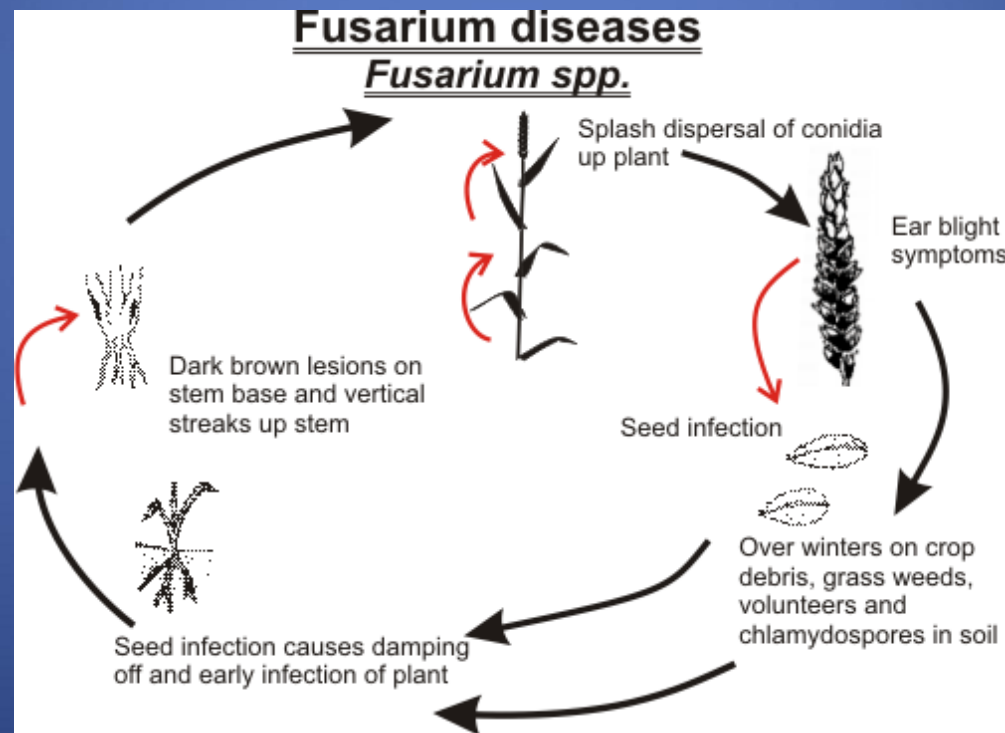
Regulatory Control



- In 1965, the Food and Drug Administration (FDA) set the first mycotoxin limit of 20 parts per billion (ppb) for aflatoxin in all foods and feed.
- But, this toxin can appear at varying levels of food production, so multiple testing at different points in the food chain is necessary.
- Using ELISA (enzyme-linked immunosorbent assay) technology, testing can be done cheaper and faster than previously.
- The FDA does not do the testing, various other agencies do, such as the Grain Inspection Packers and Stockyards Administration; but, toxic levels must be reported to the FDA.

Fusarium

- Fungal species from the genus *Fusarium* will attack corn and wheat plants.



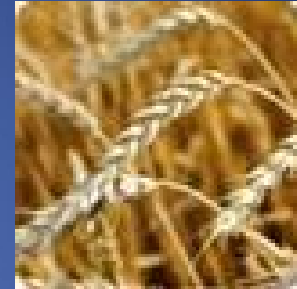
Fusarium (Cont.)

- Most are plant pathogens and can be found in soil.
- Some examples of affected plants are corn, wheat, barley, beans, with lesser contamination in rye, triticale, millet, and oats.
- Trichothecene toxins target the circulatory, alimentary, skin, and nervous systems.

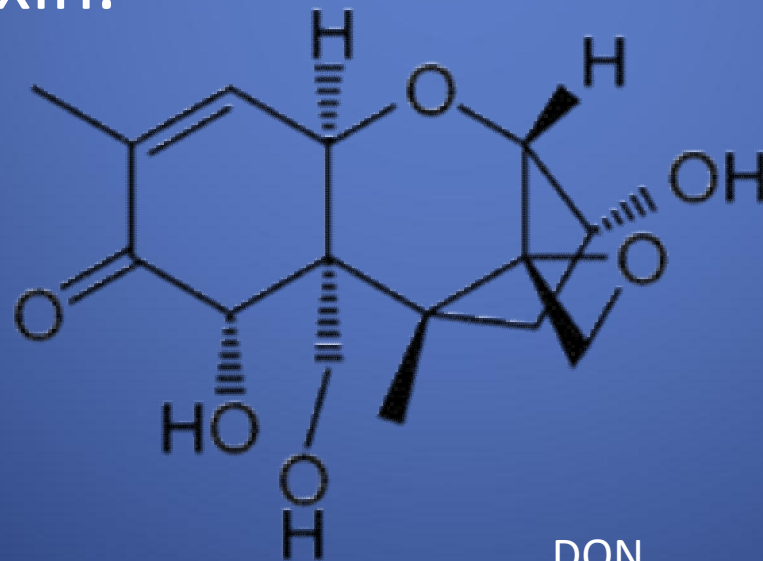


F. graminearum- Wheat

- Causes scab damage to kernels and head blight.



- Produces deoxynivalenol (DON), also called vomitotoxin.

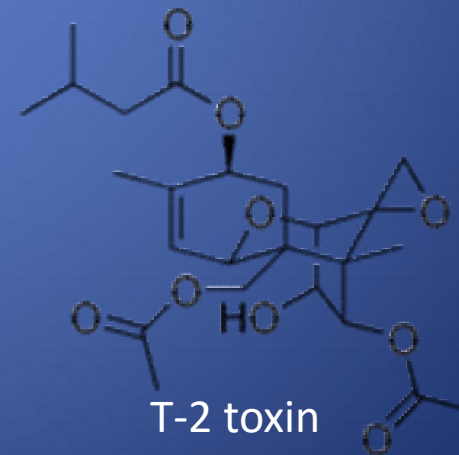


F. graminearum in Maize (Corn)

- Creates Gibberella Ear Rot
- Produces the toxins: DON and zearalenone (ZEN), and T-2 toxins.
- Have damaging effects on plants, humans, and other animals with monogastric digestive processes.



cropwatch.unl.edu





DON and T-2 Toxin

- These are tricothecenes of wheat, grain, and barley.
- They cause necrosis and hemorrhage of the digestive tract, decreased blood production in the bone and spleen, and changes to reproductive systems.
- In poultry, causes reduced egg production, beak lesions, and abnormal feathering
- Optimal temperature range is between 70 and 85 degrees Fahrenheit.
- Advisory level of DON is 1 ppm.

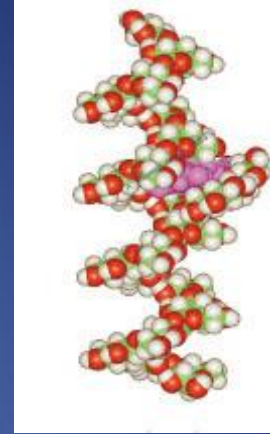


Alimentary Toxic Aleukia (ATA)

- During World War II, in Soviet Union, corn grain left to over-winter becomes contaminated with T-2 toxin.
- Severe mycotoxicosis occurs.
- Symptoms include burning in the mouth, esophagus, tongue, and stomach.
- Blood marrow formation is halted and anemia develops.
- Hemorrhage of nose, gums, mouth and stomach occurs.



Zearalenone



- A tricothecene.
- Mimics the body's production of estrogen.
- Causes feminization of male animals.
- Disrupts conception, ovulation, and fetal development in female animals.
- Pigs are especially sensitive, poultry and cows show little sensitivity.

F. moniliforme



- Plant pathogen most associated with corn. Also found in rice, sorghum, yams, hazelnuts, pecans, and cheeses.
- Diseases associated with this species include “crazy horse disease” in horses, pulmonary edema in pigs, liver cancer in rats, bone malformation in chicks and pigs.
- The fumonisins produced by *F. moniliforme* are linked with esophageal cancer in humans.
- Other toxins produced include fusaric acid, fusarins, and fusariocins.
- Advisory levels are 5 ppm in animal feed.

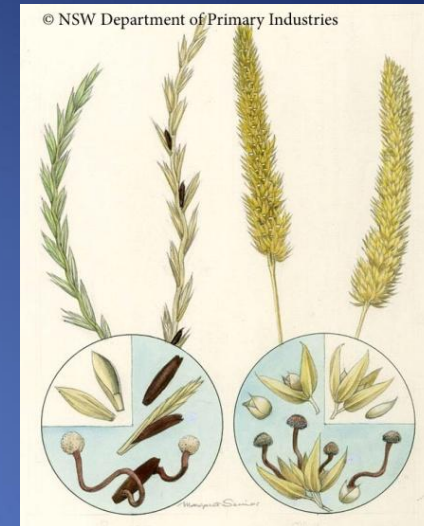


Alternaria Toxins



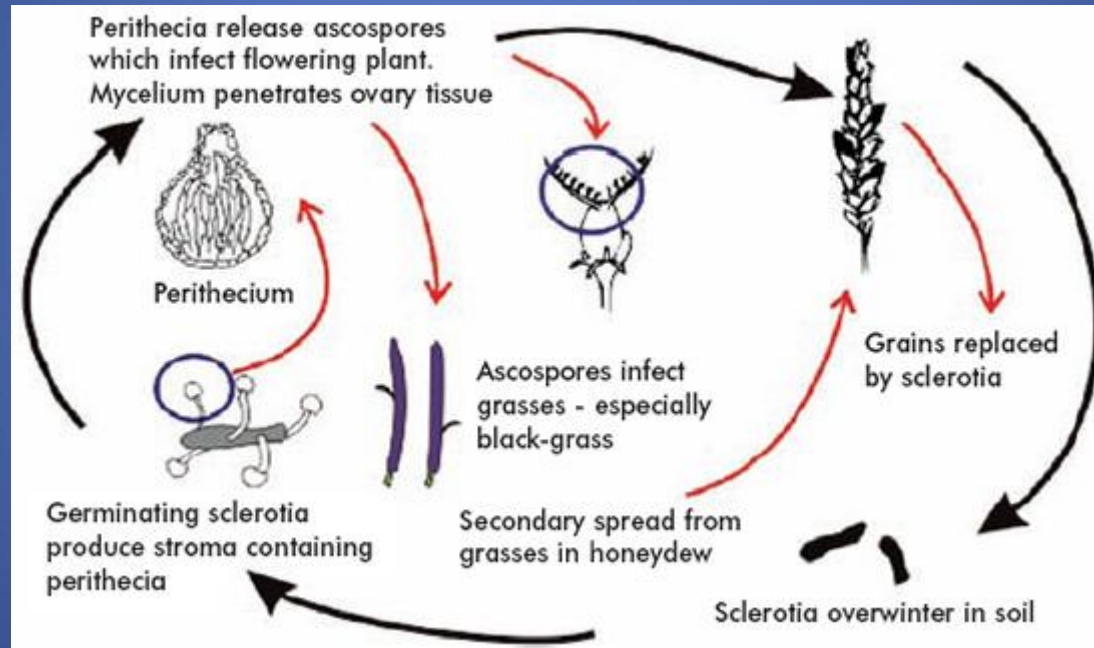
- Infects the plant in the field, such as wheat, sorghum, and barley.
- Also fruits and vegetables that can cause spoilage in refrigeration.
- Toxins include: alternariol, alternariol monomethyl ether, altenuene, tenuazonic acid, and altertoxins.
- Little is know of these toxins; but, toxic effects are seen in rats, chicks, ducklings, and turkeys.

Claviceps Toxins



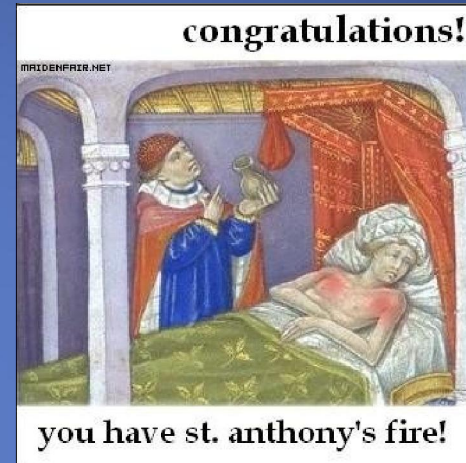
- Earliest recognized mycotoxicosis caused by *C. purpurea*, with ergot mold.
- Outbreaks have been reported since 857 A.D.
- The Middle Ages had near epidemic proportions.
- Humans consumed bread baked with grain containing ergot spores, which produced lysergic acid diethylamide (LSD) symptoms and hallucinations.

Ergot Life Cycle



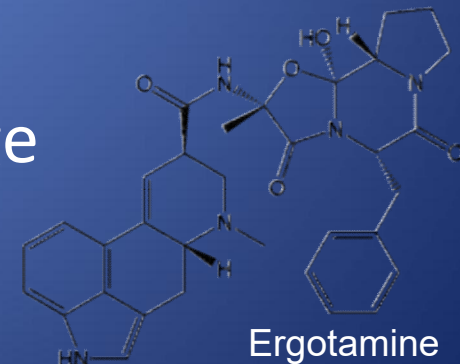
http://hgca.com/images/upload/Ergot_200810647508.jpg

Ergot Poisoning (St. Anthony's Fire)



http://www.quizilla.com/user_images

- Disease of rye, barley, oats and wheat.
- Grains are replaced by ergot sclerotia that contain toxins.
- Main toxin is called ergotamine.
- Named for the belief that a pilgrimage to the shrine of St. Anthony would alleviate the symptoms.



Ergot Poisoning (Cont.)

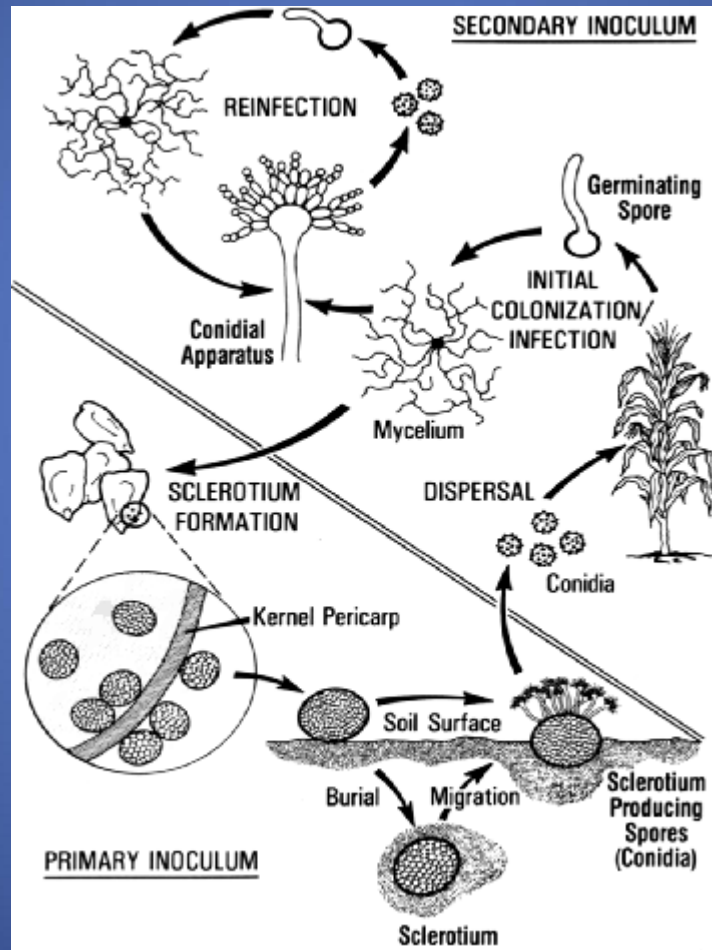
- Animal symptoms: dry gangrene, internal bleeding, vomiting, constipation, diarrhea, and in pigs: abortion of fetuses.
- Human symptoms: gastrointestinal stress; convulsions; fetal abortion; extreme burning and cold sensations in fingers, hands, and feet; gangrene of the extremities.
- Other outbreaks: Russia in 1926, Ireland in 1929, France in 1953, India in 1958, and Ethiopia in 1973.

Aspergillus Toxins



- Large genus with more than 100 species, 50 of which are known to produce mycotoxins.
- Some of which are aflatoxin, ochratoxin A, sterigmatocystin, cyclopiazonic acid, citrinin, patulin, and tremorgenic toxin.
- *Aspergillus niger* is used to make artificial citric acid; one use is in soft drinks.
- Miso, soy sauce, and sake use strains of *A. oryzae*.

Aspergillus Life Cycle

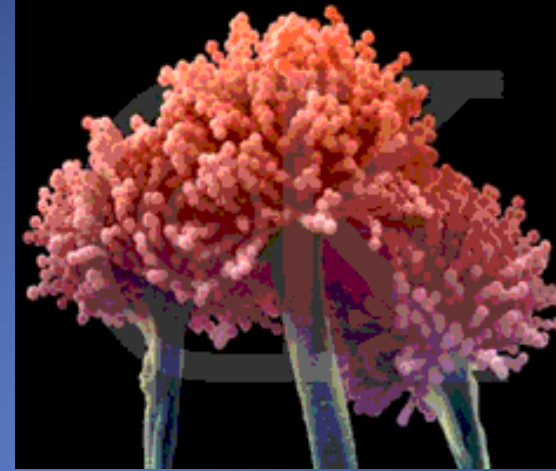


Aspergillus and Aflatoxin

- Aflatoxicosis: caused by high doses in short intervals or low doses in high intervals.
- 1961, caused the deaths of over 100,000 turkey poults: “Turkey X disease”.
- Toxin was traced to contaminated Brazilian peanut meal in poultry feed.
- Grows best between 80-90 degrees Fahrenheit.
- Damage to grain increases likelihood of fungal growth.



Aflatoxin B-1



- Definite link to cancer in animals.
- Possible link to cancer in humans. Studies done in Africa and Asia show a correlative link, but not a causative one.
- Primarily attacks the liver, in cases of cirrhosis, necrosis, and carcinomas with a secondary affect of immune suppression.
- Risk factor for neonatal jaundice, in areas of maternal consumption.
- Does not stay in the body for long periods of time, usually excreted within 96 hours, in animals.
- In milk, for human consumption, advisory level is .5 ppb.



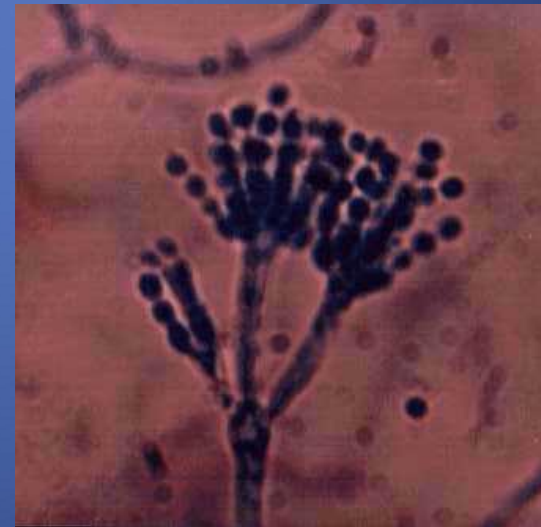
Penicillium Toxins



- Large genus with over 150 species.
- Discovered antibacterial properties within genus, causing production of penicillin.
- 100 species have mycotoxins.
- Nine specific toxins affecting human health are citreoviridin, citrinin, cyclopiazonic acid, ochratoxin A, patulin, penitrem A, PR toxin, Roquefortine C, and, Secalonic acid D.

Penicillium Toxins (Cont.)

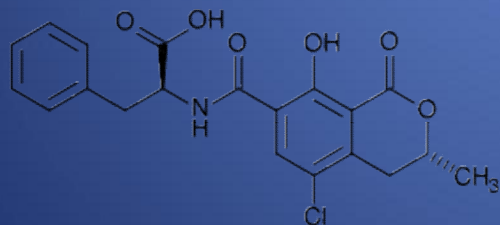
- Separated into two groups: those that affect liver and kidneys, and those that are neurotoxic.
- Liver and kidney toxins are asymptomatic and cause overall animal debility.
- Neurotoxins cause visible trembling.



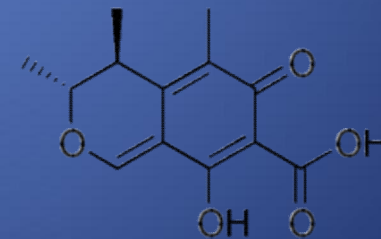
<http://farma.qfb.umich.mx/images/penicillium.jpg>

Ochratoxin A and Citrinin

- Affects kidney function.
- Causes Balkan nephropathy and Yellow Rice Fever in humans.
- Chickens, turkeys, and ducklings are affected by ochratoxicosis, causing poor weight gain, egg output, and poor shell quality.
- Ochratoxin sources are peanuts, pecans, beans, dried fruit and dried fish.
- Citrinin sources are in wheat, rice, corn, and flour.
- Citrinin is most associated with horses, pigs, dogs, and poultry.



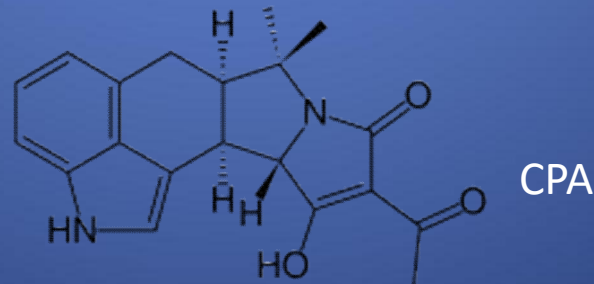
Ochratoxin A



Citrinin

Cyclopiazonic Acid (CPA)

- Found in corn and peanuts in Georgia.
- Chief species from *Penicillium* causes cheese spoilage.
- Causes fatty degeneration in liver and kidneys in animals, chickens are very susceptible.
- May act synergistically with aflatoxin.



Future Fight Against Mycotoxins

- Have farmers select strains resistant to contamination.
- Scientists hope to genetically engineer plants resistant to fungal infection.
- Use feed additives that sequester the toxins and prevent absorption from the gastrointestinal tract.

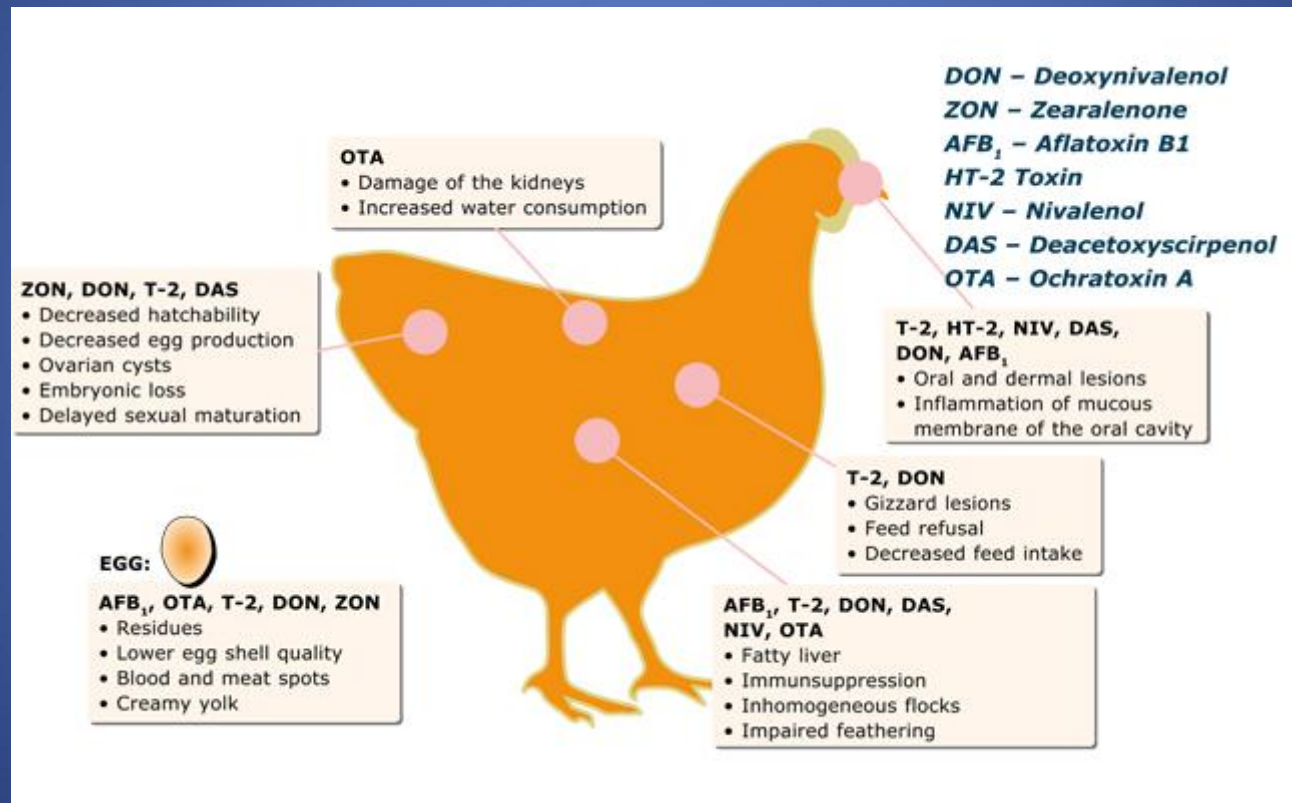


http://mycoglobe.ispa.cnr.it/images/foto_main.jpg

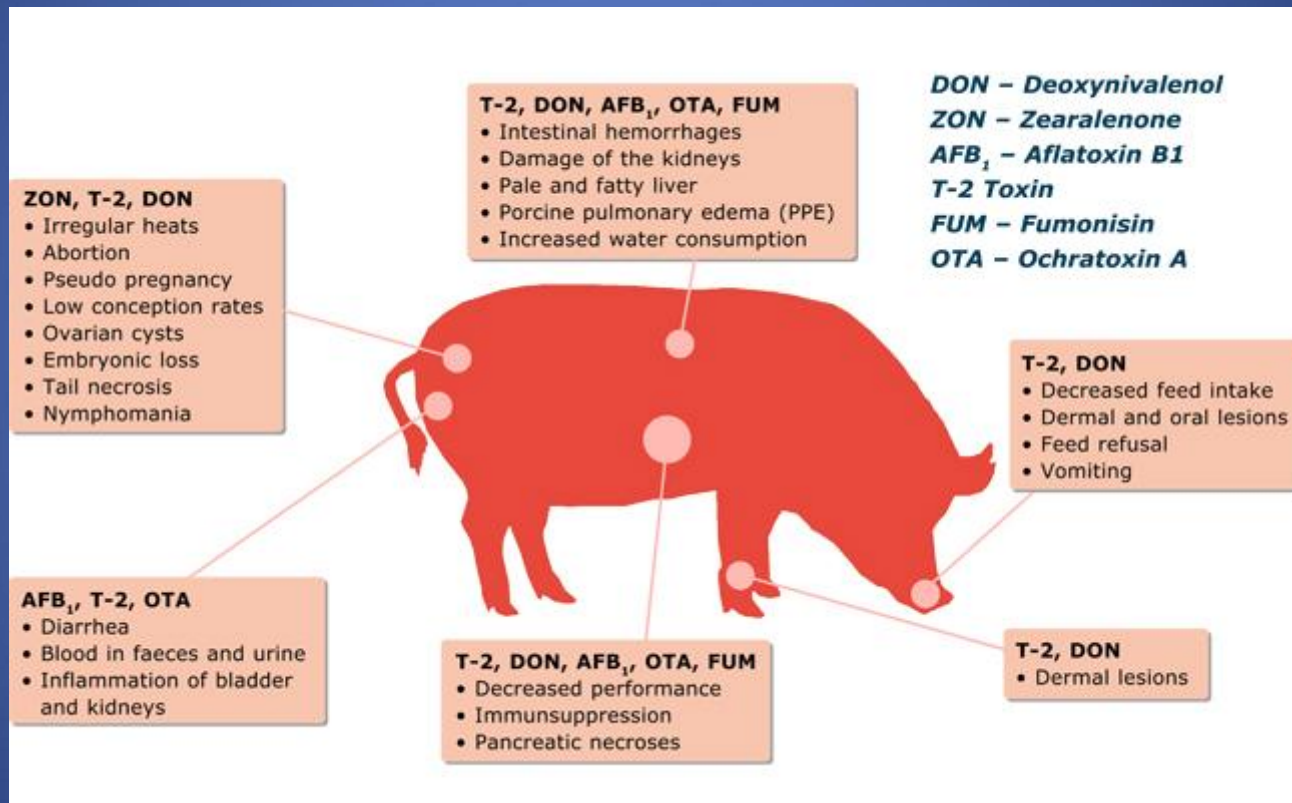
Quick Toxin Review

Organ System Affected	Toxin(s)
Vascular	Aflatoxin
Digestive	Aflatoxin, T-2toxin, Vomitotoxin
Respiratory	Trichothecenes
Nervous	Trichothecenes
Cutaneous	Tricothecenes
Urinary	Ochratoxin A, Citrinin
Reproductive	Zearalenone, T-2 toxin
Immune	Many

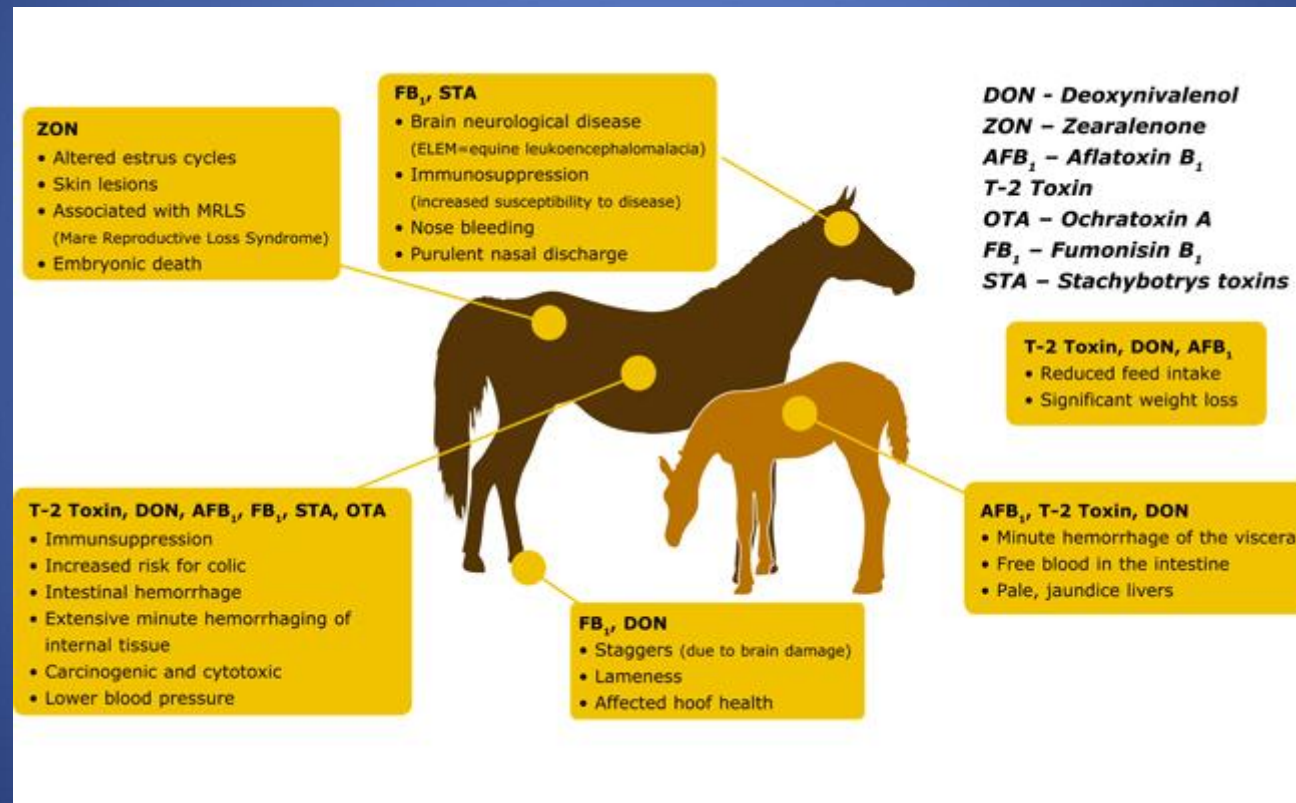
Quick Animal Anatomy Review



Quick Animal Anatomy Review



Quick Animal Anatomy Review



Vocabulary

- **Aflatoxicosis:** A poisoning that results from ingestion of aflatoxins in contaminated food
- **Ascospores:** A sexual spore formed in an ascus.
- **Blight:** General term for sudden, severe, and extensive spotting, discoloration, wilting, or destruction of leaves, flowers, stems, or the entire plant.
- **Carcinogen:** A substance or agent producing or inciting cancer.
- **Carcinoma:** A new growth or malignant tumor enclosing cells in connective tissue.
- **Cirrhosis:** A chronic disease of the liver characterized by progressive destruction and regeneration of liver cells, ultimately resulting in liver failure and death.
- **Fungus (fungi):** Organism having no chlorophyll, reproduces by sexual or asexual spores and not by fission, and, generally, a mycelium with well-marked nuclei.

Vocabulary (cont.)

- **Hyphae:** A tubular, threadlike filament of fungal mycelium.
- **Metabolite:** A product of the chemical changes in living cells by which energy is provided for vital activities and processes and new material is assimilated.
- **Mycelium:** Mass of hyphae constituting the body of a fungus.
- **Mycotoxicoses:** Literally, fungus poisonings; current usage limited to poisoning of people and animals by various food and feed products contaminated (and sometimes rendered carcinogenic) by toxin-producing fungi.
- **Necrosis:** Death of plant or animal cells, usually resulting in tissue turning dark; commonly a symptom of fungus, nematode, virus, or bacterial infection.

Vocabulary (cont.)

- **Pericarp:** Outer layer of a seed or fruit.
- **Perithecia:** A small fruiting body in certain fungi, containing ascospores.
- **Sclerotia:** Hard, frequently rounded, and usually darkly pigmented resting body of a fungus composed of a mass of special hyphae cells. The structure may remain dormant for long periods. Sclerotia germinate upon return of favorable conditions to produce stroma, fruiting bodies and mycelium.
- **Toxin:** A poisonous substance, having a protein structure, that is secreted by certain organisms and is capable of causing toxicosis when introduced into the body tissue. Toxins are also capable of inducing an antitoxin.
- **Trichothecene:** A group of chemically related compounds produced by fungi such as *Fusarium*