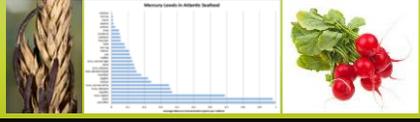


PHC 4573
Foundations of Food Safety

Food Toxicology I

Lecture 11



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Lecture Objectives

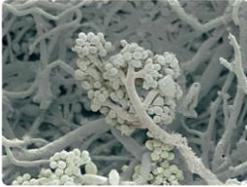
- List and describe the microbial toxins found in foods.
- Explain the potential for environmental toxins to cause unintended food hazards.
- Recognize that many foods contain natural hazards which pose health risks.
- Describe the conditions associated with the microbial, environmental, and natural toxins.

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Microbial Toxins in Foods

- Microbial toxins commonly found in foods include:
 - Mycotoxins (fungi)
 - Scombroid (histamine-producing bacteria)
 - Ciguatoxin (algae)
 - Paralytic shellfish poisoning (algae)
- Note: The toxins produced by *Clostridium botulinum*, *Staphylococcus aureus*, and *Bacillus cereus* were discussed in early lectures.



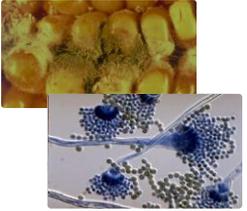
Fungal spores are easily spread due in part to their small size.

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Fungi - Mycotoxins

- Mycotoxins are toxic substances produced by some fungi. The following mycotoxins may be found in foods:
 - Aflatoxin – produced by *Aspergillus flavus* (seen on corn and under a microscope at right)
 - Ergot – produced by *Claviceps purpurea*.
 - Intestinal irritants – produced by poisonous mushrooms.



NCSU – Plant Pathology Extension

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Mycotoxin- Aflatoxin

- *Aspergillus flavus* produces a toxin called aflatoxin which causes an intoxication.
- Found in moldy grains and nuts including corn and pistachios, and also found in peanuts and soy.
- Can cause severe liver damage including cirrhosis, necrosis, and carcinoma.
 - Often fatal.



Aspergillus fungus – Iowa State University.

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Mycotoxin - Aflatoxin

- In 2013 there was a recall of dog foods contaminated with aflatoxin.
- Drought conditions resulted in overgrowth of *Aspergillus* fungus on corn.
- That corn was used to produce dog food.



U.S. Food and Drug Administration
SAFETY

Recall - Pet Food Products

On This Date: Voluntary Recall of Certain Dog Food Products
Pet Food Safety Alerts: The National Center for Human Food Product Safety

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Mycotoxin - Aflatoxin

Outbreak of Aflatoxin Poisoning --- Eastern and Central Provinces, Kenya, January-July 2004

In the United States we routinely test foods for aflatoxin and human cases are rare. In places where detection is not used, large outbreaks with high numbers of deaths (125 above) can occur. Note the cause of this outbreak was contaminated corn.

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Mycotoxins - Ergot

- Ergot is a toxin produced by the fungus *Claviceps purpurea* that infects rye.
- The toxins have hallucinogenic properties.
 - Causes a syndrome known as ergotism or "St. Vitus Dance" which includes spasms and hallucinations.

Claviceps purpurea fungus on rye.

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Mycotoxins - Ergot

- In Salem, Massachusetts in 1692 several women were accused of being witches after exhibiting strange symptoms (hallucinations and spasms).
 - 20 people were executed.
- Ergot is known to have infected rye in Salem, MA, leading some to speculate that the "witches" were in fact poison victims.

Memorial to the victims of the Salem witch trials.

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Mycotoxins - Mushrooms

- Poisonous mushrooms often look similar to hallucinogenic mushrooms.
 - Persons who abuse mushrooms often mistakenly eat the wrong ones.
- The mushrooms commonly produce gastrointestinal irritants (compounds that produce rapid, transient nausea, vomiting, abdominal cramping, and diarrhea).
- Some of the mushrooms are deadly.

Facts and Myths About Poisonous Mushrooms

Fans of eating wild mushrooms are quick to point out that some species are poisonous.

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Poisonous Mushrooms

- In this outbreak in 2012, a caregiver accidentally used poisonous mushrooms to make a soup for elderly patients.
- Four people died and several others became ill.

Mushroom Poisoning At Gold Age Villa Senior Care Facility Claims Fourth Life [Video]

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Scombroid Poisoning

- Intoxication is caused by ingesting large amounts of the chemical histamine which is produced by bacteria in seafood.
 - Tuna, mahi-mahi, sardines, etc.
- Usually results from fish being held at high temperatures for long time periods (temperature abuse).
- Toxin is heat-stable.
 - In other words, it may not be destroyed by cooking.
- Symptoms include dizziness, burning, rash, headache, and can be fatal.
- Severe cases may require treatment with fast-acting antihistamines.

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Scombroid Poisoning – Tuna Steaks



Scombroid Fish Poisoning Associated with Tuna Steaks – Louisiana and Tennessee, 2006

Imported tuna was a common food in these outbreak but elevated levels of histamine were not detected in remaining samples. The source remains unknown.

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Algal Toxins

- The algae rarely cause disease and foodborne infection due to algae is rare. Most cases are due to the following two types of toxins:
 - Ciguatera
 - Paralytic Shellfish Poisoning (PSP toxins).
 - Amesic Shellfish Poisoning.



NOAA – National Oceanic and Atmospheric Administration Center.

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Ciguatera - Algae

- Ciguatera is produced by algae (dinoflagellates – in photo at right).
- The algae are eaten by fish, which in turn eaten by larger fish, causing the toxin to accumulate to dangerous levels in large fish (a process known as bioaccumulation).
 - Prevention is eating smaller fish.
- Symptoms include nausea, diarrhea, vomiting, headache, excessive sweating, weakness, itching, etc.
- There is no specific treatment and disease is rarely fatal.



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Ciguatera – Algae (continued)

- Human cases of ciguatera (the disease caused by ciguatera) usually occur following ingestion of barracuda, snapper, jack & grouper.
- Cases are common in Hawaii and Puerto Rico.
 - However, if the fish are shipped cases can occur anywhere. In the report at right, cases occurred in New York City. The distributor of the fish is not named but reports show that they had already been issued a warning!



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The new bride ordered fish, and it killed her



Ciguatera caused a heart attack that killed a woman who ate grouper in Mexico.

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Shellfish Toxins - Algae

- Produced by several types of algae including the species that causes "red tide".
- The toxins are heat-stable (in other words, cooking does NOT destroy them).
- Infects mussels, clams, oysters, crabs, lobsters and scallops.
- Symptoms can be confused with shellfish allergies:
 - Numbness, tingling occur first.
 - Headache, dizziness, nausea.
- In severe cases, muscle paralysis and respiratory failure occur.
 - death occurs within 2-25 hours.



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Paralytic Shellfish Poisoning - Algae

- Most PSP cases occur in colder climates where the toxin (from the algae) accumulates in the shellfish.
- Saxitoxin is most common.
- Death can occur within 3 to 4 hours due to respiratory paralysis.

Paralytic shellfish poisoning poses a serious risk in four Juneau-Douglas beaches

Four beaches in the Juneau-Douglas area have elevated levels of toxins that can cause paralytic shellfish poisoning.

Public Beach, Wedge Beach, Lake Hemlock Beach and other Park off four Juneau-Douglas that exceeded the fish and shell consumption limit for safe consumption.

Whether there is a potential exposure, they will be kept off the menu for months. The risk is not apparent in the high levels of PSP testing from the size of the.

Alaska Public Media

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Amnesic Shellfish Poisoning - Algae

Brain-damaging toxin closes Down East shellfish industry

A bloom producing 'very many' domoic acid, a toxin that can cause illness, memory loss, brain damage and possibly death in humans, is unprecedented for Maine.

An unusual bloom of toxic algae has closed a third of Maine's coastline to fish and shell harvesting and triggered a national shellfish recall.

Last week, the Department of Marine Resources issued a recall of mussels, clams and scallops caught in Down East Maine after samples tested positive for domoic acid, a toxin that can cause illness, memory loss, brain damage and possibly death in humans.

At the same time, the state banned harvesting for mussels, clams, oysters and scallops within a portion of a wide stretch of coastline from Down East to the Canadian border.

This is the first time the state has banned harvesting for mussels, clams, oysters and scallops within a portion of its coastline. The recall of the toxin has been found in shellfish for the first time.

Some more serious and less common forms of domoic acid, which can cause illness, memory loss, brain damage and possibly death in humans.

Whether that poses a risk up and down the coast is not clear.

Wiscasset Daily Sun

Caused by domoic acid, this toxin produced by algae can cause severe neurological damage, including loss of short term memory.

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Environmental Toxins

- Industrial processes can release contaminants into the environment.
- Polluted air, water, and soil can result in contaminated produce, dairy, meats, and seafood.
- Some environmental contaminants can cause health problems.

Figure produced by University of Maine using FDA contamination level data.

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Environmental Toxins - Persistence

- Persistence of toxins refers to the extent to which the toxin lingers in the environment or in the body.
- Contaminants present for a short time or eliminated by the body pose little health risk.
- Contaminants which persist may also bioaccumulate.

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Environmental Toxins - Bioaccumulation

- Some toxins do not breakdown in the environment.
- These toxins move up through the food chain and they accumulate.
 - Each level has a higher concentration than the one below.
- Eventually humans consume a food which contains high levels of a toxin such as mercury in tuna.

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Environmental Toxins - PBTs

- The Environmental Protection Agency has identified a number of persistent, bioaccumulative, highly toxic chemicals it is committed to removing from the environment.
- These compounds pose a health risk to both humans and ecosystems through food and water.
- The top priority PBTs (persistent, bioaccumulative, toxins) are shown at right.

EPA's 12 Priority PBT Pollutants From the Clean Air Act's Best-Performing Toxic Strategy

- dieldrin/dielder
- heptachlor/epoxies
- chlordane
- DDT, DDE, DDD
- heptachlor/epoxies
- aldrin/dielder
- mirex
- toxaphene
- toxaphene

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Environmental Toxins - PBTs

- Aldrin/Dieldrin – Insecticide – **banned** 1985.
- Benzo(a)pyrene – product of incomplete combustion – exposed due to fires, smoked foods, etc.
- Chlordane – Pesticide – **banned** 1988.
- DDT, DDP, DDE – Pesticides – **banned** 1972.
- Hexachlorobenzene – pesticide – **banned** 1965.
- Alkyl-lead – fuel additive – banned from automobiles but used in limited capacity (racing, marine, aircraft).

EPA's First 12 Priority PBT Pollutants
From the Canada-US Bifunctional Toxics Strategy

• Aldrin/Dieldrin	• Heptachlor
• Heptachlor Epoxide	• Dieldrin
• Chlordane	• Endrin/Endrin sulfate
• DDT, DDE, DDD	• PCBs
• Hexachlorobenzene	• Dioxins and furans
• Alkyl lead	• Toxaphene

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Environmental Toxins – PBTs (continued)

- Mercury – discussed on next slides.
- Mirex – insecticide – **banned** 1978.
- Octachlorstyrene – formed during the production of magnesium.
- PCBs – discussed on next slides.
- Dioxins and Furans – discussed on next slides.
- Toxaphene – insecticide – **banned** 1980.

EPA's First 12 Priority PBT Pollutants
From the Canada-US Bifunctional Toxics Strategy

• Aldrin/Dieldrin	• Heptachlor
• Heptachlor Epoxide	• Dieldrin
• Chlordane	• Endrin/Endrin sulfate
• DDT, DDE, DDD	• PCBs
• Hexachlorobenzene	• Dioxins and furans
• Alkyl lead	• Toxaphene

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Environmental Toxins - Mercury

- Mercury is an element and it is used in the production of many products:
 - Chemicals
 - Pharmaceuticals
 - Switches
 - Thermometers
 - Light bulbs
- Once mercury enters the environment, microorganisms convert it to methylmercury which is the highly toxic mercury that builds up in fish and shellfish.
- Exposure to methylmercury results in impaired neurological development in the fetus:
 - Cognitive thinking
 - Memory
 - Attention
 - Language
 - Fine motor skills
 - Visual spatial skills



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Lecture Note - Mercury

- Mercury is used in many pharmaceuticals as a preservative.
 - Added to multi-use vials to prevent the growth of microorganisms.
 - The form of mercury used in these applications is ethyl mercury (not methylmercury).



Thimerosal, the component used in vaccines that many believe causes autism despite studies demonstrating that this is not true.

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Methyl mercury Poisoning – Minamata Disease

- Between 1932 and 1968, a petrochemical and plastics manufacturer dumped an estimated 27 tons of mercury in Minamata bay (Japan).
 - Poisoning the fish and the people who ate the fish.
 - Over 900 deaths.
 - Over 2 million people suffer(ed) chronic health problems.



Children with Congenital Minamata Disease due to in uterine methylmercury poisoning (Minamata, 1980).

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Environmental Toxins - PCBs

- PCBs are chlorinated hydrocarbons that were used in 100s of industrial and commercial applications.
- PCBs are known to cause cancer in animals.
- PCBs were banned in 1979 in the United States but they do not breakdown and can be found:
 - In the environment
 - In wildlife tissues
 - In the food chain.
- PCBs exert toxic effects on the following body systems (in addition to causing cancers):
 - Immune system
 - Endocrine system
 - Reproductive system
 - Nervous system



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Environmental Toxins – Dioxins and Furans

- Refers to a family of toxic substances that have similar chemical structures.
- They are the byproducts of industrial processes or are created during burning:
 - Burning of waste
 - Burning of wood
- Found in the food chain in meat and dairy.
 - Due to accumulation in the environment.
- Health effects include the following:
 - Chloracne (below), and other skin conditions.
 - Immune system damage
 - Developmental damage
 - Reproductive damage
 - Cancer



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Dioxin Poisoning – Yusho Disease

- In 1968 in Japan a number of patients were reported to have symptoms including acne-like eruptions, pigmentation of the skin, and eye discharge.
- Despite the knowledge gained from this outbreak, the same thing happened in Taiwan in 1979.
- The cause of the disease was later found to be rice oil (Yusho means oil disease) contaminated with dioxin-related compounds.
- A total of 1961 people are registered as yusho patients.



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Natural Toxins

- A number of plants contain natural toxins.
 - Many of these toxins are designed to protect the plants from insect damage.
- These toxins are not harmful if ingested in small amounts.
- The most common are:
 - Goitrogens
 - Cyanogens
 - Solanine



These foods contain cyanogens. Tapioca could potentially kill you, just ask Sheldon Cooper: <https://www.youtube.com/watch?v=estliq1Q5UE>

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Natural Toxins - Goitrogens

- Goitrogens can cause enlargement of the thyroid gland by blocking the uptake of iodine.
- Found in very small amounts in a large number of foods:
 - Cabbage
 - Bok choy
 - Turnips
 - Mustard greens
 - Kale
 - Brussels sprouts
 - Cauliflower
 - Broccoli
 - Kohlrabi
 - Radishes



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Natural Toxins - Cyanogens

- Some foods contain cyanogens which can convert to cyanide:
 - Apricot pits
 - Peach pits
 - Apple seeds
 - Lima beans
 - Cassava
- Lima beans with low levels of cyanogens are used in foods.
- Most people do not eat seeds (a few will not hurt you) and pits of fruits.



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Cyanogen Poisoning – Cassava - Konzo



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Natural Toxins – Cyanogens - Laetrile

FOIA NEWS RELEASE

FOIA REQUESTER RELEASE
 DATE: 01/22/2015

Media Inquiry: 313-477-0242
 Customer Inquiry: 888-495-7234

Laetrile and Amygdalin for Treatment of Cancer—A Quick Medication for "Third Cancer Patients"

The Food and Drug Administration (FDA) has announced the outcome of its investigation into the Office of Criminal Investigations, conducted jointly with the United States Attorney's Office (USAO) for the Eastern District of New York and the New York Division of the United States Postal Inspection Service (USPIS), to bring to justice a conspiracy among cancer patients to evade existing anti-drug laws, through the purchase of the drug, which has no known medical benefit.

James Cook, president of the New York-based Christus Brothers Contracting Corp., was sentenced on June 16, 2014 to 15 months in prison and 3 years of supervised release for conspiring to obtain Laetrile from the United States Postal Service.

There is no scientific evidence that Laetrile offers anything but false hope to cancer patients, some of whom have used instead of conventional treatment until it was too late for the treatments to be effective. said Dr. Lucien B. Coakley, Acting FDA Commissioner. "This sentence sends a strong message that we will not tolerate marketing of false medicines."

Following the investigation by FDA, the USAO and the USPIS, the U.S. District Court for Eastern District of New York ordered sales of Laetrile and amygdalin to cease immediately. "Since 1977, amygdalin—commonly known as Laetrile—has been sold in the United States as a cancer treatment, and continues to be sold for the treatment of the same form of cancer in patients in other parts of the New York City metropolitan area. Sales have been going on for 11 months ago, despite the fact that the drug is not approved and is not intended for sale in the United States."

James Cook, who had made almost \$500,000 from his illegal sales of Laetrile, had committed to the marketing of Laetrile in addition, pursuant to a claim that he qualified for legal aid. As a result, Cook was ordered to reimburse the government \$211,000 for the costs of its

Despite the warnings that laetrile, derived from apricot pits is NOT a cure for cancer and is in fact poisonous, a quick search in Amazon results in a product for sale.



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Natural Toxins - Solanine

- Solanine is a narcotic-like poison found in potatoes:
 - Largely in the leaves and stems but to a limited amount in the peel.
- Poisoning is rare except in times of food shortage.
- Symptoms include:
 - Vomiting
 - Diarrhea
 - Abdominal pain
 - Coma
 - Convulsive twitching
 - Confusion
 - Hallucination
- Death is rare unless the person is dehydrated.



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Lecture Summary

- Lecture Note: Information used in this lecture on Environmental Toxins was adapted from the Environmental Protection Agency Website (www.epa.gov).
- Foods are susceptible to toxic contamination from microbial, environmental, and natural toxins.
- The symptoms depend on the toxin present and there are few treatment options.
- Protecting the food supply from toxic contamination requires adherence to regulatory guidelines.

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