Chapter 13: How Safe Is Our Food Supply?

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Student learning outcomes: At the end of this chapter, you should be able to:

- Describe regulations and strategies for keeping food safe
- Compare and contrast pathogens that can contaminate food
- Apply food safety strategies in your kitchen
- Debate the pros and cons other food additives and contaminants
- Debate the pros and cons of biotechnology

THINK about this – then share within a PAIR – then SHARE with the class

- What causes food poisoning?
- What can be done to prevent food contamination and food-borne illness?

Food poisoning

- Food-borne illness: illness caused by food
- Usually causes gastrointestinal symptoms
  - Abdominal pain, nausea, diarrhea, and vomiting
  - Can cause kidney failure, arthritis, paralysis, miscarriage, death
- Usually caused by microbes (microorganisms), such as bacteria, viruses, fungi, or parasites
  - Microbes that cause disease are called pathogens (they *gen*erate *patho*logy)

Food poisoning – symptoms and severity depends on:

- Potency of contaminant
- How much of is consumed
- How often it is consumed
- Age, size, nutritional status, chronic diseases
- Absorption, metabolism, storage in the body
- Immune function // (at risk: young, elderly, pregnant women, people with AIDS or on chemotherapy or immunosuppressant drugs)

Agencies that monitor the food supply

Agencies that monitor the food supply Table 13.1

International Organizations	
Food and Agriculture Organization of the United Nations (FAO)	Promotes and shares knowledge in all aspects of food quality and safety and in all stages of food production: harvest, post-harvest handling, storage, transport, processing, and distribution.
World Health Organization (WHO)	Develops international food safety policies, food inspection programs, and standards for hygienic food preparation; promotes technologies that improve food safety and consumer education about safe food practices. Works closely with the FAO.
Federal Organizations	
U.S. Food and Drug Administration (FDA)	Ensures the safety and quality of all foods sold across state lines with the exception of red meat, poultry, and egg products; inspects food processing plants; inspects imported foods with the exception of red meat, poultry, and egg products; sets standards for food composition; oversees use of drugs and feed in food-producing animals; enforces regulations for food labeling, food and color additives, and food sanitation.
U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS)	Enforces standards for the wholesomeness and quality of red meat, poultry, and egg products produced in the United States and imported from other countries. If an imported food is suspect, it can be tested for contamination and denied entry into the country.
U.S. Environmental Protection Agency (EPA)	Regulates pesticide levels and must approve all pesticides before they can be sold in the United States; establishes water quality standards.
National Marine Fisheries Service	Oversees the management of fisheries and fish harvesting; operates a voluntary program of inspection and grading of fish products.
National Oceanic and Atmospheric Administration (NOAA)	Oversees fish and seafood products. Its Seafood Inspection Program inspects and certifies fishing vessels, seafood processing plants, and retail facilities for compliance with federal sanitation standards.
Centers for Disease Control and Prevention (CDC)	Monitors and investigates the incidence and causes of food-borne illnesses.
State and Local Governments	
Oversee all food within their jurisdiction; also inspect restaurants, grocery stores, and other retail food establishments, as well as dairy farms and milk processing plants, grain mills, and food manufacturing plants within local jurisdictions.	

Federal agencies

- Set standards and establish regulations for:
  - safe handling of food and water
  - information included on food labels
- Regulate use of additives, packaging materials, and agricultural chemicals
- Inspect food processing and storage facilities
- Monitor domestic and imported foods
- Investigate outbreaks of food-borne illness

Recent federal changes

National Food Safety Initiative

- Goal: reduce food-borne illness by improving US food safety practices and policies // Targets food safety from farm to table

FDA Food Safety Modernization Act

- Focus: *preventing* food-borne illness // Passed in 2011 in response to the continued threat from our food supply
  - FDA: inspection mandate and new legal powers

Keeping food safe

Masterfile

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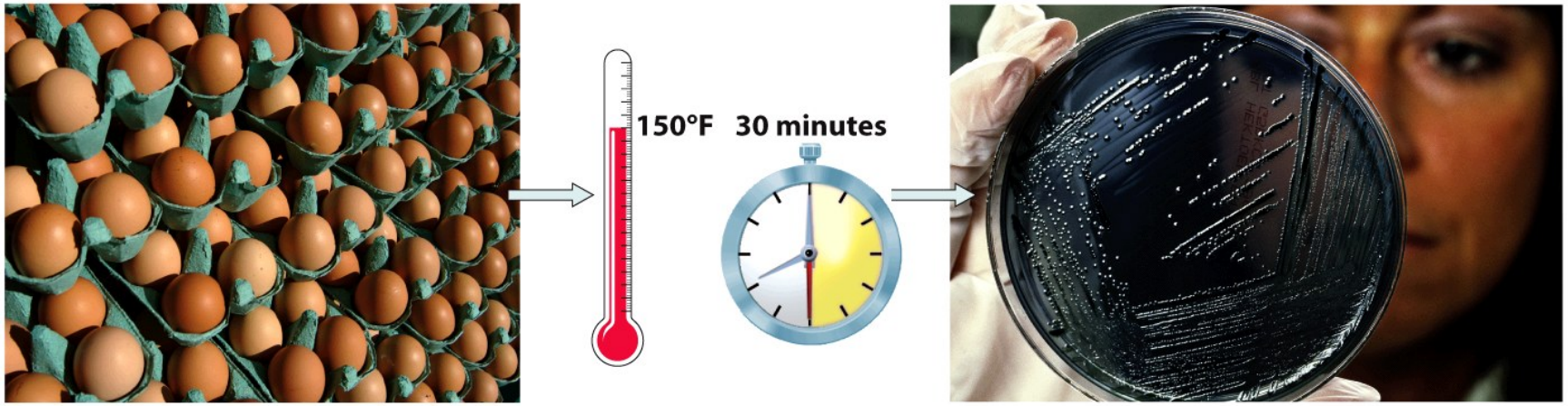
Masterfile

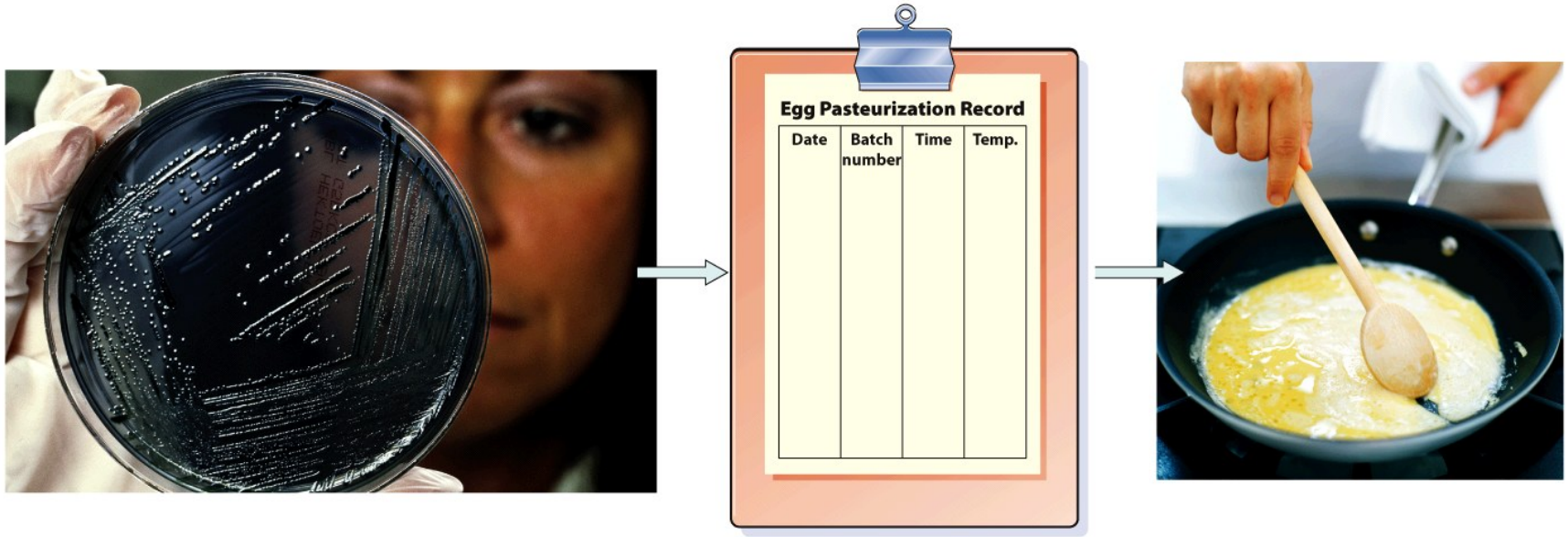
Hazard Analysis Critical Control Point (HACCP)

- Food safety system required for food manufacturers, processors, and distributors
- Analyzes food production, processing, and transport
- Goal: identify potential sources of contamination and points where measures can be taken to *prevent* contamination
- Monitors these critical control points

Hazard Analysis Critical Control Point (HACCP)



Hazard Analysis Critical Control Point (HACCP)



Consumers & food-borne illness

- Most cases of food-borne illness are caused by foods prepared at home

Consumers can:

- Carefully handle, store, and prepare food
- Report incidents involving unsanitary, unsafe, deceptive, or mislabeled food to appropriate agencies

Reporting food-related issues

How to report food-related issues Table 13.2

Before reporting a suspected case of food-borne illness, get all the facts. Determine whether you have used the product as intended and according to the manufacturer's instruction. Check to see if the item is past its expiration date. After these steps have been taken, report the incident to the appropriate agency:

- **Problems related to any food except meat and poultry, including adverse reactions:** Report emergencies to the FDA's main emergency number, which is staffed 24 hours a day: 301-443-1240. Nonemergencies can be reported to the FDA consumer complaint coordinator in your area, which you can find at www.fda.gov/Safety/ReportaProblem/default.htm.
- **Issues related to meat and poultry:** Report first to your state department of agriculture and then to the USDA Meat and Poultry Hotline (888-MPHotline or mphotline.fsis@usda.gov).
- **Restaurant food and sanitation problems:** Report directly to your local or state health department.
- **Issues related to alcoholic beverages:** Report to the U.S. Department of the Treasury's Bureau of Alcohol, Tobacco, and Firearms.
- **Pesticide, air, and water pollution:** Report first to your state environmental protection department and then to the U.S. EPA.
- **Products purchased at the grocery store:** Return to the store. Grocery stores are concerned with the safety of the foods they sell, and they will take responsibility for tracking down and correcting the problem. They will either refund your money or replace the product.

Concept check

- What causes food-borne illness?
- Why might the same food make one person sick and not another person?
- Who is responsible for the safety of your food?
- How does HACCP differ from traditional visual food inspection?

Food poisoning

- Food-borne illness: illness caused by food
- Usually causes gastrointestinal symptoms
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  - Can cause kidney failure, arthritis, paralysis, miscarriage, death
- Usually caused by microbes (microorganisms), such as bacteria, viruses, fungi, or parasites
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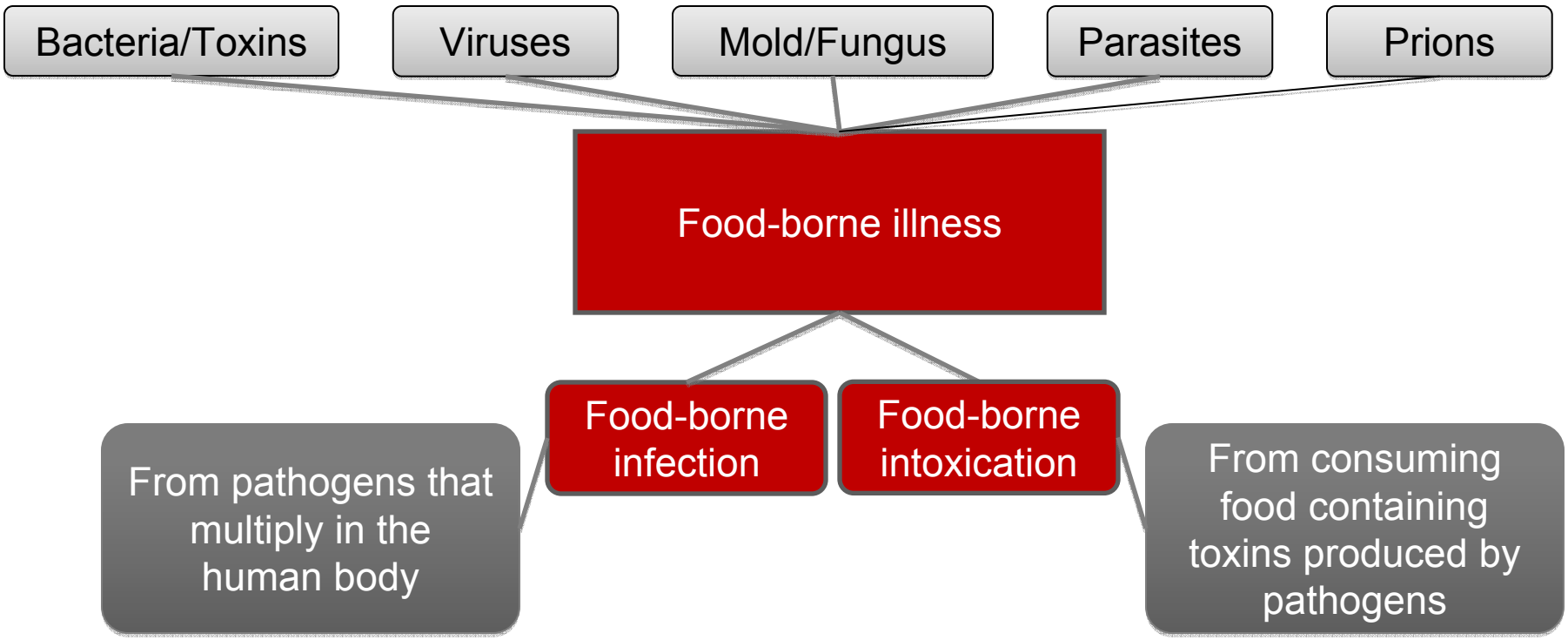
Food-borne illness: infection vs. intoxication

- Food-borne infection: caused by pathogens that multiply in the human body
  - Usually from consumption of a large number of pathogens that cause infection or produce toxins in the body
- Food-borne intoxication: caused by consuming food containing toxins produced by pathogens
  - Can be caused by food containing only a few pathogens if they have produced enough toxin

Food-borne illness



Bacteria

- In soil, on our skin, on most surfaces in our homes, and in food
- Most are harmless, some are beneficial, and a few are pathogenic

Salmonella bacteria

- Causes: Most common cause of US food-borne illness
- Common sources: Poultry and eggs are the foods most commonly contaminated; contaminated meat, dairy products, seafood, fresh produce, and cereal have caused outbreaks
- Prevention: killed by heat; thoroughly cook foods likely to be contaminated

Campylobacter jejuni bacteria

- Causes: Leading cause of acute bacterial diarrhea in developed countries
- Common sources: undercooked chicken, unpasteurized milk, and untreated water
- Prevention: grows slowly in cold temperatures and is killed by heat; carefully store and thoroughly cook foods

Escherichia coli (E. coli) bacteria

- Causes: some strains are harmless; others can cause serious food-borne infection
  - One strain in water contaminated by human or animal feces causes “travelers’ diarrhea”
  - *E. coli* O157:H7 produces a toxin causing abdominal pain, bloody diarrhea, fatal kidney failure
- Common sources: fecal contamination of water or food (for example, meats and produce)

Listeria monocytogenes bacteria

- Causes: flulike symptoms; more serious in high-risk groups (pregnant women, children, elderly people, with compromised immunity)
  - During pregnancy: causes spontaneous abortion and stillbirth, fetal meningitis and blood infections
- Common sources: everywhere in environment
- Prevention: survives and grows at refrigerator temperatures so infects ready-to-eat foods; heat hot dogs and lunchmeats to steaming point and avoid unpasteurized dairy products

Vibrio vulnificus bacteria

- Causes: gastrointestinal upset but can be deadly in people with compromised immune systems

- Common sources: grows in warm seawater; in raw or undercooked shellfish, particularly oysters

How bacteria contaminate food

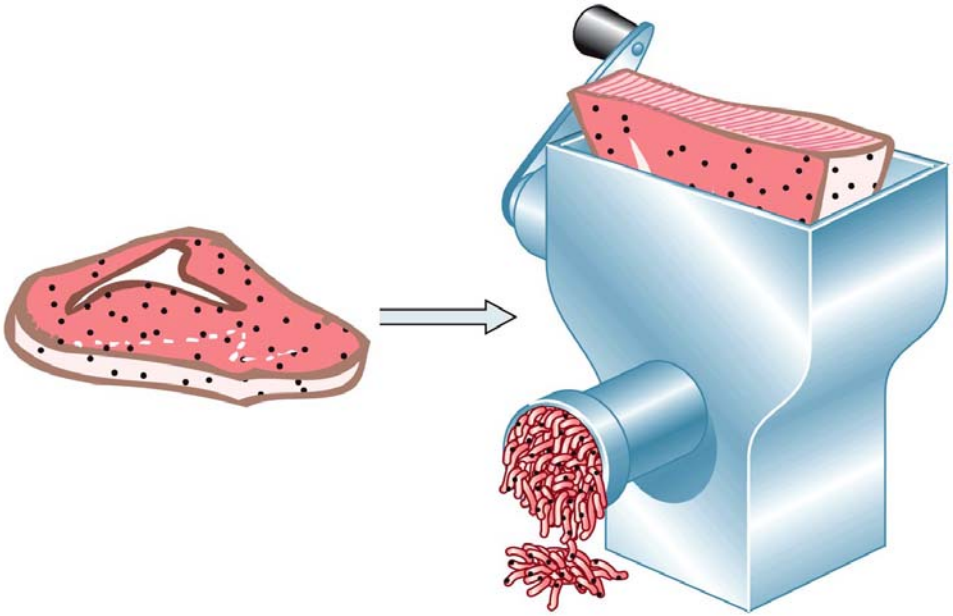
Pete Ryan/NG Image Collection

Jim Richardson/NG Image Collection

David Arnold/NG Image Collection

How bacteria contaminate food

Joel Sartore/NG Image Collection



Staphylococcus aureus bacteria

- Causes: bacterial food-borne intoxication; toxin causes vomiting soon after ingestion.

- Common sources: live in human nasal passages and transferred to food through coughing or sneezing; grow on food and produces toxin

Clostridium perfringens bacteria

- Causes: food-borne infection and intoxication
- Common sources: little oxygen gets to the center of large containers providing growth environment for these bacteria that thrive in low-oxygen environments
- Form heat-resistant spores (stage of bacterial life remaining dormant until environmental conditions favor growth)

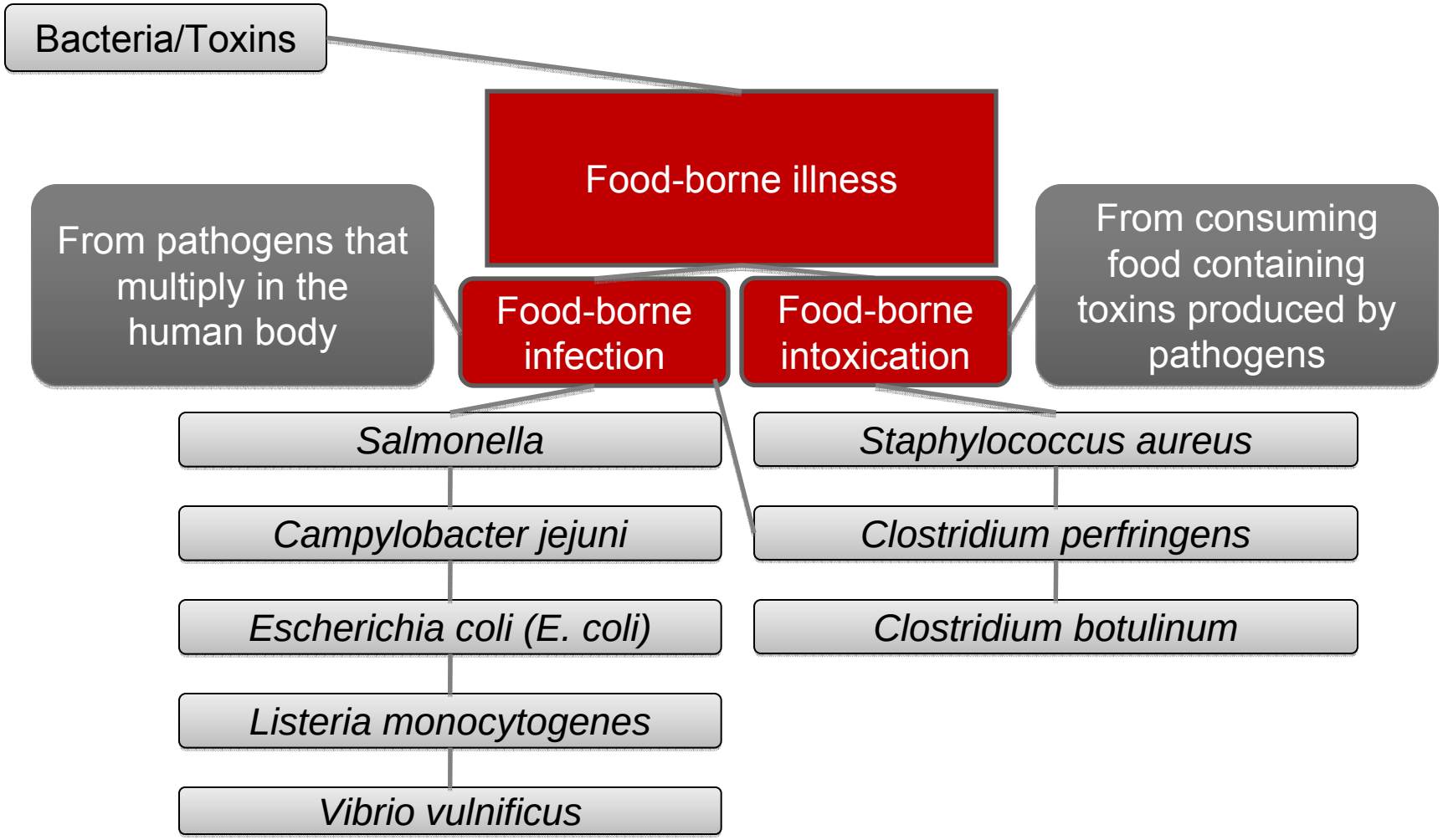
Clostridium botulinum bacteria

- Causes: blocked nerve function, resulting in vomiting, abdominal pain, double vision, and paralysis leading to respiratory failure and death; deadliest of all bacterial food toxins

- Common sources: in soil, water, and animal intestinal tracts

- Toxin produced when heat-resistant spores grow in low-oxygen, low-acid conditions; found in improperly canned foods and foods held in large containers

Bacterial food-borne illness



Botulism

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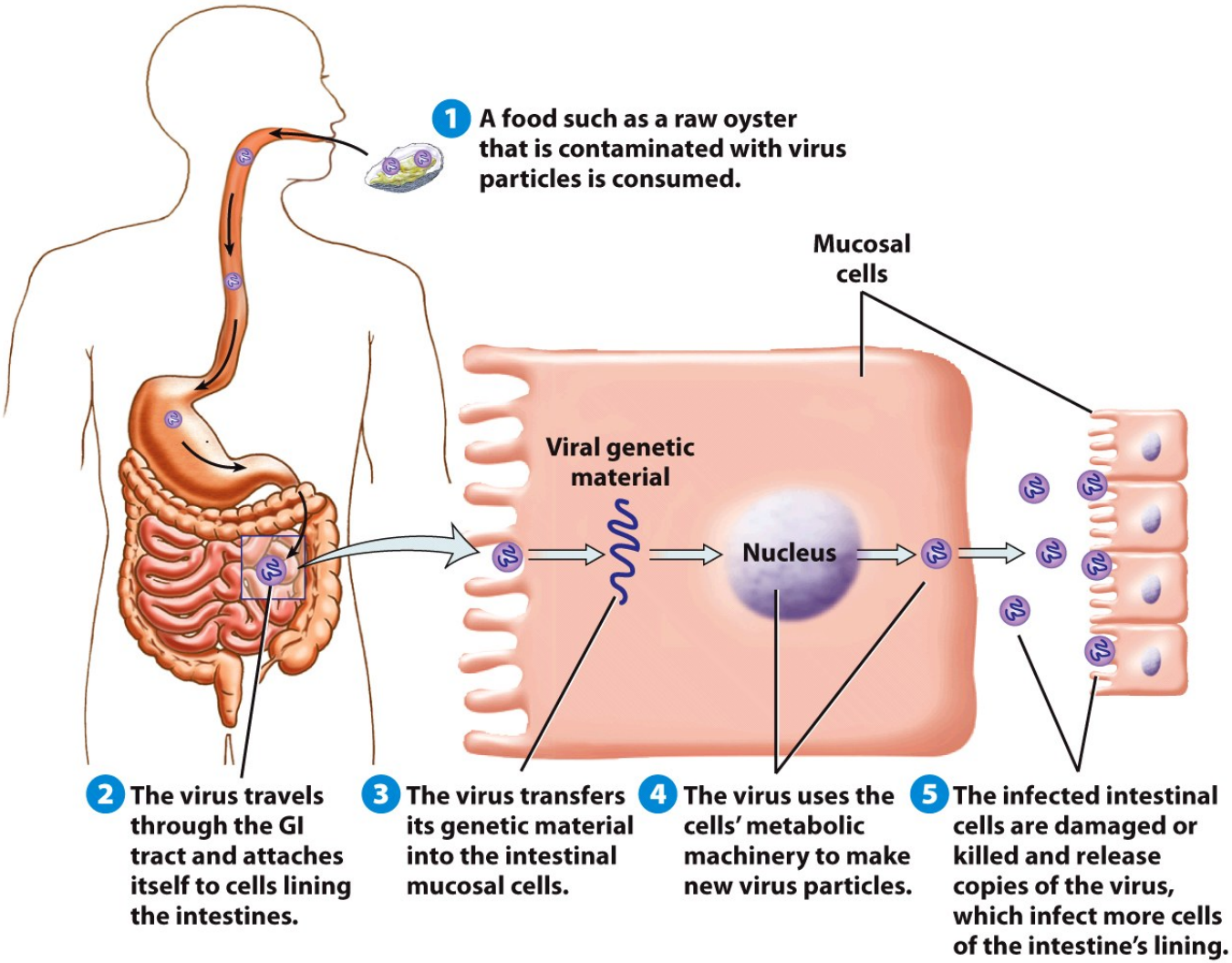
Infant botulism

- Most common form of botulism in the US
- Caused by ingestion of botulism spores
  - Spores germinate in the infant's gastrointestinal tract, producing toxin
  - In adults, competing intestinal microflora prevent spores from germinating
  - Some toxin is absorbed into the bloodstream, causing weakness, paralysis, and respiratory problems; infants generally recover
  - Never feed honey to infants under 1 year of age

Viruses

- Not classified as living or as cells since they cannot reproduce on their own
  - Human viruses reproduce only inside human cells
  - Viruses turn human cells into virus-producing factories
  - Viruses that cause human diseases cannot grow and reproduce in foods

How viruses cause illness



Noroviruses

- Group of viruses
- Cause: about 50% of all US food-borne gastroenteritis (“stomach flu”)
- Common sources: eating food contaminated with virus or touching contaminated surface and then putting fingers in mouth; Shellfish can be contaminated in water polluted with feces
- Prevention: cooking destroys noroviruses

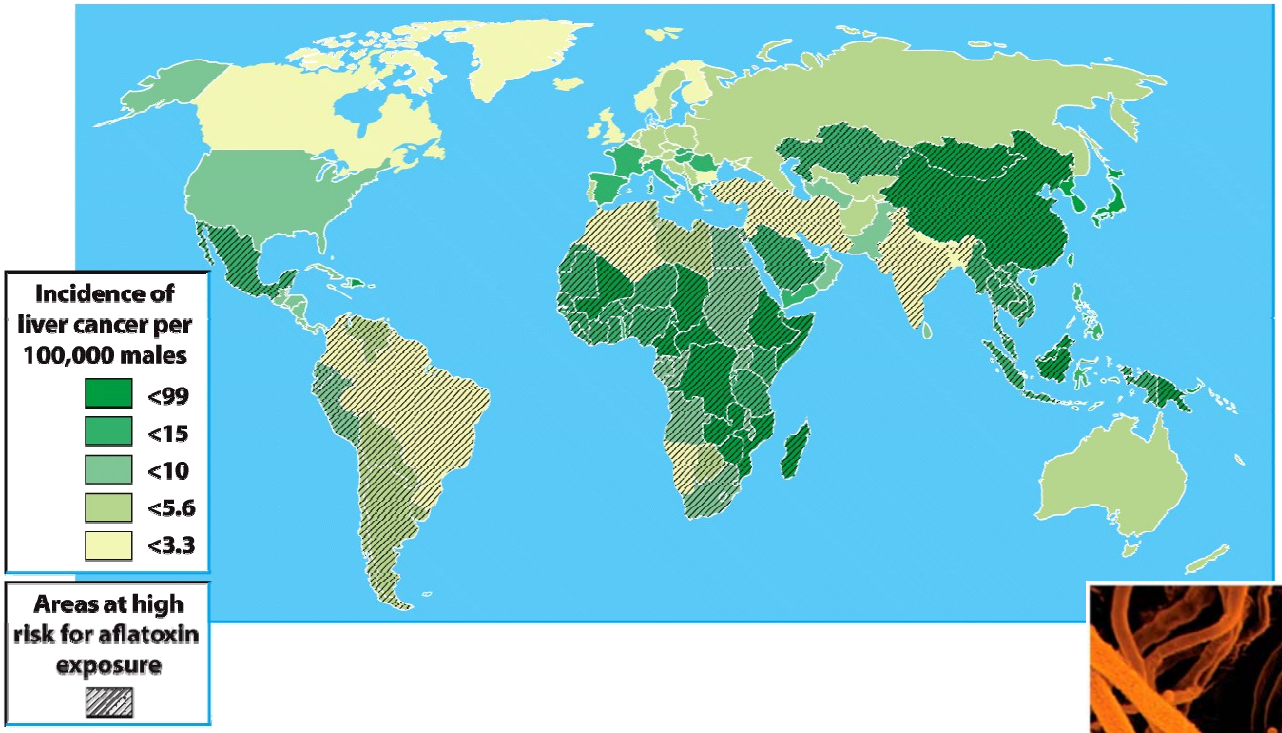
Hepatitis A

- Causes: liver inflammation, jaundice, fever, nausea, fatigue, and abdominal pain; can require months of recovery but does not require treatment nor cause permanent liver damage
- Common sources: food or water contaminated with feces
- Prevention: chlorination of drinking water, cooking food, good sanitation, vaccination

Mold/fungus

- Many types grow on foods such as bread, cheese, and fruit
- Under certain conditions, molds produce toxins (>250 different mold toxins)
- Cooking and freezing stop mold growth but do not destroy toxins already produced
- If food is moldy, discard it, clean the area where it was stored, and check neighboring foods to see if they are contaminated

Mold & liver cancer



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Parasites

- Organisms that live at the expense of others
- Some are microscopic single-celled animals; others are worms large enough to be seen with the naked eye
- Prevention: killed by thorough cooking; if raw fish is consumed, parasitic infections can be avoided by eating fish that has been frozen

Single-celled parasites

Giardia lamblia // Common sources: drinking untreated water from streams contaminated with animal feces; in day-care centers where diapers are changed and hands and surfaces are not thoroughly washed

Cryptosporidium parvum // Common sources: contaminated water, raw fruits and vegetables

Multicellular parasites

Trichinella spiralis

- Causes: once ingested, these small, wormlike organisms find their way to the muscles, where they grow, causing flulike symptoms
- Common sources: raw and undercooked pork and game meats
- Fish are a common source of parasites because they carry the larvae of roundworms, flatworms, flukes, and tapeworms

Herring worm in fish

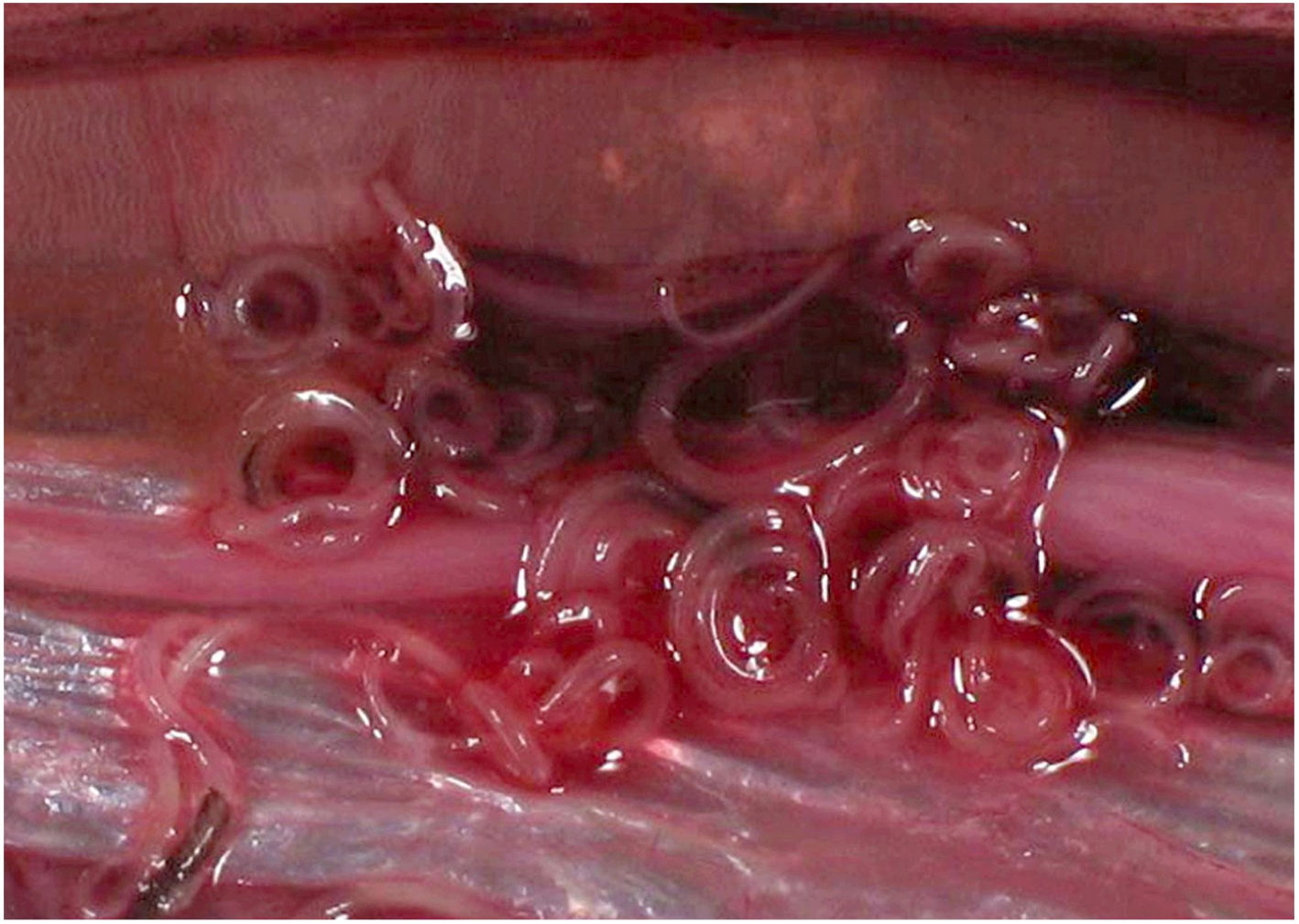


Image from http://en. wikipedia.org/wiki/File: Anisakids.jpg

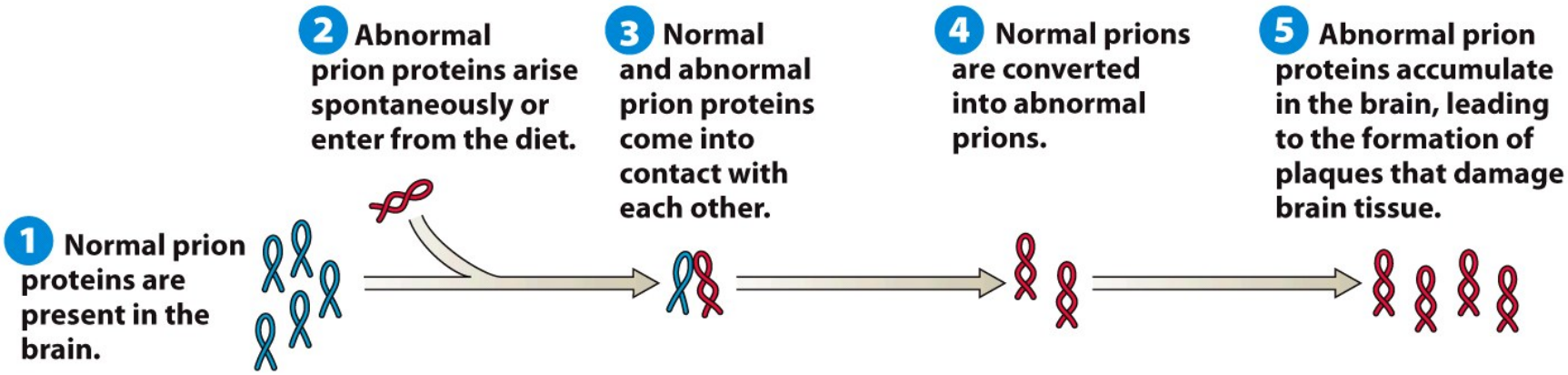
Prions

- Pathogenic protein that causes degenerative brain diseases such as spongiform encephalopathies
- Short for proteinaceous infectious particle

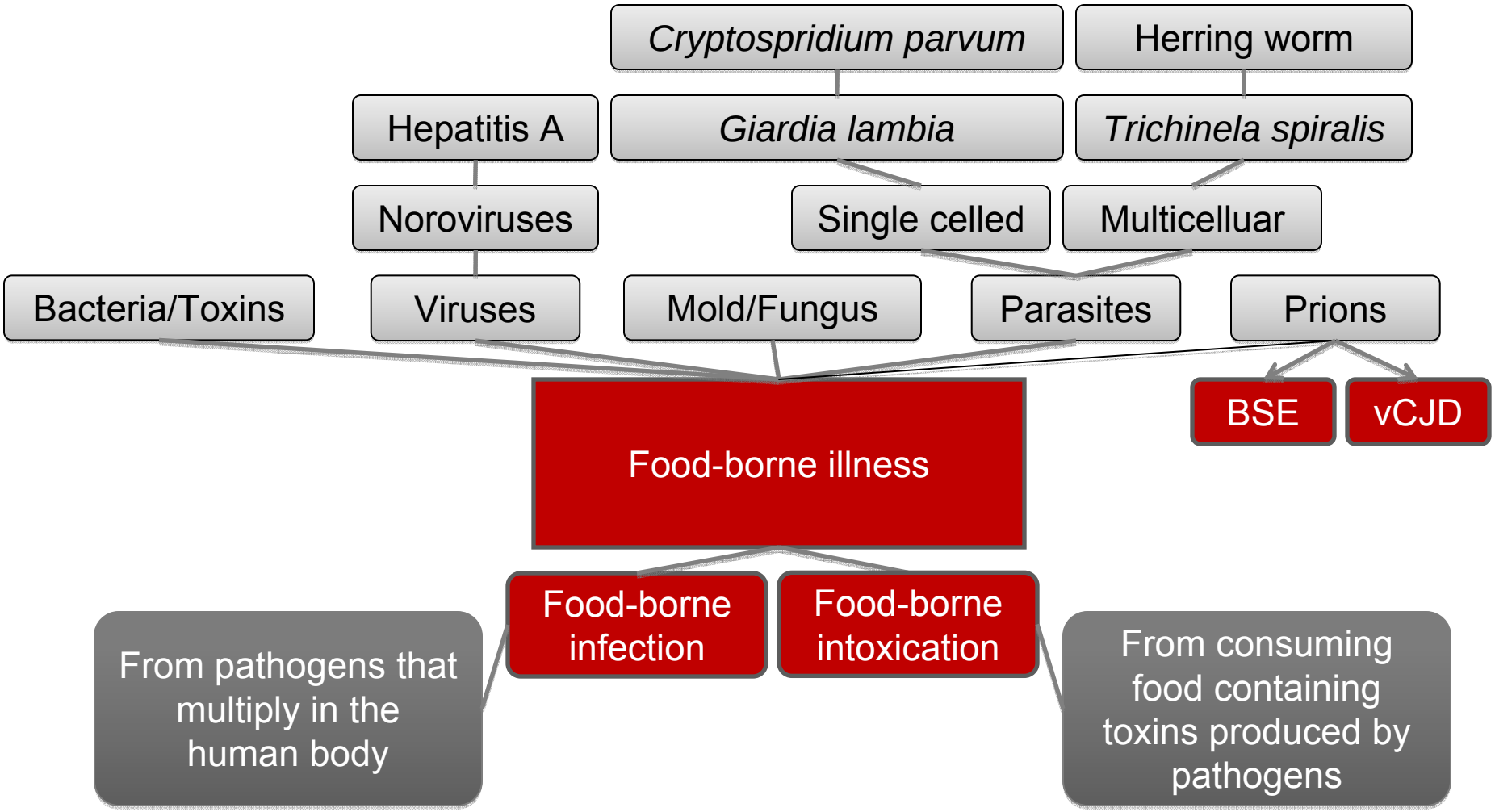
Prion diseases

- Bovine spongiform encephalopathy (BSE): deadly neurodegenerative disease in cattle
- Creutzfeldt-Jakob Disease (vCJD): human BSE
  - Causes: eating brain, nervous tissue, intestines, eyes, or tonsils from cow infected with BSE (meat and milk have not been found to transmit prions)
  - Symptoms: mood swings and numbness progressing to dementia and death
  - Prevention: prevent US cattle from contracting BSE (cooking does not destroy prions)

Prions



Food-borne illness summary



Summary of food-borne illnesses

Summary of bacterial, viral, and parasitic food-borne illnesses Table 13.3

Microbe	Sources	Symptoms	Onset (time after consumption)	Duration
Bacteria				
Salmonella	Fecal contamination, raw or undercooked eggs and meat, especially poultry	Nausea, abdominal pain, diarrhea, headache, fever	6–48 hours	1–2 days
Campylobacter jejuni	Unpasteurized milk, untreated water, undercooked meat and poultry	Fever, headache, diarrhea, abdominal pain	2–5 days	1–2 weeks
Listeria monocytogenes	Raw milk products; soft ripened cheeses; deli meats and cold cuts, raw and undercooked poultry; meats; raw and smoked fish; raw vegetables	Fever, headache, stiff neck, chills, nausea, vomiting. May cause spontaneous abortion or stillbirth in pregnant women and menengitis and blood infections in the fetus.	Days to weeks	Days to weeks
Vibrio vulnificus	Raw seafood from contaminated water	Cramps, abdominal pain, weakness, watery diarrhea, fever, chills	15–24 hours	2–4 days
Staphylococcus aureus	Human contamination from coughs and sneezes; eggs, meat, potato, and macaroni salads	Severe nausea, vomiting, diarrhea	2–8 hours	2–3 days
Escherichia coli O157:H7	Fecal contamination, undercooked ground beef	Abdominal pain, bloody diarrhea, kidney failure	5–48 hours	3 days–2 weeks or longer
Clostridium perfringens	Fecal contamination, deep-dish casseroles	Nausea, diarrhea, abdominal pain	8–22 hours	6–24 hours
Clostridium botulinum	Improperly canned foods, deep-dish, casseroles, honey	Lassitude, weakness, vertigo, respiratory failure, paralysis	18–36 hours	10 days or longer (must administer antitoxin)
Shigella	Fecal contamination of water or foods, especially salads such as chicken, tuna, shrimp, and potato salads	Diarrhea, abdominal pain, fever, vomiting	12–50 hours	5–6 days
Yersinia enterocolitica	Pork, dairy products, and produce	Diarrhea, vomiting, fever, abdominal pain; often mistaken for appendicitis	24–48 hours	Weeks

Summary of food-borne illnesses

Summary of bacterial, viral, and parasitic food-borne illnesses Table 13.3

Microbe	Sources	Symptoms	Onset (time after consumption)	Duration
Viruses				
Norovirus	Fecal contamination of water or foods, especially shellfish and salad ingredients	Diarrhea, nausea, vomiting	1–2 days	2–6 days
Hepatitis A	Human fecal contamination of food or water, raw shellfish	Jaundice, liver inflammation, fatigue, fever, nausea, anorexia, abdominal discomfort	10–50 days	1–2 weeks to several months

Summary of food-borne illnesses

Summary of bacterial, viral, and parasitic food-borne illnesses Table 13.3

Microbe	Sources	Symptoms	Onset (time after consumption)	Duration
Parasites				
Giardia lamblia	Fecal contamination of water and uncooked foods	Diarrhea, abdominal pain, gas, anorexia, nausea, vomiting	5–25 days	1–2 weeks, but may be chronic
Cryptosporidium parvum	Fecal contamination of food or water	Severe watery diarrhea	Hours	2–4 days, but sometimes weeks
Trichinella spiralis	Undercooked pork, game meat	Muscle weakness, flulike symptoms	Weeks	Months
Anisakis simplex	Raw fish	Severe abdominal pain	1 hour–2weeks	3 weeks
Toxoplasma gondii	Meat, primarily pork	Toxoplasmosis (can cause central nervous system disorders, flulike symptoms, and birth defects in the offspring of women exposed during pregnancy, see Chapter 11)	10–23 days	May become chronic

Concept check

Which of the following form spores?

a) Bacteria
b) Viruses
c) Mold/Fungus
d) Parasites
e) Prions

Concept check

Which of the following produce toxins?

a) Bacteria
b) Viruses
c) Mold/Fungus
d) Parasites
e) Prions

Concept check

Which of the following have forms that can be seen with the naked eye?

a) Bacteria
b) Viruses
c) Mold/Fungus
d) Parasites
e) Prions

Concept check

Which of the following is a protein rather an a microorganism?

a) Bacteria
b) Viruses
c) Mold/Fungus
d) Parasites
e) Prions

Concept check

Which of the following is not living?

a) Bacteria
b) Viruses
c) Mold/Fungus
d) Parasites

Application

Based on how food-borne illnesses are transmitted…..

What can you do to prevent these illnesses for you and your loved ones?

Prevent microbial food-borne illnesses

- Choose food carefully; when in doubt, throw out
- Prepare food in a clean kitchen to reduce cross-contamination (transfer to another food)
- Store food in refrigerator or freezer // Foods served cold should be kept cold until served
  - Thaw frozen foods in refrigerator or microwave (not at room temperature)
- Heat foods to recommended temperatures // Cooked foods should be kept hot until served

Safe grocery choices

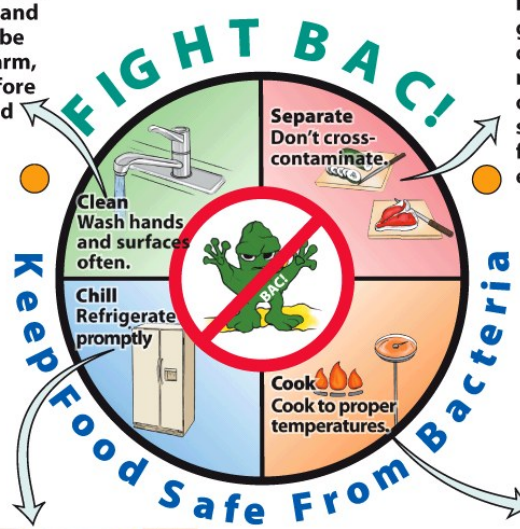
Safe grocery choices Table 13.4

- Purchase food from reputable vendors.
- Make sure jars are closed and seals are unbroken and that safety "buttons" on jar lids have not popped.
- Check to see that cans are not rusted, dented, or bulging.
- Make sure food packaging is secure.
- Select frozen foods from below the frost line in the freezer.
- Make sure frozen foods are solidly frozen and do not contain frost or ice crystals.
- Check voluntary freshness dates and avoid foods with expired dates:
  - **Sell-by or pull-by date:** Used by manufacturers to tell grocers when to remove their product from the shelves. You should buy the product before this date, but if the food has been handled and stored properly, it is usually still safe for consumption after it. For example, milk is usually still good at least a week beyond its sell-by date if it has been properly refrigerated.
  - **Best if used by, use-by, quality assurance, or freshness date:** Used to specify the last date on which the product will retain maximum freshness, flavor, and texture. Beyond this date, the product's quality may diminish, but the food may still be safe if it has been handled and stored properly.
  - **Expiration date:** Used to specify the last day on which a product should be eaten. State governments regulate these dates for perishable items, such as milk and eggs. The FDA regulates only the expiration dates of infant formula.

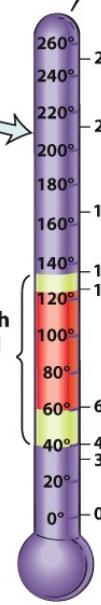
Safe handling, storage, & preparation

Hands, countertops, cutting boards, and utensils should be washed with warm, soapy water before each step in food preparation.

Foods that are going to be cooked should not be prepared on the same surfaces as foods that are eaten raw.



Safe Cooking Temperatures[19]	
Food item	**Internal temperature (°F) or description**
Beef roasts and steaks	145 (allow meat to rest 3 min before carving or consuming)
Ground meat	160
Pork	145 (allow meat to rest 3 min before carving or consuming)
Poultry	165
Fish	145 or until the flesh is opaque and separates easily with a fork
Eggs	Until the yolk and white are firm, not runny (egg dishes 160)
Leftovers and casseroles	165



Canning temperature for low-acid foods in pressure cooker

Range of cooking temperatures to kill most bacteria. The amount of time needed decreases as the temperature increases.

Minimum temperature for reheating foods.

Warming temperatures control growth but allow survival of some bacteria.

Some growth may occur: Many bacteria survive.

Some bacterial growth may occur in this zone.

Cold temperatures allow slow growth for a few cold-tolerant organisms but stop the growth of most.

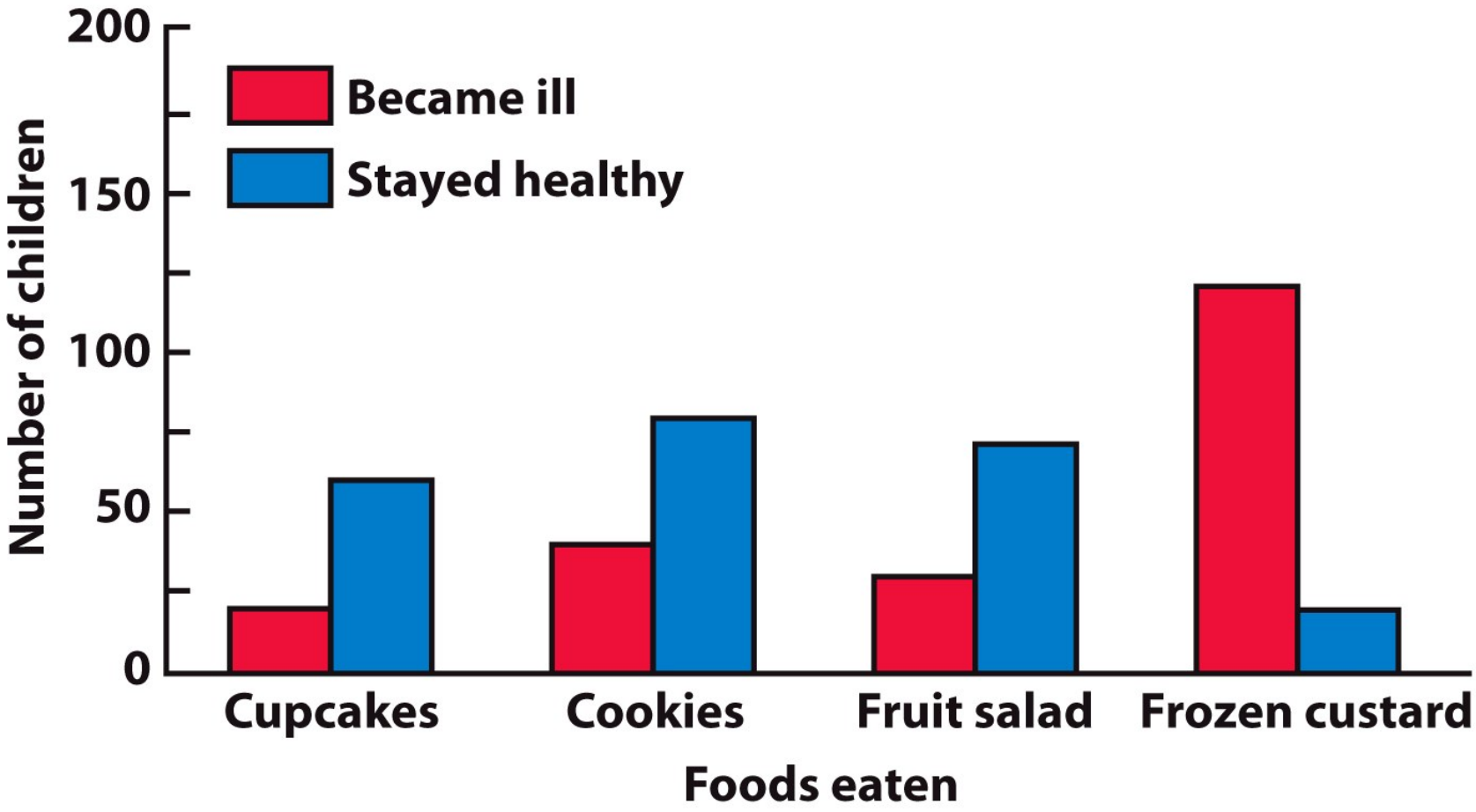
Freezing temperatures prevent bacterial growth but some bacteria are able to survive.

Danger Zone
Temperatures in this zone allow rapid bacterial growth and production of bacterial toxins. Foods should only be allowed to remain in this temperature range for minimal amounts of time.

Safe handling of cooked foods

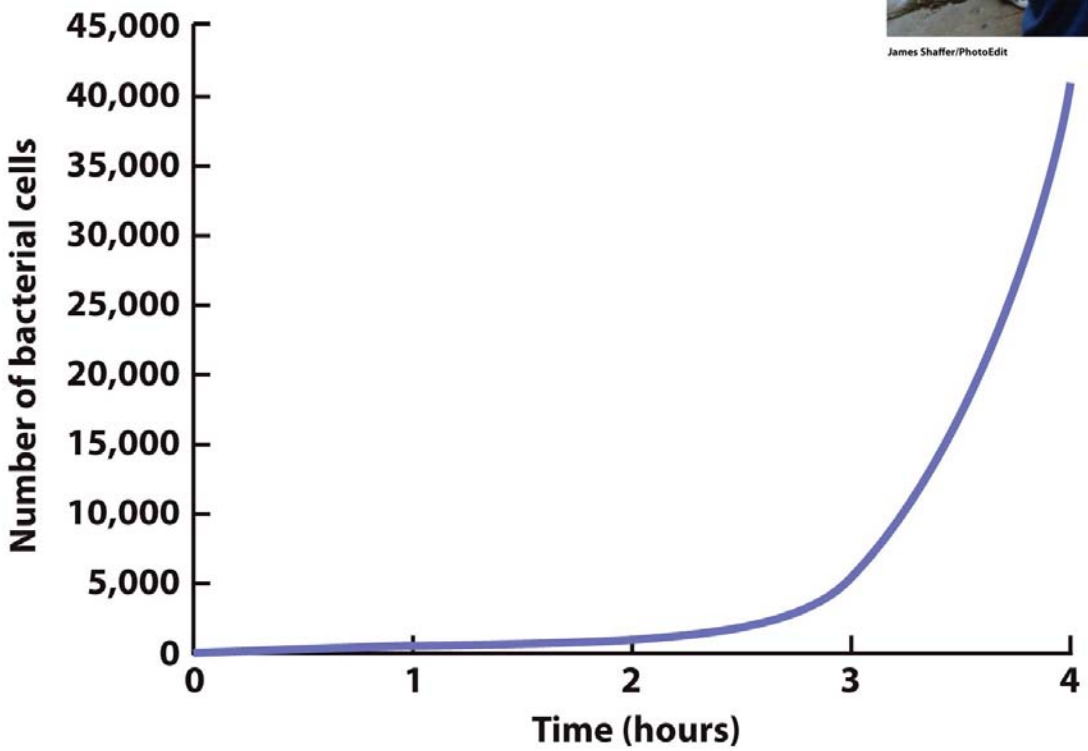
- Cross-contamination occurs when uncooked foods contact cooked or raw foods
  - Cooked meat should never be returned to the same dish that held raw meat
  - Sauces used to marinate uncooked foods should never be used as a sauce on cooked food
- Refrigerate cooked food as soon as possible
  - Large portions of food should be divided before refrigeration so they will cool quickly
  - Most leftovers should be kept for only a few days

Thinking it through



What a scientist sees

James Shaffer/PhotoEdit



Concept check

- How does *Clostridium botulinum* cause food-borne illness?
- Which pathogenic bacteria commonly contaminate chicken and eggs?
- How do viruses make us sick?
- How does refrigeration help prevent food-borne illness?

THINK about this – then share within a PAIR – then SHARE with the class

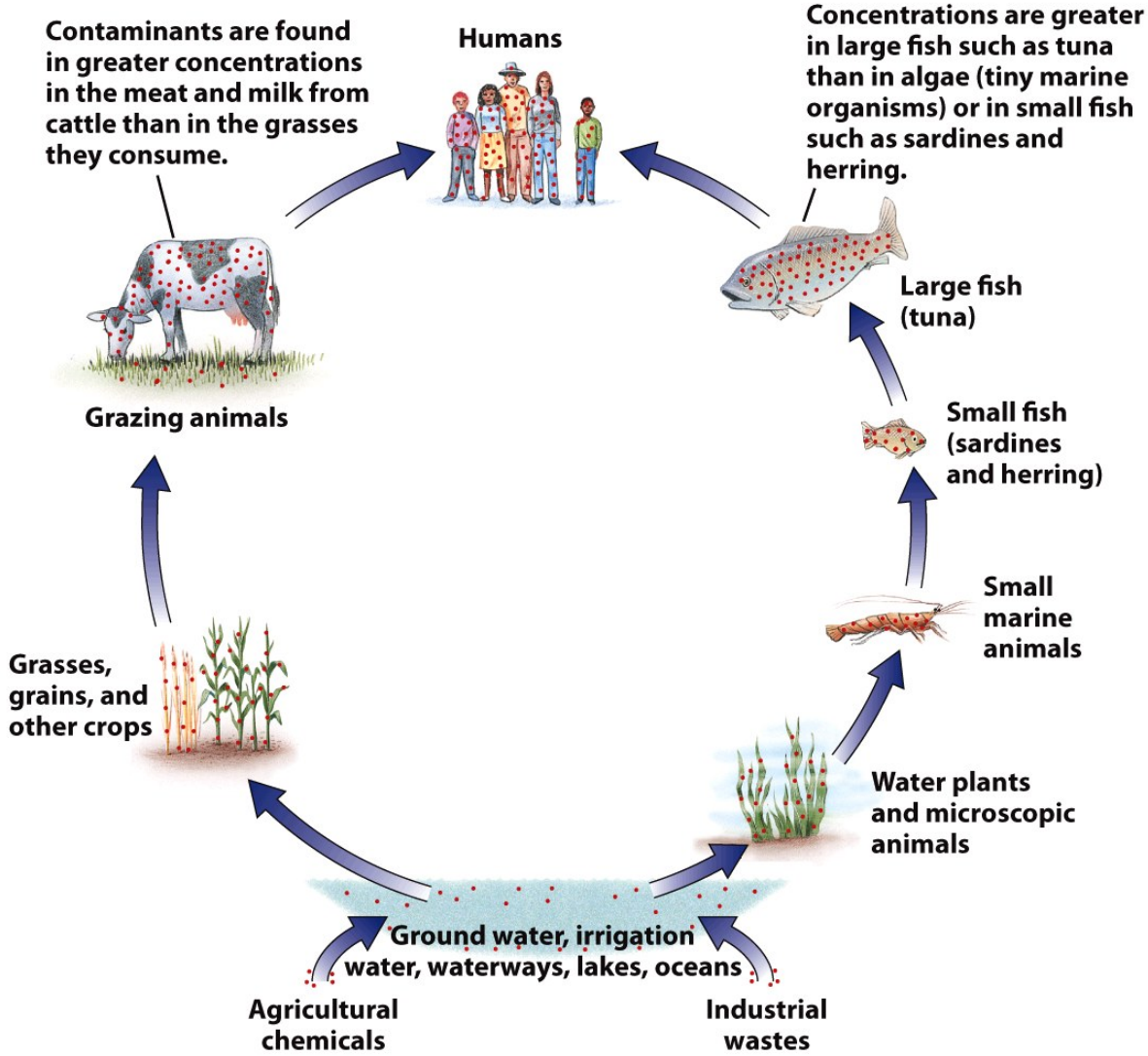
- What do you know about food processing, additives, and contaminants?
- Which food additives and contaminants may not be safe?

Chemical contaminants in food

- Chemicals used in agricultural production and industrial wastes contaminate the environment and can find their way into the food supply

- Bioaccumulation: when contaminated plants or small animals are consumed by larger animals then eaten by larger animals, reaching higher concentrations at each level of the food chain

Bioaccumulation



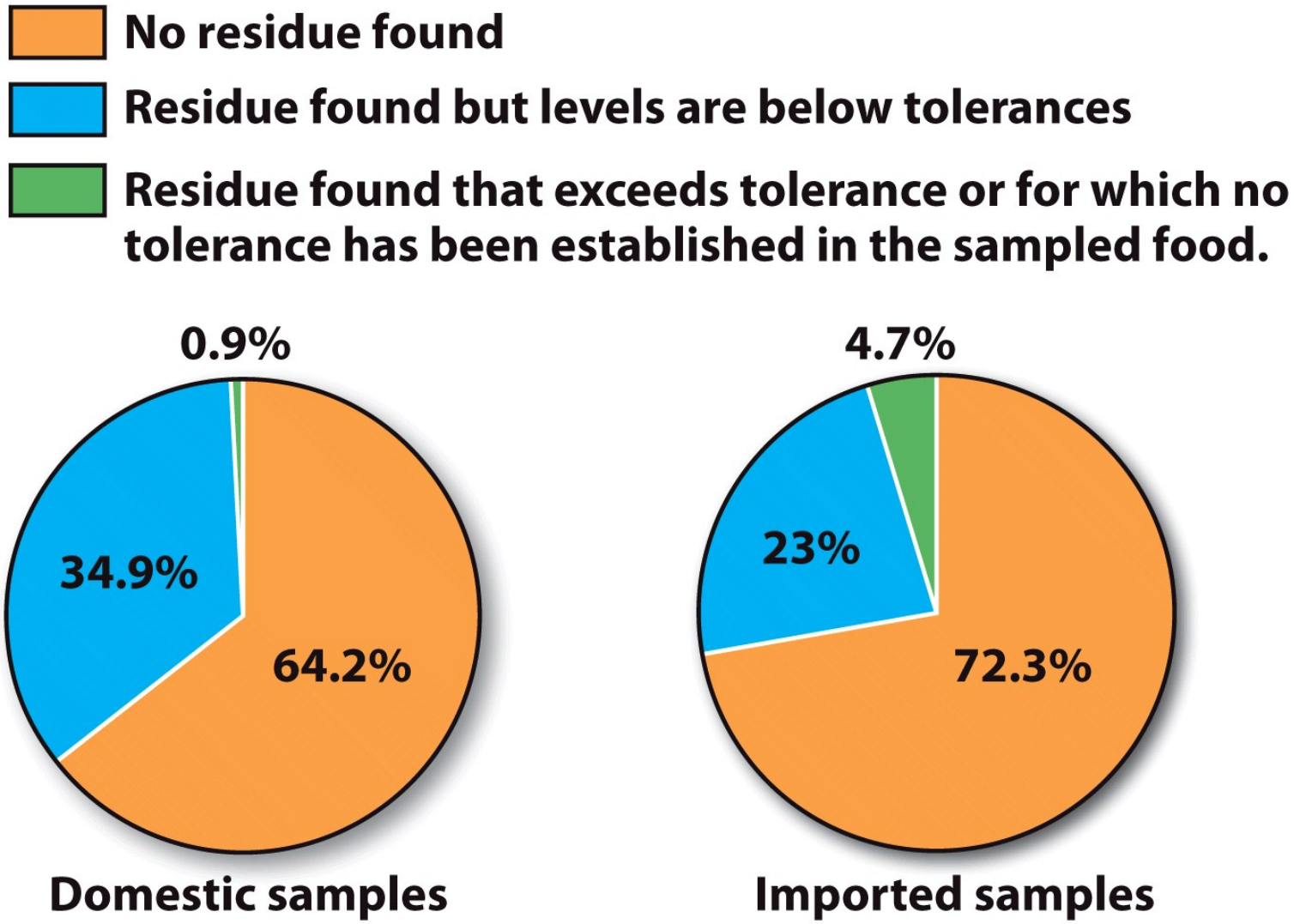
Pesticides in food

- Prevent plant diseases and insect infestations
- Applied both before and after harvest
- \+ Produce higher yields and look more appealing from less insect damage
- – Found on treated plants and in meat, poultry, fish, and dairy products since they enter water, soil, and other parts of environment
  - Risks: depend on the size, age, and health of the consumer and on the type and amount consumed

Pesticides regulation

- Types of pesticides, how often used, and amount of residue that may remain when foods reach consumers are regulated
- EPA: approves and registers pesticides used in food production and establishes tolerances (maximum amounts of pesticide residues that may remain in or on a food)
- FDA and USDA: monitor pesticide residues in foods

Pesticide tolerances



Integrated pest management

- Agricultural pest control method that combines chemical and nonchemical methods and emphasizes use of natural toxins and more effective pesticide application
- Limits pesticide use
- Uses information about pest life cycles and their environmental interactions to manage pest damage economically and with least hazard to people, property, and the environment

Organic foods

- Produced, processed, and handled according to USDA National Organic Program standards
- Reduced chemical pesticides and fertilizer use // USDA determines substances that can or cannot be used
- Most conventional pesticides, synthetic fertilizers, sewage sludge, genetically modified ingredients, irradiation, antibiotics, and growth hormones are prohibited
- Recycling of resources // Conservation of soil and water
- USDA must certify before labeled “organic”

Labeling organic foods

Labeling term	Meaning
100% organic	Contains 100% organically produced raw or processed ingredients.
Organic	Contains at least 95% organically produced raw or processed ingredients.
Made with organic ingredients	Contains at least 70% organically produced ingredients.

Debate

Should you go organic?

Drew Rush/NG Image Collection

Polychlorinated biphenyls (PCBs)

- Group of carcinogenic compounds
- Prior to 1970s, PCBs in runoff from manufacturing plants' contaminated water
  - Still in environment and accumulate in fish from contaminated waters since PCBs do not degrade
  - Prenatal exposure and contaminated breast milk causes nervous system damage and learning deficits
  - Check with local health departments for recommendations regarding fish consumption during pregnancy and lactation

Other manufacturing contaminants

- Chlordane (used to control termites)
- Radioactive substances
- Cadmium: interferes with mineral absorption, causes kidney damage, impairs brain development
- Lead & Arsenic (increases cancer risk)
- Mercury: damages nerve cells; more damaging during prenatal development

Mercury poisoning

James L. Stanfiled/NG Image Collection

Antibiotics & hormones in animals

- Improve health, increase growth, or otherwise enhance food production.
- To prevent from being passed to consumers:
  - types of drugs used and when they can be administered are regulated
  - animal tissues are monitored for drug residues

Antibiotics in animals

- + Animals are treated with antibiotics when sick or to prevent disease and promote growth
- + Increases meat production and reduces costs
- – If used improperly, antibiotic residues can remain in meat
- – Creates antibiotic-resistant bacteria

Hormones in animals

- Used to increase weight gain in sheep and cattle and milk production in dairy cows
- Some hormones, such as estrogen and testosterone, occur naturally
  - Generally administered in slow-release form, and levels are no higher in treated animals than in untreated animals
- Must demonstrate that synthetic hormone residues in meat are within safe limits

Bovine somatotropin (bST)

- Has created public concern
- Produced naturally by cows and stimulates milk production
- Genetically-engineered synthetic hormone is produced by bacteria and injected into cows to further increase milk production
- Milk from cows that have been treated with genetically-engineered bST is indistinguishable from other milk

Bovine somatotropin (bST)

Courtesy Lori Smolin

Minimize food contaminants

- Choose a wide variety of foods
- Choose organic or locally-grown produce
- Wash and in some cases peel produce
- Trim fat from meat and remove poultry skin
- Choose wisely and consume a variety of fish
  - Remove fish skin, fatty material, and dark meat
  - Broil, poach, boil, and bake fish
  - Do not eat lobster “tomale” or blue crab “mustard”

Minimize food contaminants

Jim Richardson/NG Image Collection

George F. Mobley/NG Image Collection

What should I eat?

- Avoid ingesting pathogenic microbes
- Reduce pesticides and pollutants in your food

Concept check

- How can a pesticide used on broccoli plants end up in milk?
- How can organic food cause food-borne illness?
- What can you do to minimize PCBs in your diet?

Technology for Keeping Food Safe

- Food spoils when its taste, texture, or nutritional value is changed by natural food enzymes or by microbes that grow on food

- Techniques that preserve food work by destroying enzymes present in the food, by killing microbes, or by slowing microbial growth

Technology for Keeping Food Safe

FAT TOM Table 13.5

The acronym FAT TOM reminds us of the factors that affect microbial growth. Most food preservation techniques modify one or more of these factors to stop or slow microbial growth.

Food	This is where the bacteria grow.
Acidity	Most bacteria grow best at a pH near neutral. Some food additives, such as citric acid and ascorbic acid (vitamin C), are acids, which prevent microbial growth by lowering the pH of food.
Time	The longer a food sits at an optimum growth temperature, the more bacteria it will contain. Preservation methods such as canning and pasteurization kill microbes by heating food to an appropriate temperature for the right amount of time.
Temperature	The high temperatures of canning, cooking, and pasteurization kill microbes, and the low temperatures of freezing and refrigeration slow or stop microbial growth.
Oxygen	In order to grow, most bacteria need oxygen, so packaging that eliminates oxygen prevents their growth.
Moisture	Bacteria need water to grow, so preservation methods such as drying or use of high concentrations of salt or sugar, which draw water away by osmosis, prevent bacteria from growing.

Food preservation

- Older methods: heating, cooling, drying, smoking, adding substances (sugar or salt)
- Newer methods: irradiation, specialized packaging
- Risk: substances enter food

Additives vs. contaminants

- Food additive: any substance that can be expected to become part of a food
  - FDA regulates the types and amounts of food additives
- Accidental contaminants: unexpected substances that enter food /// Not regulated

High & low temperature preservation

- Provide appealing, safe foods
- Cooking: kills microbes, destroys most toxins
- Pasteurization: process of heating food products to kill microbes
- Sterilization and aseptic processing: placement of sterilized food in sterilized package using sterile process
- Refrigeration or freezing does not kill microbes but slows or stops microbial growth

Aseptic processing

Annie Griffiths Belt/NG Image Collection

Carcinogens from cooking meats

- Polycyclic aromatic hydrocarbons (PAHs):
  - formed when fat drips on a grill and burns then rise with smoke and deposited on food surface
  - Limit: use lower-fat meat and a layer of aluminum foil to prevent fat from dripping on coals

Carcinogens from cooking meats

- Heterocyclic amines (HCAs)
  - produced by burning of substances in meats
  - Limit: precook meat, marinate meat before cooking, cook at lower temperatures, reduce cooking time with smaller pieces of meat, avoid overcooking

Acrylamide

- Formed from chemical reactions during high-temperature baking or frying, particularly in carbohydrate-rich foods
- Highest levels in French fries and snack chips
- Smaller amounts in coffee and foods made from grains (breakfast cereal and cookies)
- High doses <u>may cause cancer, reproductive problems, and nervous system toxicity</u>

Food irradiation (cold pasteurization)

- Used in more than 40 countries and used infrequently in the US because of public suspicion and of lack of irradiation facilities

- Exposes food to high doses of X-rays, gamma radiation, or high-energy electrons to kill microbes and insects and inactivate enzymes that cause germination and ripening of fruits and vegetables

Food irradiation (cold pasteurization) +/-

- Food additive: produces compounds not present in the original foods (regulated)
- Opponents claim: introduces carcinogens and allows sale of previously-contaminated foods
- Decreases nutrients

Food irradiation (cold pasteurization) +/-

- Irradiated food is not radioactive
- Studies: benefits outweigh potential risks
- Reduces pesticides and preservatives
- Potential for improving food safety

Food irradiation (cold pasteurization)

NON – IRRADIATED IRRADIATED

Council for Agricultural Science and Technology (CAST), 1989. *Ionizing Energy in Food Processing and Pest control: II. Applications*

Food packaging

- Keeps molds and bacteria out, keeps moisture in, and protects food from physical damage
- Substances in paper and plastic containers, packaging, and dishes can leach into food
  - Regulated by the EPA and FDA; regulations apply only to the intended use of the product
  - For example, plastics can migrate into food when heated in a microwave oven; only containers designed for microwave cooking should be used

Bisphenol A from plastics

Alaska Stock Images/NG Image Collection

Modified atmosphere packaging (MAP)

- Preservation technique to prolong shelf life of processed or fresh food by changing the gases surrounding food in the package
  - Uses packaging materials impermeable to gases
  - Air in package is vacuumed out to remove oxygen
  - Product remains in a vacuum or the package is infused with another gas
  - Lack of oxygen prevents aerobic bacteria growth, slows ripening and oxidation reactions, which cause fruit and vegetable discoloration and rancidity in fats

Food additives

- Make food safer; maintain palatability and wholesomeness; improve color, flavor, texture; aid in processing; enhance nutritional value
- Direct food additives: substances added intentionally foods
- Indirect food additives: substances that get into food unintentionally
- The FDA regulates the amounts and types of direct and indirect food additives in food

Regulation of food additives

- Manufacturer submits petition to use a new food additive describing chemical composition and how it is manufactured and detected in food
- Manufacturer must prove:
  - effective for intended purpose at proposed levels
  - safe for its intended use
  - use is necessary

Reducing nitrosamine risk

INGREDIENTS: MECHANICALLY SEPARATED CHICKEN, WATER, PORK, MODIFIED CORN STARCH, DEXTROSE, SALT, BEEF, CONTAINS 2% OR LESS OF THE FOLLOWING: CORN SYRUP, FLAVORINGS, SODIUM PHOSPHATES, POTASSIUM LACTATE, SODIUM DIACETATE, SODIUM ASCORBATE (VITAMIN C), OLEO RESIN OF PAPRIKA, SODIUM NITRITE

Additives exempt from regulation

- Prior-sanctioned substances: > 600 additives in use when legislation was passed
- Generally recognized as safe (GRAS): additives considered safe based on history of use in food before 1958 or on published scientific evidence
- If new evidence suggesting additive in either category is unsafe, FDA may require removal

Regulation of food additives

- Can be added only at levels 100 times below highest level shown to have no harmful effects

- Delaney Clause: states that a substance that induces cancer in either an animal species or humans, at any dosage, may not be added to food; part of the 1958 Food Additive Amendment

Sensitivities to additives

- Some individuals are allergic or sensitive to certain food additives
- Examples:
  - Monosodium glutamate (MSG) can cause *MSG symptom complex* or *Chinese restaurant syndrome*
  - Sulfites can cause symptoms ranging from stomach ache and hives to severe asthma
  - FD&C yellow no. 5 (listed as tartrazine on medicine labels) may cause itching and hives

Color additives

- Colors are classified as certified or exempt
- Certified colors: human-made, meet strict specifications for purity, and must be listed by name in the ingredient list
- Exempt colors: include pigments from natural sources (such as dehydrated beets and carotenoids); these may be listed collectively in the ingredient list as "artificial color"

Food additives

Common food additives[40] Table 13.6

Type of additive	What's on the label	What they do	Where they are used
Preservatives	Ascorbic acid, citric acid, sodium benzoate, calcium propionate, sodium erythorbate, sodium nitrite, calcium sorbate, potassium sorbate, BHA, BHT, EDTA, tocopherols	Maintain freshness; prevent spoilage caused by bacteria, molds, fungi, or yeast; slow or prevent changes in color, flavor, or texture; and delay rancidity	Jellies, beverages, baked goods, cured meats, oils and margarines, cereals, dressings, snack foods, fruits and vegetables
Sweeteners	Sucrose, glucose, fructose, sorbitol, mannitol, corn syrup, high-fructose corn syrup, saccharin, aspartame, sucralose, acesulfame potassium (acesulfame-K), neotame	Add sweetness with or without extra calories	Beverages, baked goods, table-top sweeteners, many processed foods
Color additives	FD&C blue nos. 1 and 2, FD&C green no. 3, FD&C red nos. 3 and 40, FD&C yellow nos. 5 and 6, orange B, citrus red no. 2, annatto extract, beta-carotene, grapeskin extract, cochineal extract or carmine, paprika oleoresin, caramel color, fruit and vegetable juices, saffron, colorings or color added	Prevent color loss due to exposure to light, air, temperature extremes, and moisture; enhance colors; give color to colorless and "fun" foods	Processed foods, candies, snack foods, margarine, cheese, soft drinks, jellies, puddings and pie fillings
Flavors, spices, and flavor enhancers	Natural flavoring, artificial flavor, spices, monosodium glutamate (MSG), hydrolyzed soy protein, autolyzed yeast extract, disodium guanylate or inosinate	Add specific flavors or enhance flavors already present in foods	Many processed foods, puddings and pie fillings, gelatin mixes, cake mixes, salad dressings, candies, soft drinks, ice cream, BBQ sauce

Food additives

Common food additives[40] Table 13.6

Type of additive	What's on the label	What they do	Where they are used
Nutrients	Thiamine hydrochloride, riboflavin (vitamin B_2), niacin, niacinamide, folate or folic acid, beta-carotene, potassium iodide, iron or ferrous sulfate, alpha-tocopherols, ascorbic acid, vitamin D, amino acids (L-tryptophan, L-lysine, L-leucine, L-methionine)	Replace vitamins and minerals lost in processing; add nutrients that may be lacking in the diet	Flour, breads, cereals, rice, pasta, margarine, salt, milk, fruit beverages, energy bars, breakfast drinks
Emulsifiers	Soy lecithin, mono- and diglycerides, egg yolks, polysorbates, sorbitan monostearate	Allow smooth mixing and prevent separation; reduce stickiness; control crystallization; keep ingredients dispersed	Salad dressings, peanut butter, chocolate, margarine, frozen desserts
Stabilizers and thickeners, binders, and texturizers	Gelatin, pectin, guar gum, carrageenan, xanthan gum, whey	Produce uniform texture, improve "mouth-feel"	Frozen desserts, dairy products, cakes, pudding and gelatin mixes, dressings, jams and jellies, sauces
pH control agents and acidulants	Lactic acid, citric acid, ammonium hydroxide, sodium carbonate	Control acidity and alkalinity, prevent spoilage	Beverages, frozen desserts, chocolate, low-acid canned foods, baking powder
Leavening agents	Baking soda, monocalcium phosphate, calcium carbonate	Promote rising of baked goods	Breads and other baked goods
Anti-caking agents	Calcium silicate, iron ammonium citrate, silicon dioxide	Keep powdered foods free-flowing, prevent moisture absorption	Salt, baking powder, confectioners' sugar
Humectants	Glycerin, sorbitol	Retain moisture	Shredded coconut, marshmallows, soft candies, confections

Concept check

- What is pasteurization?
- How does irradiation help extend the shelf life of food?
- How does modified atmosphere packaging prevent food spoilage?
- Why are food additives regulated?

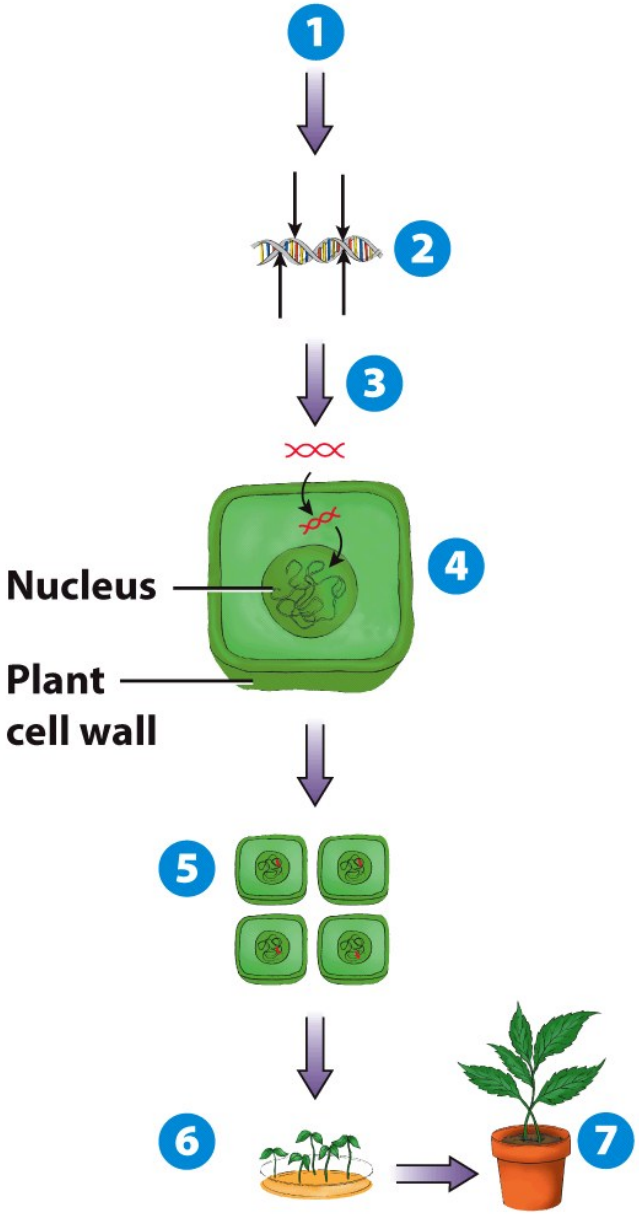
THINK about this – then share within a PAIR – then SHARE with the class

- What do you know about biotechnology?

Genetically modified (GM) crops

- Gene (piece of DNA) for desired characteristic (for example, disease and drought resistance) is transferred from plant, animal, or bacterial cells into plant cells
- Creates recombinant DNA - a *combina*tion of DNA from two organisms
- Modified cells divide and differentiate into plant
- New plant is a transgenic organism
- Each cell in plant contains transferred gene

Genetically modified (GM) crops



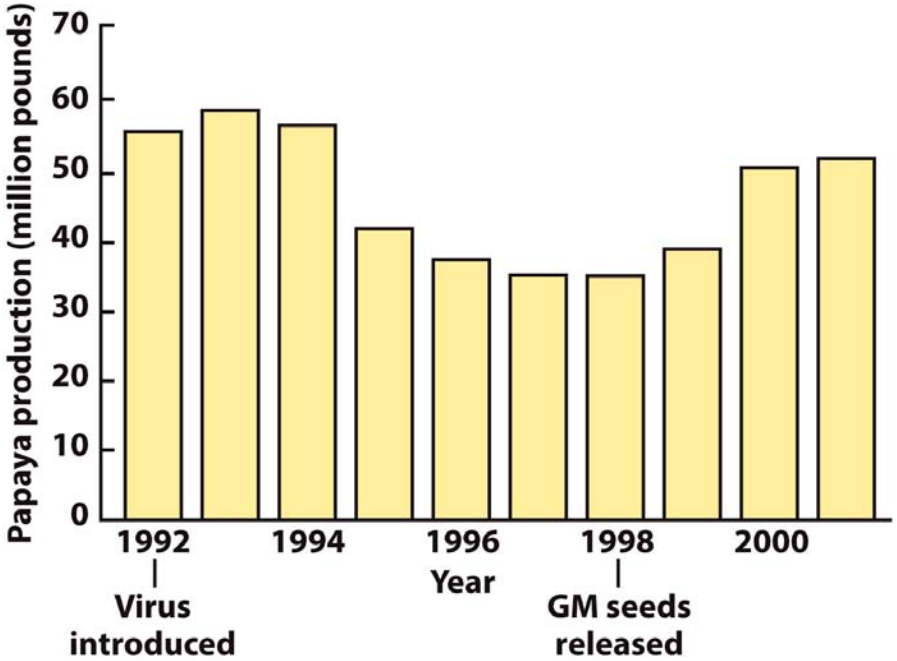
Food applications of biotechnology

- To alter quantity, quality, cost, safety, shelf life
  - Making plants resistant to herbicides, insects, and various plant diseases increases crop yields and reduces damage from insects and plant diseases
  - Altering enzyme activity and other traits increases shelf life of fresh fruits and vegetables and consumer appeal (for example, seedless grapes)
- Food processing examples: enzymes in production of cheese, high-fructose corn syrup, and reduced lactose dairy products

Food applications of biotechnology

Courtesy Marlin E. Rice

Courtesy Golden Rice Humanitarian Board, www.goldenrice.org



Biotechnology for malnutrition

- For protein deficiency: corn, soybean, and sweet potato varieties with enhanced essential amino acids levels
- For vitamin A deficiency: genes for β-carotene synthesis enzymes inserted into rice
- To address multiple nutrient deficiencies: cassava with increased zinc, iron, protein, and vitamin A levels

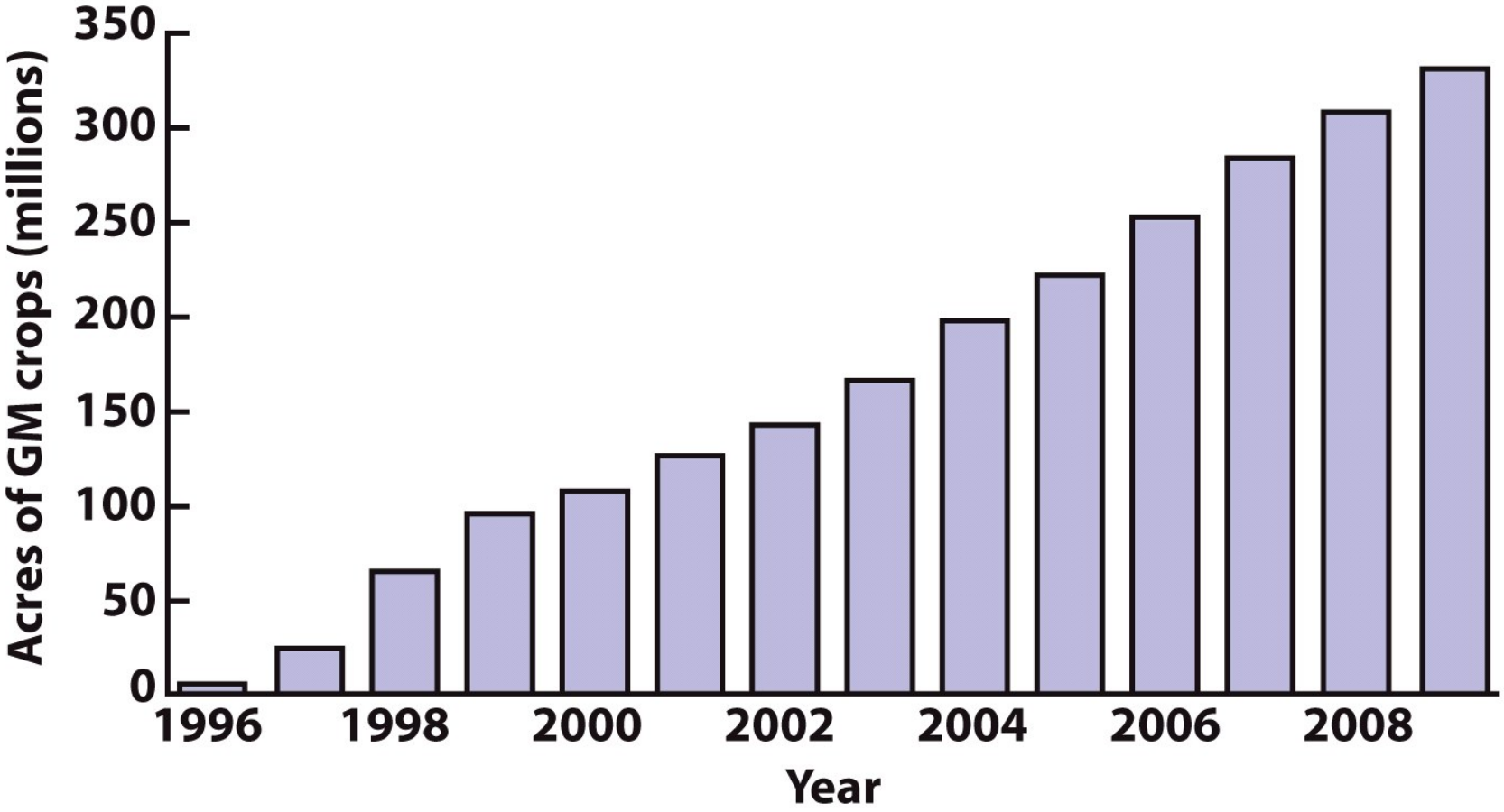
Biotechnology concerns

- Nutrient content may be negatively affected
- Allergen or toxin may be introduced
- GM crops will be used to the exclusion of other varieties, reducing biodiversity which may reduce ability to adapt to new conditions, diseases, or other hazards
- GM crops may create “superweeds”
- GM crops producing pesticides may promote evolution of pesticide-resistant insects

US genetically-modified crops

- Most common: /// Soybeans, corn, cotton, and rapeseed (or canola)
- Foods likely to contain GM ingredients:
  - Containing corn, high-fructose corn syrup, soybeans, cottonseed oil and canola oil

Growth of GM crops



Biotechnology regulation

- FDA, USDA, EPA: oversee plant biotechnology
- Safety and environmental issues monitored at all stages of the process
- FDA: regulates safety and labeling of GM foods
- USDA: regulates research and development of new agricultural products
- EPA: regulates pesticides that may be present in foods and sets pesticide tolerance levels

Labeling of GM foods

- Not required to have special labeling unless:
  - nutritional composition has been altered
  - it contains potentially harmful allergens, toxins, pesticides, or herbicides, or new ingredients
  - it has been changed significantly enough so that its traditional name no longer applies

Labeling of GM foods

- Premarket approval required if new food contains substance not commonly found in foods or without a history of safe use in foods

Concept check

- Where does the DNA introduced into GM plants come from?
- How does biotechnology increase crop yields?
- Why might a GM food cause an allergic reaction when the unmodified food does not?
- What types of GM foods carry special labels?

What is happening in this picture?

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What are similarities and differences between:

- Bacteria and viruses?
- Microrganisms and prions?
- Food additives and contaminants?
- Antibiotics and growth hormone?
- Direct and indirect additives?

Applications

What advice could you give to a loved one to increase the safety of the foods they eat?

Nutrition in the news

- Food-borne illness outbreaks
- Contaminants in foods linked to autism, hyperactivity, etc.
- Contaminants in fish
- BPA (bisphenol A) in plastics
- Organic foods
- Genetically-modified foods
- Labeling of genetically-modified foods

Checking student learning outcomes

- How do the government and food companies keep our food safe?
- How can you keep food safe?
- How are pathogens that contaminate food similar and different?
- What are the benefits and risks of food additives and contaminants?
- What are the benefits and risks of biotechnology?