UNIT 8
Aquatic and Terrestrial Pollution

TOPIC 8.1

Sources of Pollution

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.A

Identify differences between point and nonpoint sources of pollution.

ESSENTIAL KNOWLEDGE

STB-3.A.1

A point source refers to a single, identifiable source of a pollutant, such as a smokestack or waste discharge pipe.

STB-3.A.2

Nonpoint sources of pollution are diffused and can therefore be difficult to identify, such as pesticide spraying or urban runoff.

Categories of water pollution

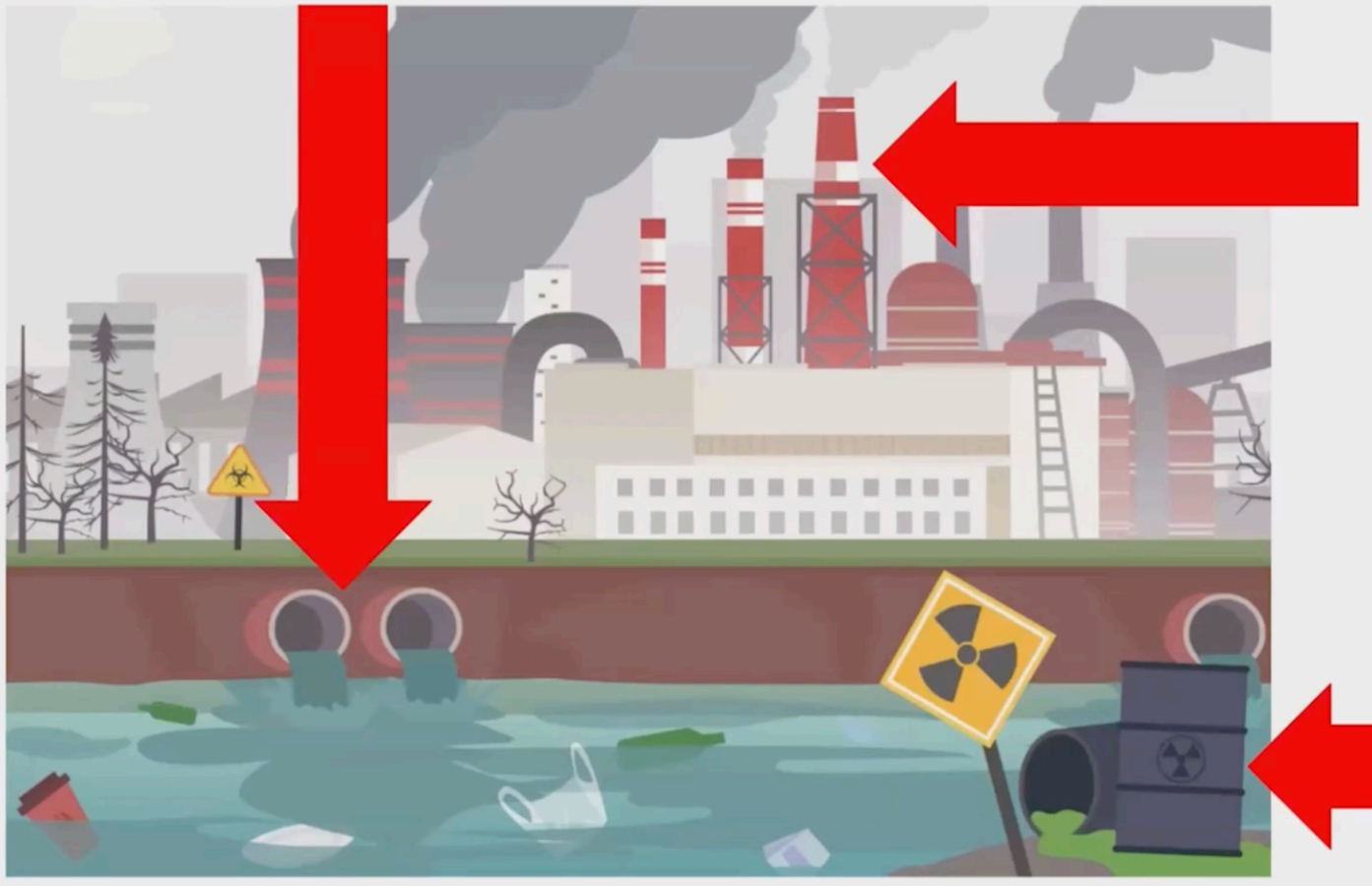
Point source	Nonpoint source

- Categories differentiate the sources of contamination in order to manage them effectively.
- EPA sets water quality standards, and these classifications help determine protection strategies.
- Ground and surface waters can be impacted by both point and nonpoint source pollution.

Point Source pollution

Pollution that enters the environment from a single source and is clearly identified.

Point Source pollution



Pollution that enters the environment from a single source and is clearly identified.

Controlling point source pollution

- The **Clean Water Act** requires industries of point sources to get a permit from the state and/or EPA before they can discharge any effluent into a body of water.
- The point source will also have to use effective technologies to treat the effluent before it can be discharged.

Point Sources

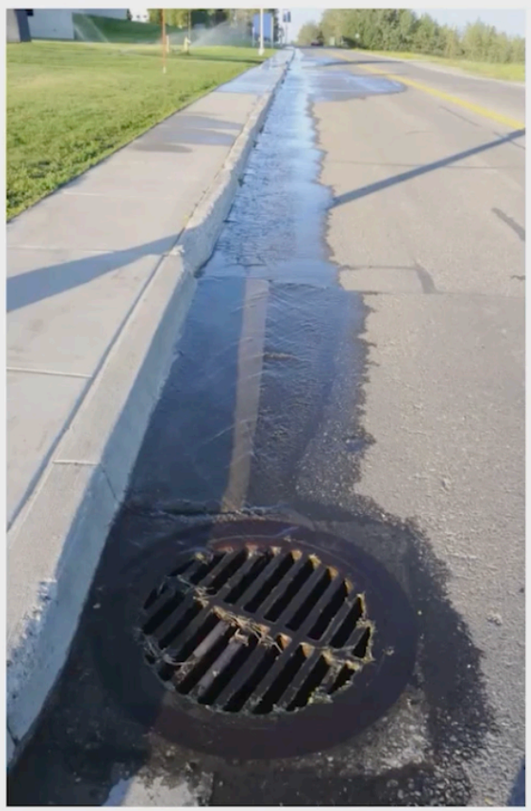
- Wastewater treatment plants
- Electronic or automobile manufacturers
- Paper or pulp mills
- Oil refineries
- Concentrated animal feeding operations (CAFO)
- Leaking underground gasoline storage tanks

Nonpoint source pollution

Agricultural and residential areas can have excess chemicals such as:

- fertilizers
- herbicides
- insecticides

Nonpoint source pollution



Gary Whitton / Shutterstock.com

Water from rain, snowmelt, and irrigation running off parking lots, roads, and lawns in urban/suburban areas can be a source of

- oil
- grease
- toxic chemicals

Nonpoint source

Sediment is one of the most significant nonpoint source pollutants in the United States

Sediment (soil particles made of sand, gravel, and clay) from improperly managed

- construction sites
- crop and forest lands
- eroding stream banks

A different approach for management

Nonpoint sources are not regulated through permitting but **managed** through programs that encourage partnerships between private landowners and business with local and state governments working together.

Describe environmental concepts

Waste from which of the following is an example of nonpoint source pollution?

A Overflow from a sewage treatment plant

B Outgassing from a municipal landfill

C Dumping at a food-processing plant

D Drainage from an abandoned mine

E Runoff from agricultural fields

TOPIC 8.2

Human Impacts on Ecosystems

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.B

Describe the impacts of human activities on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.B.1

Organisms have a range of tolerance for various pollutants. Organisms have an optimum range for each factor where they can maintain homeostasis. Outside of this range, organisms may experience physiological stress, limited growth, reduced reproduction, and in extreme cases, death.

STB-3.B.2

Coral reefs have been suffering damage due to a variety of factors, including increasing ocean temperature, sediment runoff, and destructive fishing practices.

STB-3.B.3

Oil spills in marine waters cause organisms to die from the hydrocarbons in oil. Oil that floats on the surface of water can coat the feathers of birds and fur of marine mammals. Some components of oil sink to the ocean floor, killing some bottom-dwelling organisms.

STB-3.B.4

Oil that washes up on the beach can have economic consequences on the fishing and tourism industries.

continued on next page

LEARNING OBJECTIVE

STB-3.B

Describe the impacts of human activities on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.B.5

Oceanic dead zones are areas of low oxygen in the world's oceans caused by increased nutrient pollution.

STB-3.B.6

An oxygen sag curve is a plot of dissolved oxygen levels versus the distance from a source of pollution, usually excess nutrients and biological refuse.

STB-3.B.7

Heavy metals used for industry, especially mining and burning of fossil fuels, can reach the groundwater, impacting the drinking water supply.

STB-3.B.8

Litter that reaches aquatic ecosystems, besides being unsightly, can create intestinal blockage and choking hazards for wildlife and introduce toxic substances to the food chain.

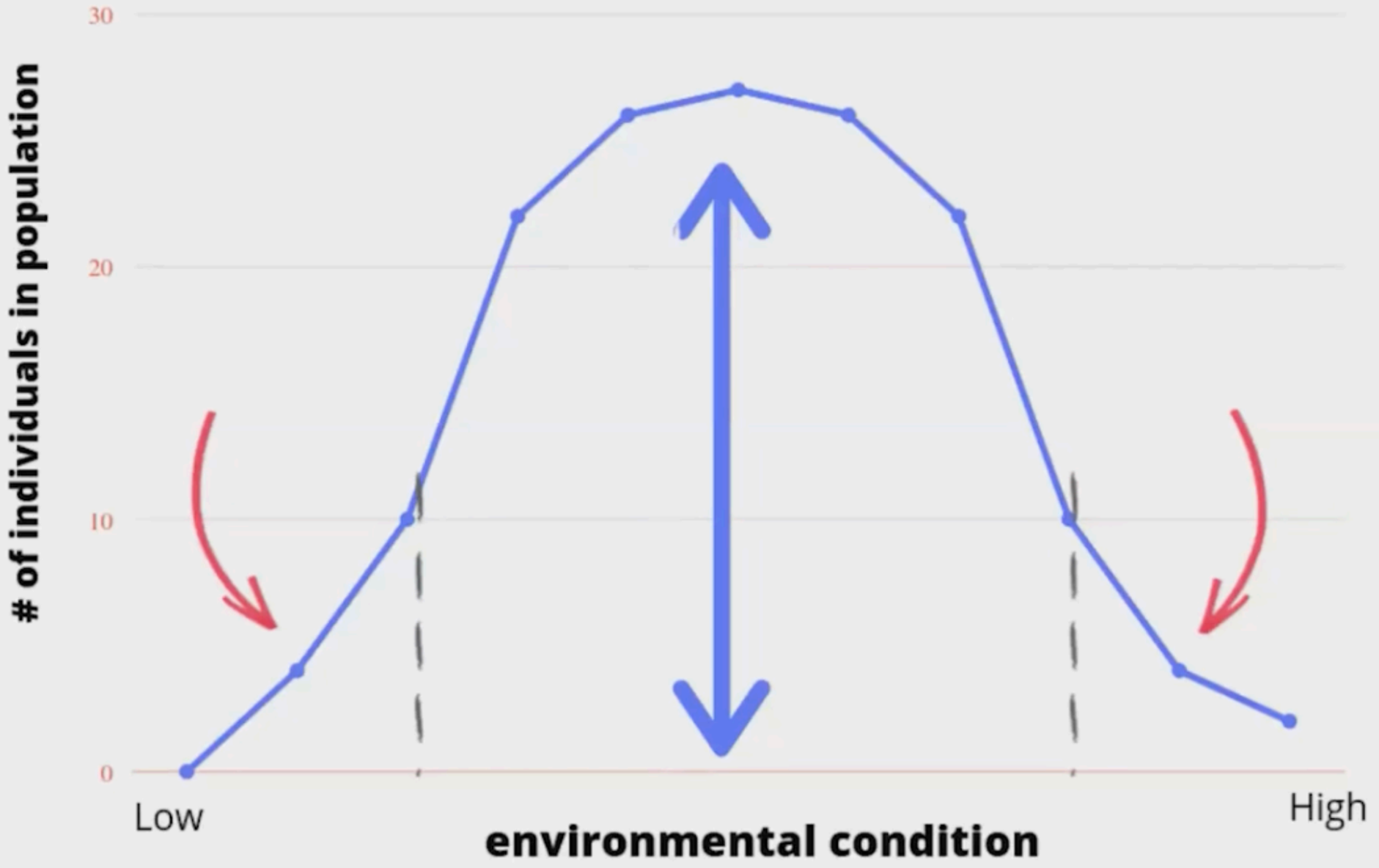
STB-3.B.9

Increased sediment in waterways can reduce light infiltration, which can affect primary producers and visual predators. Sediment can also settle, disrupting habitats.

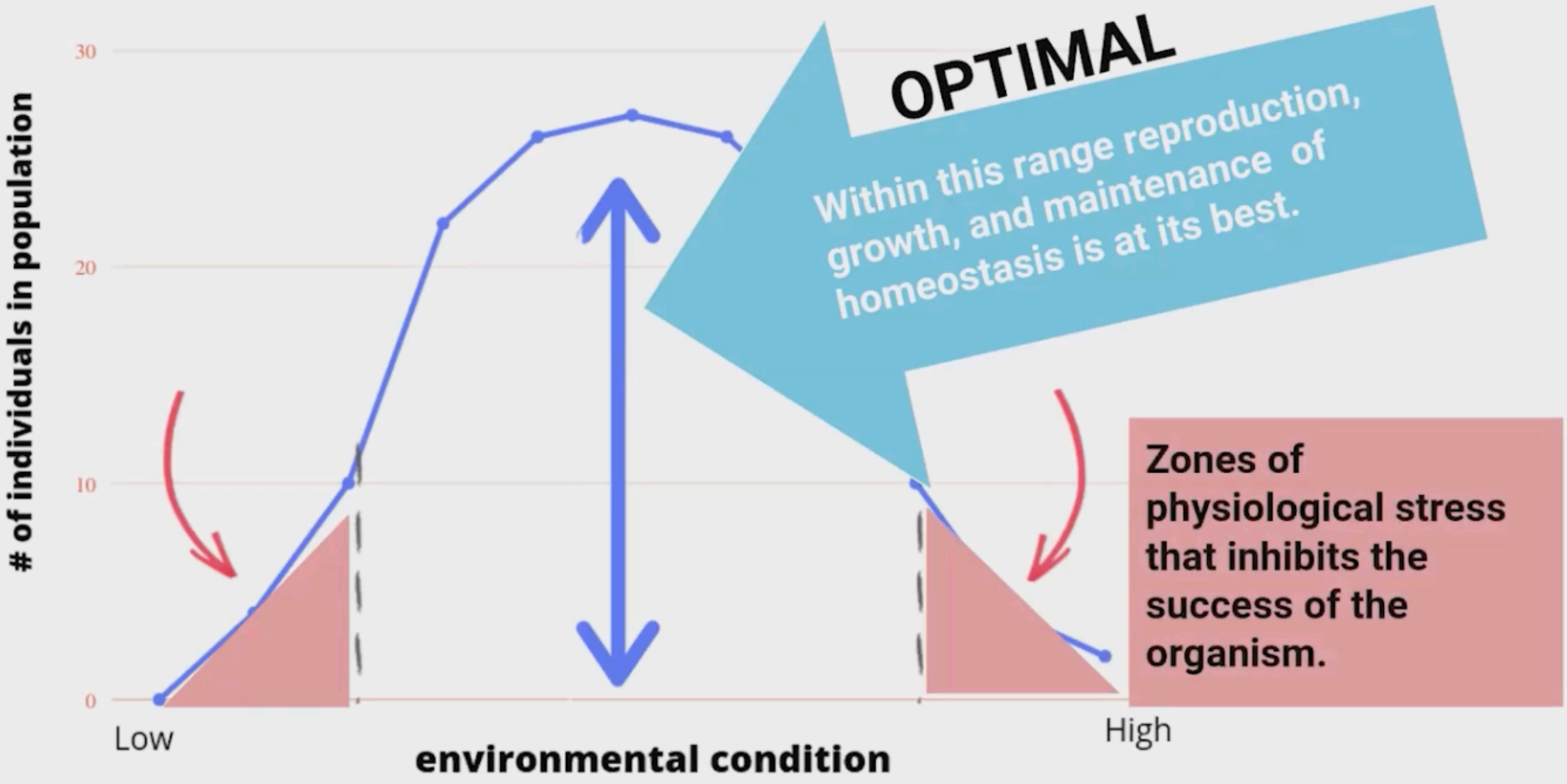
STB-3.B.10

When elemental sources of mercury enter aquatic environments, bacteria in the water convert it to highly toxic methylmercury.

Range of Tolerance



Range of tolerance

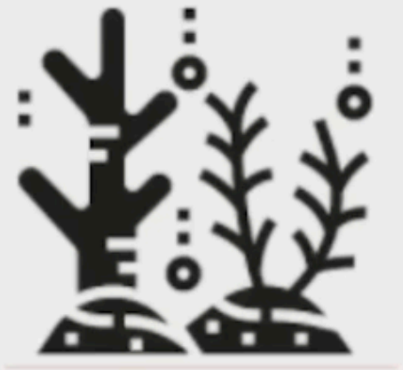


Coral reefs are important ecosystems

Critical ecosystem in the oceans cover less than 1% of the area but support 25% of marine species.

Animals that live symbiotically with algae that photosynthesize.

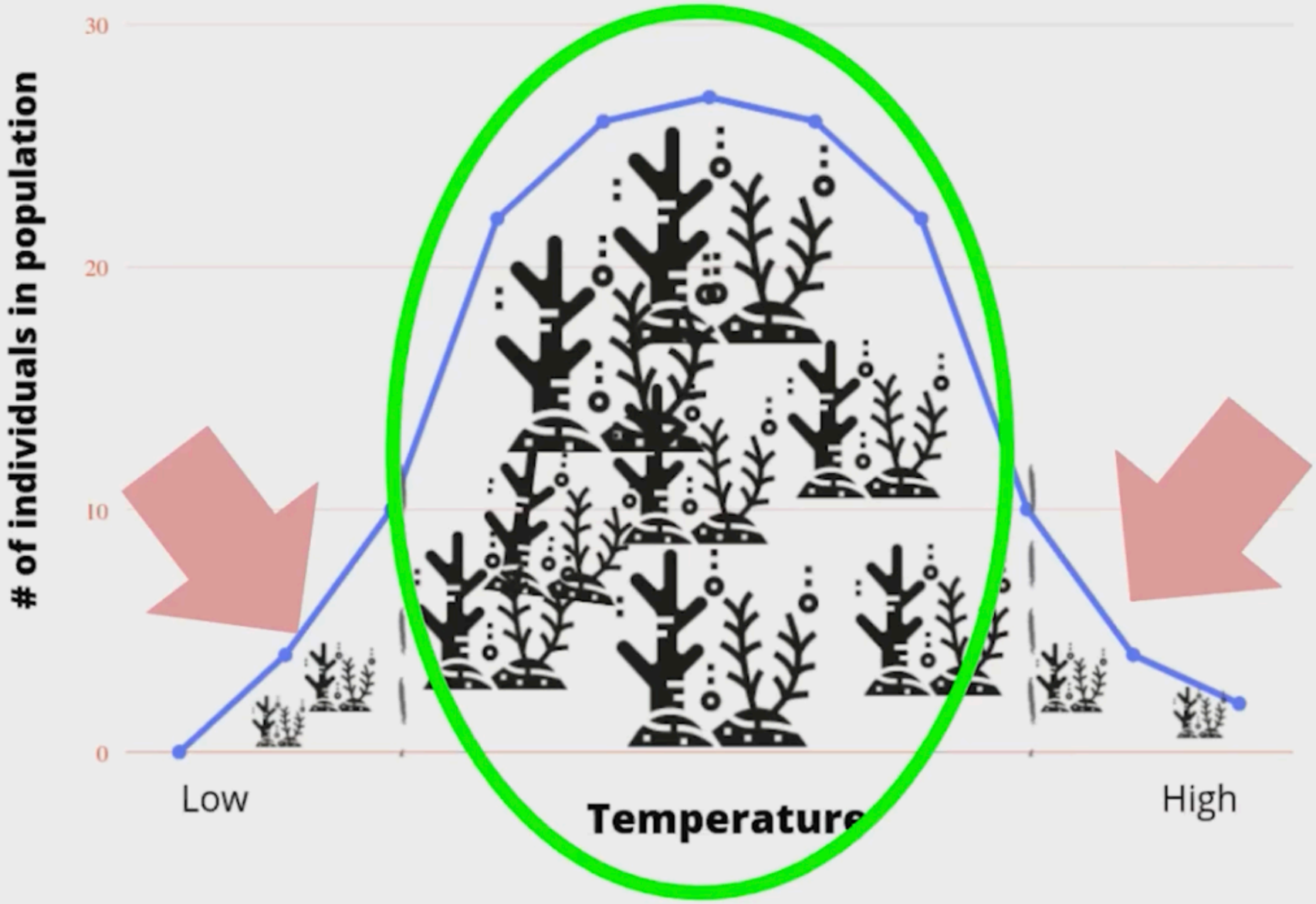
Range of Tolerance



Reef-building species

20 -29° C

68-84.2° F



As ocean temperatures rise

High temperatures cause a process called **coral bleaching** to occur.

The coral expels the symbiont out of its cells, resulting in a loss of a food supply and the color from the chlorophyll pigment of the algae.

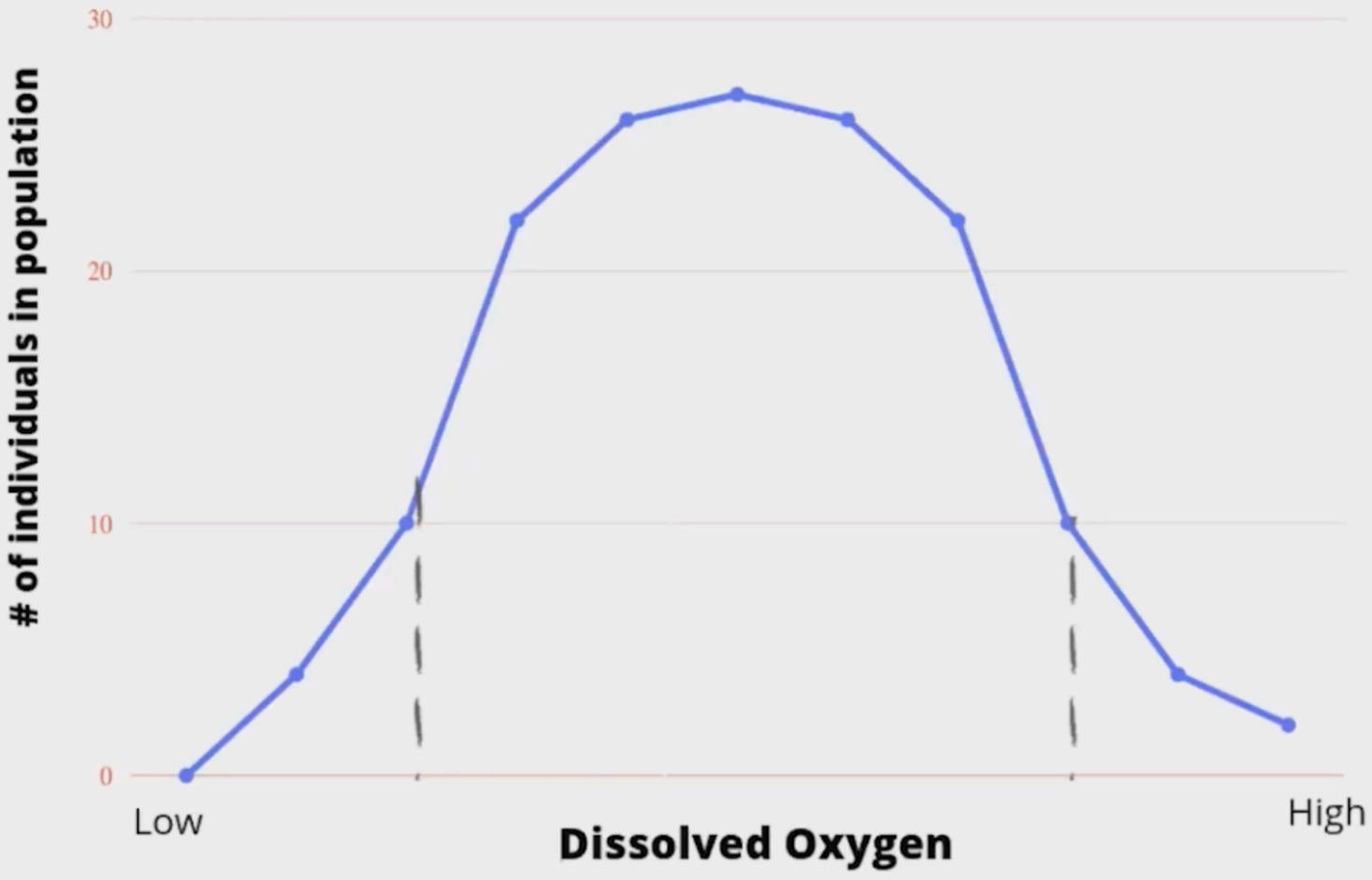
Destructive Fishing Practices

- **Bottom trawling** scrapes nets along the ocean floor and breaks and crushes coral.
- **Marine debris** like unattended nets, traps, and monofilament fishing line can damage and injure reefs and reef-dependent organisms like young fish.
- **Overfishing** removes fish, especially herbivores, which help maintain healthy algae populations in the reef ecosystem.
- **Cyanide fishing** is when sodium cyanide is poured over an area to stun fish so they are easier to catch for the aquarium and restaurant trade. This poisons corals.

Sedimentation threatens coral

Sedimentation, soil particles of rock, clay, and sand, can bury corals, blocking the sunlight needed by the symbiont so no photosynthesis can occur, again resulting in the death of the coral.

Dissolved oxygen is critical



Range of tolerance applies to dissolved oxygen (DO) for species living in aquatic environments.

DO is usually measured in ppm.

Dead zone in the Gulf of Mexico

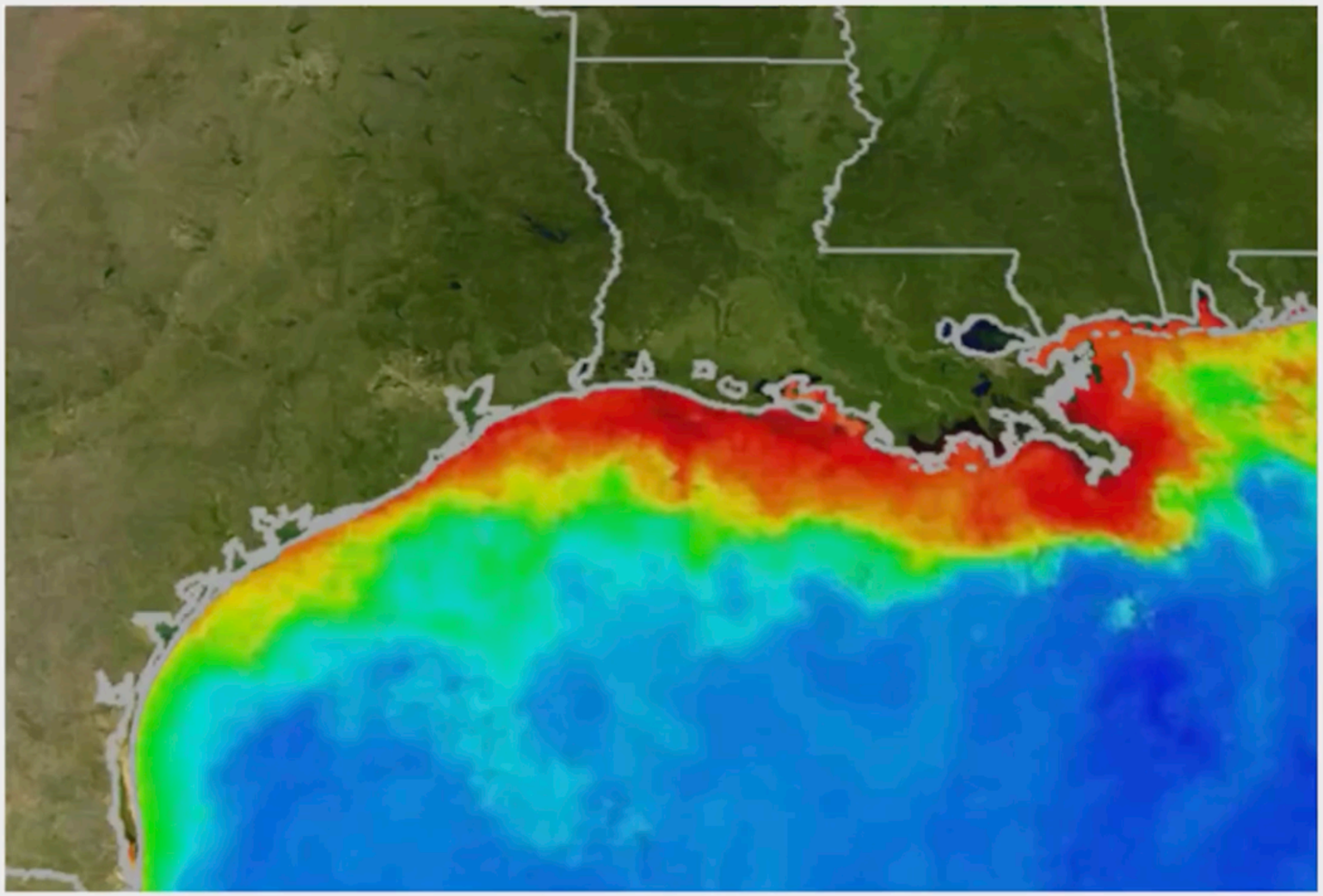


Photo courtesy of NASA

Excess nutrients like nitrogen and phosphate from agricultural runoff promotes a bloom of aquatic producers like algae. When they die, they are digested by oxygen-consuming microorganisms.

Dissolved oxygen levels decrease to dangerous levels and even death for most organisms.

(**Eutrophication Topic 8.5**)

Plotting dissolved oxygen

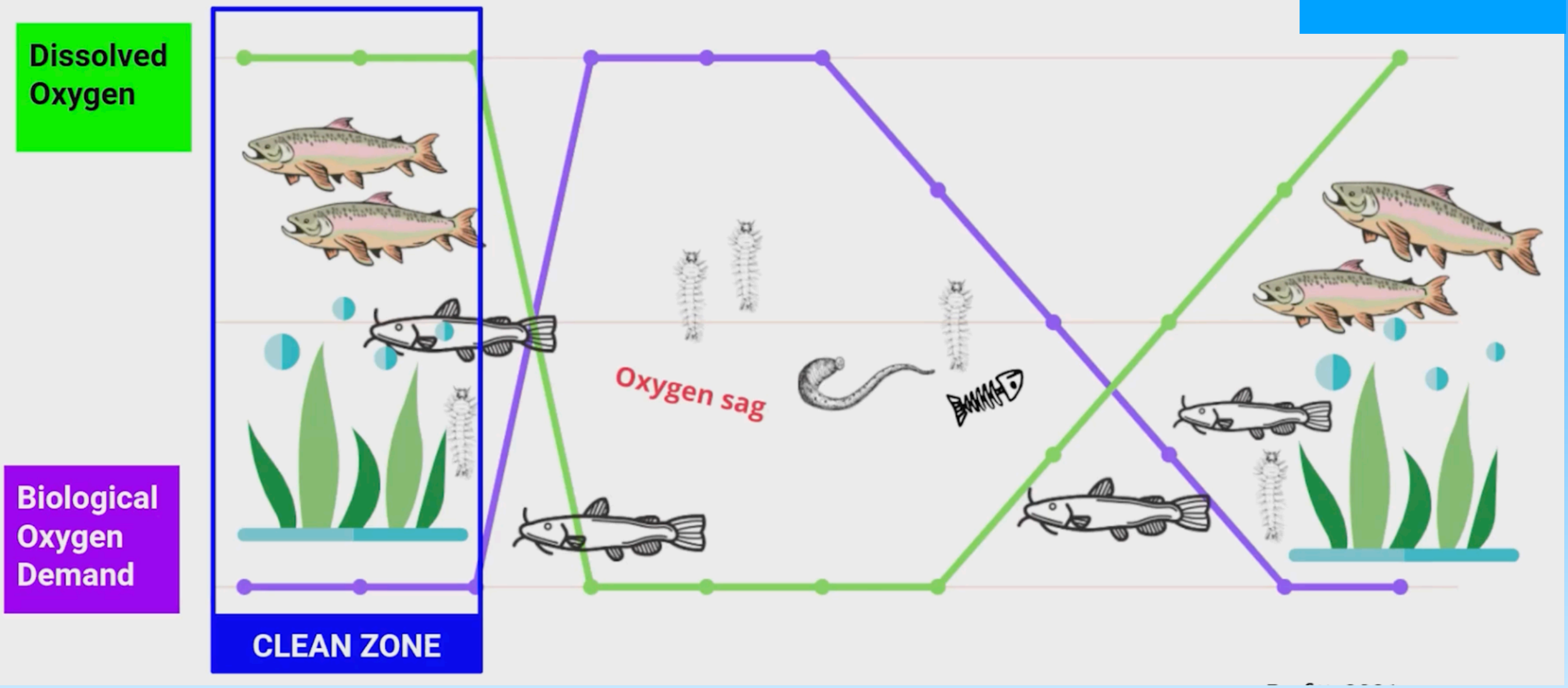
An oxygen sag curve is a plot of dissolved oxygen levels versus distance from a source of pollution with excess nutrients.

Biological Oxygen Demand

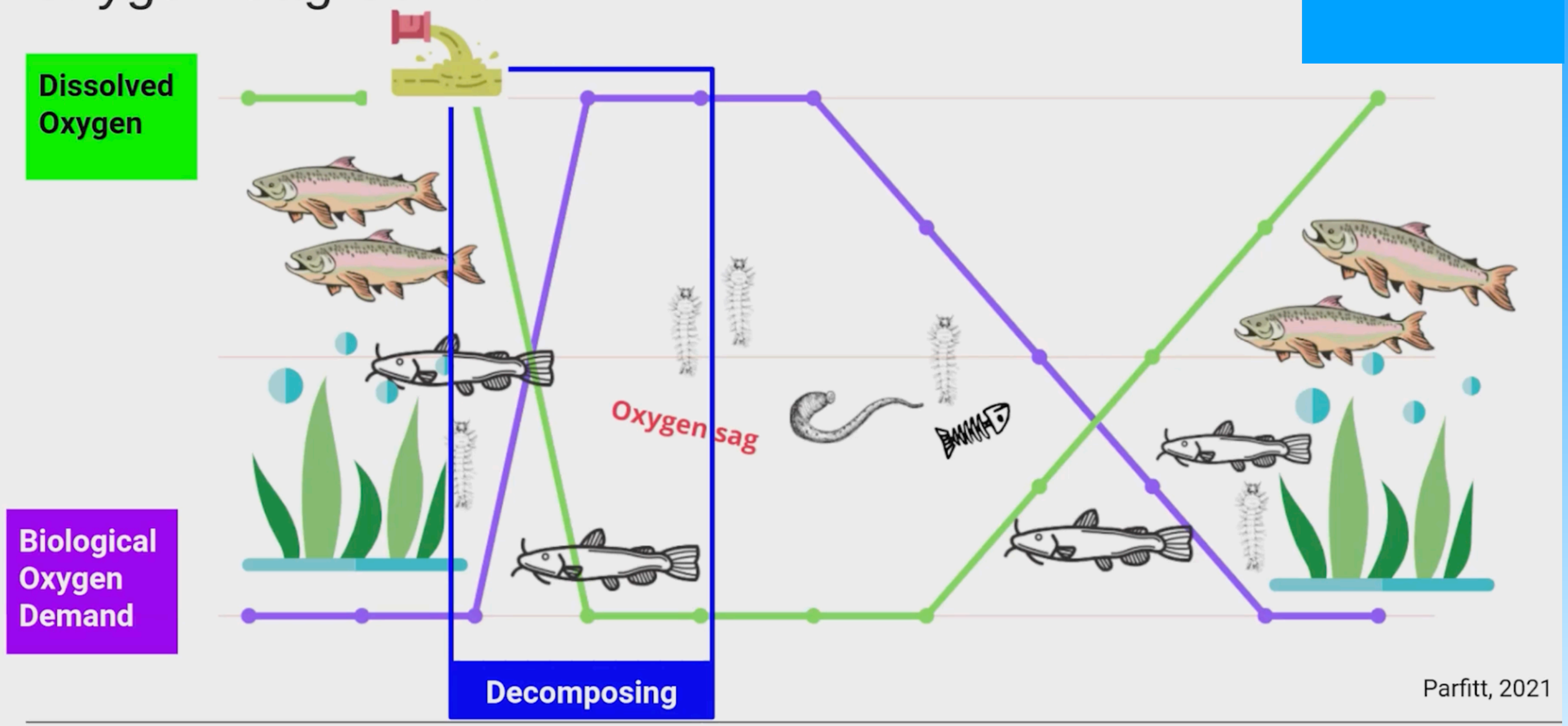
Dissolved Oxygen

- **Low oxygen tolerant species**
- **Low oxygen intolerant species**

Oxygen Sag Curve

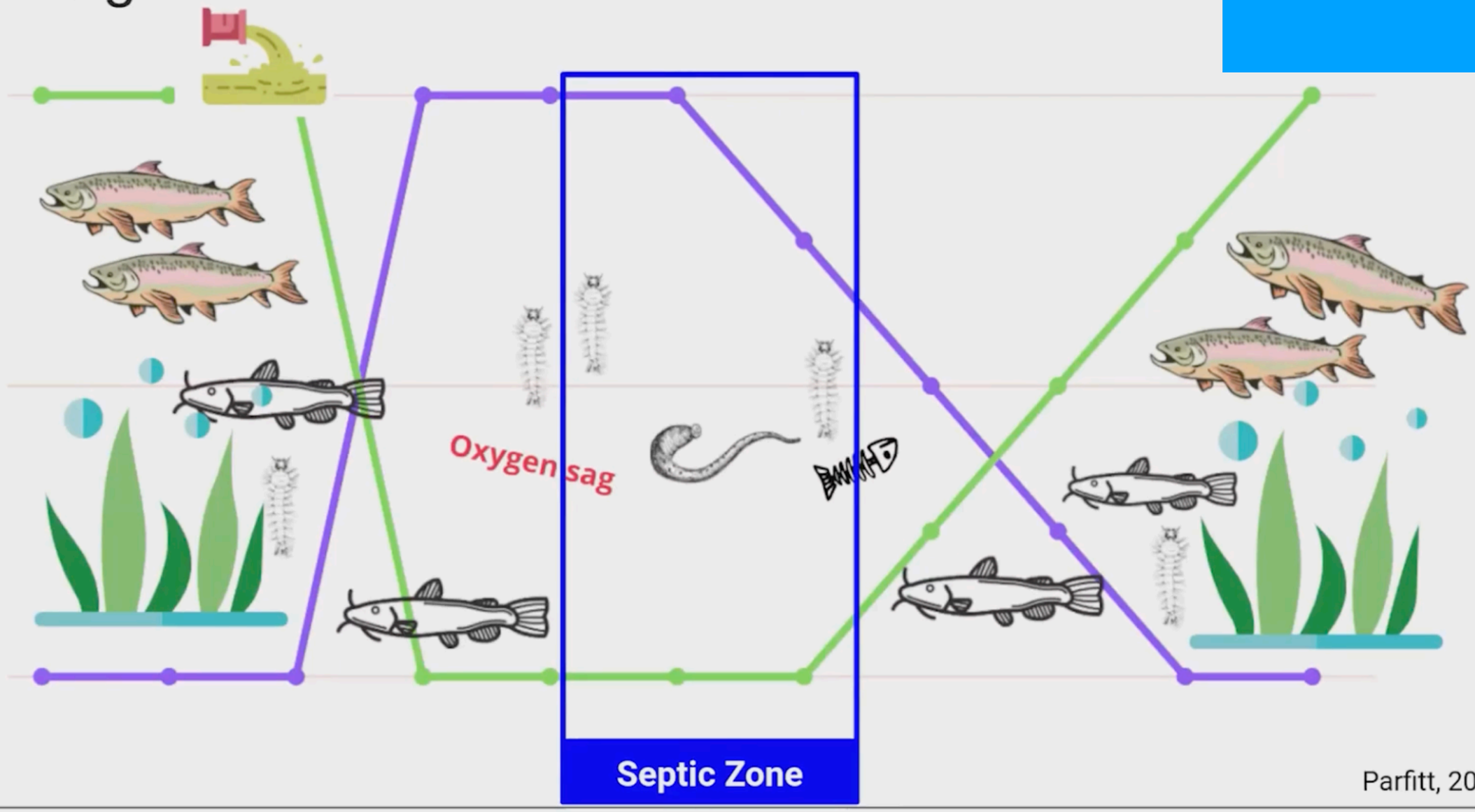


Oxygen Sag Curve



Parfitt, 2021

Oxygen Sag Curve



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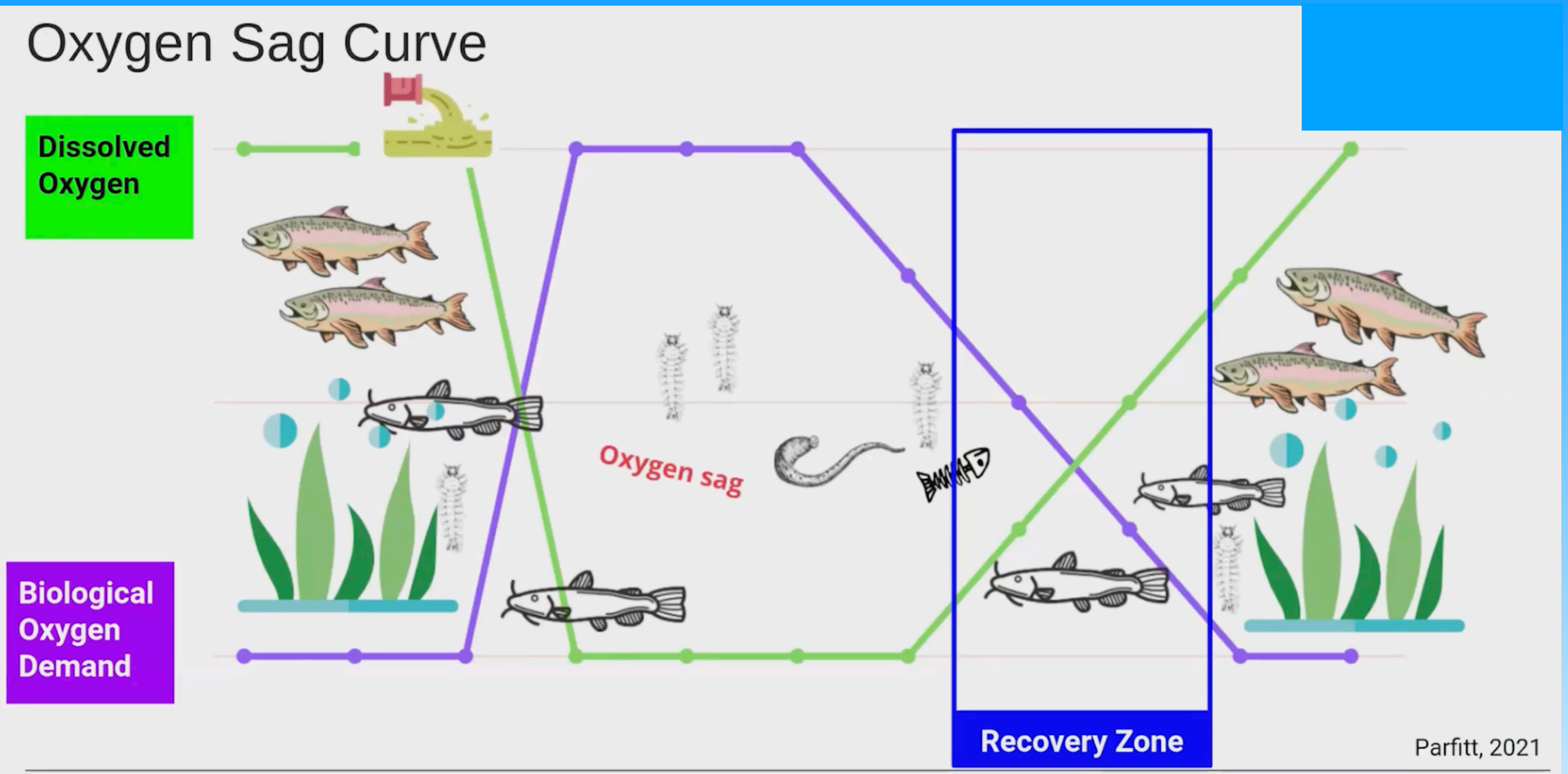
Oxygen Sag Curve



Parfitt, 2021

Ideas to take away

- All organisms have a **range of tolerance** for environmental conditions like dissolved oxygen and temperature.

- Physiological stress occurs as species approach the **upper and lower limits** of that range.

- Corals are threatened by **sedimentation**, **destructive fishing techniques**, and **increasing ocean temperatures.**

- Excess nutrients can result in conditions with low dissolved oxygen levels. These are known as **dead zones**.

- An **oxygen sag curve** plots the relationship between distance from an input of pollution and dissolved oxygen levels in an aquatic system.

Oil spills are always a risk

Extracting and transporting petroleum has risks of spills. Accidental spills of all sizes can occur with oil tankers, pipelines, rail cars, and extraction sites.

One of the largest spills in the United States was from the 2010 explosion of the **BP Deepwater Horizon drill rig** in the Gulf of Mexico with over 180 million gallons of oil spilled.

Another was the 1989 **Exxon Valdez** spill in Alaska which spilled 11 million gallons of oil.

Both had devastating and long lasting impacts on wildlife, ecosystems, and economies.

Oil spills impact wildlife

Oil that floats on the surface of the water can coat the feathers of birds, robbing them of both insulation and the ability to fly.

The fur of marine mammals like seals and sea otters can become saturated with oil, inhibiting their waterproofing and ability to maintain their body temperature.

They can ingest the hydrocarbons as they try to groom the oil from their fur, and like all organisms that ingest or inhale hydrocarbons, die from poisoning.

Entire food chains are impacted

Some components of oil sink to the ocean floor.

These oil blobs can stay at the bottom for a long time as they are not broken up by wave and wind action on the ocean surface.

Organisms living at the bottom are at risk of death through oil ingestion and submersion.

Coastal economies are also impacted

Oil spills damage fisheries for years as the growth and development of all fish species and the plankton that supports them is impacted.

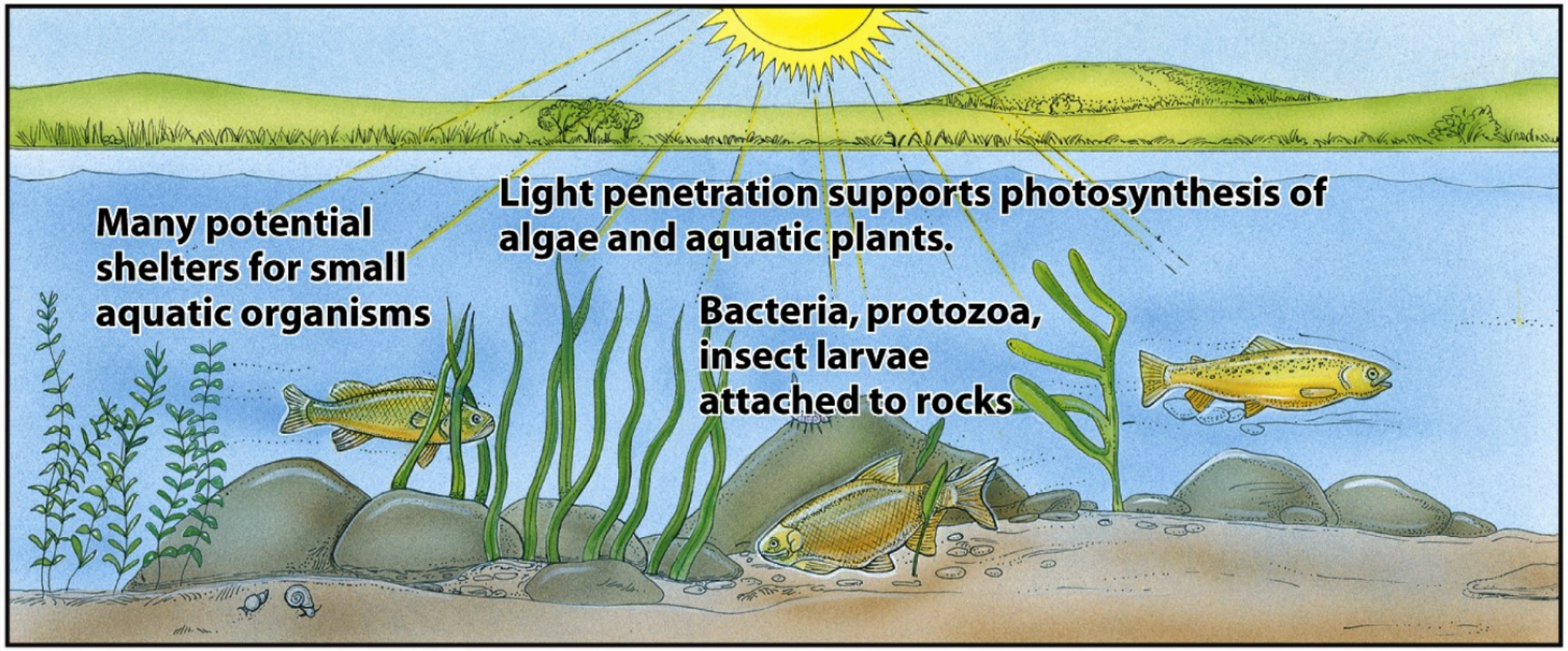
With both the Exxon spill and the BP Deepwater Horizon spill, oil that washed up on beaches impacted tourism, real estate, and fishing industries.

With the Deepwater Horizon spill losses in the billions of dollars was felt in Mississippi, Louisiana, Florida, and Alabama.

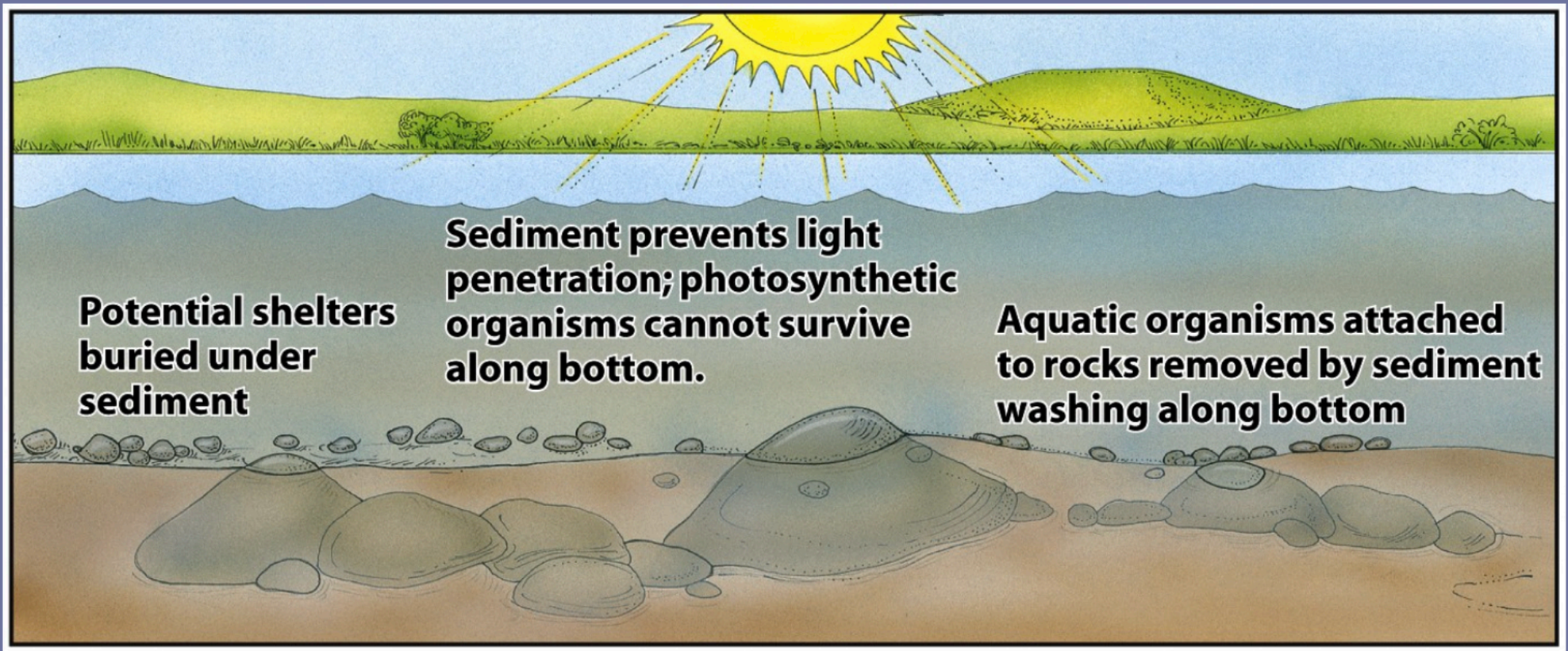
Sedimentation is a nonpoint source pollutant

Sediment is particles of soil, clay, and sand that can be carried from the land to water sources.

Poorly managed construction sites, road building, tilling of farm fields, and overgrazing of riparian habitats can cause sedimentation.



Stream ecosystem with low level of sediment



Same stream with high level of t

Screenshot

Producers and consumers are impacted

Sediment suspended in the water column can affect primary producers (plants) because light infiltration is reduced. This impacts the ability of plants to photosynthesize and add oxygen to the water.

Predators that use vision as their primary sense for hunting are also impacted.

As the sediment settles, it can disrupt the eggs and larvae of aquatic species like fish, insects, and mollusks.

Ideas to take away

- Oil spills kill marine and aquatic animals and birds as they are poisoned by ingesting and inhaling toxic hydrocarbons.

- With oil coating their feathers or fur, birds and mammals can lose their ability to survive.

- Some oil sinks to the ocean floor killing bottom-dwelling organisms.

- Oil-damaged beaches and shores can damage the tourism and fishing industries.

- Sediments in water can reduce light for aquatic plants, inhibit visual predators, and smother eggs and larvae of aquatic organisms.

Heavy metals in drinking water cause health issues

Heavy metals that can be found in drinking water include:

lead	**arsenic**	**cadmium**
mercury	**copper**	**chromium**

Mining companies often use acid to release metals from ore. This acid mine drainage can be a point source pollution for surface waters and groundwater. Other industries, like smelting, chemical production, wastewater, and fossil fuel combustion can also release heavy metals into the environment.

Heavy metals in drinking water can cause cancer, organ damage, and neurological issues.

Mercury causes neurological damage

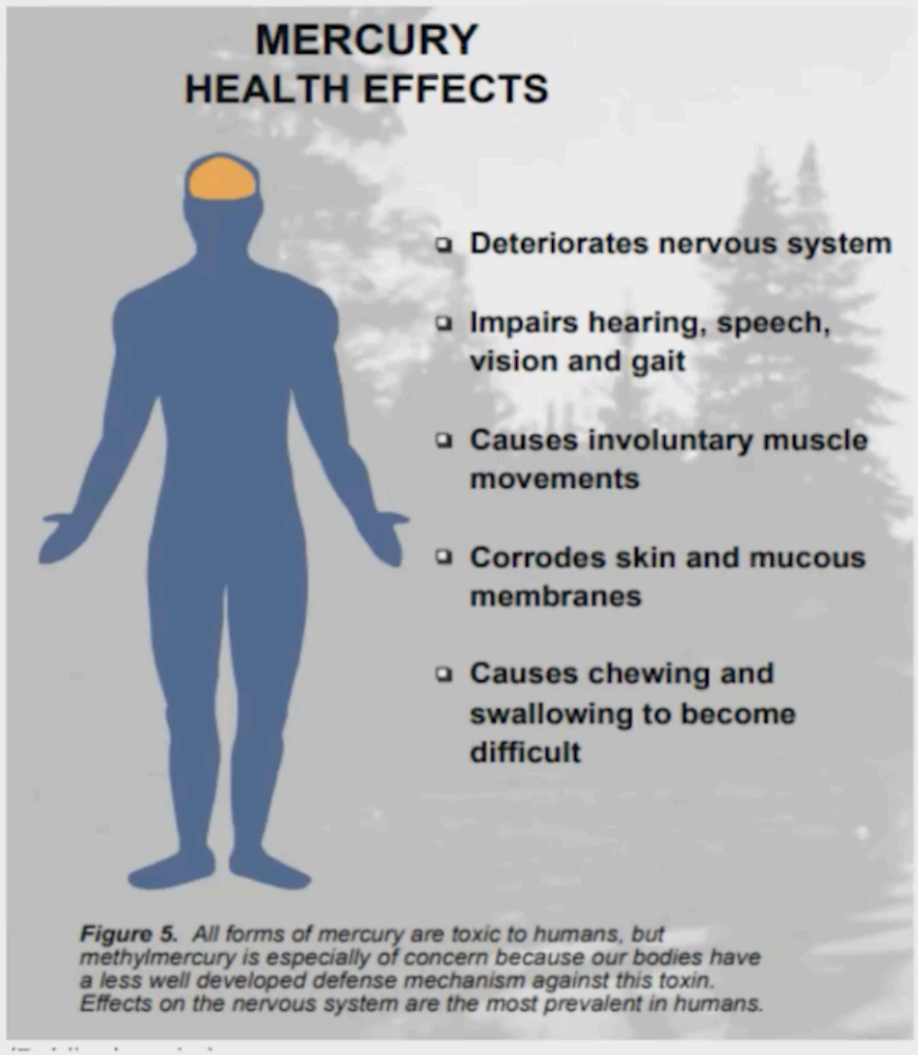


Figure 5. *All forms of mercury are toxic to humans, but methylmercury is especially of concern because our bodies have a less well developed defense mechanism against this toxin. Effects on the nervous system are the most prevalent in humans.*

Credit: USGS, Public domain

Mercury poisoning is most often through eating fish or other aquatic organisms.

Mercury can be used in many industrial processes and end up in wastewater. There it is converted by bacteria into **methylmercury,** which is toxic and will bioaccumulate in organisms and biomagnify in the food chain.

In addition to severe neurological damage, methylmercury can cause birth defects.

In the 1950s, Minimata, Japan, was the site of mercury poisoning of over 2,000 people and thousands of animals.

Plastic waste is a threat to wildlife

Plastic waste in waterways and the oceans has increased.

Ingestion of this litter has no nutritional value and can also block the digestive system, leading to painful starvation.

Entanglement and suffocation result in death

Litter can contribute toxins

Microplastics, tiny degraded plastic particles and fibers, can contribute toxins to the environment in two ways:

- the release of endocrine-disrupting chemicals like BPA added to plastic polymers when they are produced.
- chemicals like pesticides cling to the tiny particles and are then ingested by plankton and other organisms.

Apply appropriate mathematical relationships to solve a problem

Plastic that is generated and used in coastal communities, meaning within 50 miles of a coast, is most at risk of entering an ocean. If the global production of plastic in 2010 was 298 million tons and 110 million tons was plastic produced in coastal communities, what is the correct method to determine the percentage of plastic that was most at risk of entering the ocean in 2010?

Pause the video and study the answers below.

A. 298 million tons x 110 million tons/100

B. 50 miles x 110 million tons/100

C. 298 million tons/110 million tons x 100

D. 110 million tons/298 million tons x 100

Ideas to take away

- Heavy metals discarded as waste by industries can contaminate drinking water and cause health issues like cancer, organ damage, and neurological issues.

- Bacteria converts mercury into methylmercury, a highly toxic chemical that biomagnifies in aquatic food chains.

- Litter, especially plastic, can cause entanglement, starvation through intestinal blockage, and suffocation or choking of wildlife.

- Toxic chemicals can enter the food chain as litter breaks down into microparticles and is ingested by organisms.

TOPIC 8.3

Endocrine Disruptors

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.C

Describe endocrine disruptors.

STB-3.D

Describe the effects of endocrine disruptors on ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.C.1

Endocrine disruptors are chemicals that can interfere with the endocrine system of animals.

STB-3.D.1

Endocrine disruptors can lead to birth defects, developmental disorders, and gender imbalances in fish and other species.

Endocrine disruptors are a group of diverse chemicals

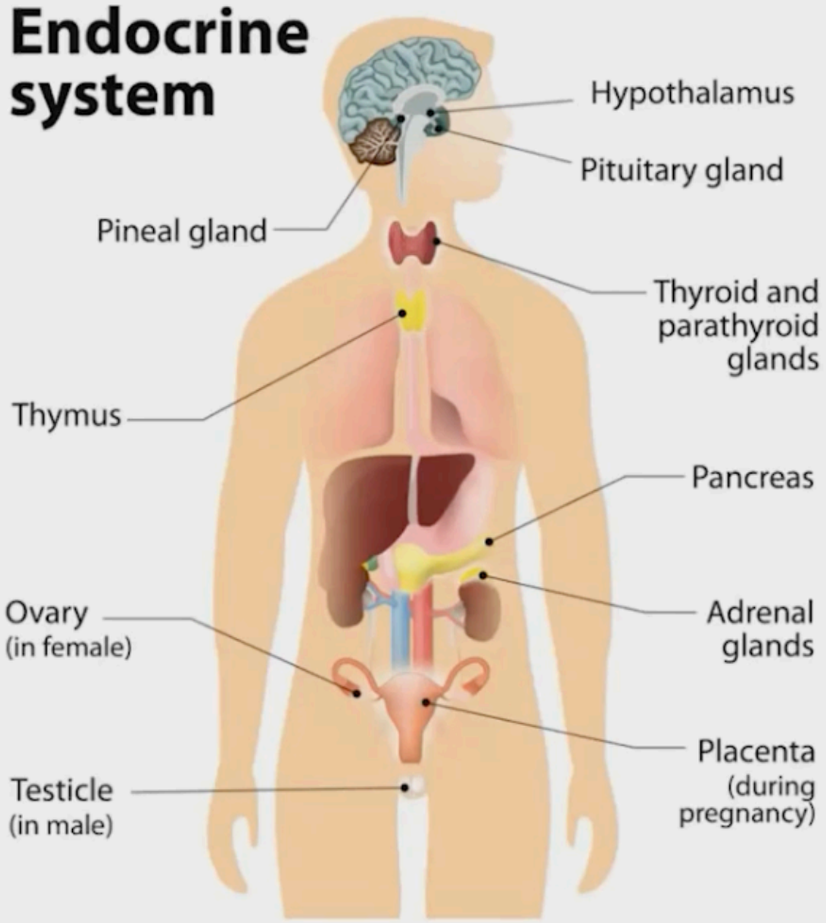
Synthetic chemicals used as

- Industrial solvents/lubricants and their byproducts
  - polychlorinated biphenyls (PCBs)
  - polybrominated biphenyls (PBBs)
  - dioxins
- Plastics and plastizers
  - bisphenol A (BPA)
  - phthalates
- Pesticides and fungicides
- Pharmaceuticals

Natural chemicals in foods

- Phytoestrogens found in soy

Endocrine system function



Designua / Shutterstock.com

Any chemical that interferes with the production, transport, metabolism, or function of hormones in bodies.

Hormones are associated with homeostasis, reproduction, and development. Hormones you might recognize:

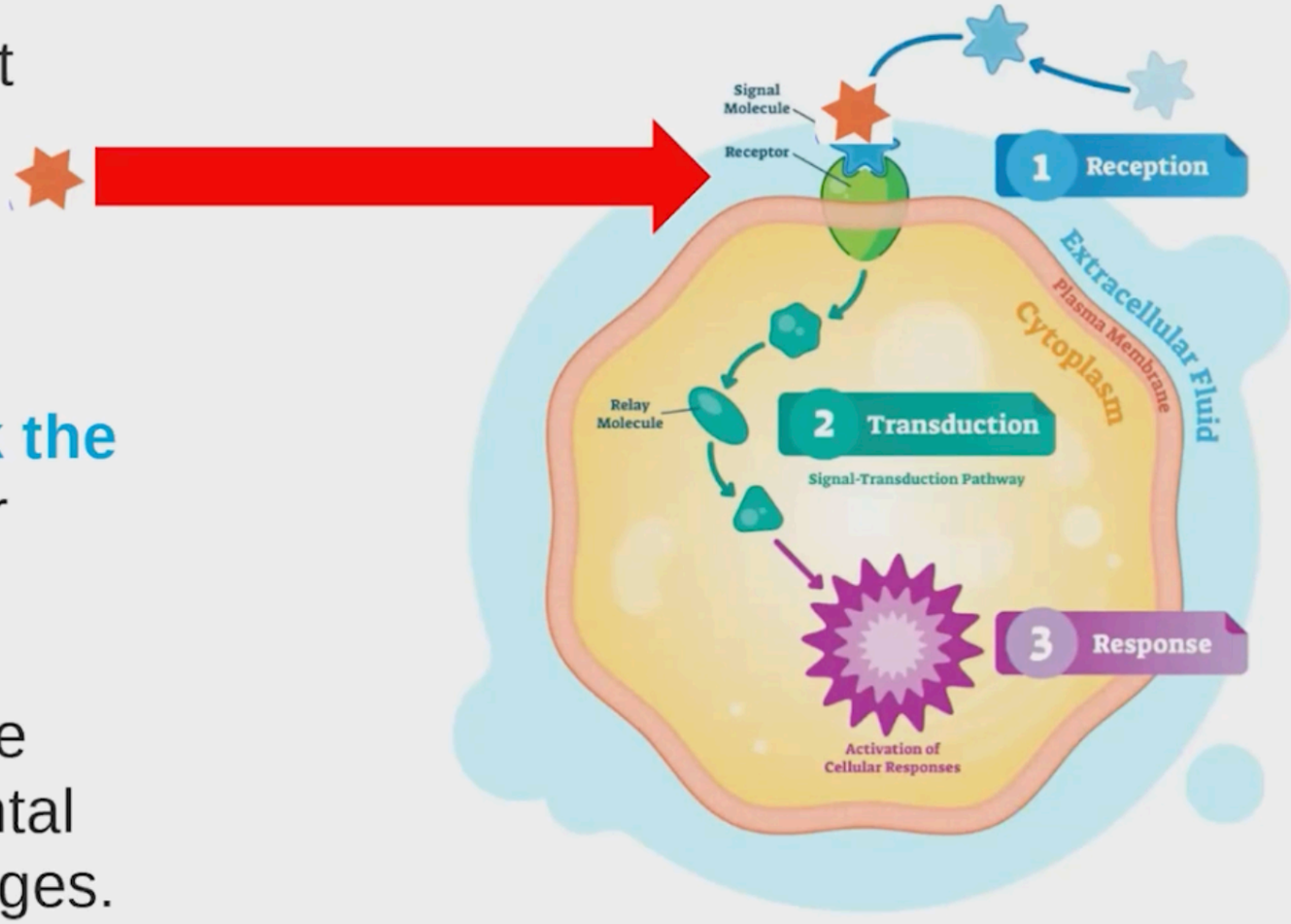
- estrogen
- testerone
- insulin
- serotonin
- norepinephrine

Cell signalling is disrupted

Endocrine disruptors can **mimic** the structure of a signaling chemical that would normally bind with a cell receptor to trigger a cellular response.

Endocrine disruptors can also **block the signal** from reaching the receptor or block the transduction cascade.

Consequences included reproductive abnormalities, birth and developmental defects, or possible behavioral changes.



VectorMine / Shutterstock.com

Widespread, persistent exposure

Some exposures can be from spills or leaching of improperly disposed of toxic waste.

Some exposures are more persistent as the chemicals are in the soil, water, and air as well as materials in our homes and workplaces.

Exposure in aquatic systems

Endocrine disruptor chemicals enter waterways and bioaccumulate in organisms and biomagnify in the food chain so that top-level consumers are most impacted.

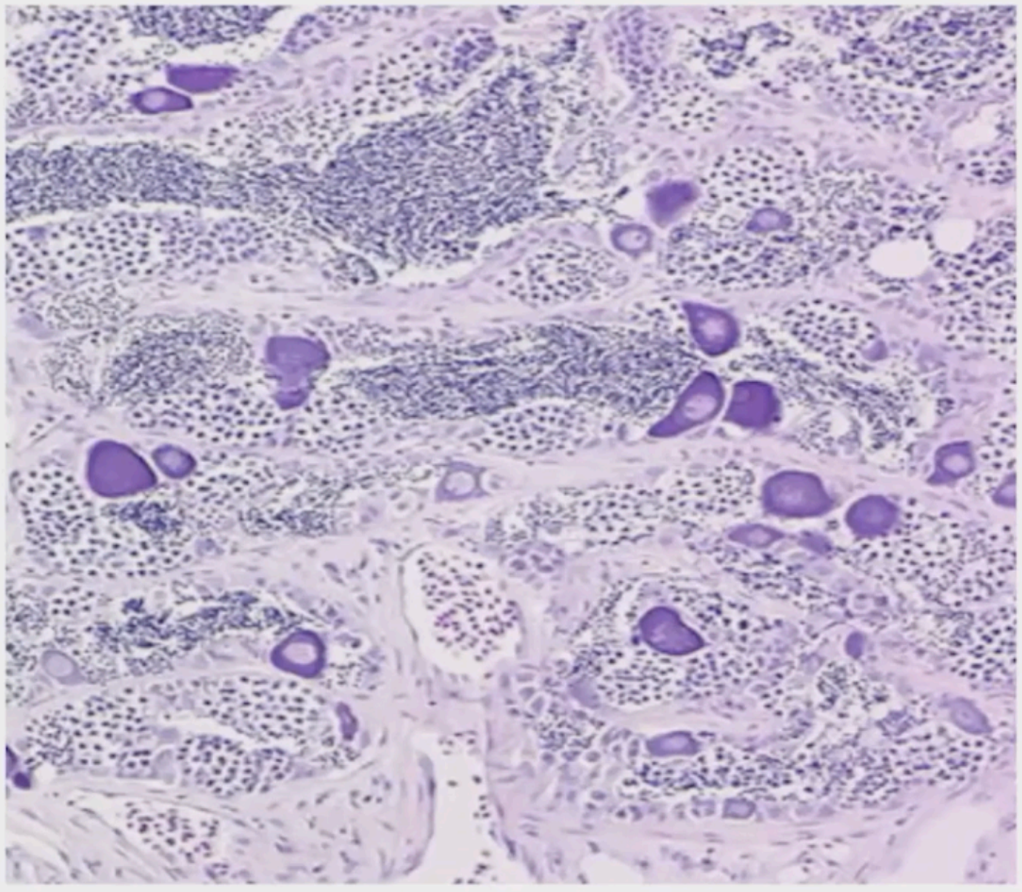
People, predatory fish and amphibians that consume high numbers of prey with endocrine disruptors in their body tissue will accumulate high levels of the chemicals.

Evidence of disruption

This is a tissue cross section of the gonads (testes) of a **male** smallmouth bass.

This sample shows eggs, not sperm, present in the gonads.

In humans, low sperm counts have been recorded in communities with high pesticide use.



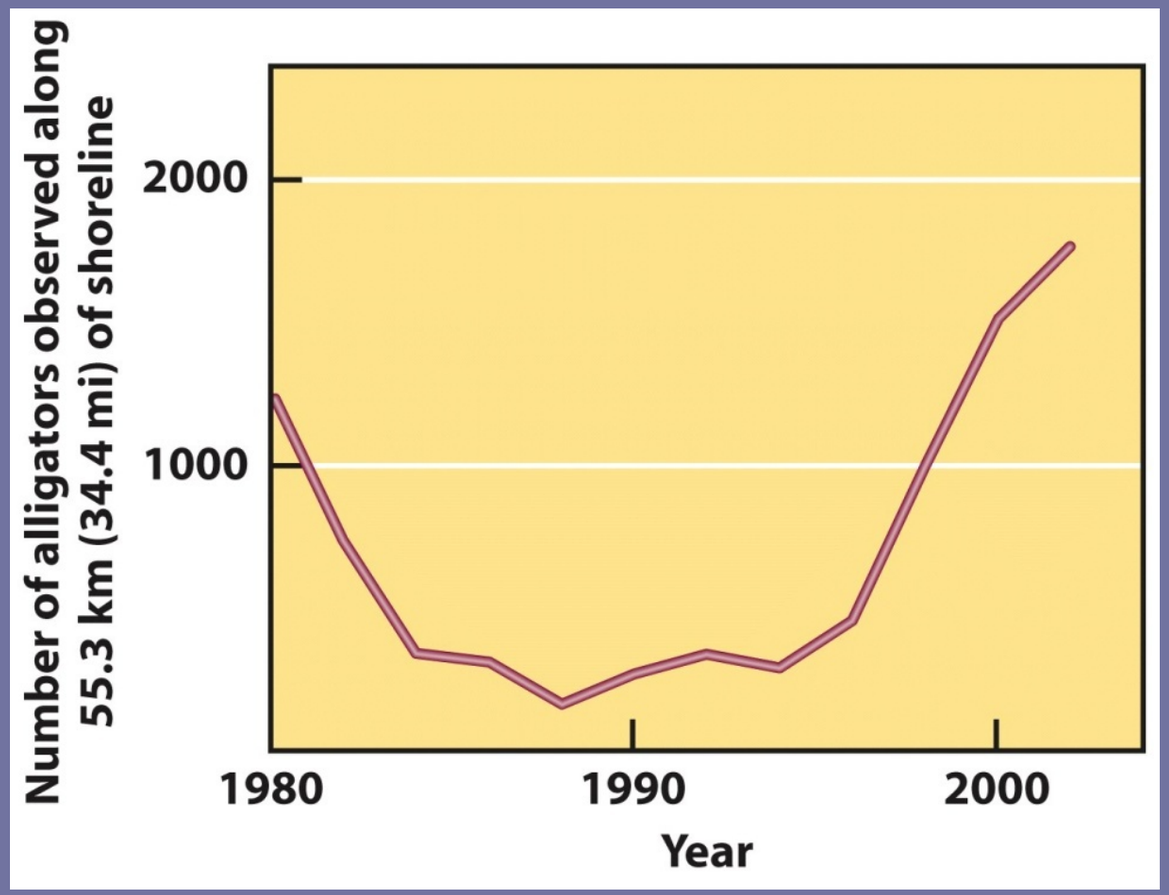
Evidence of disruption

Photo by Steve Mierzykowski/U.S. Fish and Wildlife Service

Developmental abnormalities in amphibians and fish in the wild have been recorded by investigators.

Endocrine Disrupters

- Case Study: 1980 chemical spill into Lake Apopka, FL
  - Male alligators began to exhibit low testosterone levels and high estrogen levels



Describe an environmental concept or process

Describe why researchers would most likely find evidence of endocrine disruption in fish and amphibians that are predators.

A Predators are larger than prey and easier to catch.

B Chemicals biomagnify in an aquatic food chain.

C Smaller organisms like invertebrates that frogs eat don't have hormones.

D Predators are lower on the food chain.

Ideas to take away

- Endocrine disruptors are chemicals that **interfere with hormone production and function.**
- Abnormalities in reproductive organs and cells as well as embryological development are consequences to exposure in aquatic organisms.
- Endocrine disruptors **bioaccumulate** in organisms and then **biomagnify** in a food chain so top-level consumers are most impacted.
- Synthetic endocrine disruptors are chemicals used in plastics, industrial processes, pesticides, fungicides, and pharmaceuticals.

TOPIC 8.4

Human Impacts on Wetlands and Mangroves

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.E

Describe the impacts of human activity on wetlands and mangroves.

ESSENTIAL KNOWLEDGE

STB-3.E.1

Wetlands are areas where water covers the soil, either part or all of the time.

STB-3.E.2

Wetlands provide a variety of ecological services, including water purification, flood protection, water filtration, and habitat.

STB-3.E.3

Threats to wetlands and mangroves include commercial development, dam construction, overfishing, and pollutants from agriculture and industrial waste.

Wetlands

Credit: USFWS

Wetlands are defined as having water covering the soil or is near the surface of the soil for all, or most of, the year.

Coastal (or tidal) wetlands have fluctuating salinity and water levels as they are influenced by the tides.

Inland (or nontidal) wetlands are along rivers and floodplains, in depressions or low-lying areas near lakes and ponds and often have a seasonal nature to them.

Filtration improves water quality

Water can move slowly in wetlands, giving sediment, nutrients, and pollutants time to drop out of suspension in the water column to the bottom of the wetland.

Excess nutrients from leaking septic systems, agriculture runoff, and municipal sewage, can be taken up by plant roots for use in growth or further broken down by microbes in the wetland soils.

Pollutants can stick to soil particles or be taken up by plants.

Much of the sediment, nutrient, and pollutant load is reduced as water moves out of wetlands because of this filtering capacity

Flood control

Wetlands act like sponges, holding water in place and releasing it slowly.

By slowing the movement of water, flood heights are reduced along with their erosive powers.

Coastal shorelines are protected and stabilized.

Increased biological productivity

Wetlands are some of the most productive ecosystems on the planet.

Shallow water and plenty of plants allow for diverse habitats for animals and birds.

Nutrient-rich soils enhance plant growth which in turn provides food for diverse and abundant species.

Maintaining water flow during dry periods

Groundwater is recharged as water is held in wetland soils.

This also helps maintain surface water flows during dry seasons.

Ideas to take away

- Wetlands are areas that are covered by water, or have water near the surface of the soil for all, most of, the year.

- Wetlands are incredibly rich and productive ecosystems.
- Water purification through filtering, flood control and shoreline stabilization, and groundwater replenishment result from wetlands.

Mangroves are tidal wetlands

Nattapong2012 / Shutterstock.com

Wetlands are
remarkably productive
ecosystems and important
to our world's biological diversity.

Both inland and coastal wetlands can be impacted by human activities.

Mangroves are a particularly productive and valuable type of coastal wetland.

In addition to living in a variety of saltwater conditions and providing shelter and food for a host of species, mangroves can absorb four times the carbon dioxide that upland forests can.

Threats to wetlands

Development of commercial properties like restaurants, malls, airports, business offices, gas stations, etc. can all be damaging to wetlands.

Development can include filling in wetlands to build access roads, parking areas, or place utilities.

Construction can increase sedimentation, destroy habitat, and redirect water flow.

In the United States, development in wetlands is highly regulated through the **Wetlands Protection and Restoration Act**. Many states and tribal governments also have regulations for wetland protection.

Threats to wetlands

Dam construction restricts and reduces water flowing into wetlands by disconnecting rivers from their floodplains and wetland areas.

The natural downstream flow of sediments that create deltas and build up estuaries along coasts is reduced.

Migration of fish and other species can be impacted.

Threats to wetlands

Overfishing is when people harvest fish faster than they can be replenished by reproduction in the population.

The size, age, and type of fish remaining can be altered by overfishing. This can create imbalance in the entire food web within a wetland area.

Animals and birds that eat fish can be greatly impacted and their role within the wetland system can be threatened. Some, like alligators, can be ecosystem engineers that impact the physical structure of habitats.

Threats to wetlands

Excess nutrients and pollutants from **agricultural and industrial operations** can impact wetlands.

This is an example of a CAFO, concentrated animal feeding operation. These operations raise and house millions of animals.

Inorganic Plant and Algal

Screenshot

Waste management is critical

Evgeny_V / Shutterstock.com

This is a manure lagoon
found at concentrated
animal feeding operations (CAFOs).

The heavy plastic lining and thick-walled embankment are to prevent leakage of nutrients and bacteria like e.coli.

Management of manure, as well as other agricultural practices like pesticide and insecticide use and soil management can help protect wetlands, surface and groundwater.

Describe potential approaches to environmental problems

A small community is having issues with too much wastewater from its treatment plant entering local surface waters during heavy rainstorms. Which of the following choices below would be an acceptable long-term solution for the community?

A. Build larger, shallower holding tanks closer to the local streams.

B. Channelize the local streams to allow the water to flow more swiftly to get the wastewater further from town.

C. Construct a wetland between the plant and stream to trap and filter the runoff.

D. Charge residents higher fees to offset pollution clean up costs.

Ideas to take away

- Commercial development can damage wetlands by destroying habitat, altering water flow, and increasing sedimentation.
- Dam construction disconnects wetlands from their water sources and prevents migration of species and the natural flow sediments for delta formation.
- Agricultural and industrial activities can contribute excess nutrients and pollutants to wetlands.
- Overfishing can shift the ages and types of fish remaining causing imbalance in the food web of wetland communities.

TOPIC 8.5

Eutrophication

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.F

Explain the environmental effects of excessive use of fertilizers and detergents on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.F.1

Eutrophication occurs when a body of water is enriched in nutrients.

STB-3.F.2

The increase in nutrients in eutrophic aquatic environments causes an algal bloom. When the algal bloom dies, microbes digest the algae, along with the oxygen in the water, leading to a decrease in the dissolved oxygen levels in the water. The lack of dissolved oxygen can result in large die-offs of fish and other aquatic organisms.

STB-3.F.3

Hypoxic waterways are those bodies of water that are low in dissolved oxygen.

STB-3.F.4

Compared to eutrophic waterways, oligotrophic waterways have very low amounts of nutrients, stable algae populations, and high dissolved oxygen.

STB-3.F.5

Anthropogenic causes of eutrophication are agricultural runoff and wastewater release.

Every summer, Lake Erie sees massive algae blooms

Credit: USGS, Public domain

Eutrophication is when a waterway receives excess nutrients.

Toxic algae can threaten the drinking water of 11 million people in southwest Ohio and impact tourism, fishing, and recreation.

Algae blooms are not limited to Lake Erie.

In most cases, eutrophication is caused by the excess nutrient nitrogen from agricultural or urban runoff but also from phosphate in detergents,

Sources of cultural eutrophication

Excess fertilizers from farm fields

Sewage from wastewater treatment

Nitrogen from animal manure

Phosphate from detergents

Materials are washed by rain, melting snow, and irrigation into streams, ponds, and lakes.

By 2010, 17 states had banned detergents that contained phosphates so the nutrient didn't get into municipal wastewater.

Aquatic plants and algae thrive

With this overabundance of nutrients, plants, algae, and cyanobacteria (sometimes called blue-green algae) grow rapidly!

A **eutrophic** waterway is one that has high levels of algae as a result of excess nutrients.

An **oligotrophic** waterway have very low amounts of nutrients.

Low oxygen levels can result in die-offs of fish and other animals.

Aquatic organisms that can’t tolerate low oxygen levels will leave. If they can’t leave, they die. This adds more waste to be digested by oxygen-consuming microbes.

Eutrophic vs. Oligotrophic

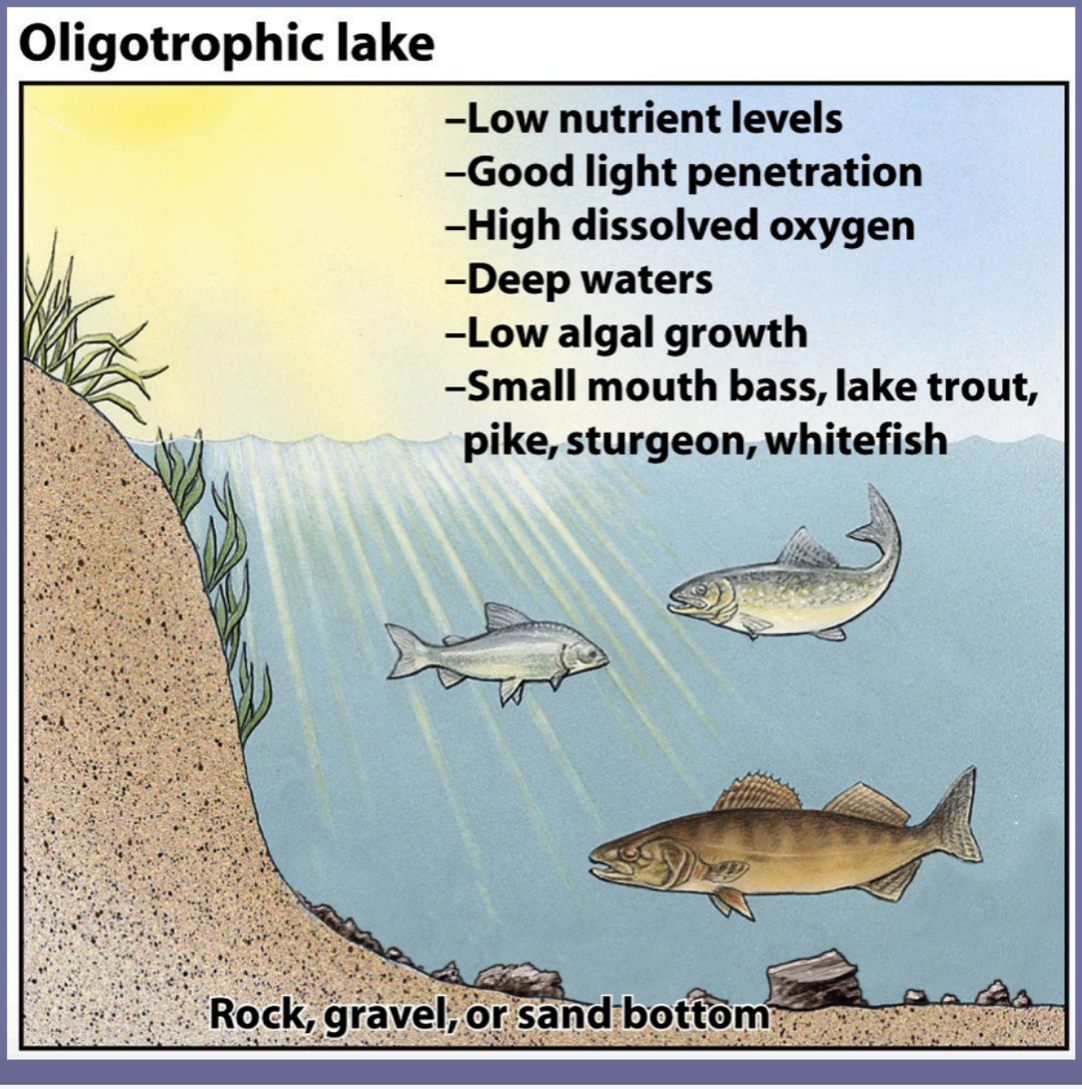
Eutrophic	Oligotrophic
High nutrient levels	low nutrient levels
High plant and algae populations	stable plant and algae populations
low dissolved oxygen	high dissolved oxygen

Ideas to take away

- Excessive use of fertilizers and detergents can increase nutrient levels in aquatic systems.
- Eutrophic describes a body of water that is enriched with excess nutrients and the evidence is usually seen by algae and plant blooms.
- Oligotrophic describes a body of water with very low nutrient levels and stable algae populations as well as high dissolved oxygen levels.

Sewage: Eutrophication

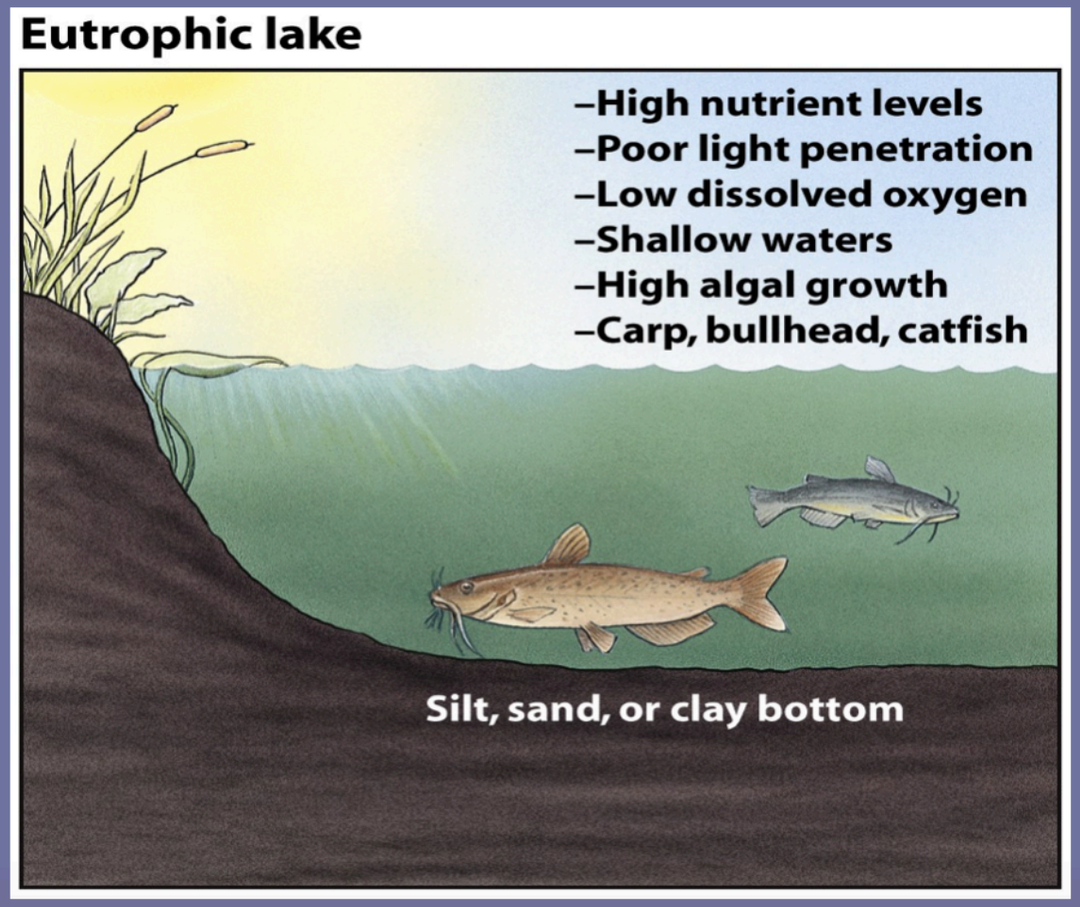
- Oligotrophic
  - Unenriched, clear water that supports small populations of aquatic organisms



Screenshot

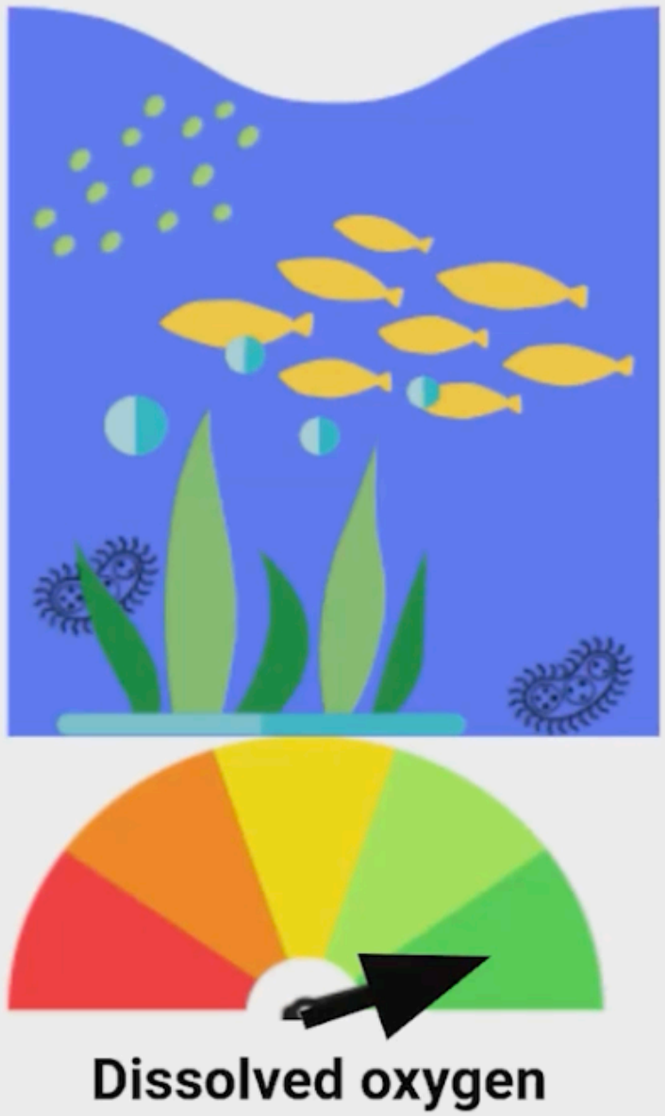
Sewage: Eutrophication

- Eutrophic
  - Slow-flowing stream, lake or estuary enriched by inorganic plant and algal nutrients such as phosphorus and nitrogen ions
  - cultural eutrophication is a result of human activity



Screenshot

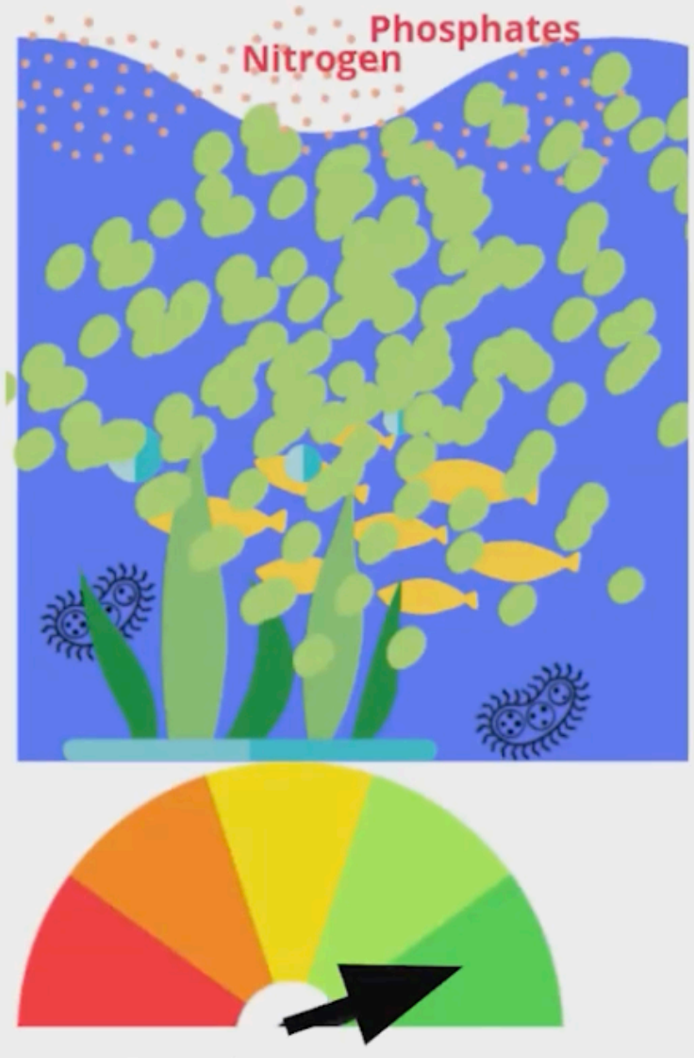
Stable aquatic system



An aquatic system with a stable amount of algae, aquatic plants, and fish.

Dissolved oxygen (DO) is high.

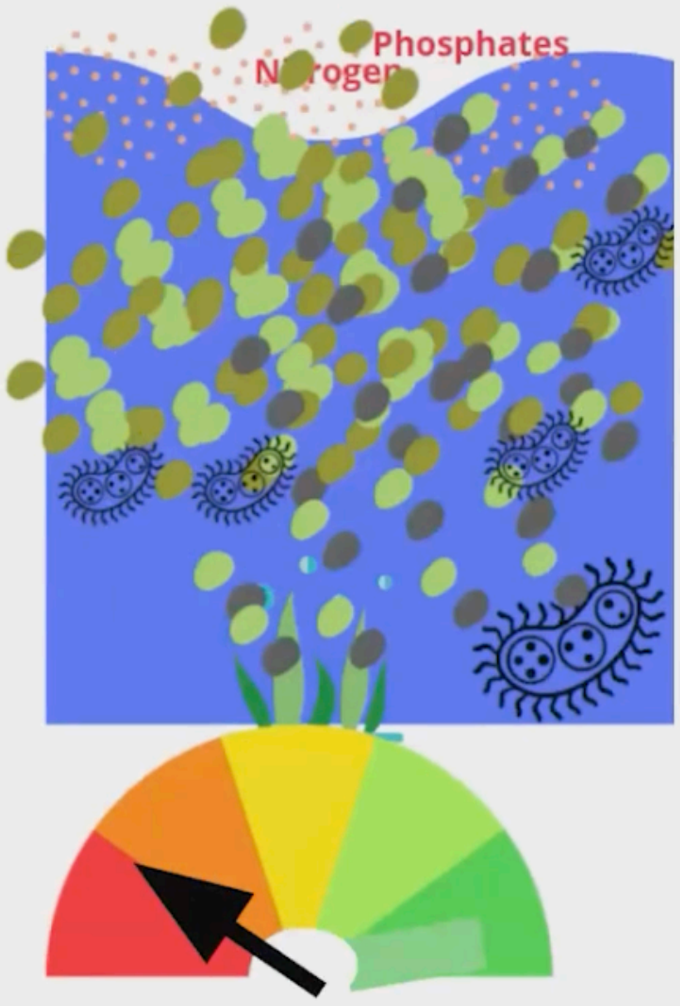
Eutrophic aquatic system



A storm event washes excess fertilizer into the aquatic system. The algae grow and reproduce creating a bloom.

Parfitt, 2021

Hypoxic aquatic system



As the algae die they sink to the bottom where oxygen-consuming microbes digest the dead cells. Oxygen is rapidly consumed reducing it to dangerously low levels.

Parfitt, 2021

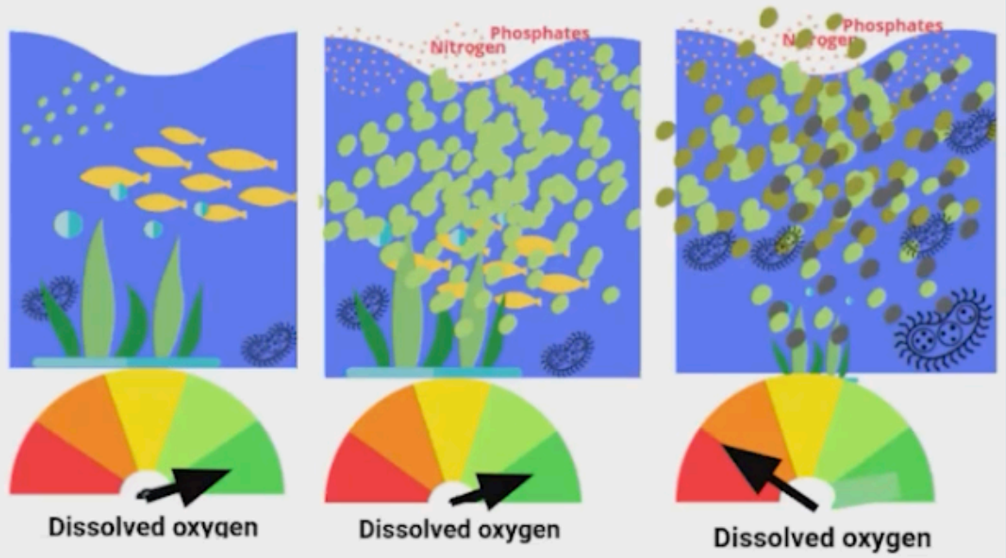
Hypoxia creates dead zones

- Organic dead zones are areas of low oxygen in the world's oceans and lakes caused by increased nutrient pollution.
- An oxygen sag curve is a plot of dissolved oxygen levels versus the distance from a source of pollution, usually excess nutrients and biological refuse.

Topic 8.2 Human Impacts on ecosystems video 2 discusses dead zones and a way of plotting the relationship between dissolved oxygen and the pollution source.

Explain how environmental concepts represented visually relate to broader issues.

Broader environmental issues relate to eutrophication. Which issue do you think relates most strongly to the series of graphics that show the steps of eutrophication due to excess nutrients entering an aquatic system?



Choose the broader environmental issue from the choices below:

A Renewable energy production

C Agricultural practices and land use

B Stratospheric ozone damage

D Infectious diseases and pathogens

Ideas to take away

- Eutrophication occurs through a series of steps:
    - excess nutrients from fertilizers and detergents cause algae to rapidly reproduce, or create a bloom.
    - As the algae die and fall to the bottom of the pond or stream, oxygen-consuming microbes digest the dead cells reducing dissolved oxygen levels.
    - Reduced dissolved oxygen can lead to die-offs of fish and other aquatic organisms.
- Hypoxic waterways have low dissolved oxygen levels.

TOPIC 8.6

Thermal Pollution

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.G

Describe the effects of thermal pollution on aquatic ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.G.1

Thermal pollution occurs when heat released into the water produces negative effects to the organisms in that ecosystem.

STB-3.G.2

Variations in water temperature affect the concentration of dissolved oxygen because warm water does not contain as much oxygen as cold water.

Sources of thermal pollution

IrinaK / Shutterstock.com

When heated water is discharged into bodies of water, it is considered thermal pollution.

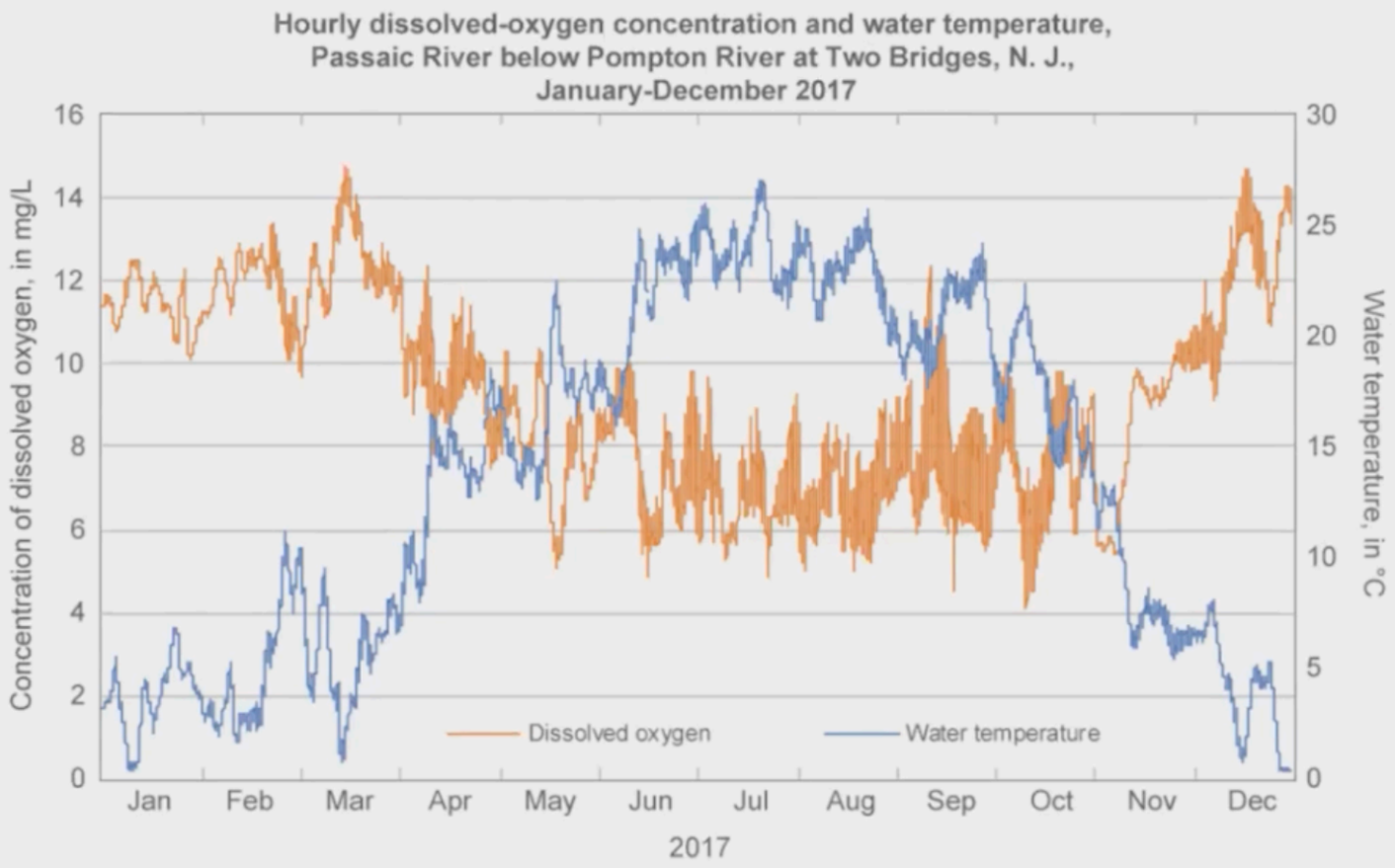
Power and industrial plants draw in water to cool machinery or products. They then discharge the heated water back into a water source.

Source of thermal pollution

Other sources include:

- Soil erosion
- Deforestation/shade reduction
- Discharge from wastewater treatment
- Urban runoff

Impacts of thermal pollution



Warm water does not hold as much dissolved oxygen as colder water.

Impacts of thermal pollution

Slight variations in temperature can impact survival of eggs and larvae of fish and aquatic insects that have narrow ranges of tolerance.

Die-offs can occur when dissolved oxygen levels are too low.

Feeding, breeding, and migration behaviors can also be altered.

Explain environmental concepts, processes, or models in applied contexts.

A town in the mountains of Idaho is famous for its pristine trout fishing river that runs through town. Trout need high dissolved oxygen levels to thrive. Over the past 5 years, there has been a number of housing and commercial developments built on unused agricultural lands to accommodate growth in the area. Fishing guides have observed fewer trout in the river and the water temperature has increased.

What might explain the change in the river?

A Increased nutrients from nearby agricultural operations have increased water temperatures.

B Surface runoff from paved areas have warmed water and reduced dissolved oxygen in the river.

C Surface runoff from paved areas have warmed water and increased dissolved oxygen levels in the river.

D Industry discharging hot water into the river has raised dissolved oxygen levels.

Parfitt, 2021

Ideas to take away

- Thermal pollution occurs when heat is released into water and negatively impacts aquatic organisms.
- Cold water contains more dissolved oxygen than warm water.
- When dissolved oxygen levels drop, it can lead to die-offs in aquatic organisms.

TOPIC 8.7

Persistent Organic Pollutants (POPs)

Required Course Content

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.H

Describe the effect of persistent organic pollutants (POPs) on ecosystems.

ESSENTIAL KNOWLEDGE

STB-3.H.1

Persistent organic pollutants (POPs) do not easily break down in the environment because they are synthetic, carbon-based molecules (such as DDT and PCBs).

STB-3.H.2

Persistent organic pollutants (POPs) can be toxic to organisms because they are soluble in fat, which allows them to accumulate in organisms' fatty tissues.

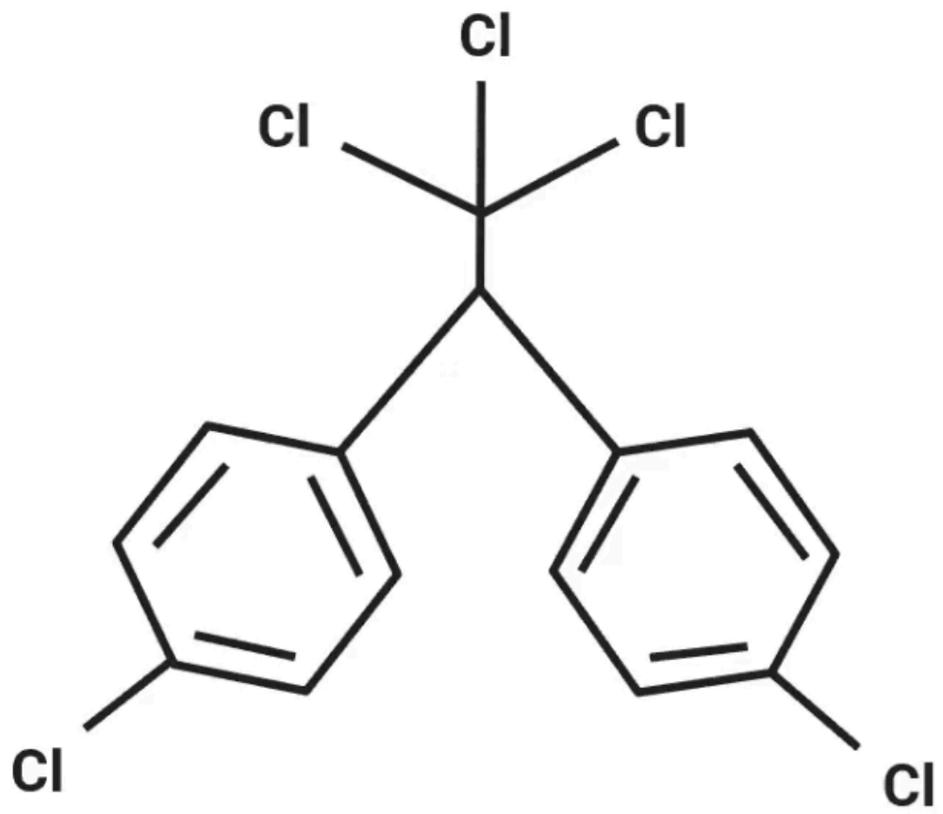
STB-3.H.3

Persistent organic pollutants (POPs) can travel over long distances via wind and water before being redeposited.

What are persistent organic pollutants?

- Persistent
- Organic
    - Often in rings, with chlorine attached to outside of ring
- Synthetic
- Nonpolar

DDT



Source: Morris

- Dicloro-diphenyl-trichloroethane
- Insecticide
- Colorless crystal
- Banned for use in United States

DDT

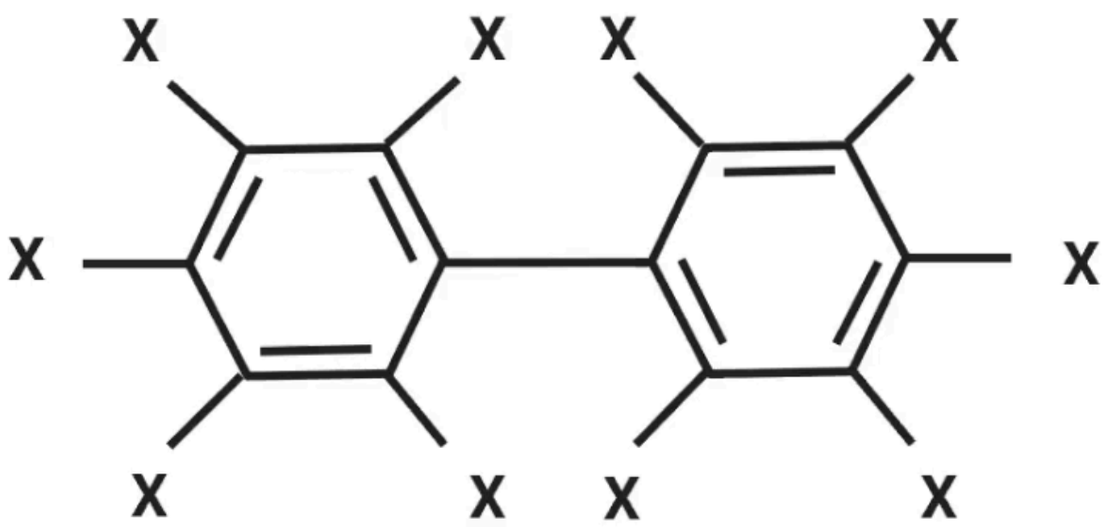
Source: US National Archives

Source: CDC
Reference to specific commercial products, manufacturers, companies, or trademarks does not constitute its endorsement or recommendation by the U.S. Government, Department of Health and Human Services, or Centers for Disease Control and Prevention
This image is available on the CDC website for no charge


D.D.T.
Powerful Insecticide
Harmless to Humans
Applied by
TODD INSECT FOG APPLICATOR
Operating with
Nassau County Extermination Comm.
L. I. State Park Comm.
TIFA


"DDT is good for me-e-e!"zz

PCBs



Source: Morris

- Polychlorinated biphenyl
- Industrial fluid
- Yellow liquid
- Banned for use in United States

Persistent Organic Pollutants (POPs)

1. What are they:
    - Persistent
    - Organic
    - Synthetic
    - Often cyclical, with chlorine atoms
    - Nonpolar
2. DDT
    - Insecticide
    - Rachel Carson
    - Now banned for use in United States
    - Used in other countries to help control spread of malaria

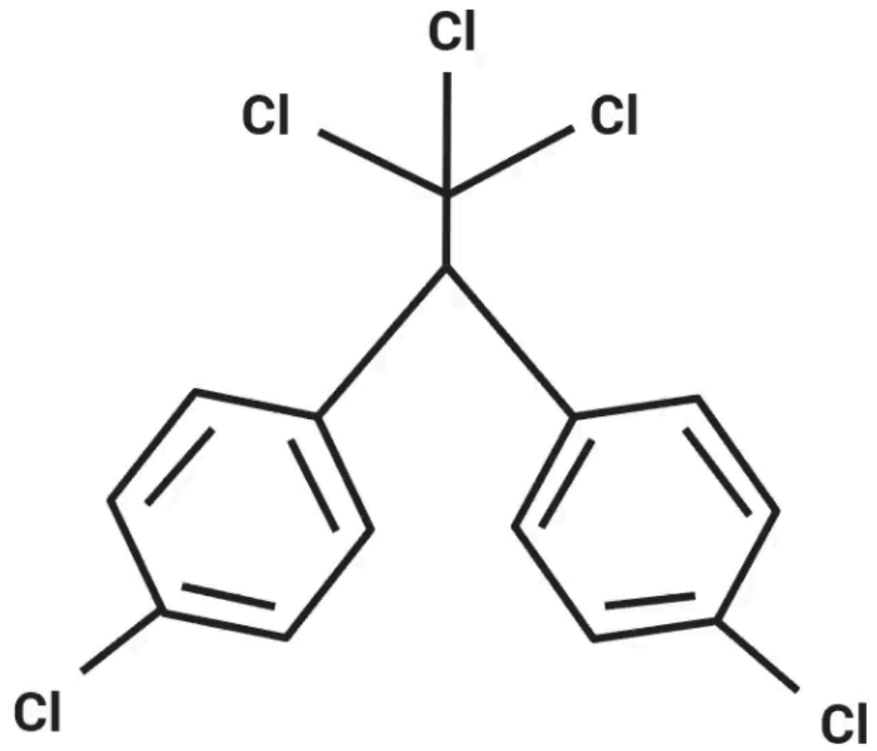
3. PCB
    - Industrial chemical
    - Now banned for use in United States

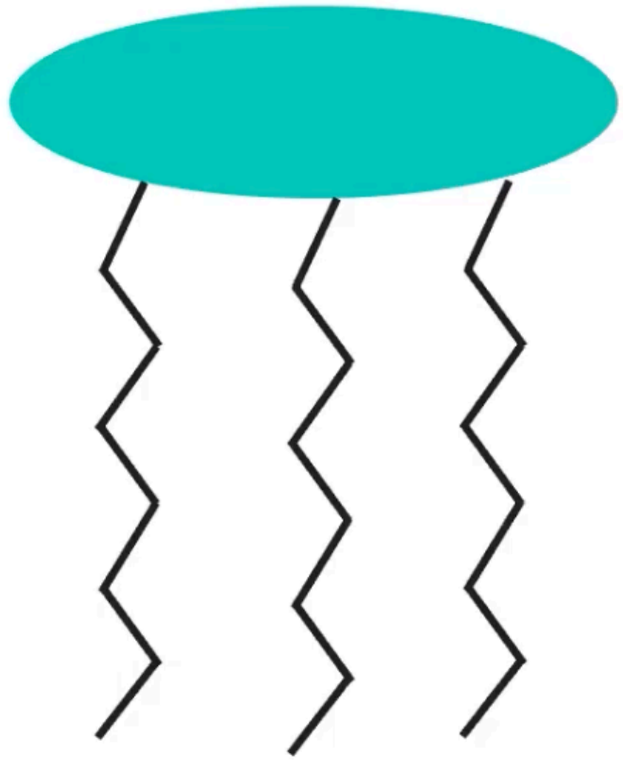
POPs contaminate water and soil

Source: US Environmental Protection Agency

- Clean Water Act
- Safe Drinking Water Act
- RCRA – Resource Conservation and Recovery Act
- CERCLA – Comprehensive Environmental Response, Compensation and Liability Act
- Stockholm Convention

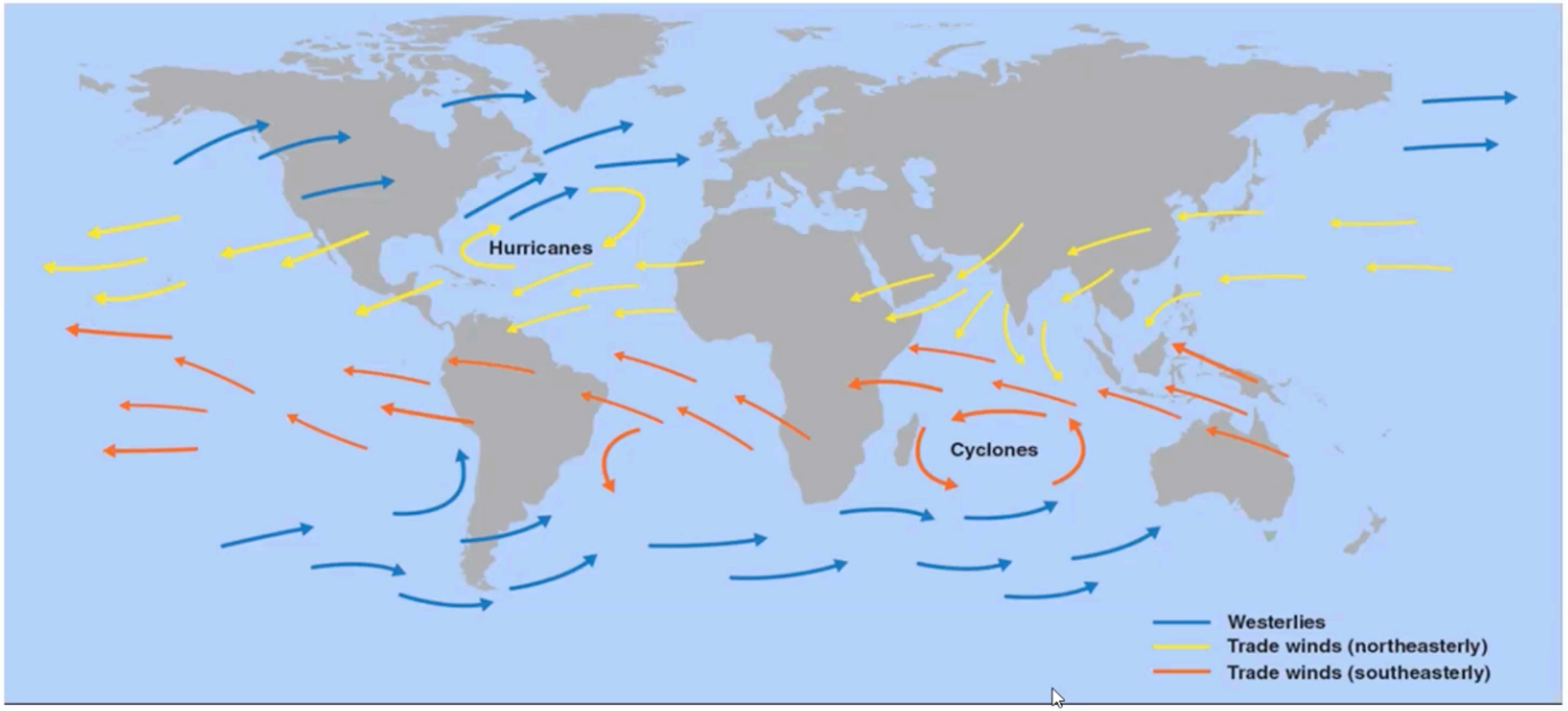
POPs are fat-soluble



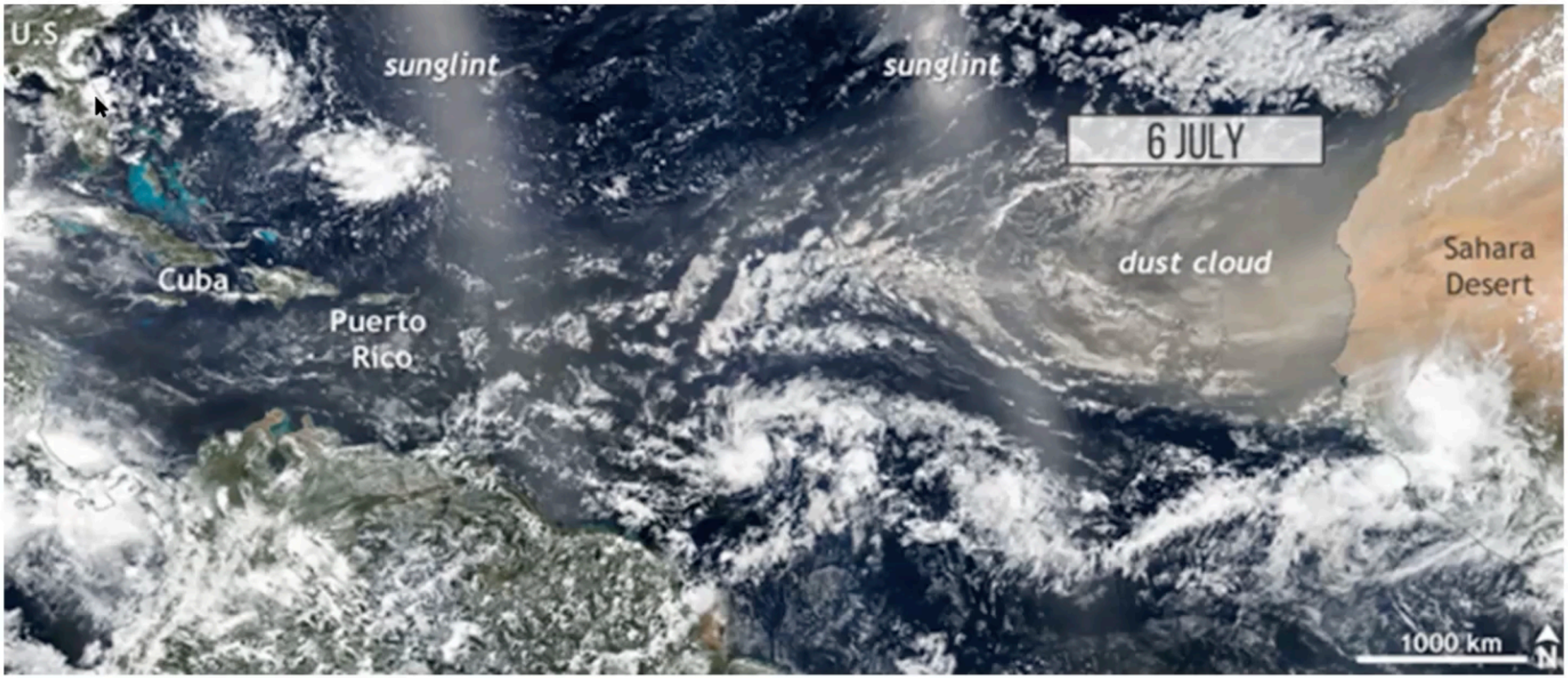


Source: Morris

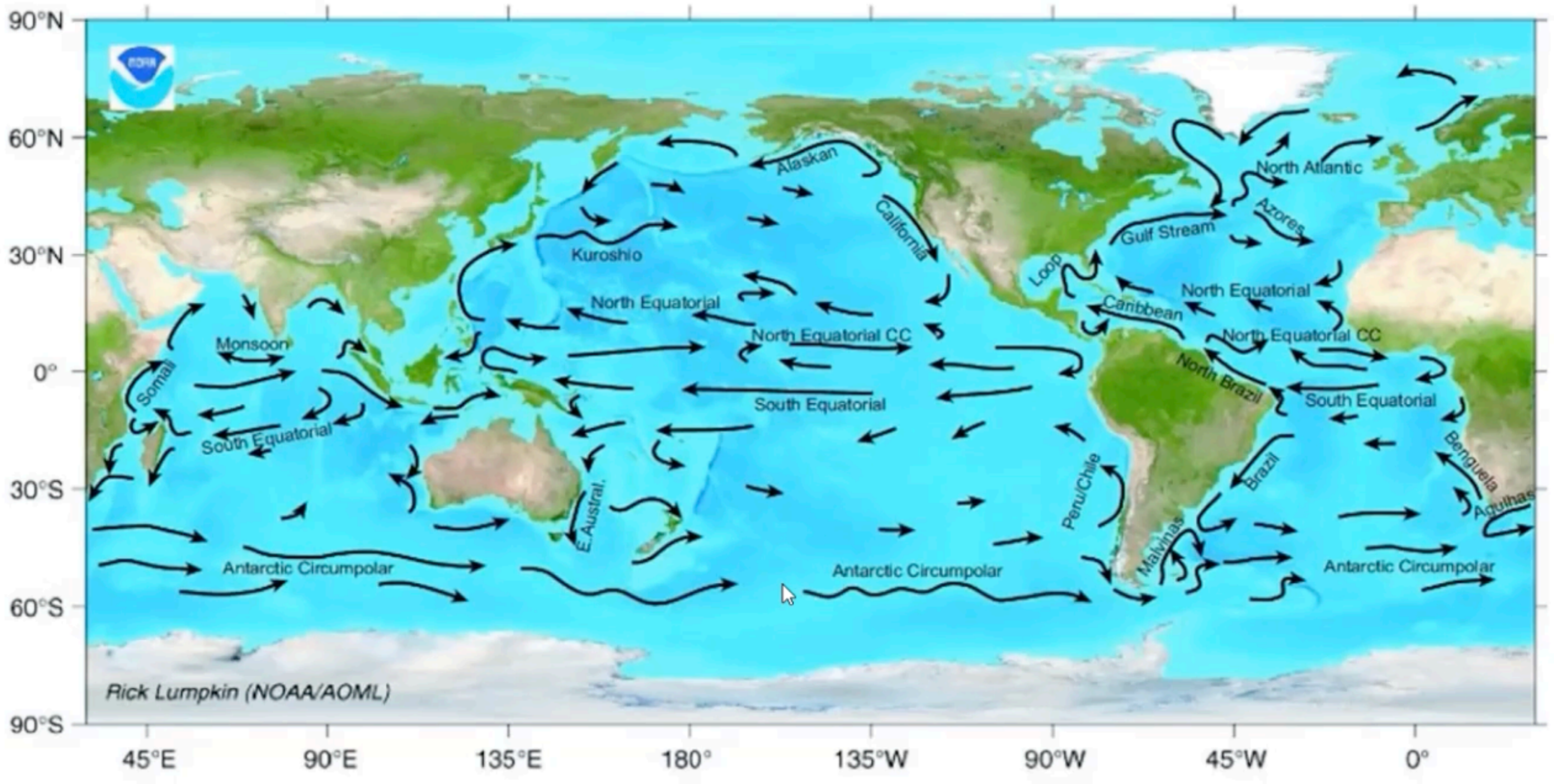
POPs can travel long distances



POPs can travel long distances



POPs can travel long distances



MCQ Practice

Chlordane is categorized as a persistent organic pollutant. Which of the following choices is the BEST evidence to support this categorization?

A Chlordane was used to control termite populations in the US before it was federally banned for use.

B Chlordane is a white crystalline solid.

C Chlordane is a 5-carbon ring, which makes it a very stable compound.

D Chlordane is toxic to a wide variety of organisms.

POPs have long-term effects

1. They contaminate both water and soil for long periods of time.

2. They are fat-soluble:

   - Accumulate over time

3. Local use of POPs can have a global impact.

TOPIC 8.8

Bioaccumulation Biomagnification

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-3.I Describe bioaccumulation and biomagnification.	**STB-3.I.1** Bioaccumulation is the selective absorption and concentration of elements or compounds by cells in a living organism, most commonly fat-soluble compounds. **STB-3.I.2** Biomagnification is the increase in concentration of substances per unit of body tissue that occurs in successively higher trophic levels of a food chain or in a food web.
STB-3.J Describe the effects of bioaccumulation and biomagnification.	**STB-3.J.1** Some effects that can occur in an ecosystem when a persistent substance is biomagnified in a food chain include eggshell thinning and developmental deformities in top carnivores of the higher trophic levels. **STB-3.J.2** Humans also experience harmful effects from biomagnification, including issues with the reproductive, nervous, and circulatory systems. **STB-3.J.3** DDT, mercury, and PCBs are substances that bioaccumulate and have significant environmental impacts.

Solubility Of Chemicals, Bioaccumulation, and Biomagnifications

- The movement of a chemical in the environment depends in part on its solubility.

- **Solubility** How well a chemical dissolves in a liquid. A water-soluble chemical can be washed off surfaces, percolate into groundwater, and runoff into surface waters including rivers and lakes.

- Fat soluble chemicals are not very soluble in water and are found in higher concentrations bound to soils, including the benthic soils that underlie bodies of water.

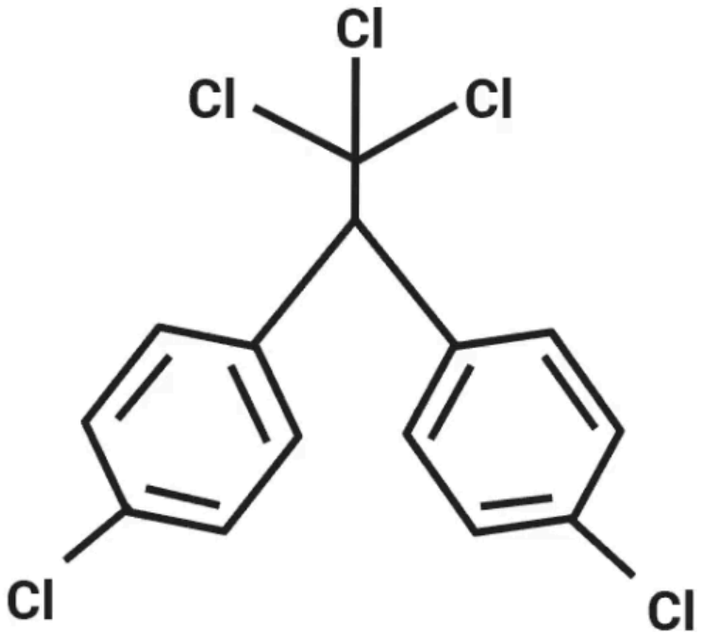
Solubility Of Chemicals, Bioaccumulation, and Biomagnifications

- **Bioaccumulation** An increased concentration of a chemical within an organism over time.

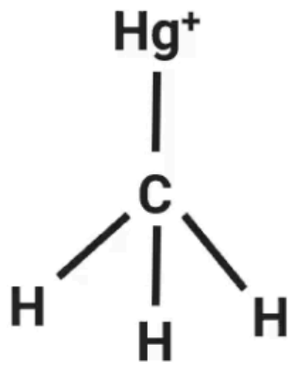
- **Biomagnification** The increase in chemical concentration in animal tissues as the chemical moves up the food chain.

- **Persistence** The length of time a chemical remains in the environment.

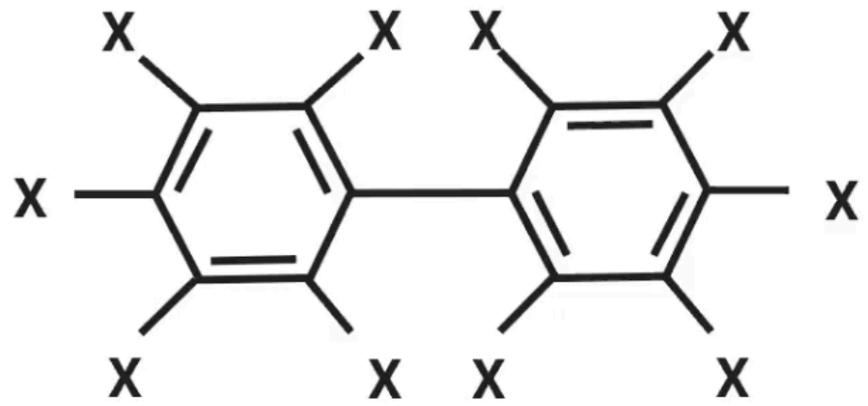
Substances that bioaccumulate



DDT

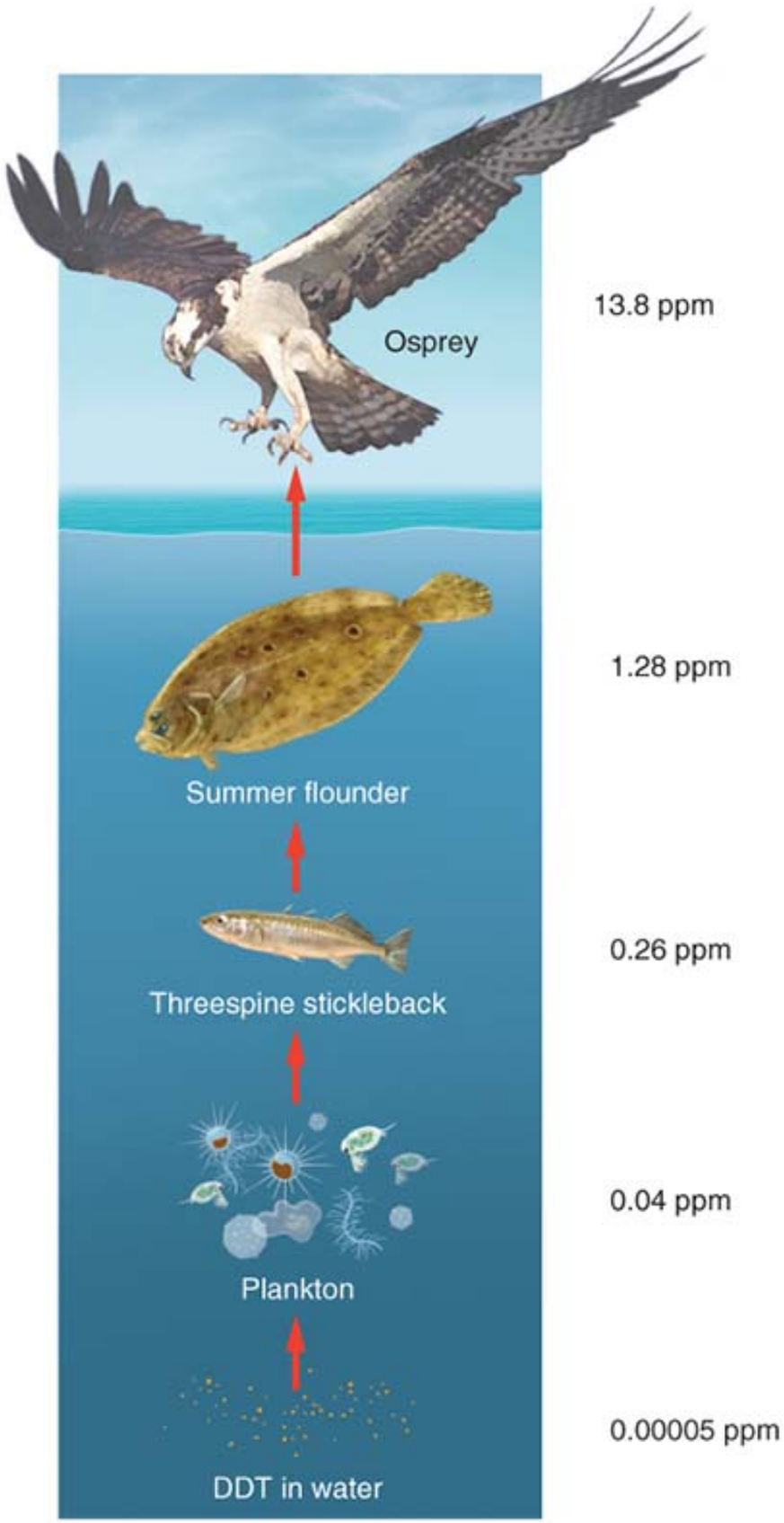


Methylmercury



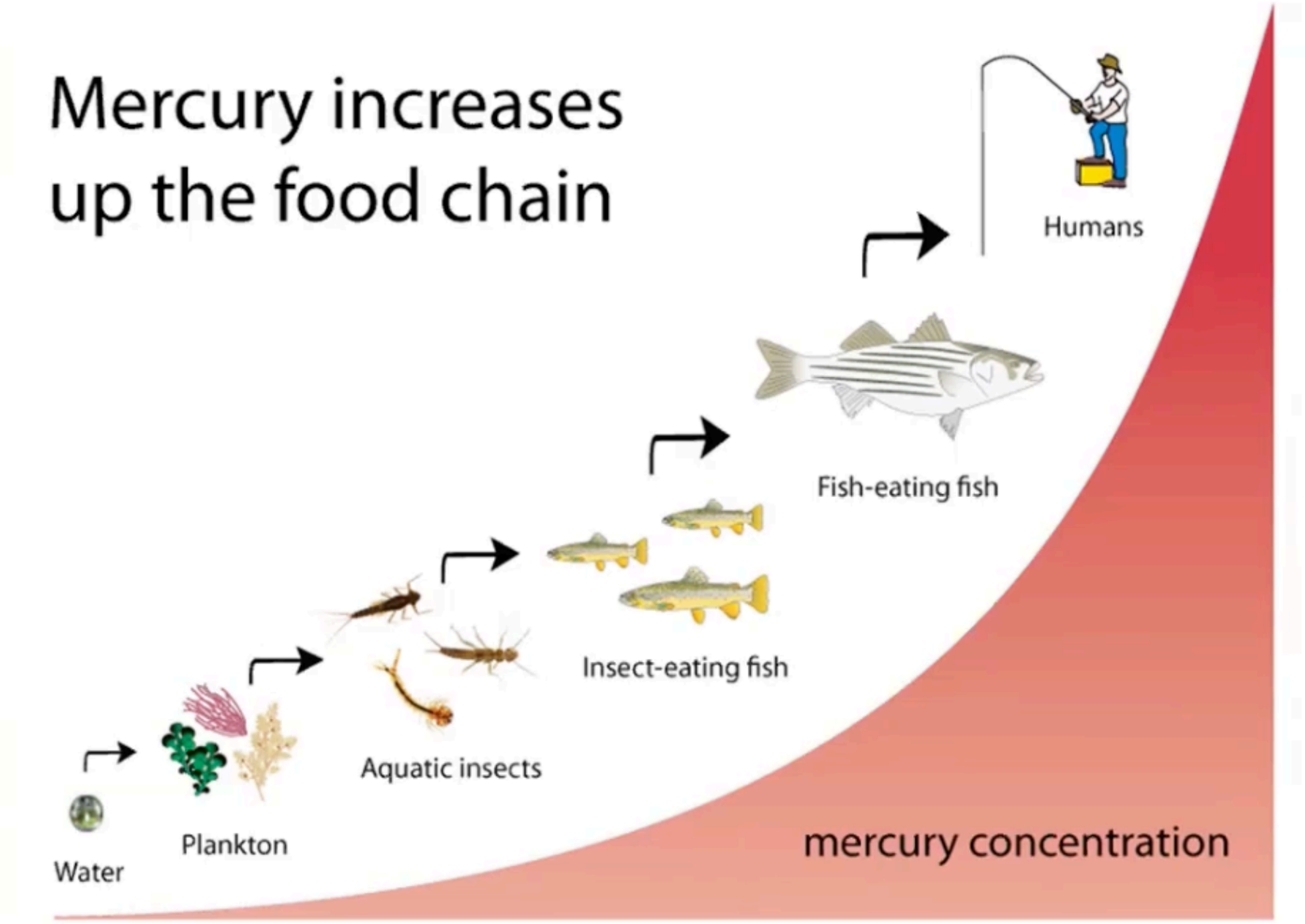
PCB

Bioaccumulation, and Biomagnification



The biomagnification of DDT. The initial exposure is primarily in a low trophic group such as the plankton in a lake. Consumption causes the upward movement of the chemical where it is accumulated in the bodies at each trophic level. The combination of bioaccumulation at each trophic level and upward movement by consumption allows the concentration to magnify to the point where it can be substantially more concentrated in the top predator than it was in the water.

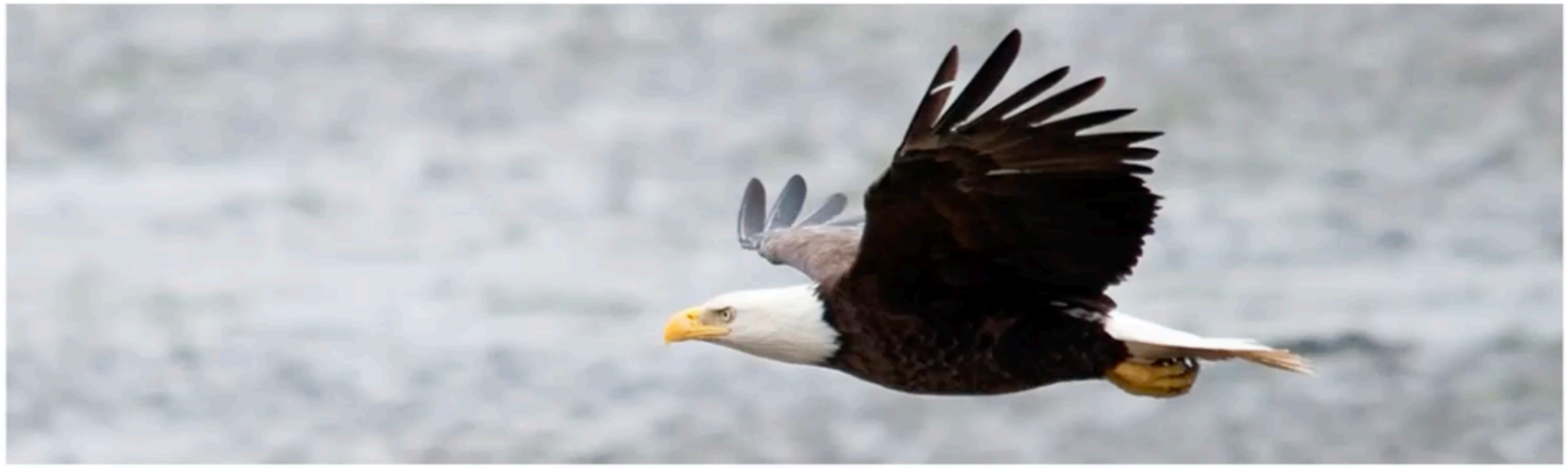
Biomagnification



Persistence, bioaccumulation, and biomagnification

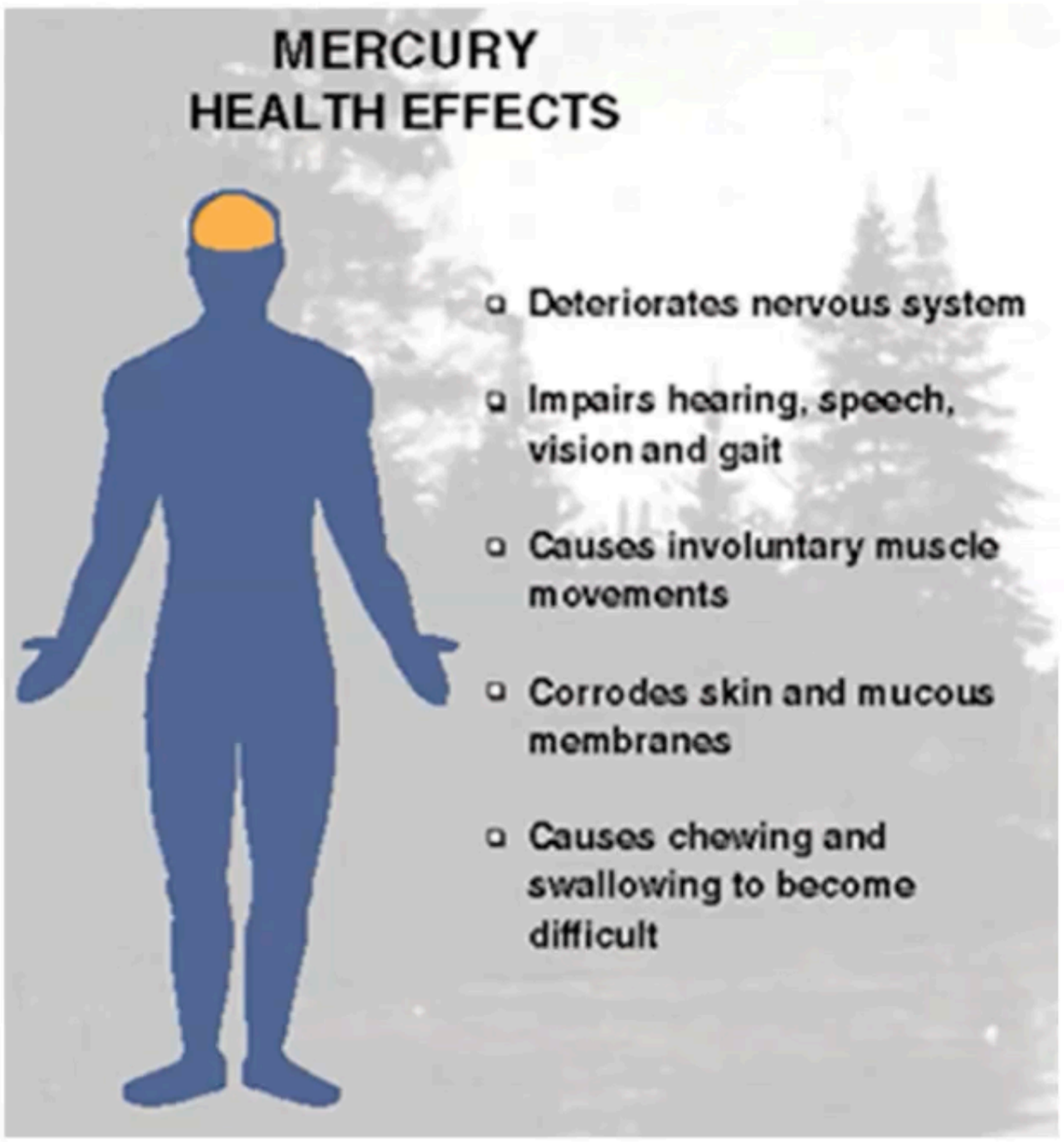
1. Substances like DDT, mercury and PCBs are persistent.
2. These substances bioaccumulate in fatty tissue.
3. Consumption along a food chain/food web increases the concentration of the substance in the fatty tissues of organisms at each successive trophic level.
4. Apex predators suffer the greatest effects of these substances because bioaccumulation has concentrated the substance in their fatty tissues.

Apex predators and biomagnification



Apex predators and biomagnification

Humans and biomagnification



Biomagnification has consequences

1. Organisms at the top of a food chain suffer the greatest effects of toxic substances that bioaccumulate in the body
    - Biomagnification
    - Examples of toxic substances – POPs like DDT and PCBs, heavy metals like mercury and lead
2. Apex predators (ex – raptors):
    - Developmental deformities
    - Eggshell thinning, specifically from DDT
3. Humans:
    - Learning disabilities, kidney/liver dysfunction, damage to reproductive/circulatory/nervous systems, birth defects

Putting it all together…

1. Bioaccumulation/biomagnification as it applies to
    - Persistence
    - Fat-solubility
    - Food chains/food webs and apex predators
    - Human consumption of natural resources
    - Anthropogenic pollution
2. Detail specific consequences of bioaccumulation/biomagnification
    - Identify a specific chemical and where the chemical came from
    - Describe how it got into the environment
    - Describe how its concentration increased to a level that is harmful to human health
    - Specifically describe effects on human health

Table 57.1 The persistence of various chemicals in the environment

Chemical	Source	Half-Life
Malathion	Insecticide	1 day
Radon	Rocks and soil	4 days in air
Vinyl chloride	Industry, water from vinyl chloride pipes	4.5 days in air
Phthalates	Plastics, cosmetics	2.5 days in water
Roundup	Herbicide	7 to 70 days in water
Atrazine	Herbicide	224 days in wetland soils
Polychlorinated biphenyls (PCBs)	Industry	8 to 15 years in water
DDT	Insecticide	30 years in soil

TOPIC 8.9

Solid Waste Disposal

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-3.K Describe solid waste disposal methods.	**STB-3.K.1** Solid waste is any discarded material that is not a liquid or gas. It is generated in domestic, industrial, business, and agricultural sectors. **STB-3.K.2** Solid waste is most often disposed of in landfills. Landfills can contaminate groundwater and release harmful gases. **STB-3.K.3** Electronic waste, or e-waste, is composed of discarded electronic devices including televisions, cell phones, and computers. **STB-3.K.4** A sanitary municipal landfill consists of a bottom liner (plastic or clay), a storm water collection system, a leachate collection system, a cap, and a methane collection system.
STB-3.L Describe the effects of solid waste disposal methods.	**STB-3.L.1** Factors in landfill decomposition include the composition of the trash and conditions needed for microbial decomposition of the waste.

continued on next page

LEARNING OBJECTIVE

STB-3.L

Describe the effects of solid waste disposal methods.

ESSENTIAL KNOWLEDGE

STB-3.L.2

Solid waste can also be disposed of through incineration, where waste is burned at high temperatures. This method significantly reduces the volume of solid waste but releases air pollutants.

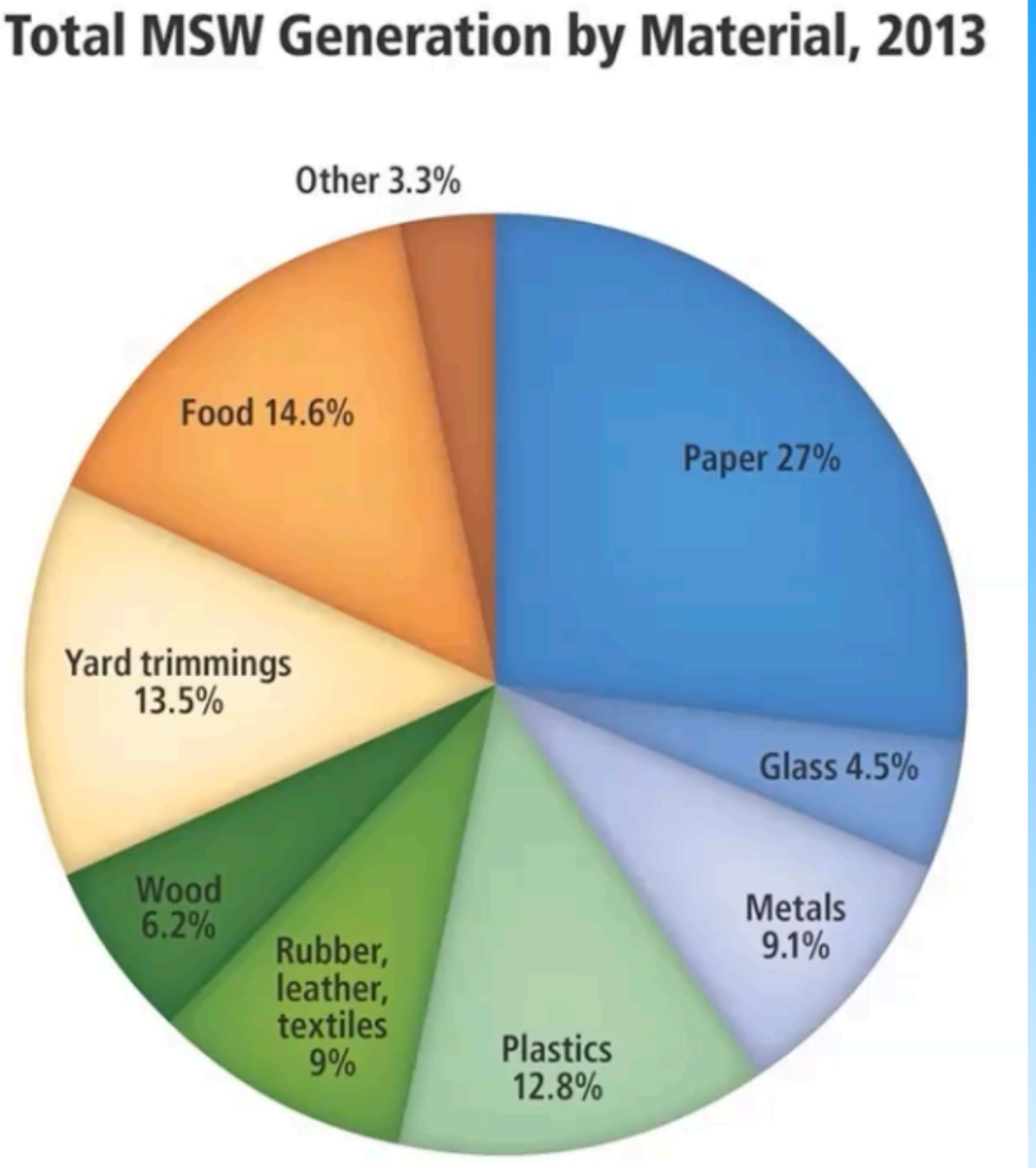
STB-3.L.3

Some items are not accepted in sanitary landfills and may be disposed of illegally, leading to environmental problems. One example is used rubber tires, which when left in piles can become breeding grounds for mosquitoes that can spread disease.

STB-3.L.4

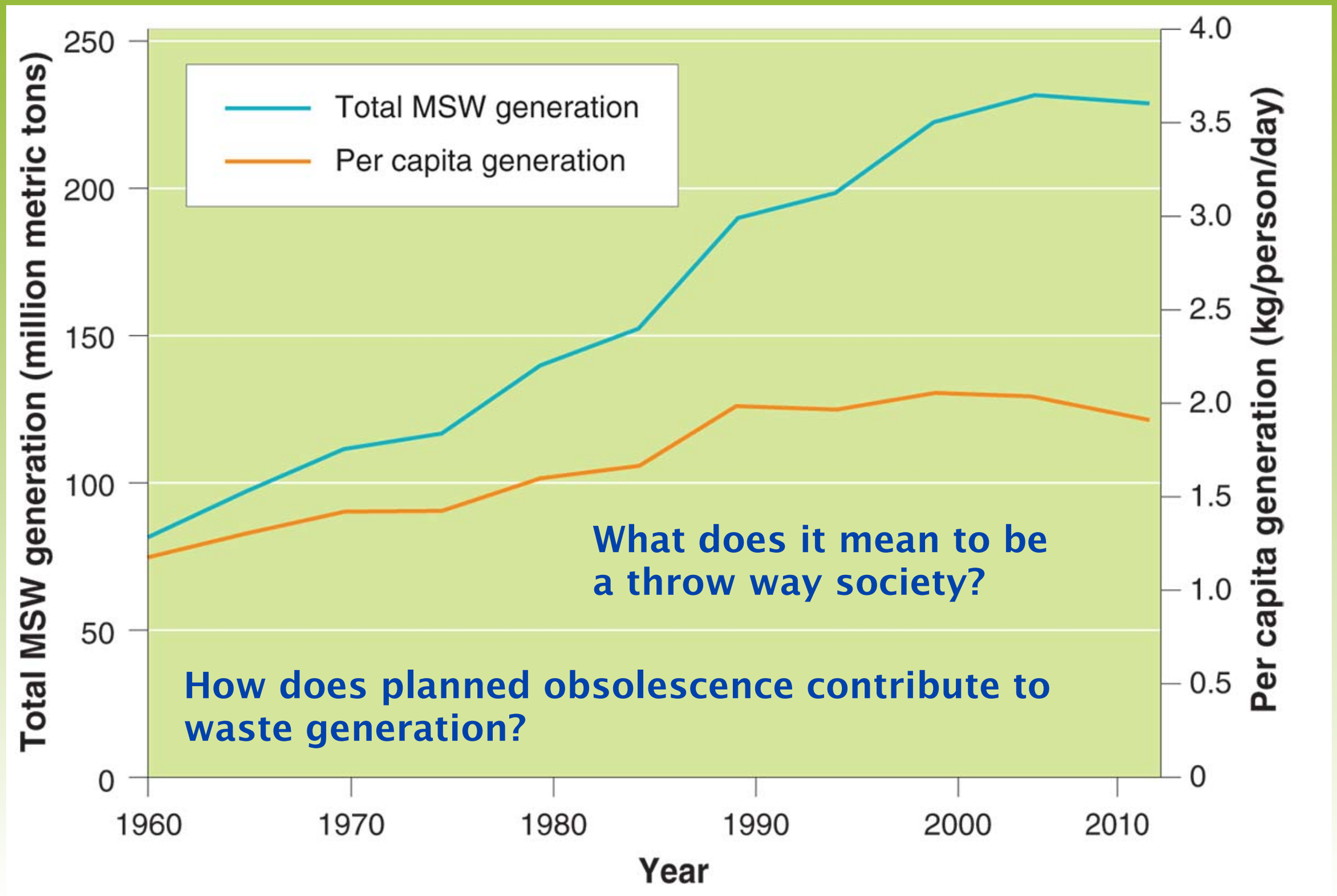
Some countries dispose of their waste by dumping it in the ocean. This practice, along with other sources of plastic, has led to large floating islands of trash in the oceans. Additionally, wildlife can become entangled in the waste, as well as ingest it.

Municipal Solid Waste - MSW



The Throw-Away Society

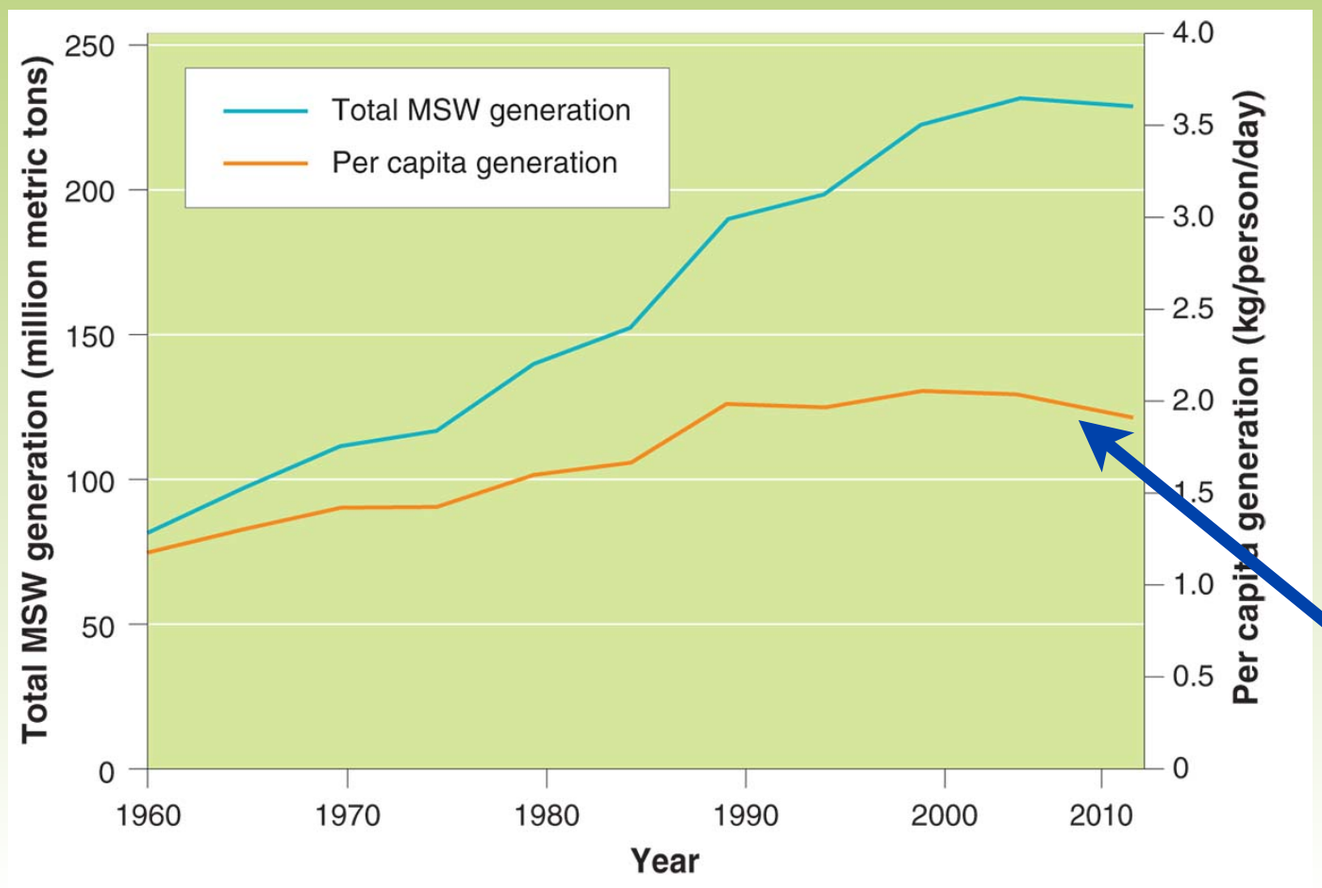
Municipal solid waste generation in the United States, 1960–2011. Total MSW generation and per capita MSW generation had been increasing from 1960 through 2008. They have recently started to decrease.



The solid waste stream contains materials from many sources

What are the main sources of waste in the U.S.?

What are the main sources of MSW in the U.S.?



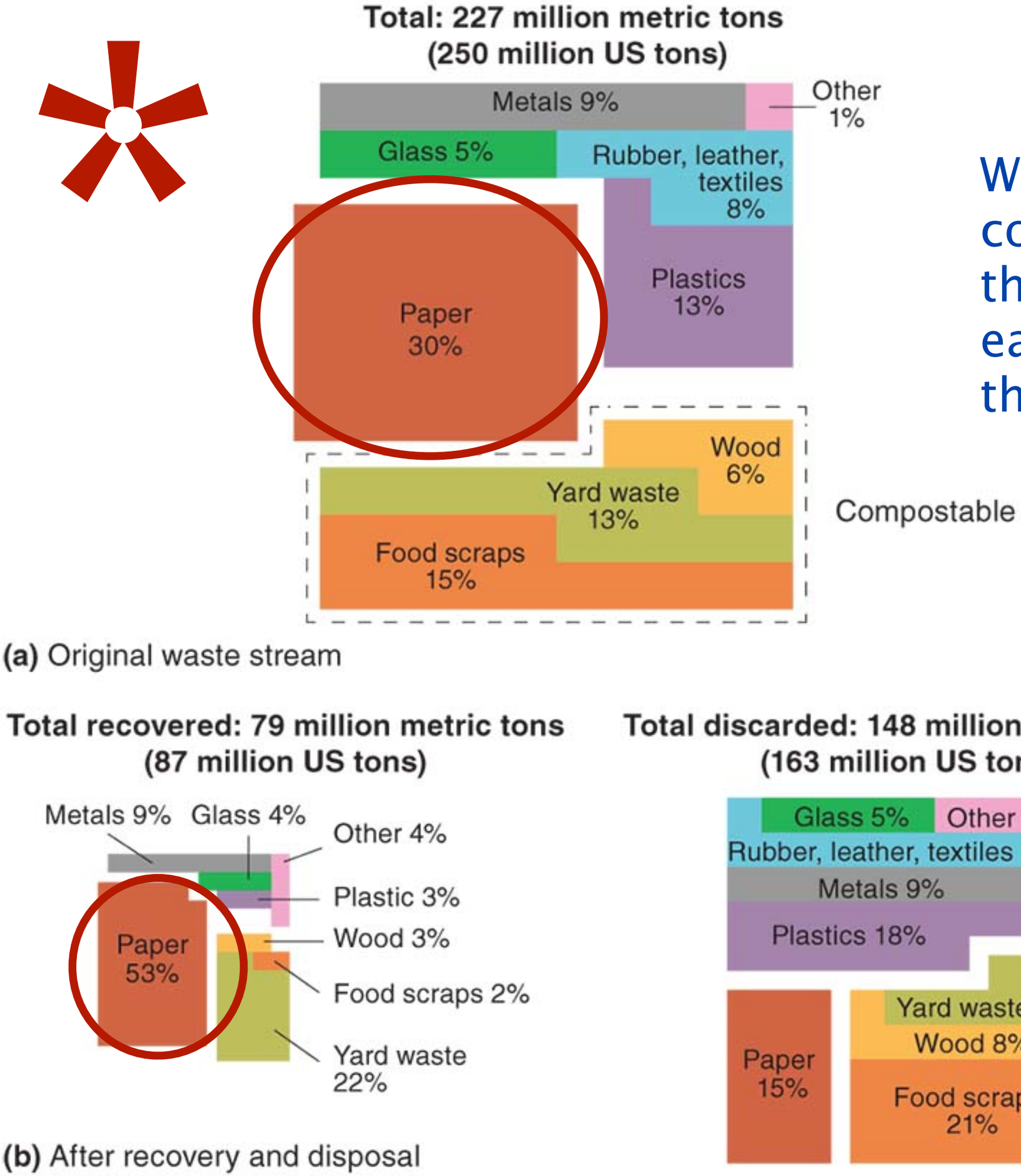
WHY?

Composition of Municipal Solid Waste

Composition and sources of municipal solid waste (MSW) in the United States.

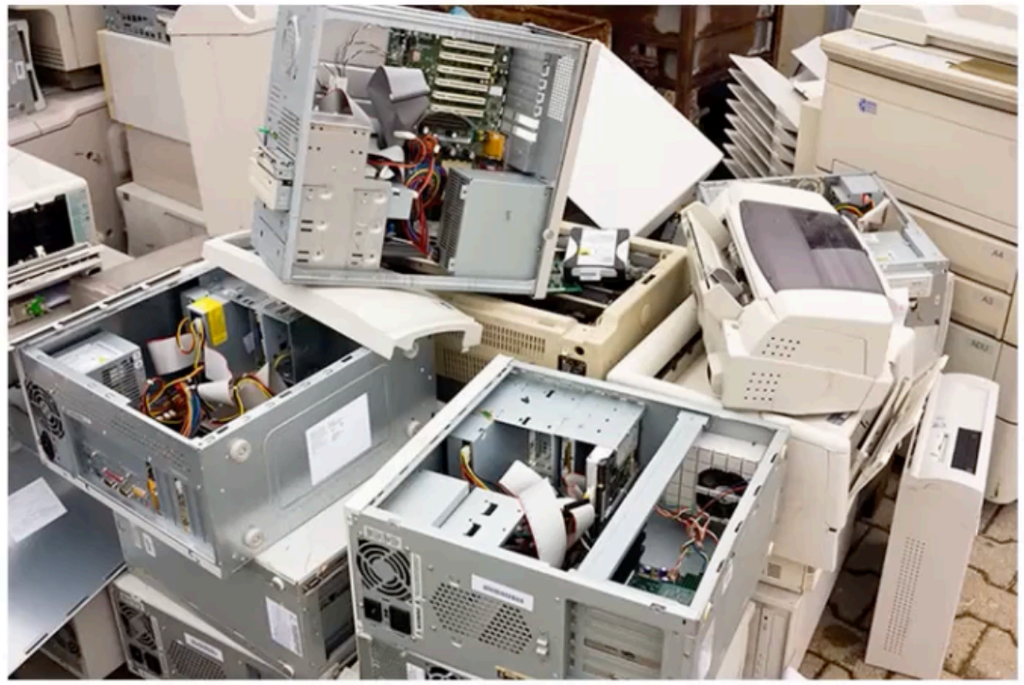
(a) The composition, by weight, of MSW in the United States in 2011 before recycling. Paper, food, and yard waste make up more than half of the MSW by weight.

(b) The breakdown of the material that is recovered and the material that is discarded. Paper makes up more than half of the material that is recovered. Food and yard waste make up almost one-third of material that is discarded.



Which group of materials could be removed from the waste stream most easily and would make the greatest impact?

E-Waste



Source: City of San Diego

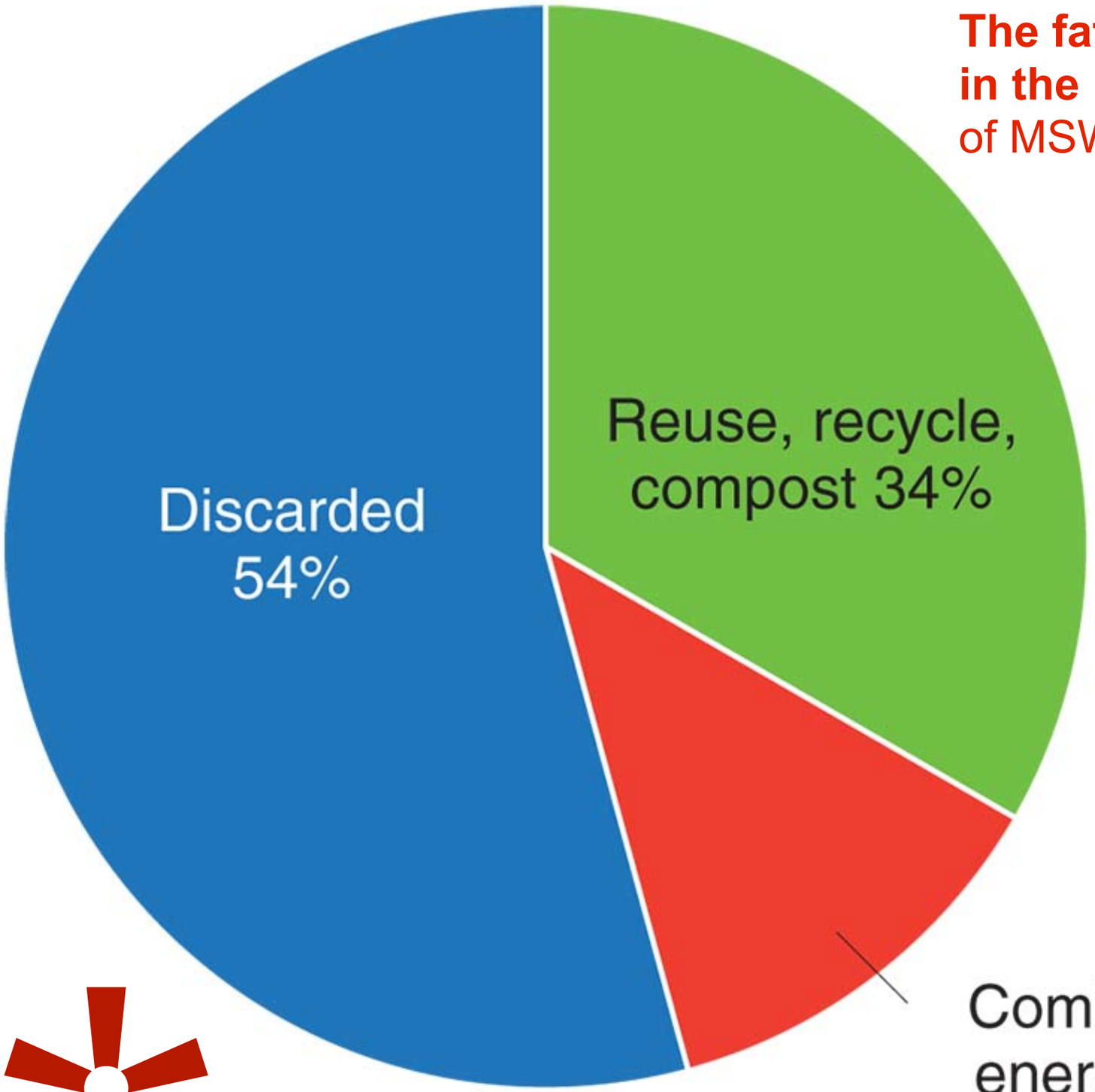
Photo by NIOSH

Open Landfill

Source: Landfill Effluent Guidelines, accessed on 01-11-21, https://www.epa.gov/eg/landfills-effluent-guidelines

- Odor
- Poor containment of solid waste and leachate
- Flammable
- Animal disturbances
- Low aesthetic value

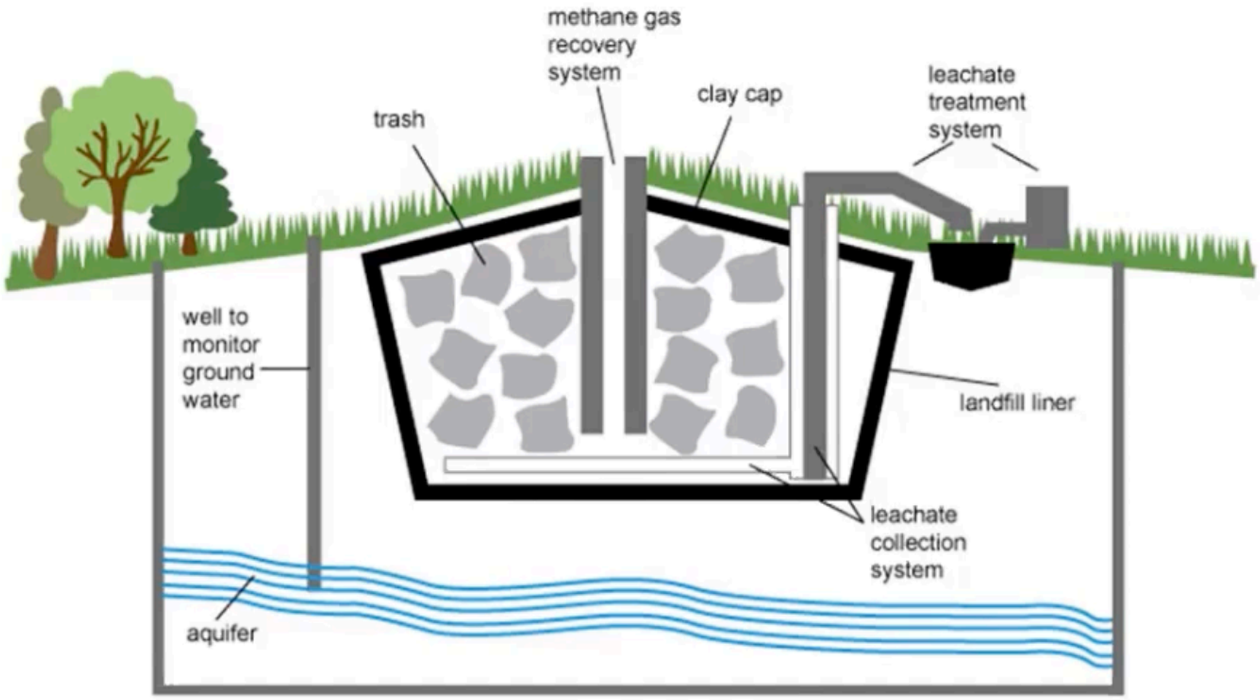
Landfills are the primary destination for MSW



The fate of municipal solid waste in the United States. The majority of MSW is disposed of in landfills.

Sanitary Landfill

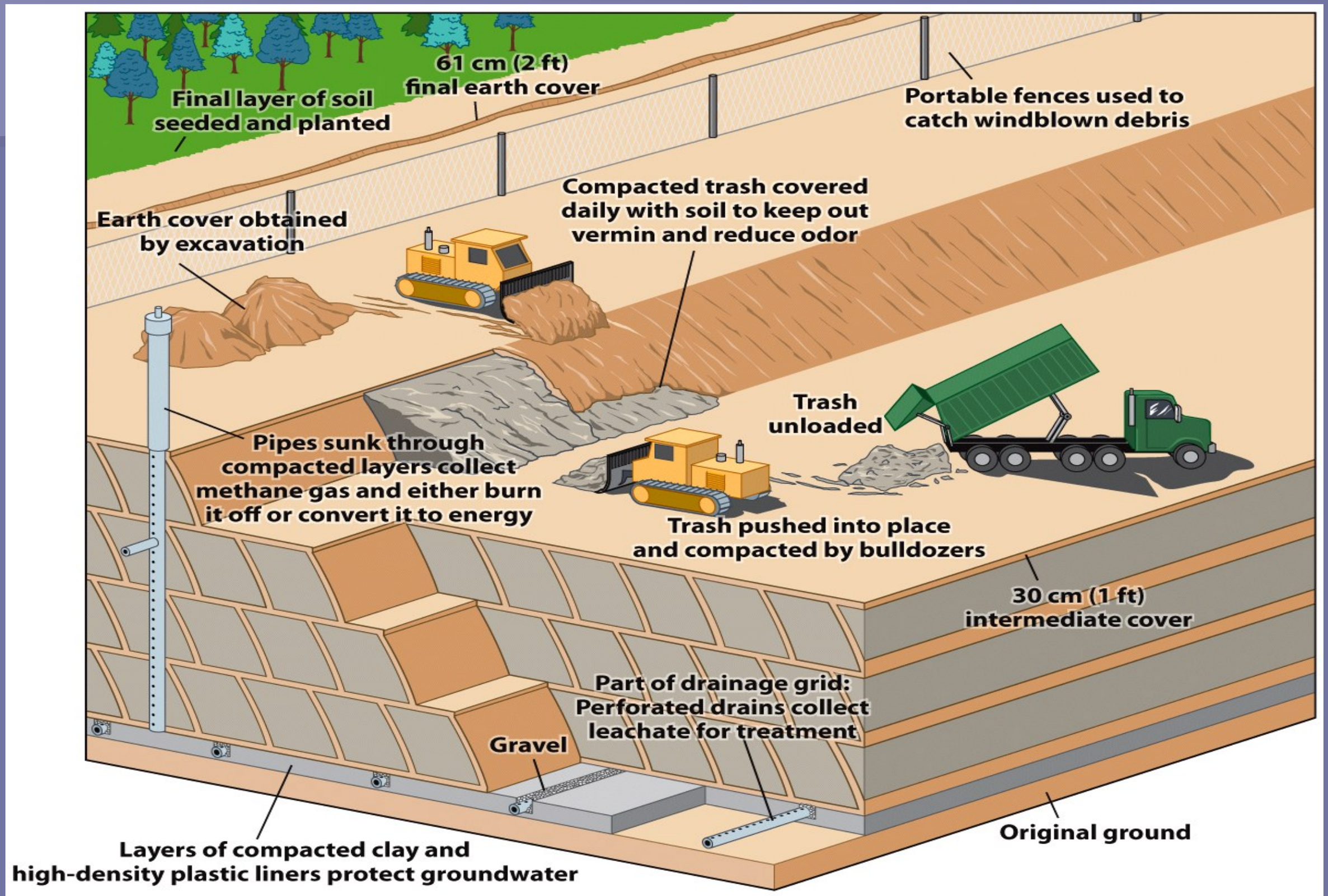
Modern landfill



Source: Adapted from National Energy Education Development Project (public domain)

- Liner (clay, plastic)
- Garbage
- Leachate and methane (CH_4) collection/monitoring systems
- When full: cap and continuous monitoring

Sanitary Landfill



Sanitary Landfill

- Considerations for choosing a Landfill
  - local topography and drainage patterns
  - proximity to aquifer recharge zones
  - permeability of underlying rock formations
  - community attitudes

Landfill Basics

A modern sanitary landfill. A landfill constructed today has many features to keep components of the solid waste from entering the soil, water table, or nearby streams. Some of the most important environmental features are the clay liner, the leachate collection system, the cap—which prevents additional water from entering the landfill—and, if present, the methane extraction system.

Describe features of a modern sanitary landfill.

How do modern sanitary landfills compare to open dumps of the past?

List items that should not go into modern sanitary landfills.

Choosing a Site for a Sanitary Landfill

- **Siting** The designation of a landfill location, typically through a regulatory process involving studies, written reports, and public hearings.

Explain

- Landfill siting has been the source of considerable environmental injustice. People with financial resources or political influence often adopt a “not-in-my-backyard,” or NIMBY, attitude about landfill sites.

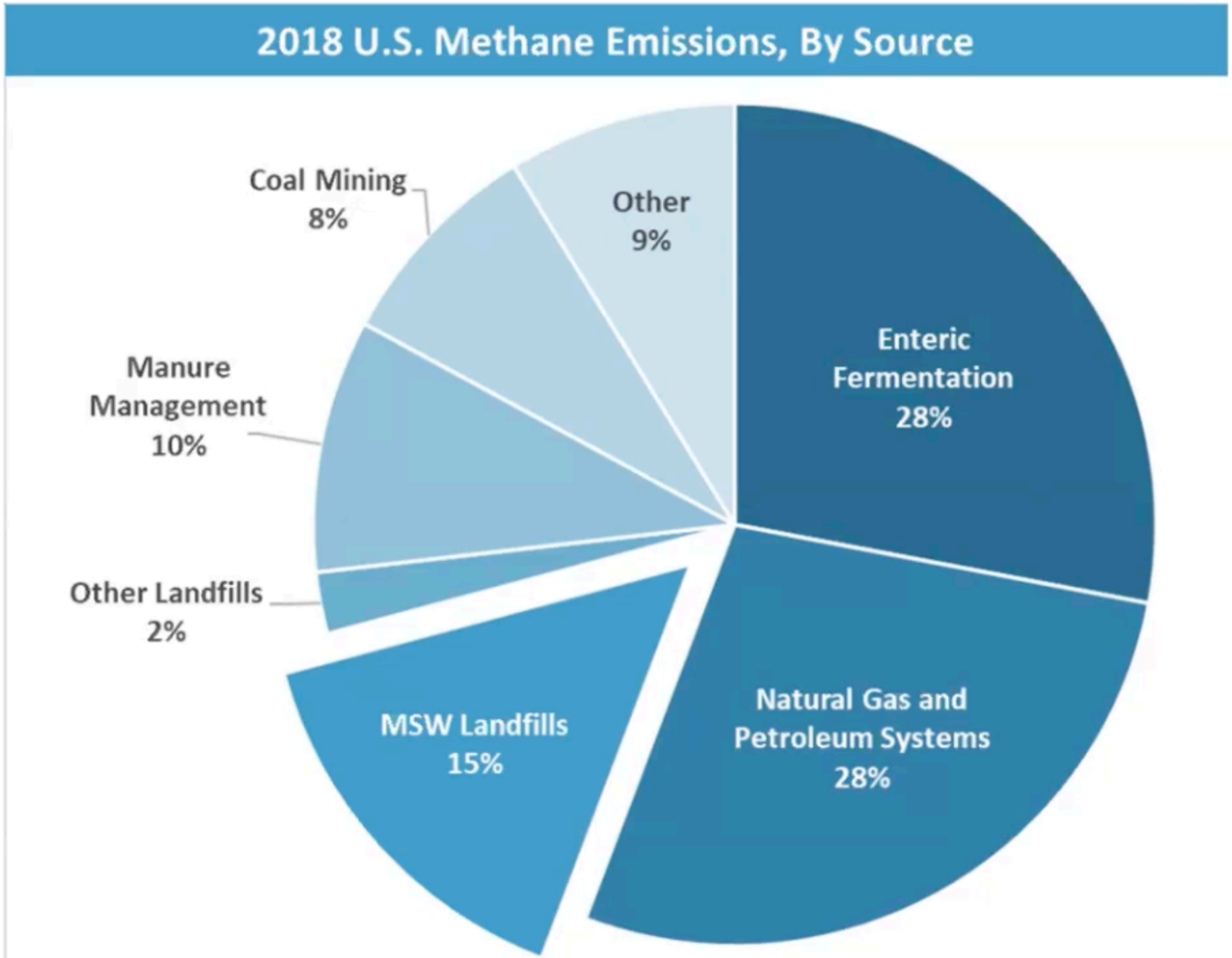
- A site may be chosen not because it meets the safety criteria better than other options but because its neighbors lack the resources to mount an effective opposition.

List parameters used when choosing a site for a modern sanitary landfill.

Sanitary landfill liner and leachate pond

Anaerobic decomposition produces methane

Anaerobic decomposition produces methane



Note: All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018*. U.S. EPA. 2020.

Capped landfill

Capped landfill

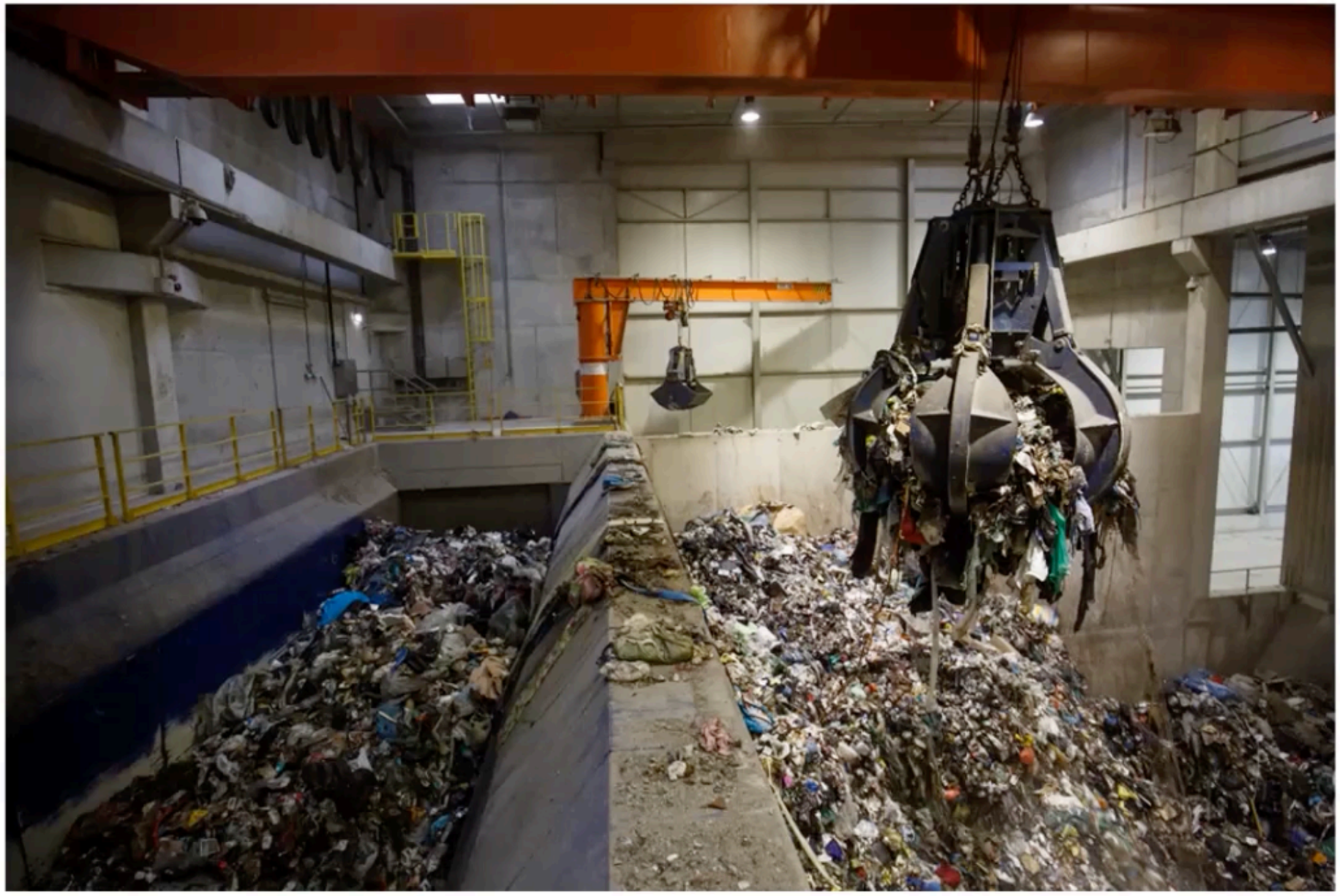
Before

After

Solid waste management

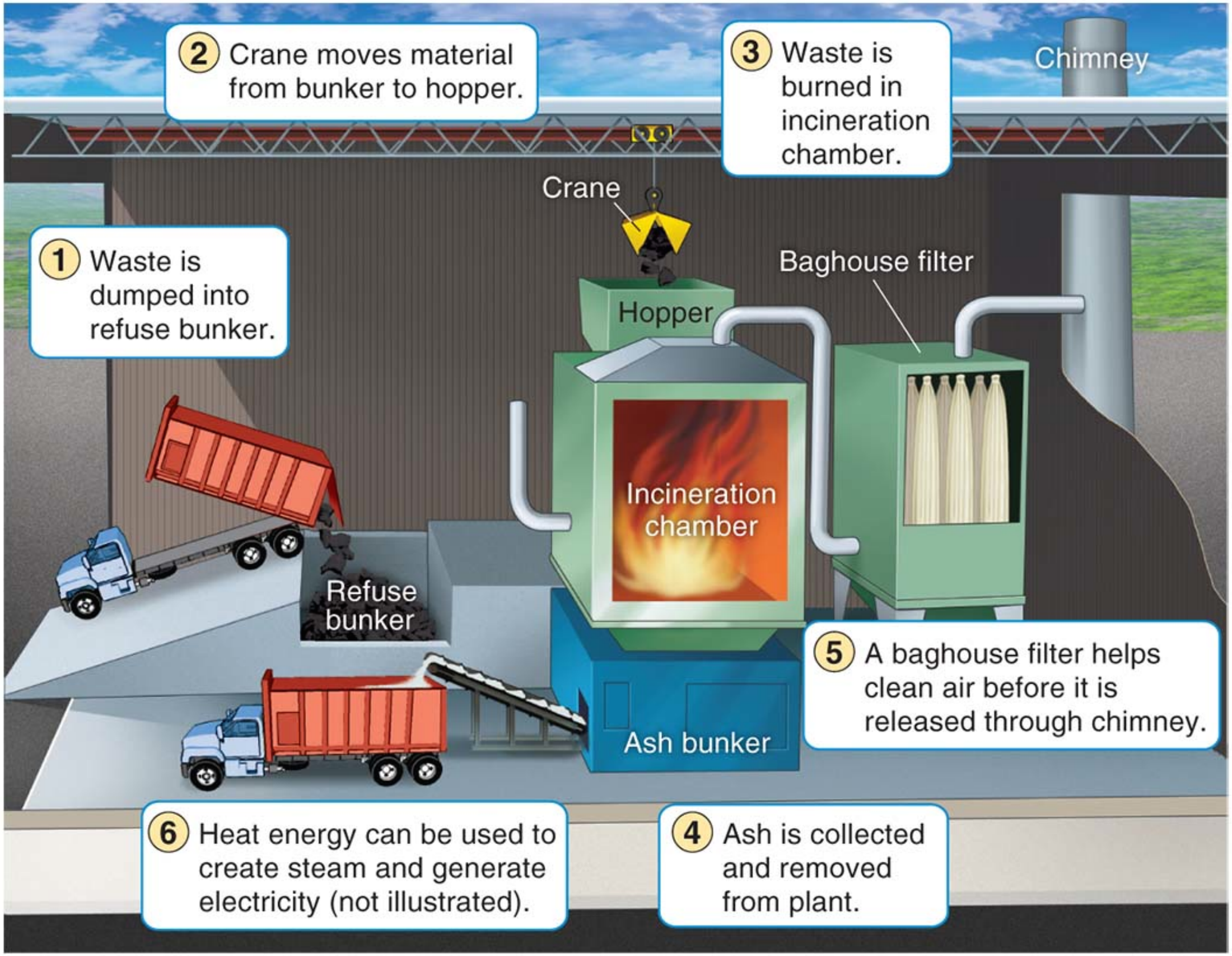
1. Solid waste comes from many sources: domestic, industrial, business, agricultural
2. Solid waste comes in a variety of categories:
    - E-waste
3. Solid waste most often goes to landfills
4. Sanitary municipal landfill:
    - Bottom liner (clay or plastic)
    - Storm water collection system
    - Leachate collection system
    - Methane collection system
    - Cap when full, with monitoring ongoing
5. Anaerobic decomposition produces methane

Solid waste can be incinerated

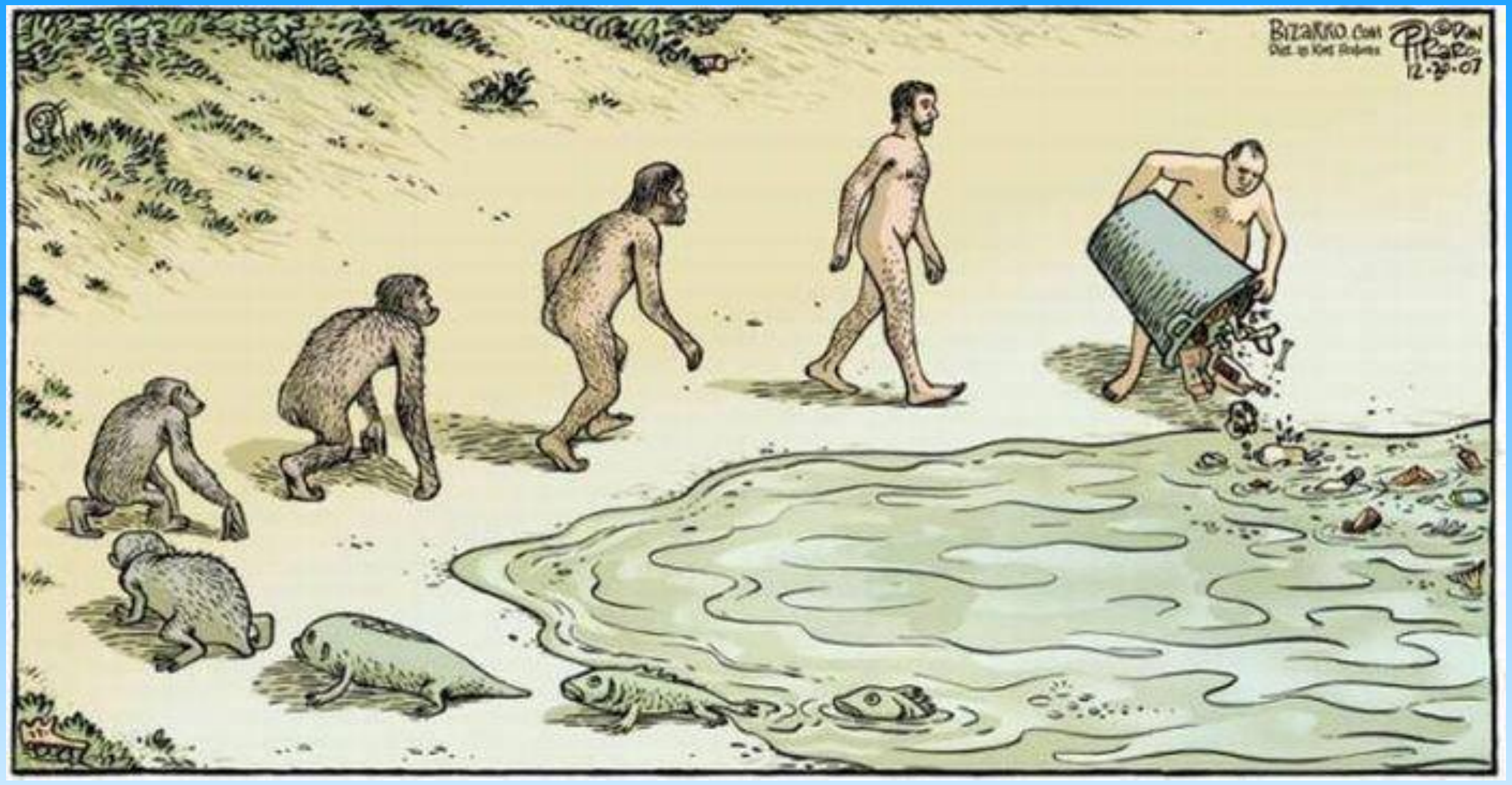


zlikovec/Shutterstock.com

Incineration Basics



Solid waste can be illegally dumped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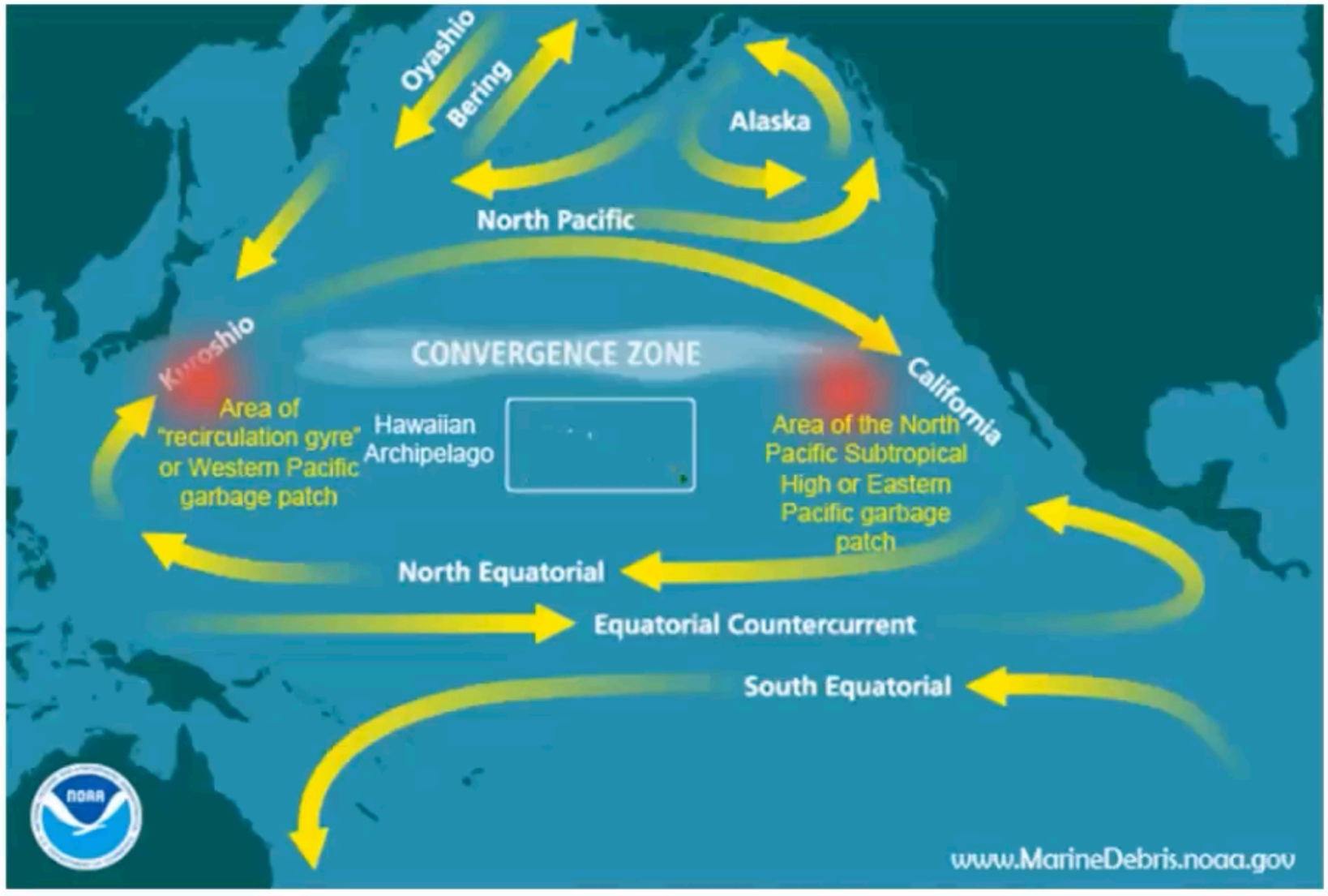
Solid waste in the ocean

Solid waste in the ocean

Loretta Sze/Shutterstock.com

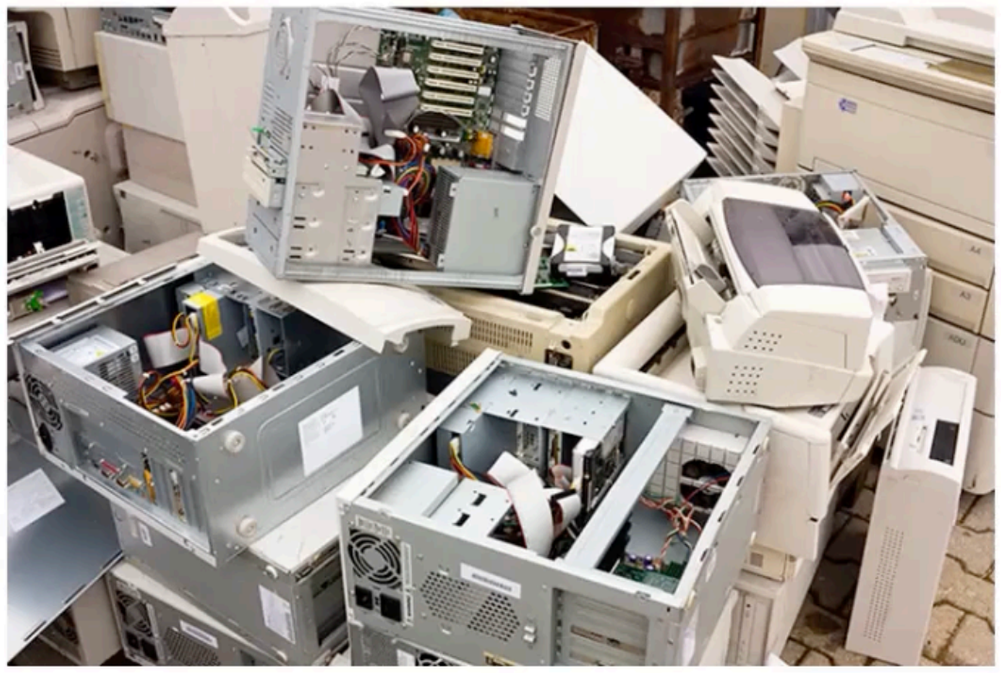
Solid waste in the ocean



Alternative methods of solid waste management

1. Incineration
    - Pro: reduces waste, can be used as energy source (Topic 8.10)
    - Con: solid waste still remains, air pollutants released
2. Illegal terrestrial dumping
    - Pro: does not take up large space, convenient
    - Con: unregulated methane/leachate emissions, emissions of pollutants associated with specific dumped items, disease
3. Dumping in ocean
    - Pro: convenient, no drawbacks associated with landfills
    - Con: impacts marine ecosystems and organisms

E-waste contains persistent pollutants

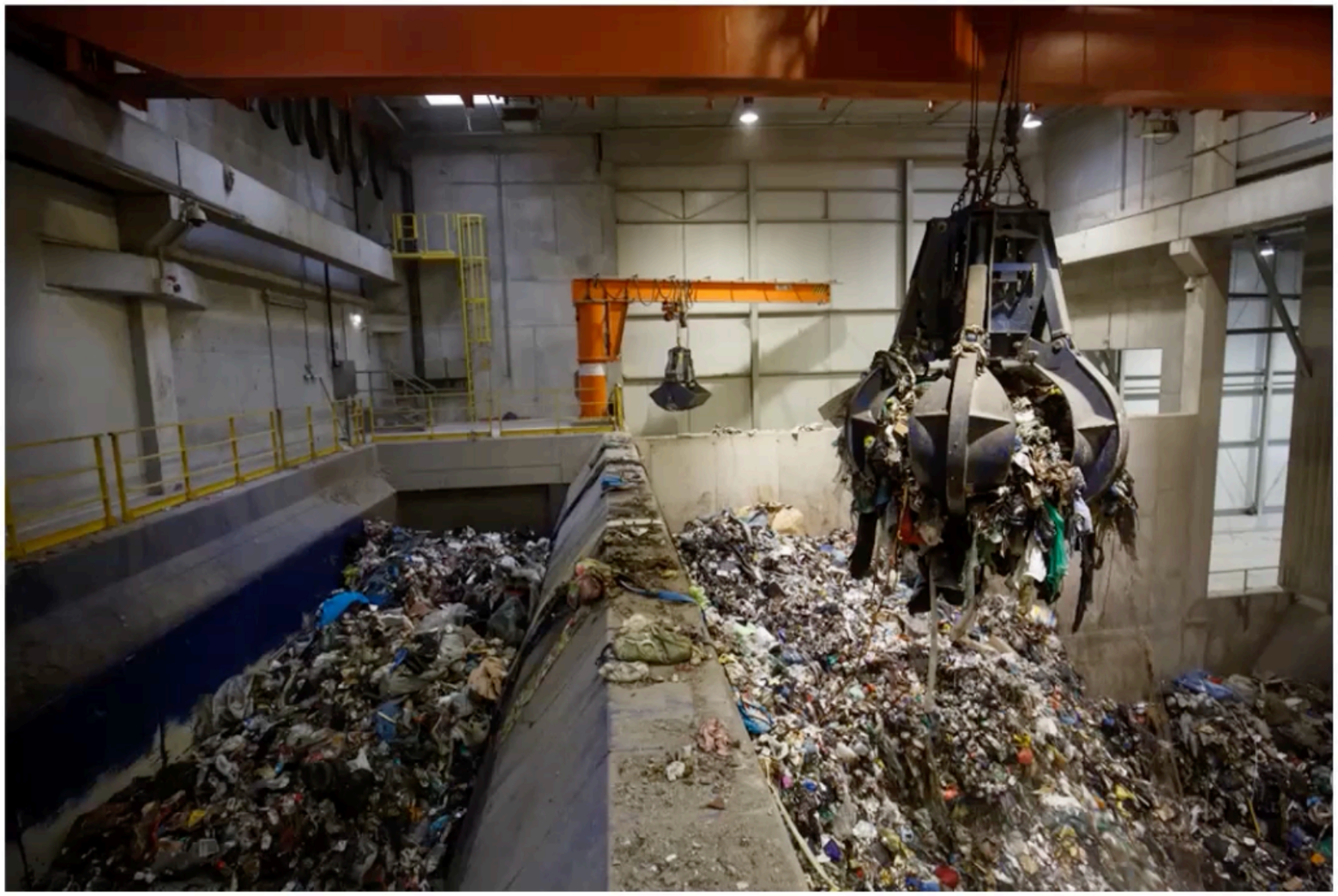


Source: City of San Diego

- Example: mercury, lead

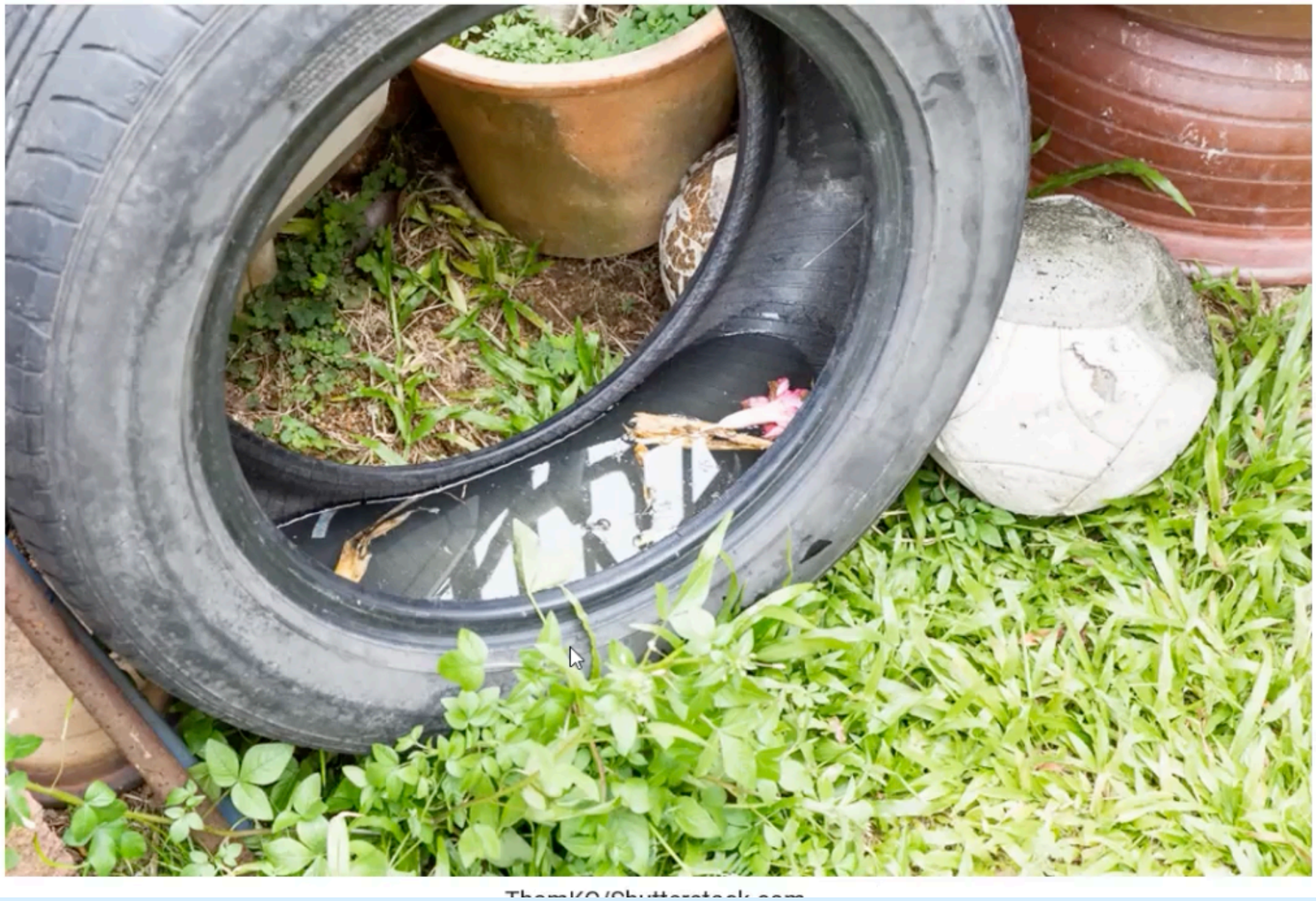
- Clean Water Act
- Safe Drinking Water Act
- RCRA – Resource Conservation and Recovery Act
- CERCLA – Comprehensive Environmental Response, Compensation and Liability Act

Incineration can produce air pollution



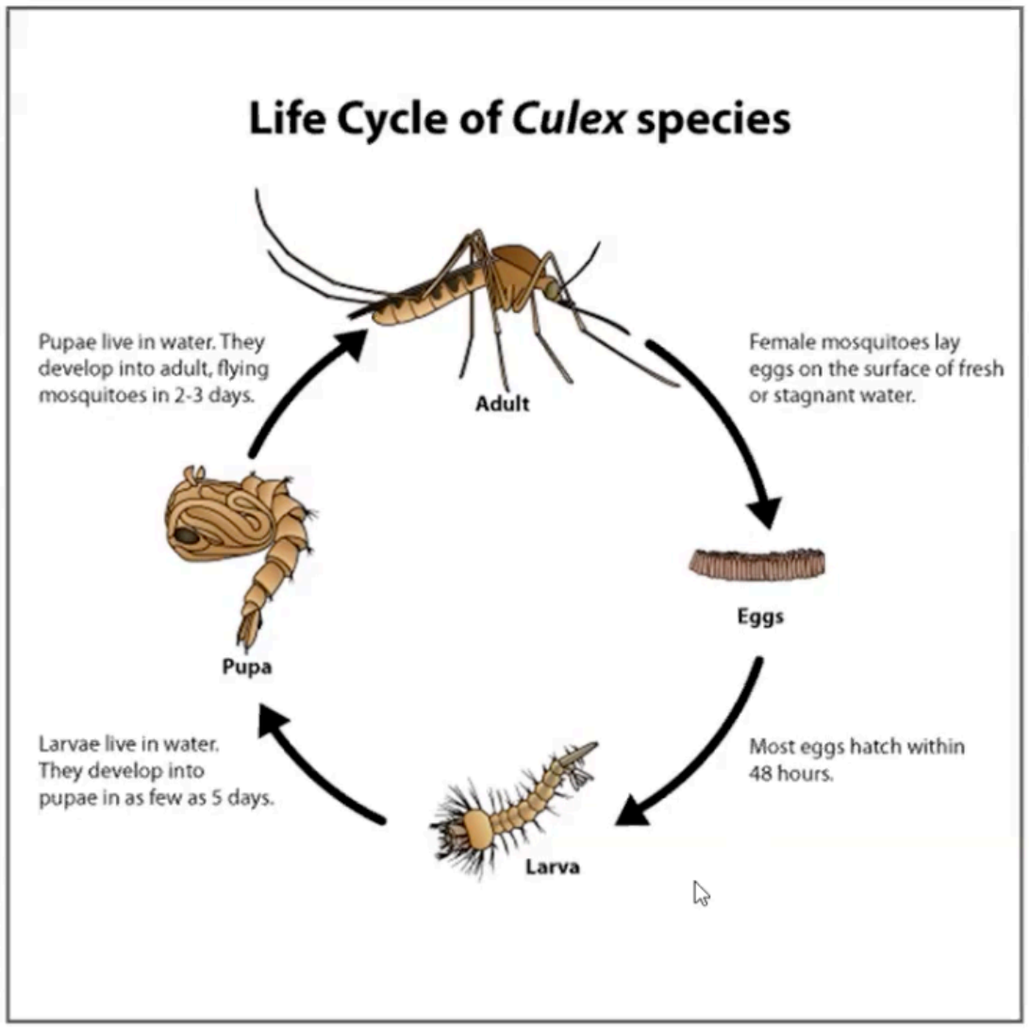
Clean Air Act

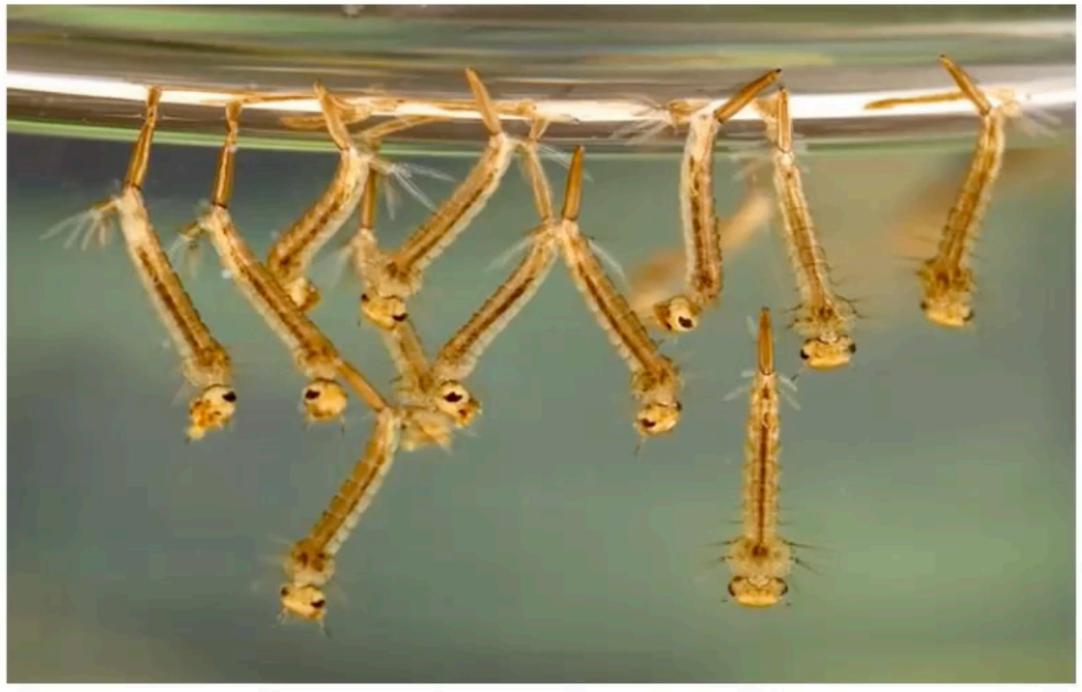
Mosquitoes breed in shallow water



- Special Problem: Tires
  - Made from materials that cannot be recycled
  - Can be incinerated or shredded

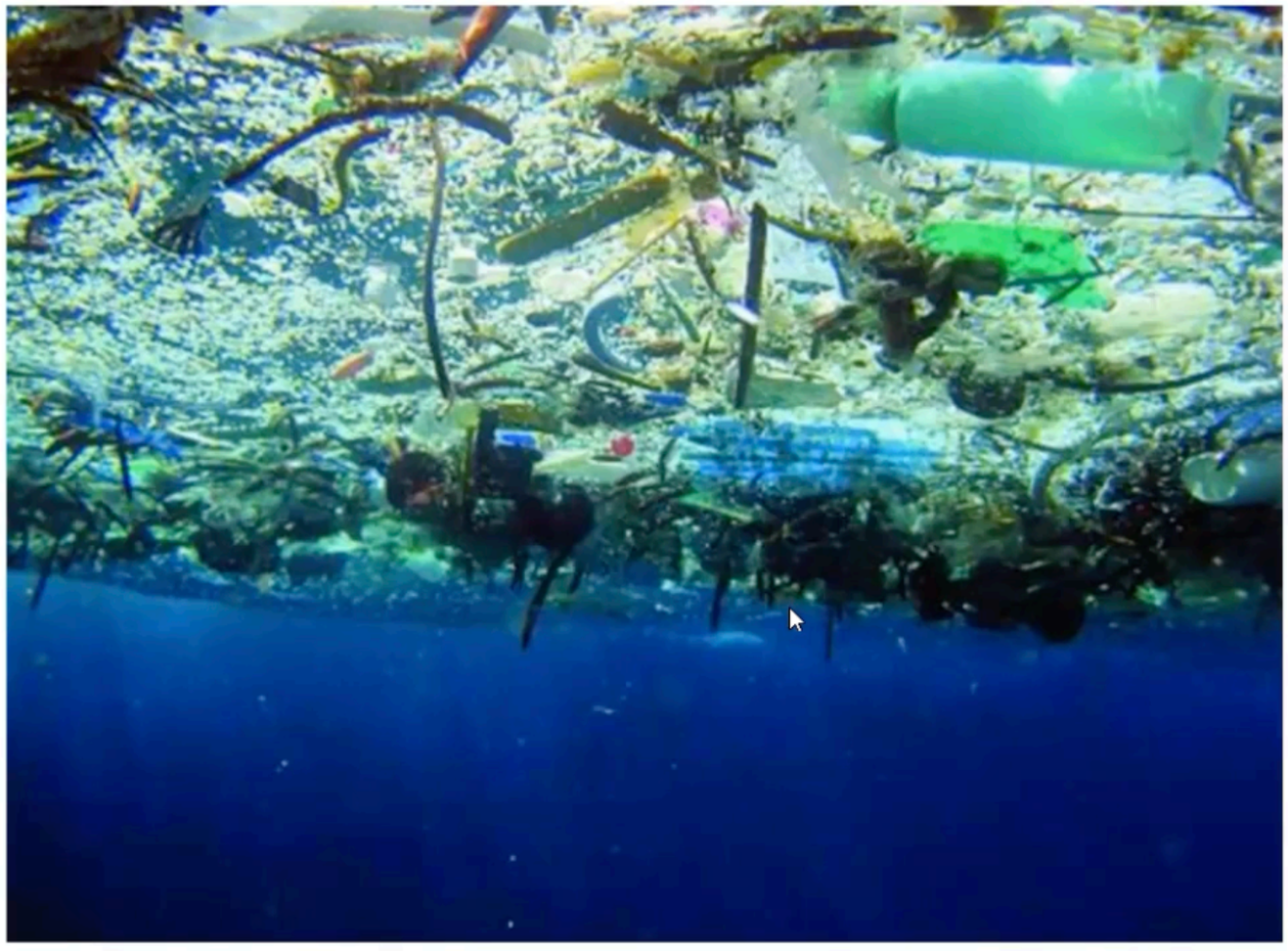
Mosquitoes breed in shallow water





Both images: Life Cycle of *Culvex* Species Mosquitoes, accessed on 01-11-21, https://www.cdc.gob/mosquitoes/about/life-cycles/culex.html

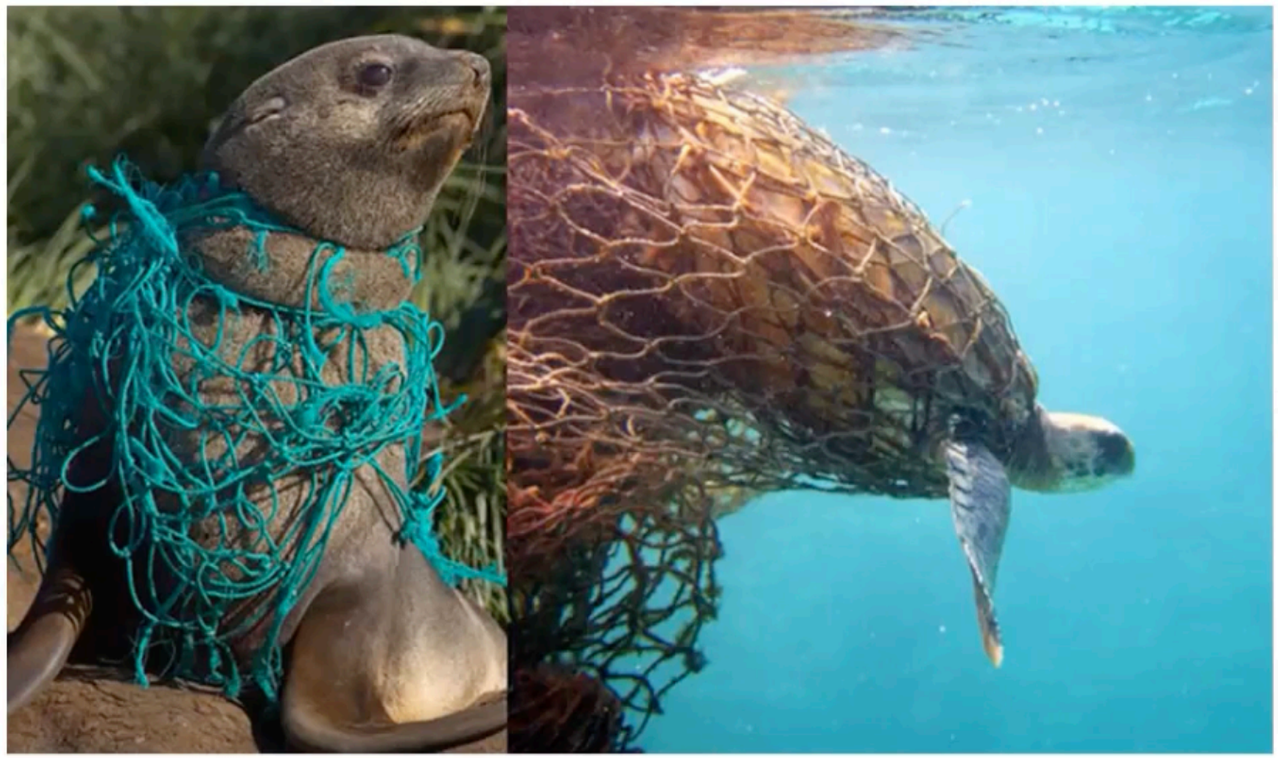
Solid waste in the ocean



Source: NOAA

Source: US Geological Survey

Solid waste in the ocean



Source: NOAA

Willyam Bradberry/Shutterstock.com

HOW LONG UNTIL IT'S GONE?

Estimated decomposition rates of common marine debris items

Waxed Carton
3 months

Cardboard Box
2 months

Apple Core
2 months

Foamed Buoy
50 years

Plastic Grocery Bag
10 – 20 years

Plywood
1 – 3 years

Disposable Diaper
450 years

Cigarette Butt
1 – 5 years

Newspaper
6 weeks

Paper Towel
2 – 4 weeks

Wool Socks
1 – 5 years

Plastic Bottle
450 years

Photo-degradable
Beverage Holder
6 months

Aluminium Can
200 years

Fishing Line
600 years

Styrofoam Cup
50 years

Tin Can
50 years

Plastic Beverage Holder
400 years

Glass Bottle
undetermined

Cotton Shirt
2 – 5 months

Estimated individual item timelines depend on product composition and environmental conditions.

Source: NOAA (National Oceanic and Atmospheric Administration), US / Woods Hole Sea Grant, US
Graphics: Oliver Lüde / Museum für Gestaltung Zürich, ZHdK

Poorly managed solid waste can impact the environment

1. Unregulated methane and leachate production can impact groundwater and the atmosphere.
2. Tires act as breeding grounds for mosquitoes, a vector of disease.
3. Solid waste in the ocean can impact marine life:
    - Solid waste in marine environments can be deliberately or accidentally dumped
    - Physical entanglement
    - Mistaken for food, damaging digestive system
    - Bioaccumulation/biomagnification of some toxins – ingested plastic can play a part in this process

TOPIC 8.10

Waste Reduction Methods

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.M

Describe changes to current practices that could reduce the amount of generated waste and their associated benefits and drawbacks.

ESSENTIAL KNOWLEDGE

STB-3.M.1

Recycling is a process by which certain solid waste materials are processed and converted into new products.

STB-3.M.2

Recycling is one way to reduce the current global demand on minerals, but this process is energy-intensive and can be costly.

STB-3.M.3

Composting is the process of organic matter such as food scraps, paper, and yard waste decomposing. The product of this decomposition can be used as fertilizer. Drawbacks to composting include odor and rodents.

STB-3.M.4

E-waste can be reduced by recycling and reuse. E-wastes may contain hazardous chemicals, including heavy metals such as lead and mercury, which can leach from landfills into groundwater if they are not disposed of properly.

STB-3.M.5

Landfill mitigation strategies range from burning waste for energy to restoring habitat on former landfills for use as parks.

LEARNING OBJECTIVE

STB-3.M

Describe changes to current practices that could reduce the amount of generated waste and their associated benefits and drawbacks.

ESSENTIAL KNOWLEDGE

STB-3.M.6

The combustion of gases produced from decomposition of organic material in landfills can be used to turn turbines and generate electricity. This process reduces landfill volume.

continued on next page

The three Rs divert materials from the waste stream

- **Reduce, reuse, recycle** A popular phrase promoting the idea of diverting materials from the waste stream. *Also known as* **the three Rs**.

Reduce

- Reduce is the first choice among the three Rs because reducing inputs is the optimal way to achieve a reduction in solid waste generation.

- **Source reduction** An approach to waste management that seeks to cut waste by reducing the use of potential waste materials in the early stages of design and manufacture.

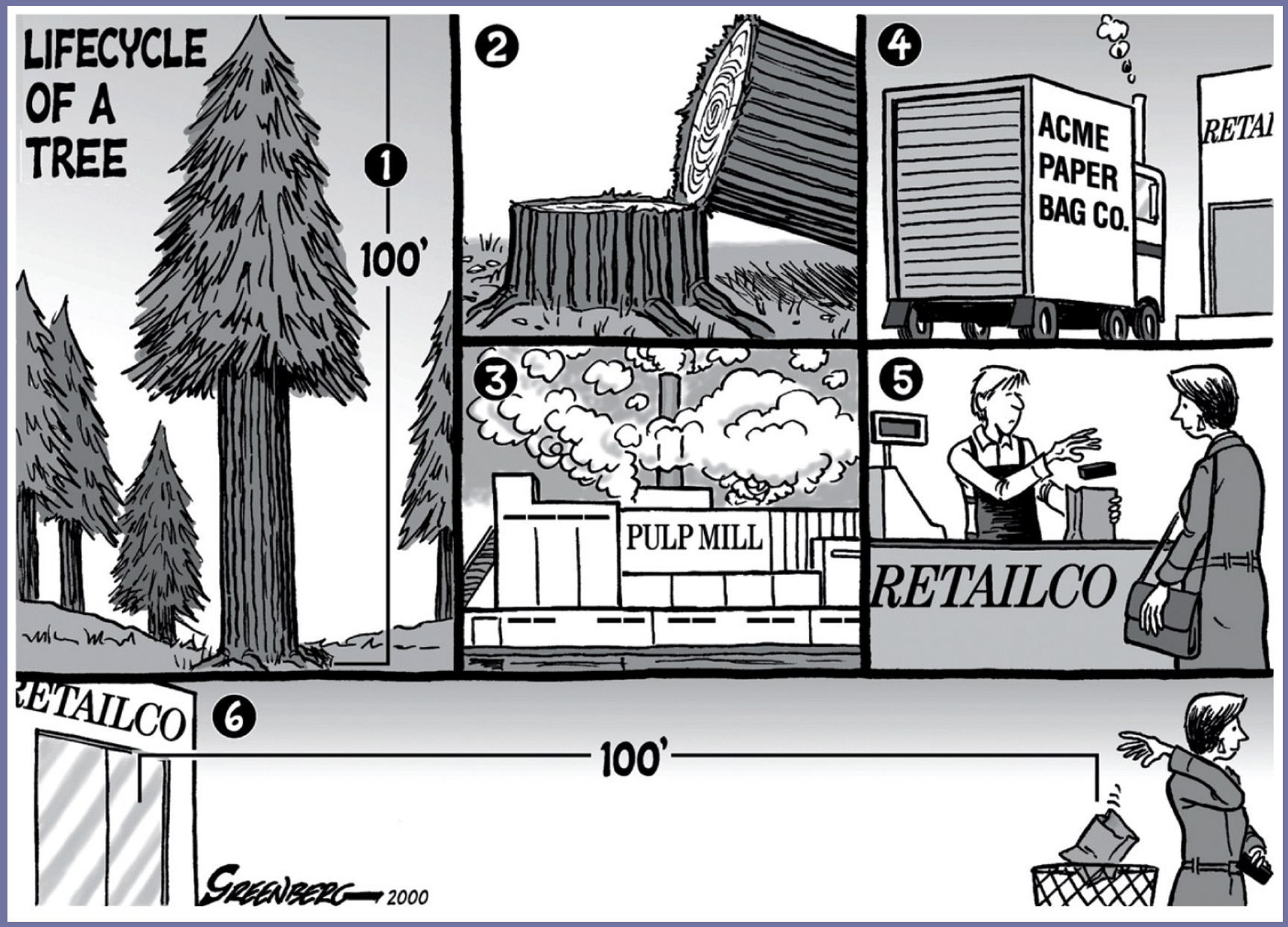
- Source reduction can also increase energy efficiency; manufacturing produces less waste and can minimize disposal processes.

- Source reduction may also involve substituting less toxic materials or products.

What are some examples of source reduction?

Reducing Waste

- Purchase products with less packaging



Reuse

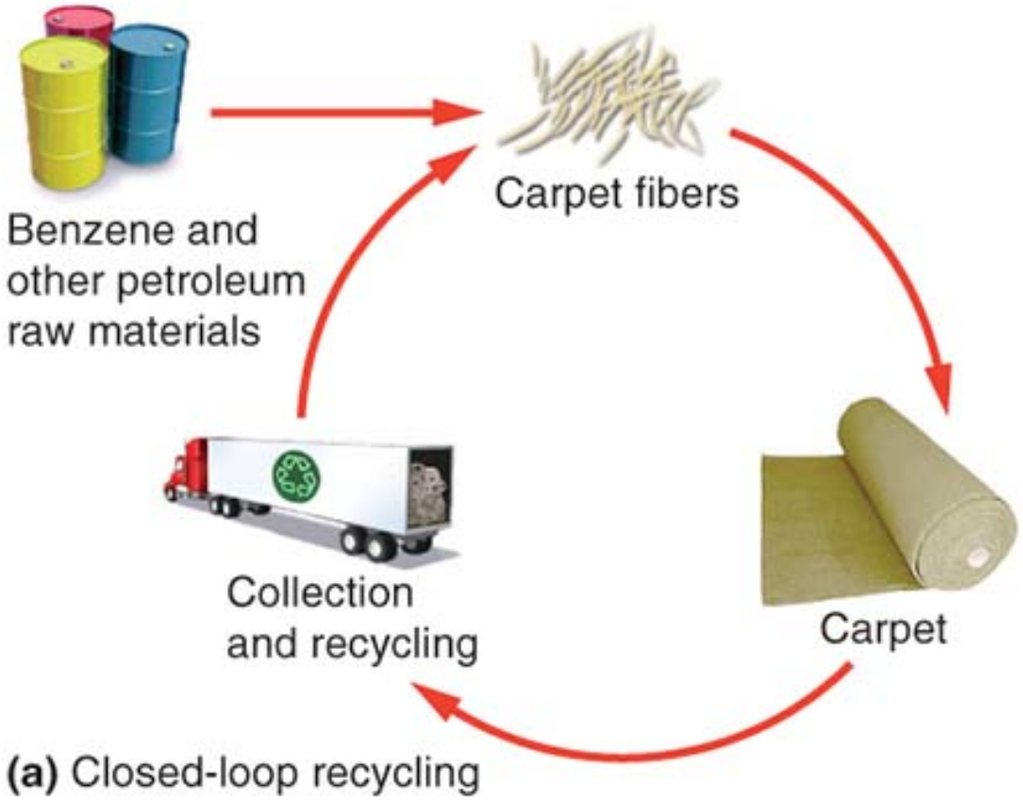
- **Reuse** Using a product or material that was intended to be discarded.
- Optimally, no additional energy or resources are needed for the object to be reused.
- Energy may be required to prepare or transport an object for reuse by someone other than the original user.

Recycle

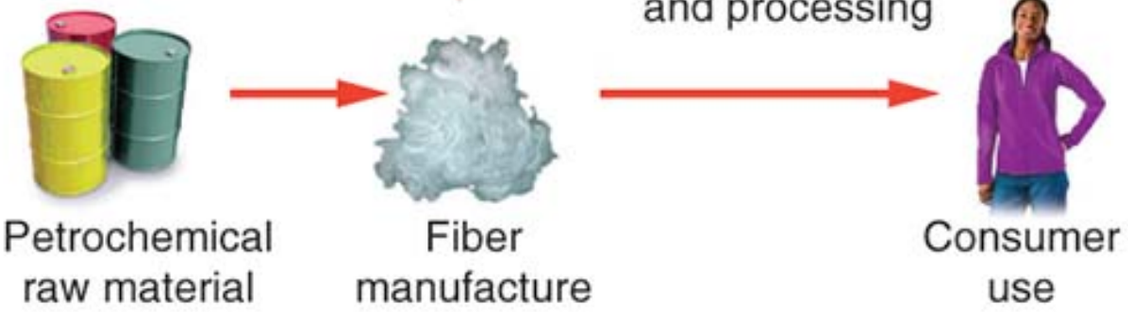
- **Recycling** The process by which materials destined to become municipal solid waste (MSW) are collected and converted into raw material that is then used to produce new objects.

- **Closed-loop recycling** Recycling a product into the same product.

- **Open-loop recycling** Recycling one product into a different product.



(a) Closed-loop recycling



(b) Open-loop recycling

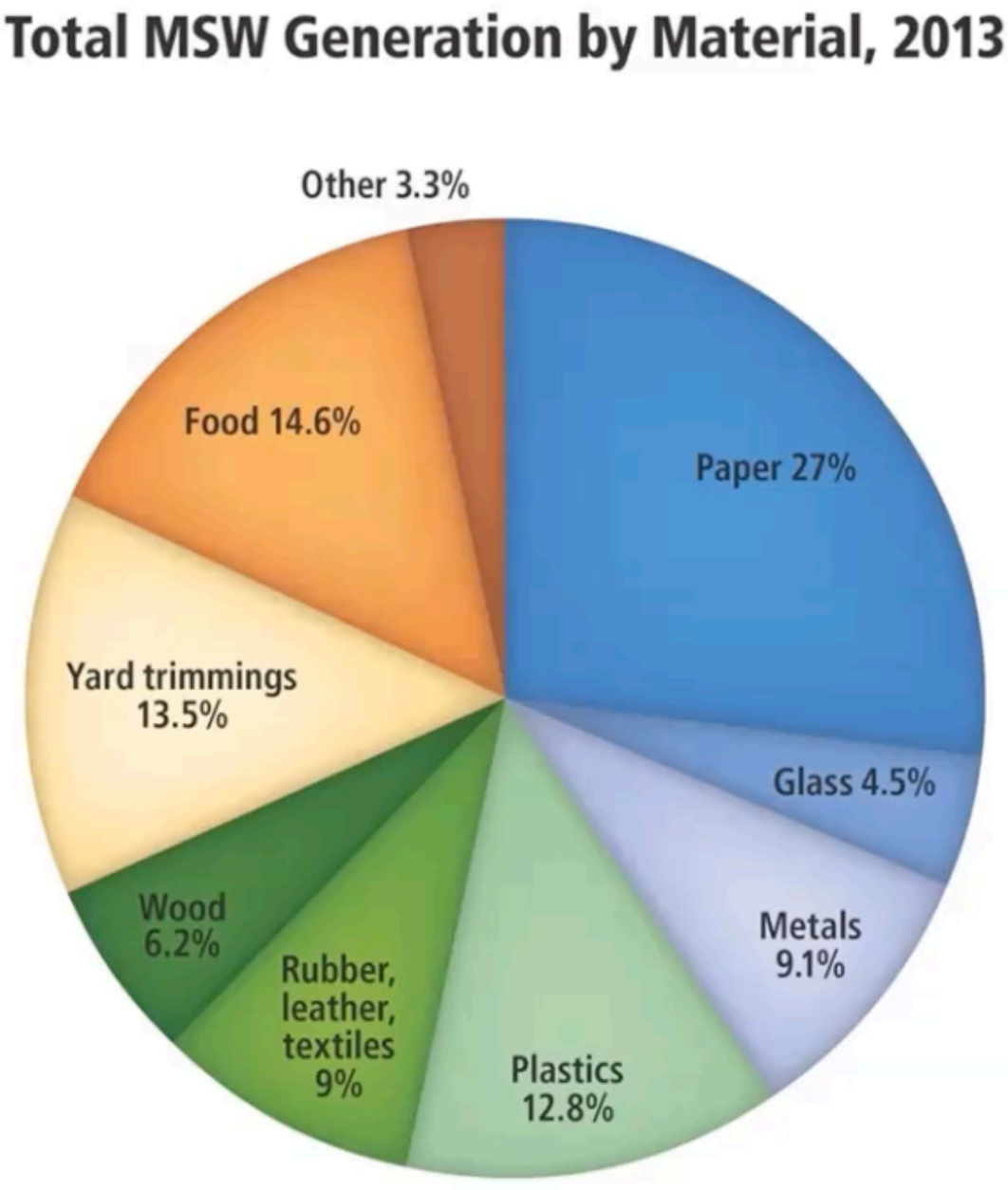
Closed- and open-loop recycling.

(a) In closed-loop recycling, a discarded carpet can be recycled into a new carpet, although some additional energy and raw material are needed.

(b) In open-loop recycling, a material such as a beverage container is used once and then recycled into something else, such as a fleece jacket.

Reduce and reuse first…

Municipal Solid Waste - MSW



Recycling


WASTE SORTING
PAPER
PLASTIC
GLASS
METAL
ORGANIC
E-WASTE
SPECIAL
MIXED
m.malinka/Shutterstock.com

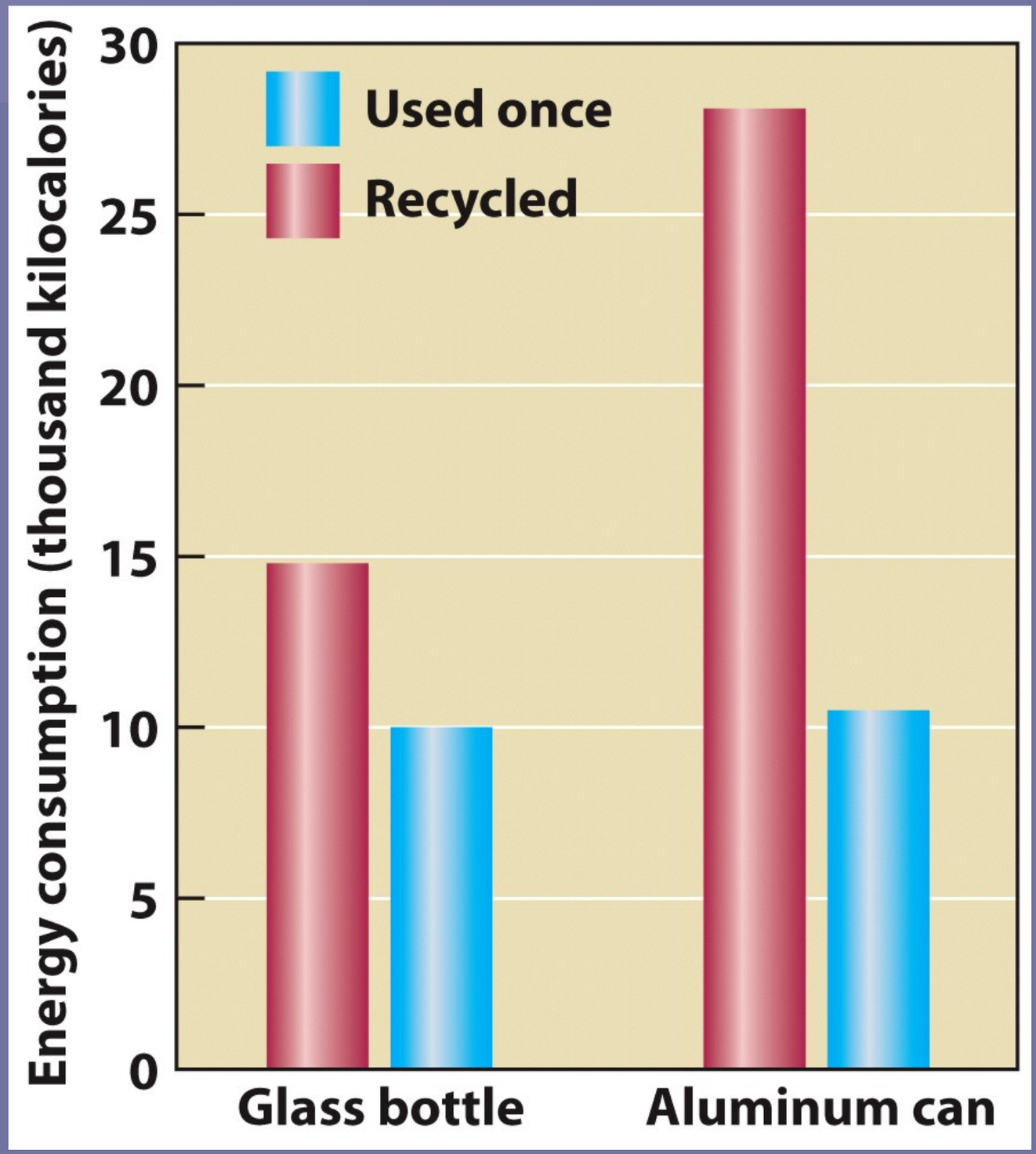
Recycling can be costly

Recycling Materials

- Recycling involves melting or shredding old products to make new products
- Every ton of recycled paper saves:
  - 17 trees
  - 7000 gallons of water
  - 4100 kwatt-hrs of energy
  - 3 cubic yards of landfill space
- Recycle
  - Glass bottles, newspapers, steel cans, plastic bottles, cardboard, office paper

Recycling

- Recycling Paper
  - US recycles 50%
  - Many developed countries are higher
- Recycling Glass
  - US recycles 25%
  - Costs less than new glass (right)



Recycling

- Recycling Aluminum
  - Making new can from recycled one costs far less than making a brand new one
  - 49% of aluminum was recycled in 2007
  - saves: energy, materials (bauxite ores), land and it reduces pollutants
- Recycling Metals other than Aluminum
  - Lead, gold, iron, steel, silver and zinc
  - Metallic composition is often unknown
    - Makes recycling difficult

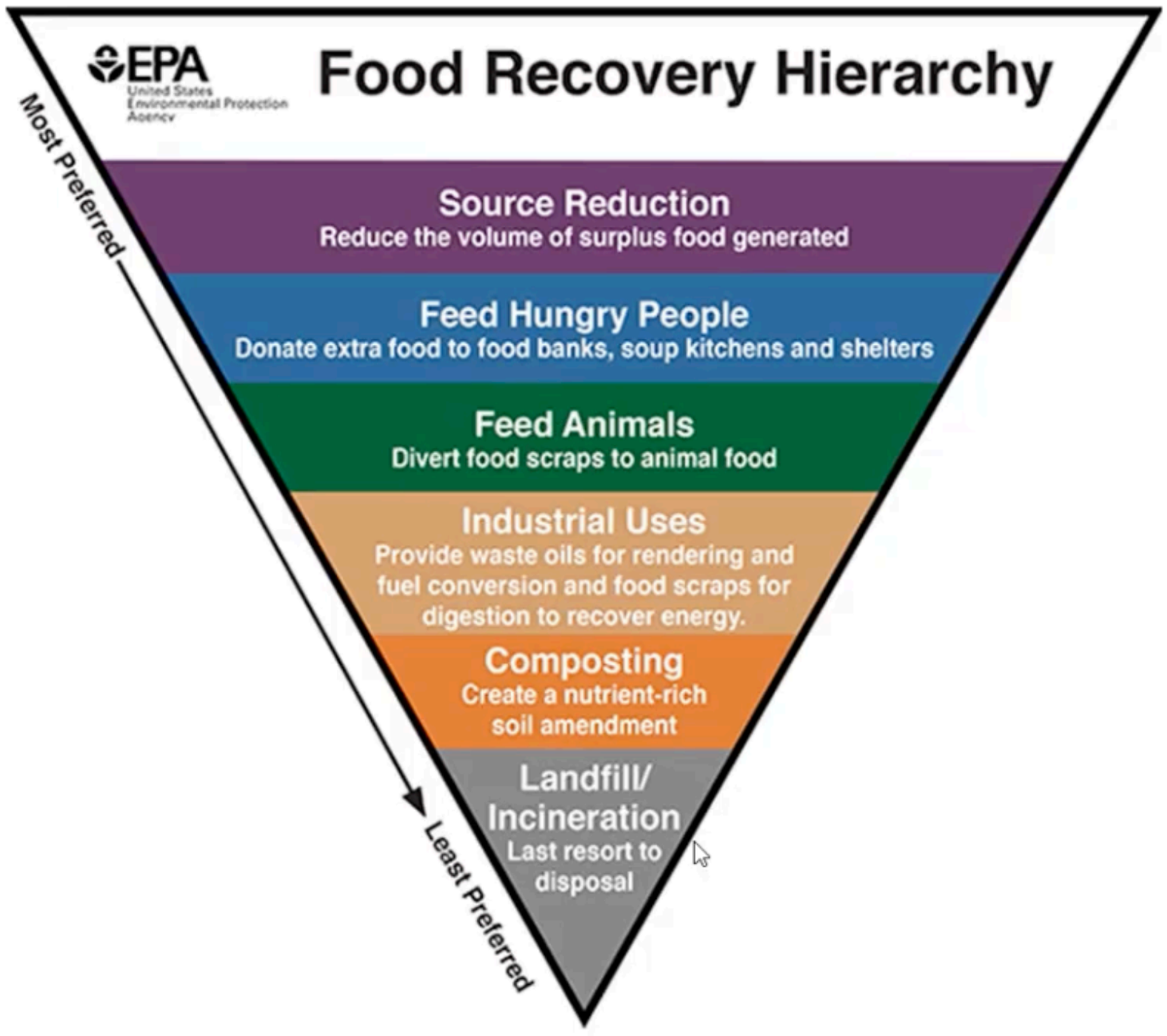
Recycling

- Recycling Plastic
  - 12% of all plastic was recycled in 2007
    - Less expensive to make from raw materials
  - 37% of PET was recycled in 2007
    - Mostly water and soda bottles

Recycling

- Recycling Tires
  - Few products are made from old tires
    - Playground equipment
    - Trashcans
    - Garden hose
    - Carpet
    - Roofing materials
  - 36% of tires are currently recycled to make other products

Composting



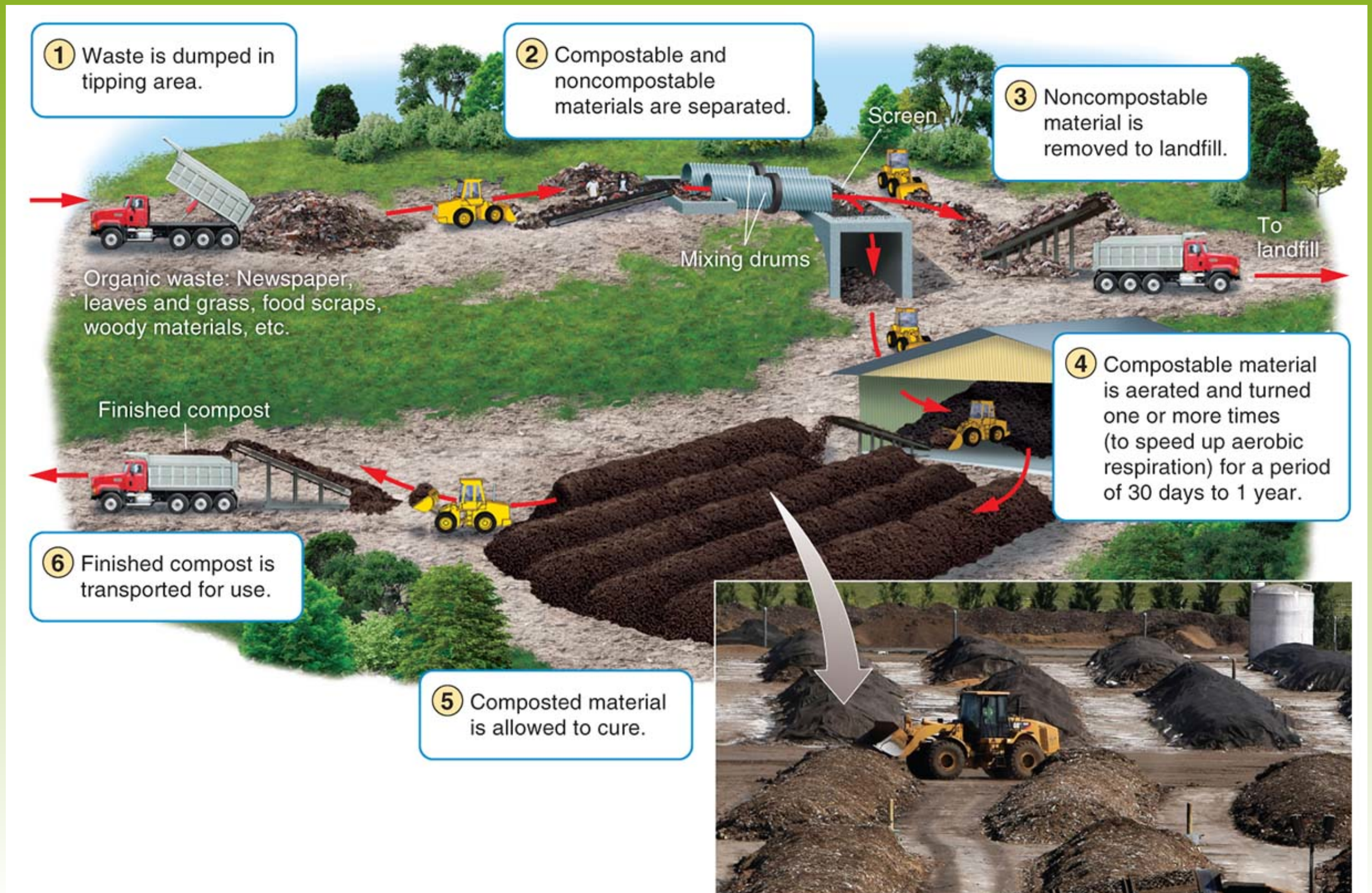
Source: United States Environmental Protection Agency

Composting

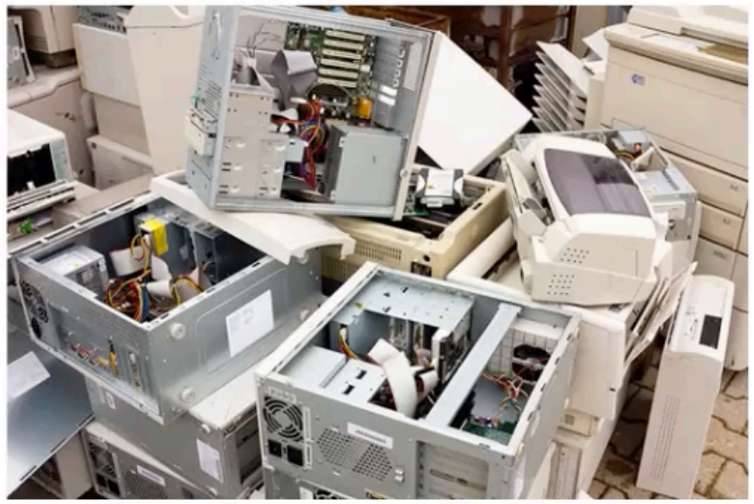

FOOD WASTE
vegetables, fruits, meat, cereals
YARD DEBRIS
branches, flowers, leaves
PAPER PRODUCTS
boxes, paper cups, napkins
COMPOST ITEMS
COMPOSTABLE PLASTICS
disposable tableware, bags, packaging
MISCELLANEOUS
tea bags, pet hair, wooden sticks

Composting

A municipal composting facility. A typical facility collects almost 100,000 metric tons of food scraps and paper per year and turns it into usable compost. Most facilities have some kind of mechanized system to allow mixing and aeration of the organic material, which speeds conversion to compost.



E-Waste



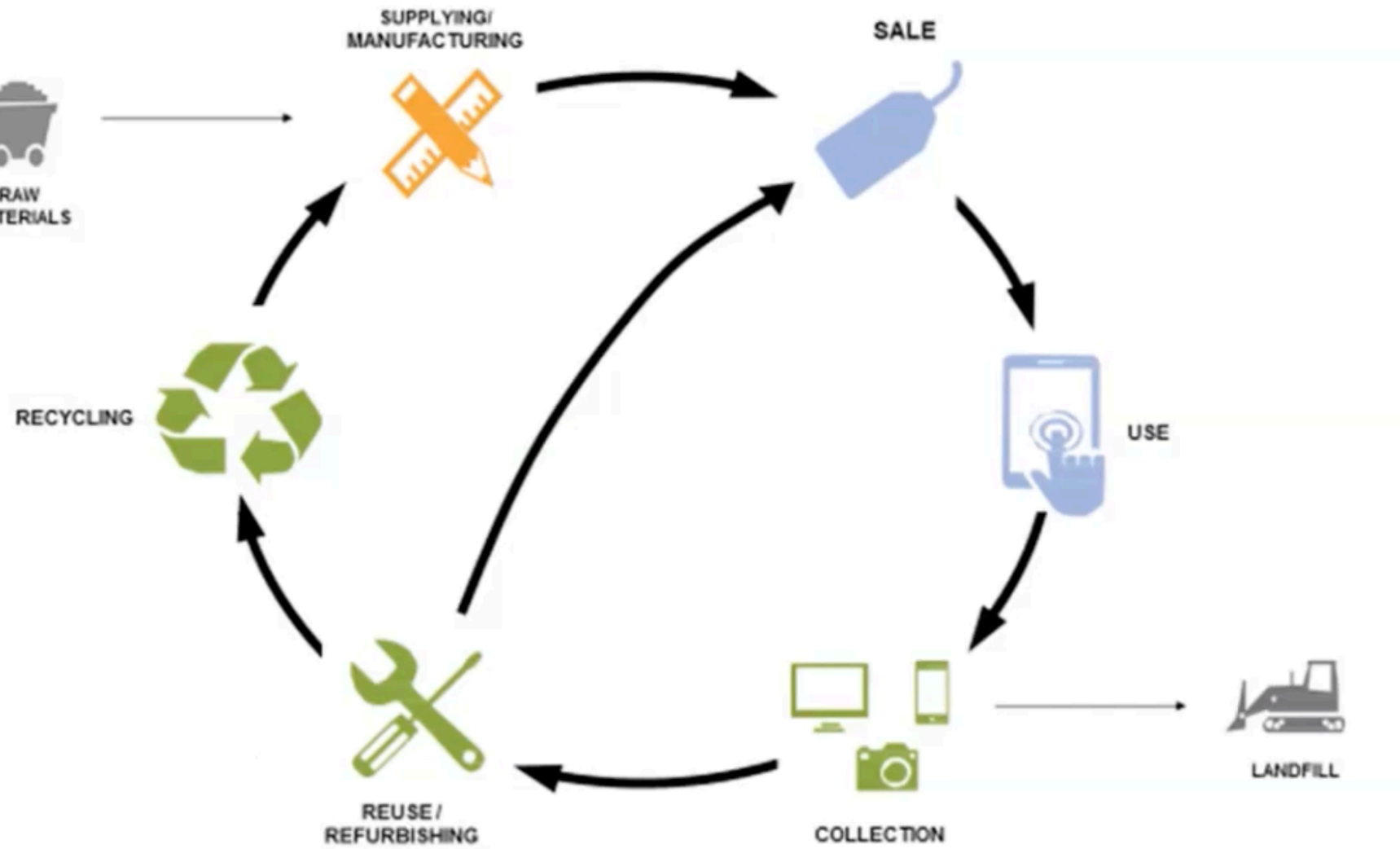
Source: City of San Diego

Photo by NIOSH

- Contains hazardous chemicals like heavy metals (lead, mercury)
  - Can leach into soil and groundwater

- Clean Water Act
- Safe Drinking Water Act
- RCRA – Resource Conservation and Recovery Act
- CERCLA – Comprehensive Environmental Response, Compensation and Liability Act

E-Waste

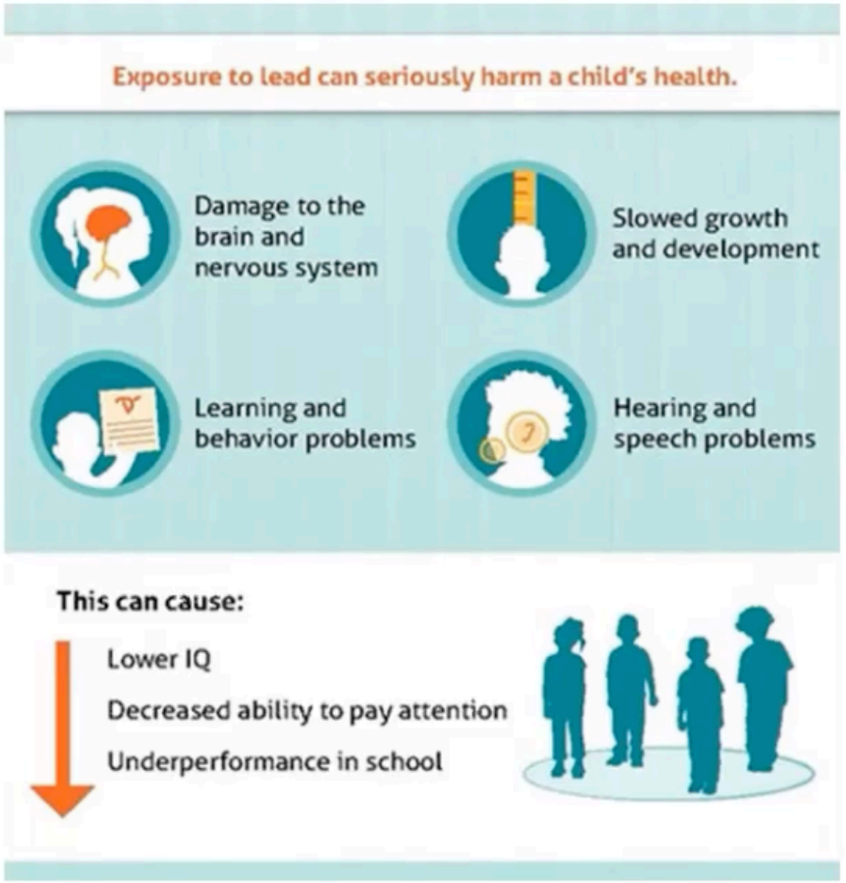

SUPPLYING/
MANUFACTURING
SALE
RAW
MATERIALS
RECYCLING
USE
REUSE /
REFURBISHING
COLLECTION
LANDFILL

E-Waste

Picture above: City of San Diego

Picture to right: Photo by NIOSH

E-Waste



Content source: National Center for Environmental Health, Division of Environmental Health Science and Practice

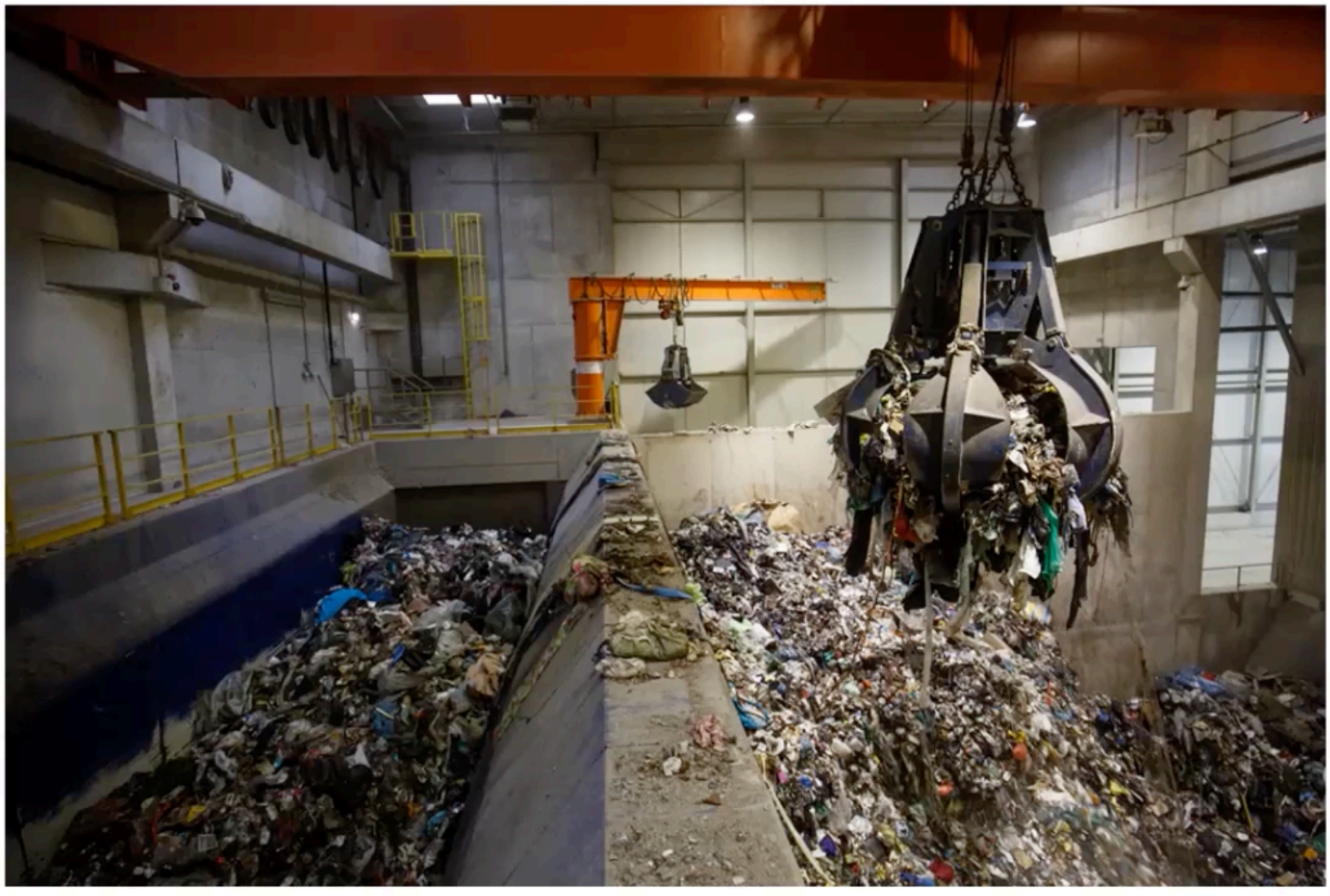
Reference to specific commercial products, manufacturers, companies, or trademarks does not constitute its endorsement or recommendation by the U.S. Government, Department of Health and Human Services, or Centers for Disease Control and Prevention

Source: US Geological Survey

Recycle waste before it goes to a landfill

1. Reduce, reuse, recycle
2. Recycling takes many substances out of the waste stream
   - Paper, wood, lawn waste, glass, metal, etc.
   - Reduces need to mine minerals
   - Costly to pick up, further sort, truly recycle
   - Fees and fines can incentivize recycling
3. Composting produces topsoil
   - Can be done individually or large-scale
   - Can include household scraps, yard waste, agricultural residues
   - Not all household scraps can be composted
   - Can produce odor and attract vermin if not properly maintained
4. E-waste
   - Contains hazardous materials like mercury and lead, so removing it from waste stream is beneficial
   - Heavy metals have human health impacts
   - Relevant laws – RCRA and CERCLA, Clean Water Act, Safe Drinking Water Act

Waste to energy plants



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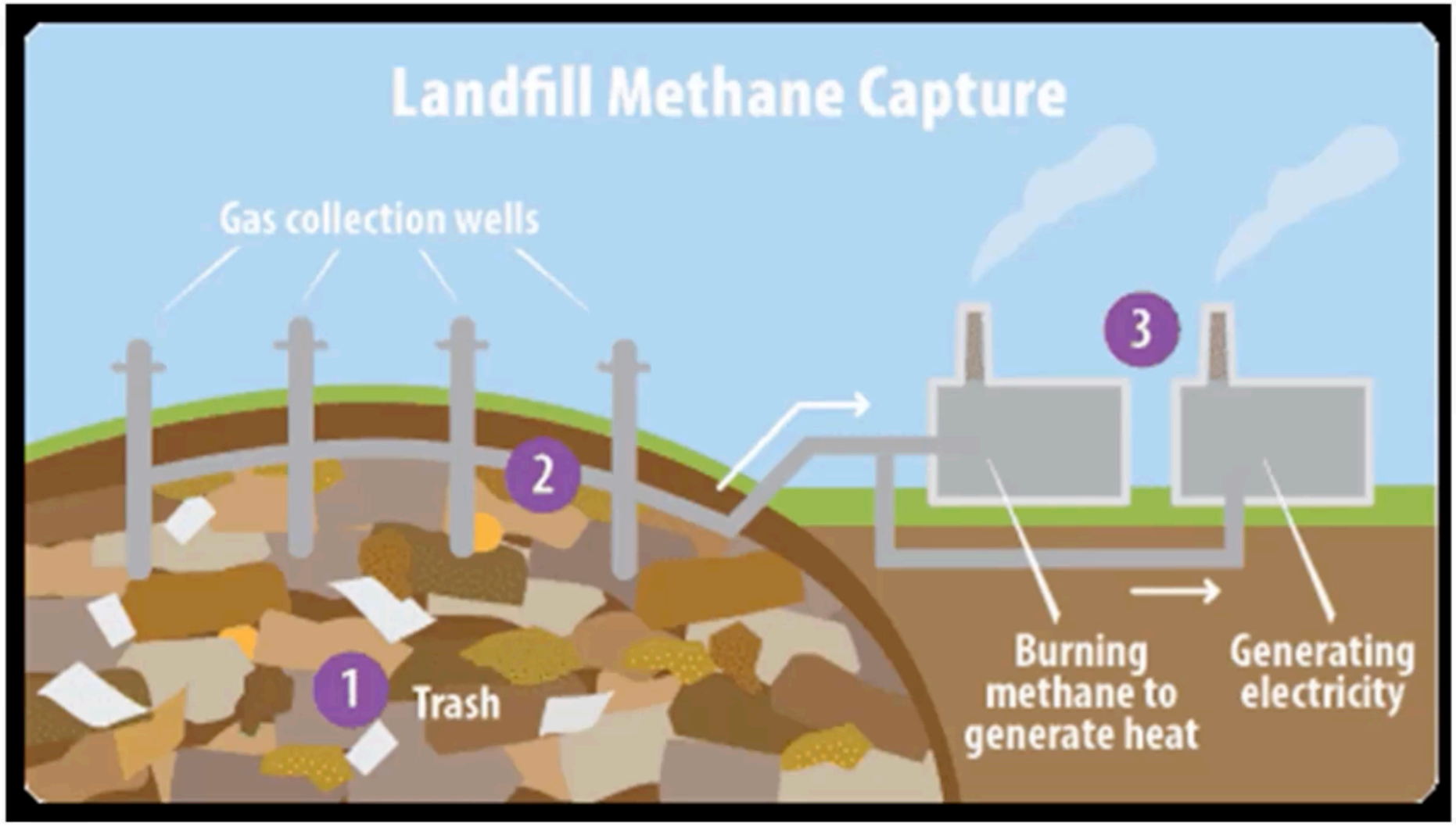
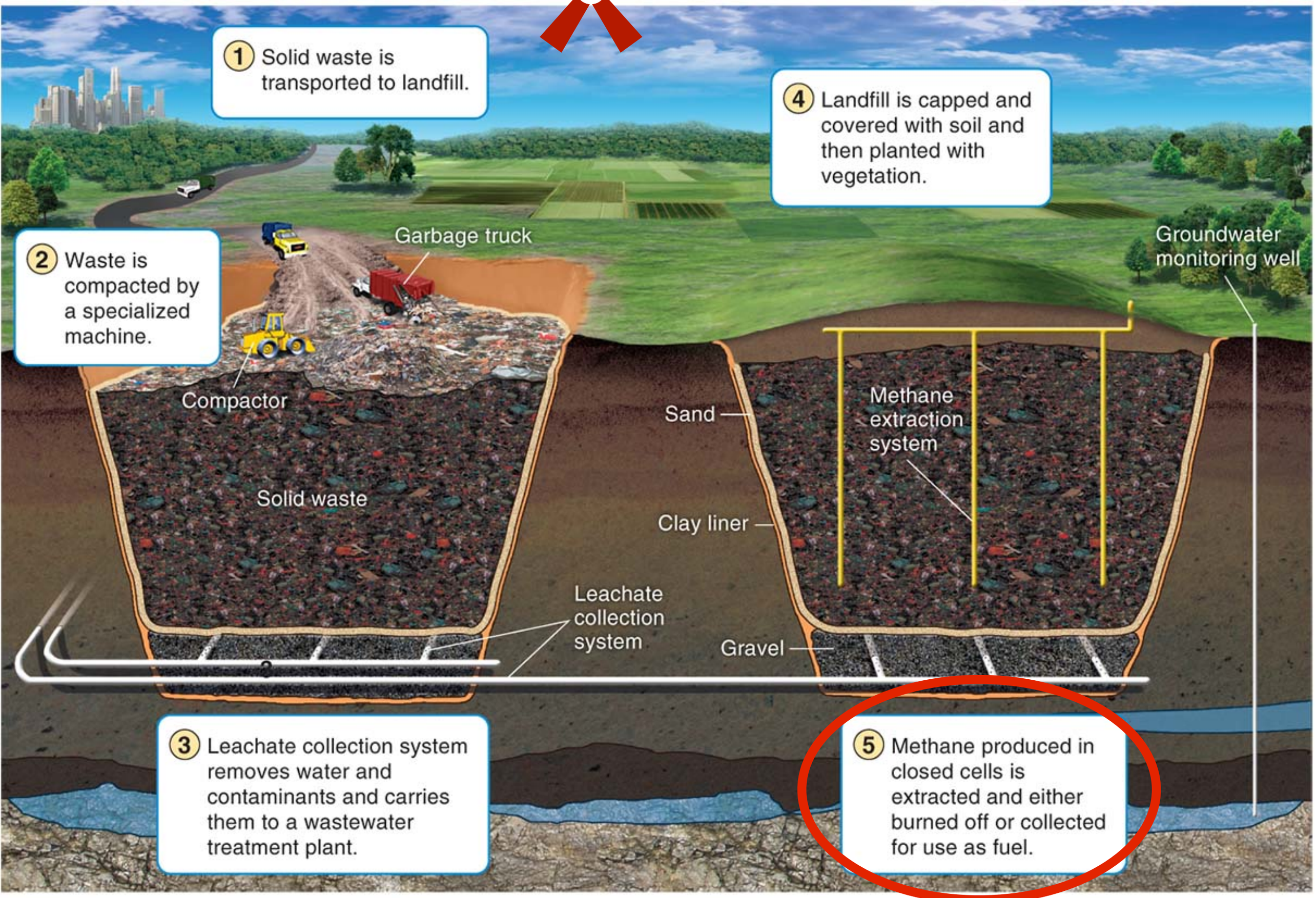
Methane recovery and use

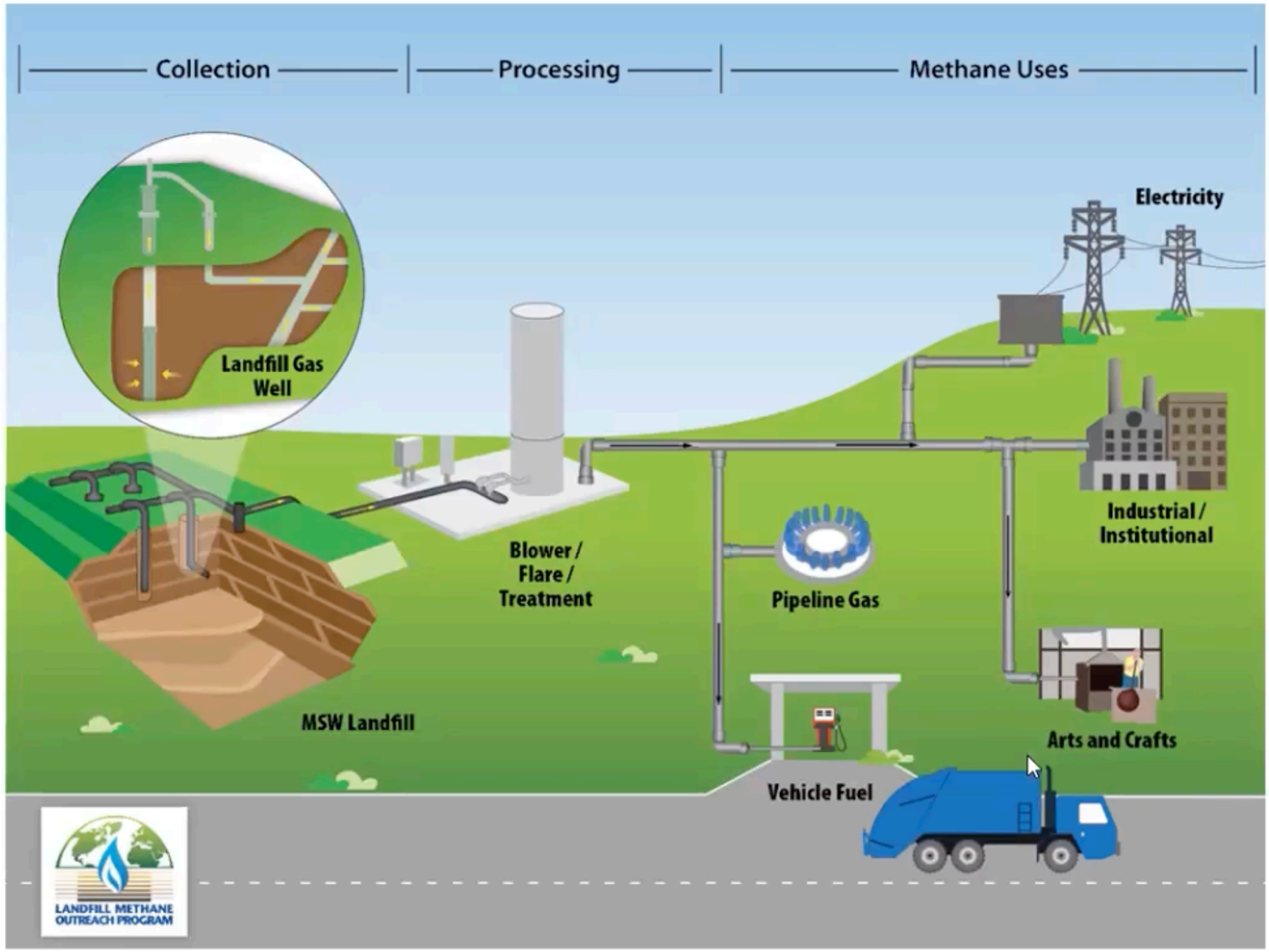
Methane recovery and use



Landfill Basics

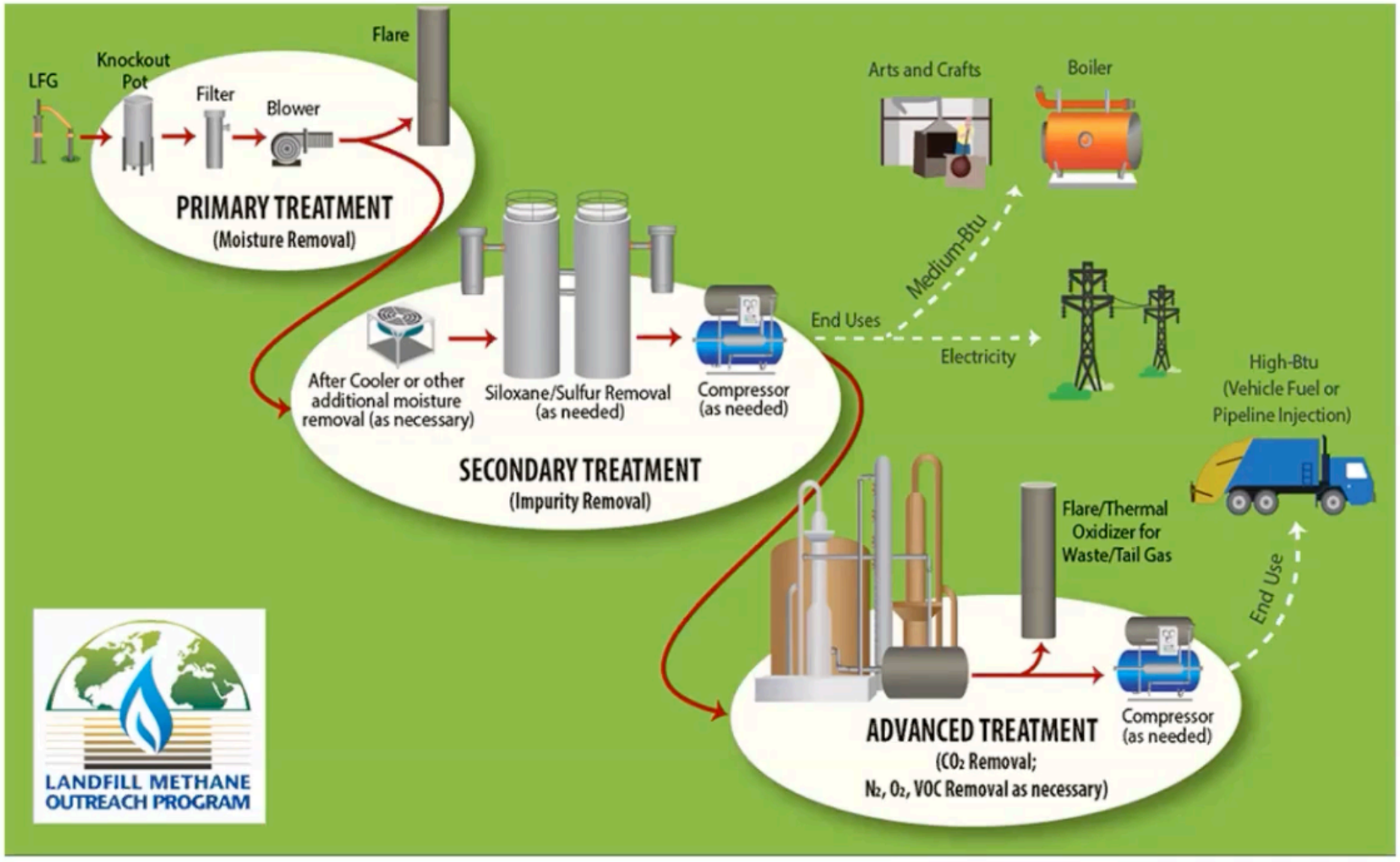


Methane recovery and use



Source: US Environmental Protection Agency

Methane recovery and use



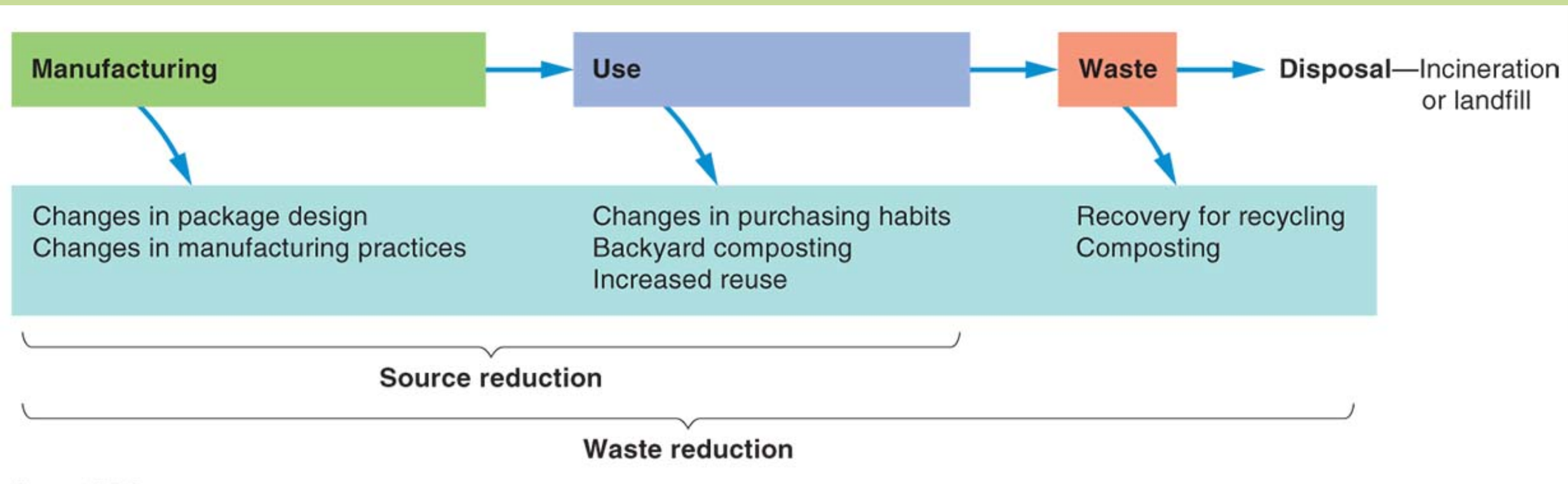
Source: US Environmental Protection Agency

Landfill mitigation strategies

1. Waste to energy plant:
    - Sort waste → some goes to recycling, rest goes to incinerator → waste is burned → water boils → steam turns turbine → turbine turns generator → electricity!
    - Reduces amount of waste in landfill
    - Some waste still produced: ash, hazardous waste, air pollution
2. Methane gas capture and use:
    - Decomposition reduces volume of waste in landfill
    - Gas can be burned to create electricity
    - Some gas can still escape: greenhouse gas
    - Gas is low-quality, requires refining
3. Cap full landfill to use as park, golf course, recreational area, etc.
    - Improves aesthetics of area, can be a source of revenue
    - Still requires monitoring

Integrated waste management is a more holistic approach

A holistic approach to waste management. Depending on the kind of waste and the geographic location, reducing waste can take much less time and money than disposing of it. Horizontal arrows indicate the waste stream from manufacture to disposal and curved arrows indicate ways in which waste can either be reduced or removed from the stream, thereby reducing the amount of waste incinerated or placed in landfills.



Released FRQ Practice - Math

Approximately 30 million mobile devices were sold in 1998 in the United States.

The number sold increased to 180 million devices in 2007.

a. **Calculate** the percent increase of mobile device sales from 1998 to 2007.

b. Each mobile device sold in 2007 contained an average of 0.03 gram of gold. **Calculate** the number of grams of gold that were used in the production of the mobile devices sold in 2007.

Released FRQ Practice - Math

Approximately 30 million mobile devices were sold in 1998 in the United States.

The number sold increased to 180 million devices in 2007.

a. Calculate the percent increase of mobile device sales from 1998 to 2007.

(2 points: 1 point for a correct setup and 1 point for the correct answer)

$$\frac{(180 \text{ million} - 30 \text{ million})}{30 \text{ million}} \times 100\% = 500\%$$

OR

$$\frac{(180 - 30)}{30} \times 100\% = 500\%$$

(Note: Students must show the calculation in order to receive credit for the correct answer. Math setup must be shown for second point.)

Released FRQ Practice - Math

b. Each mobile device sold in 2007 contained an average of 0.03 gram of gold.

Calculate the number of grams of gold that were used in the production of the mobile devices sold in 2007.

(2 points: 1 point for a correct setup and 1 point for the correct answer)

$$1.8 \times 10^8 \text{ devices} \times \frac{3 \times 10^{-2} \text{ grams}}{\text{device}} = 5.4 \times 10^6 \text{ grams or } 5{,}400{,}000 \text{ grams}$$

OR

$$180{,}000{,}000 \text{ devices} \times \frac{0.03 \text{ grams}}{\text{device}} = 5{,}400{,}000 \text{ grams or } 5.4 \times 10^6 \text{ grams}$$

(Note: Students must show the calculation to receive credit for the correct answer. Math setup must be shown for second point. Mass units and correct numbers must be shown for second point.)

TOPIC 8.11

Sewage Treatment

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.N

Describe best practices in sewage treatment.

ESSENTIAL KNOWLEDGE

STB-3.N.1

Primary treatment of sewage is the physical removal of large objects, often through the use of screens and grates, followed by the settling of solid waste in the bottom of a tank.

STB-3.N.2

Secondary treatment is a biological process in which bacteria break down organic matter into carbon dioxide and inorganic sludge, which settles in the bottom of a tank. The tank is aerated to increase the rate at which the bacteria break down the organic matter.

STB-3.N.3

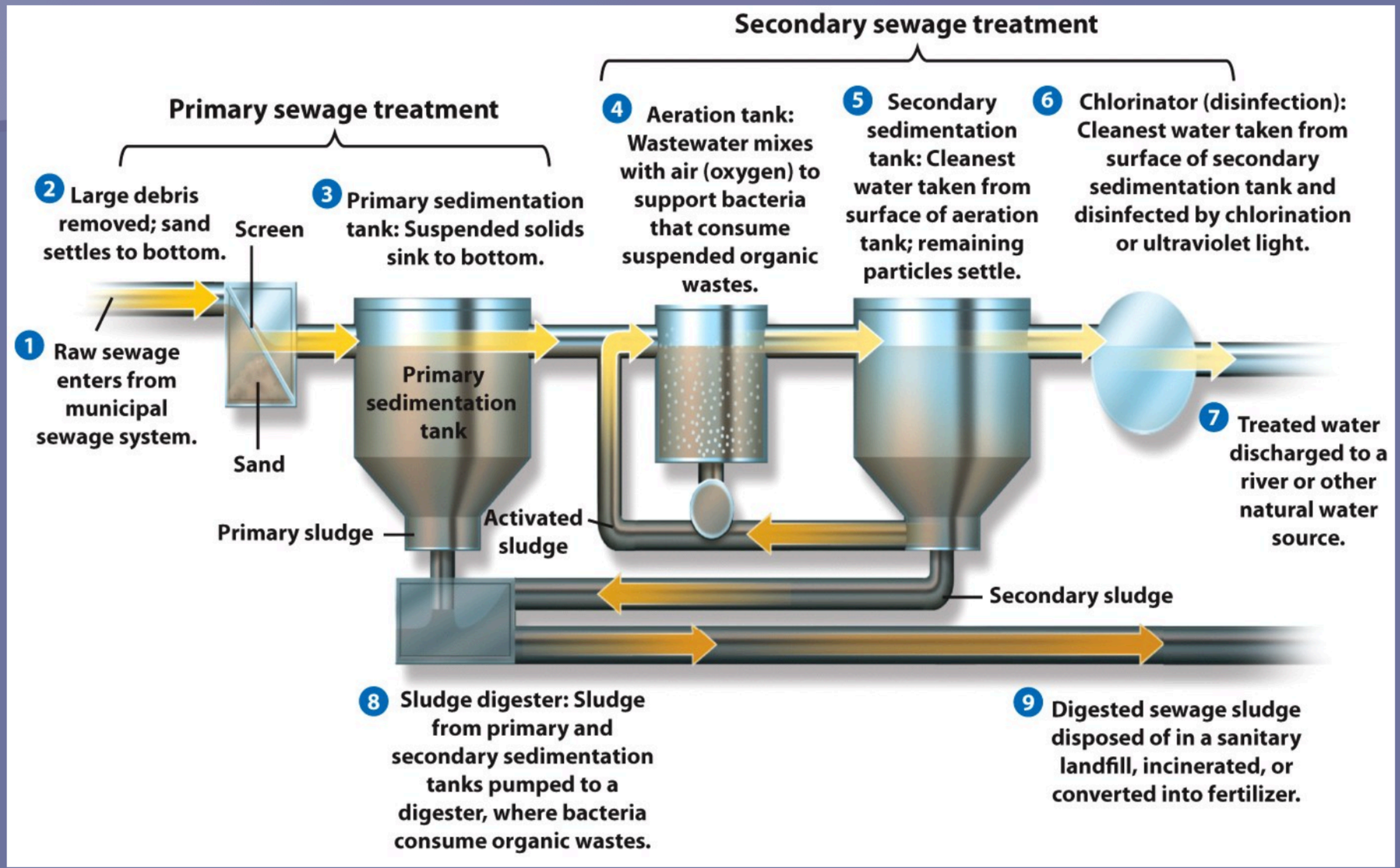
Tertiary treatment is the use of ecological or chemical processes to remove any pollutants left in the water after primary and secondary treatment.

STB-3.N.4

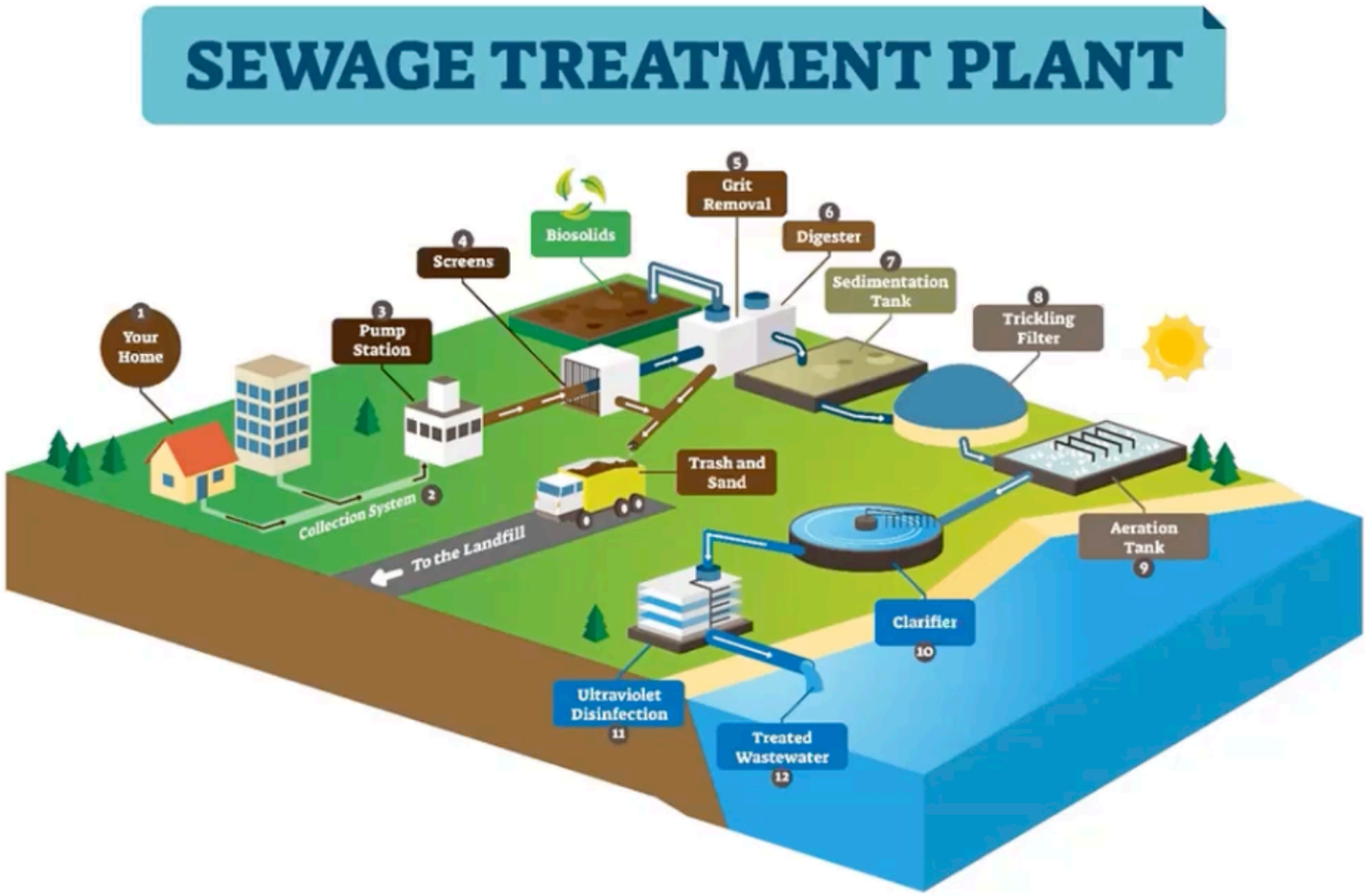
Prior to discharge, the treated water is exposed to one or more disinfectants (usually, chlorine, ozone, or UV light) to kill bacteria.

Sewage treatment plant

Municipal Sewage Treatment

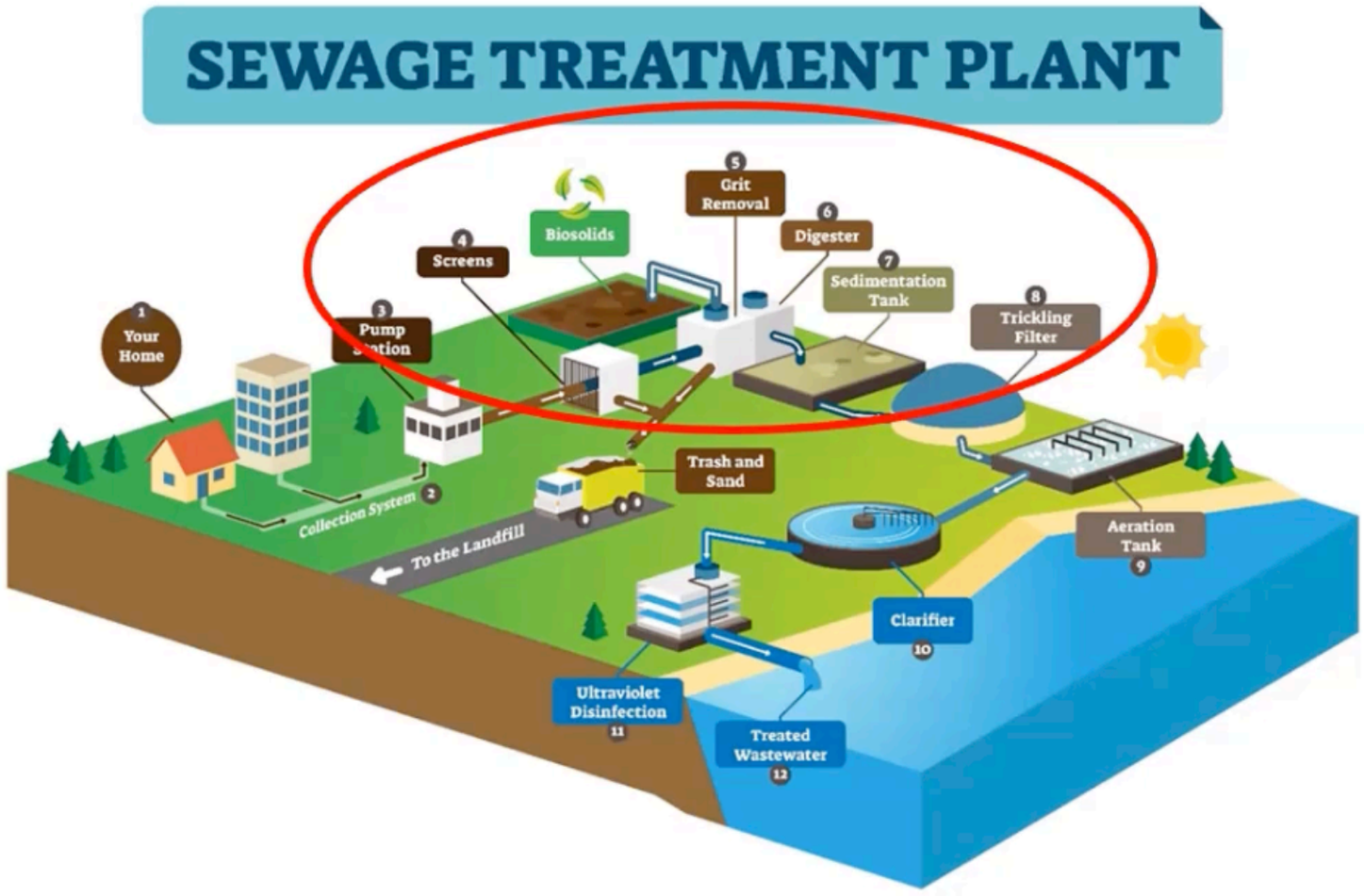


Sewage treatment plant



1. Primary treatment: physical processes
2. Secondary treatment: biological processes
3. Tertiary treatment and disinfection: ecological/chemical processes

Primary treatment



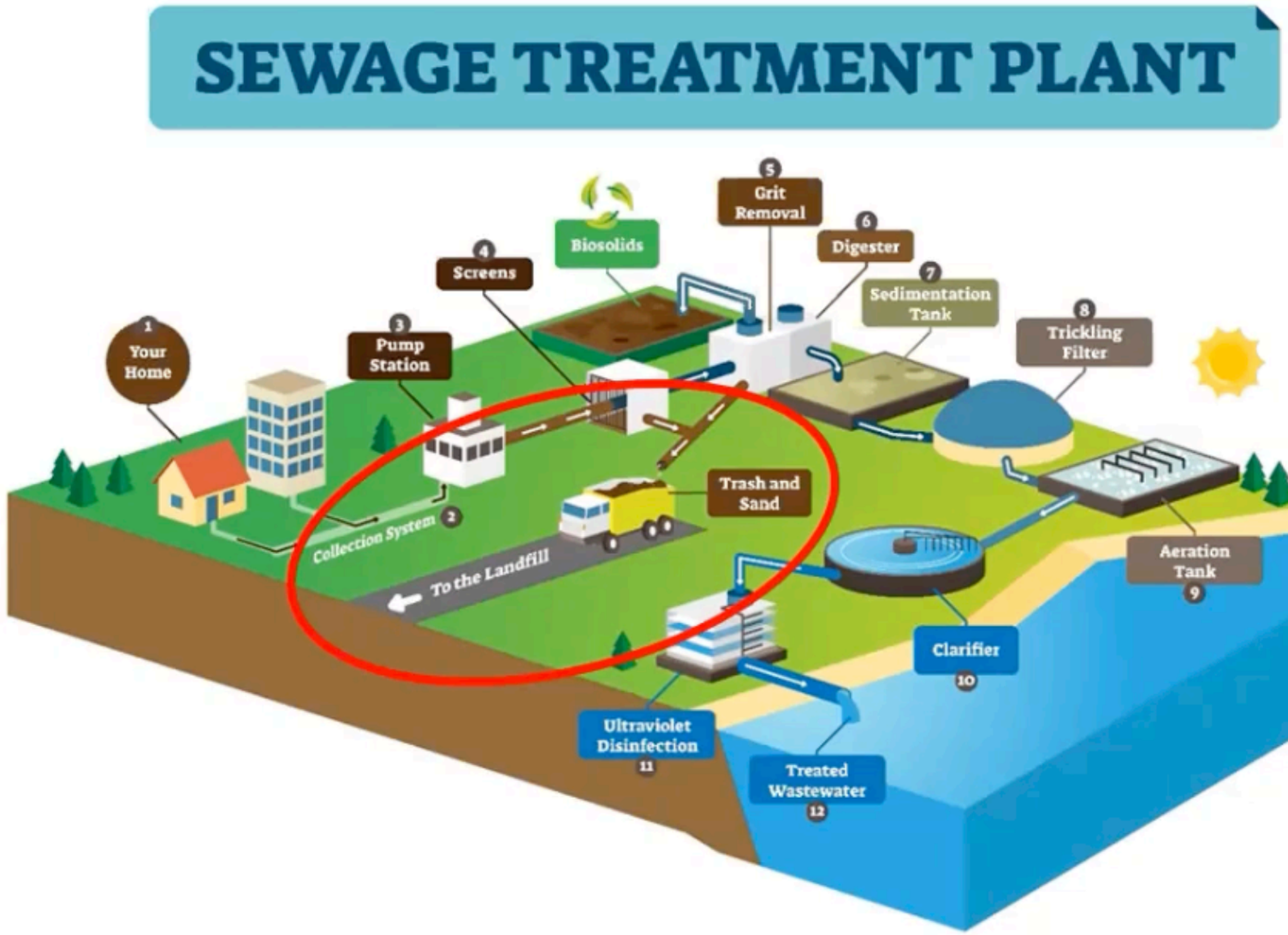
Removal of:

- Sticks
- Rocks
- Rags
- Toys
- Other large objects

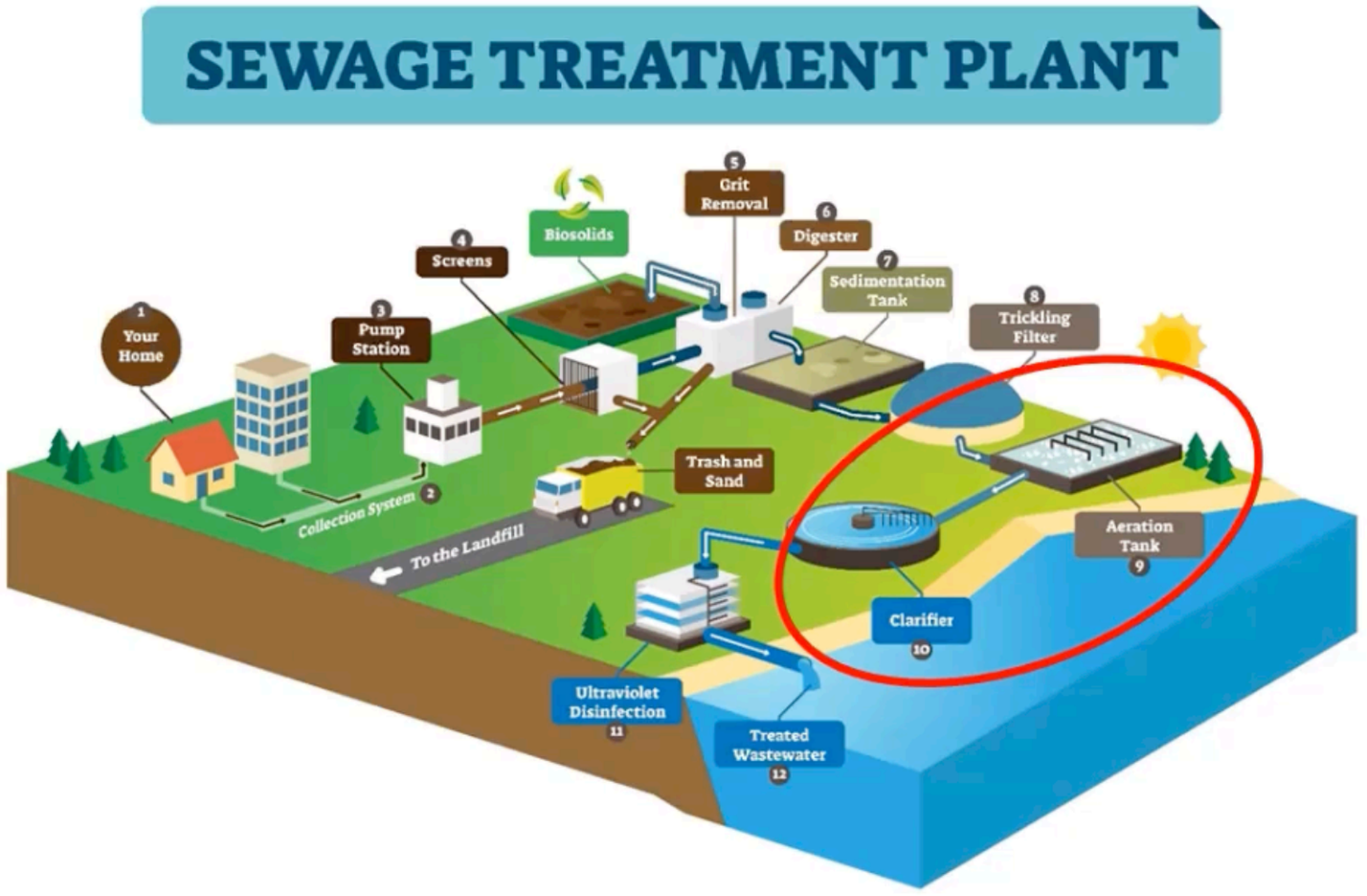
Screening tank

Sattawat thuangchon/Shutterstock.com

Removed objects go to landfill



Secondary treatment



Bacteria perform aerobic decomposition to break down organic matter

- Aeration

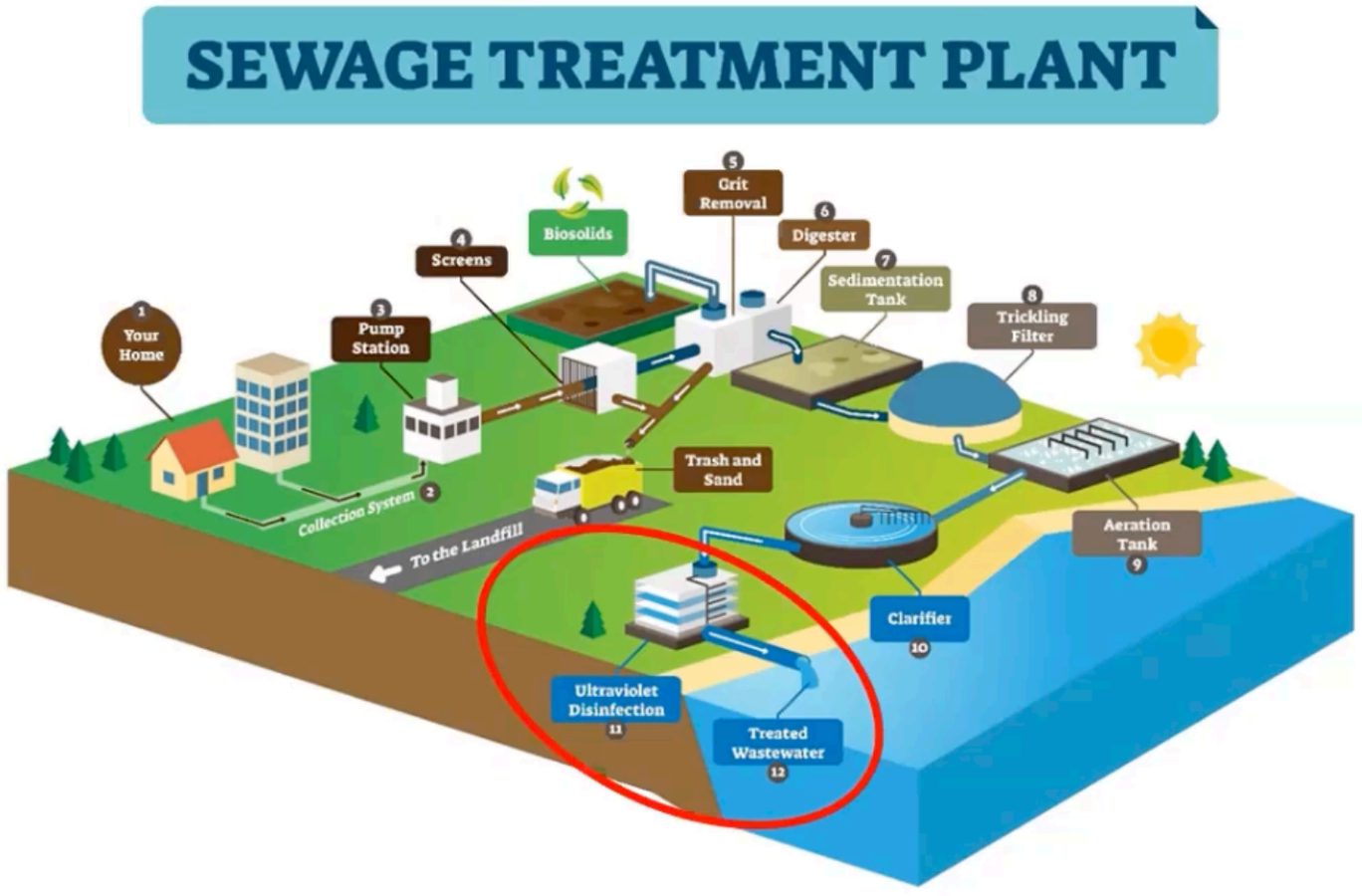
Aeration tank

Sokekyalyaynen/Shutterstock.com

Sewage treatment plant

Source: US Environmental Protection Agency

Tertiary treatment and disinfection



Removes final impurities and pollutants like nitrogen/phosphorus-based chemicals

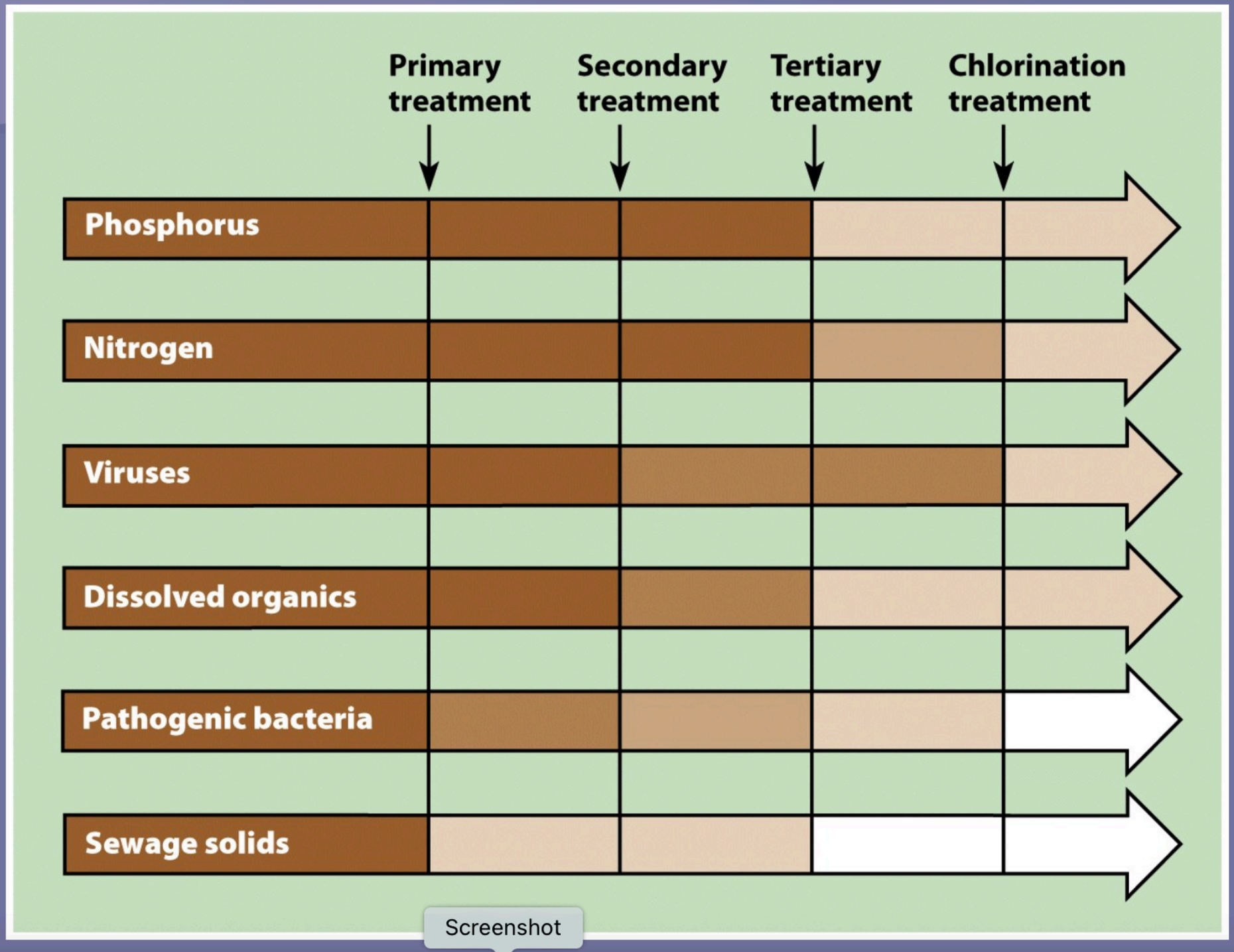
Disinfection uses:

- Chlorine
- Ozone
- UV light

<u>Pollutants: Pathogenic contaminants</u>

- *E. coli* bacteria
- Coliform bacteria
- *Giardia*
- Pathogens
- Microorganisms/bacteria
- Cholera
- Viruses

Municipal Sewage Treatment



Screenshot

Water quality is monitored at all stages

Clean Water Act

Safe Drinking Water Act

Sewage treatment follows a series of steps

1. Primary treatment
    - Physical process: screens and grates
    - Removes large objects
2. Secondary treatment
    - Biological process: bacteria break down organic matter via aerobic decomposition
    - Products: carbon dioxide and sludge
3. Tertiary treatment
    - Ecological/chemical processes
    - Removes removing pollutants, nitrogen/phosphorus compounds
4. Disinfection
    - Kills bacteria
    - Ozone, chlorine, or UV light
5. All steps monitored
    - Clean Water Act, Safe Drinking Water Act

TOPIC 8.12

Lethal Dose 50% (LD_{50})

Required Course Content

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.A

Define lethal dose 50% (LD_{50}).

ESSENTIAL KNOWLEDGE

EIN-3.A.1

Lethal dose 50% (LD_{50}) is the dose of a chemical that is lethal to 50% of the population of a particular species.

Everything has an LD_{50}

Lethal dose 50%:

- Amount of a substance that is lethal to 50% of a population of animals
- Common unit: mg substance/kg body mass
- Data is extrapolated to predict effects on humans.

Cozine/Shutterstock.com

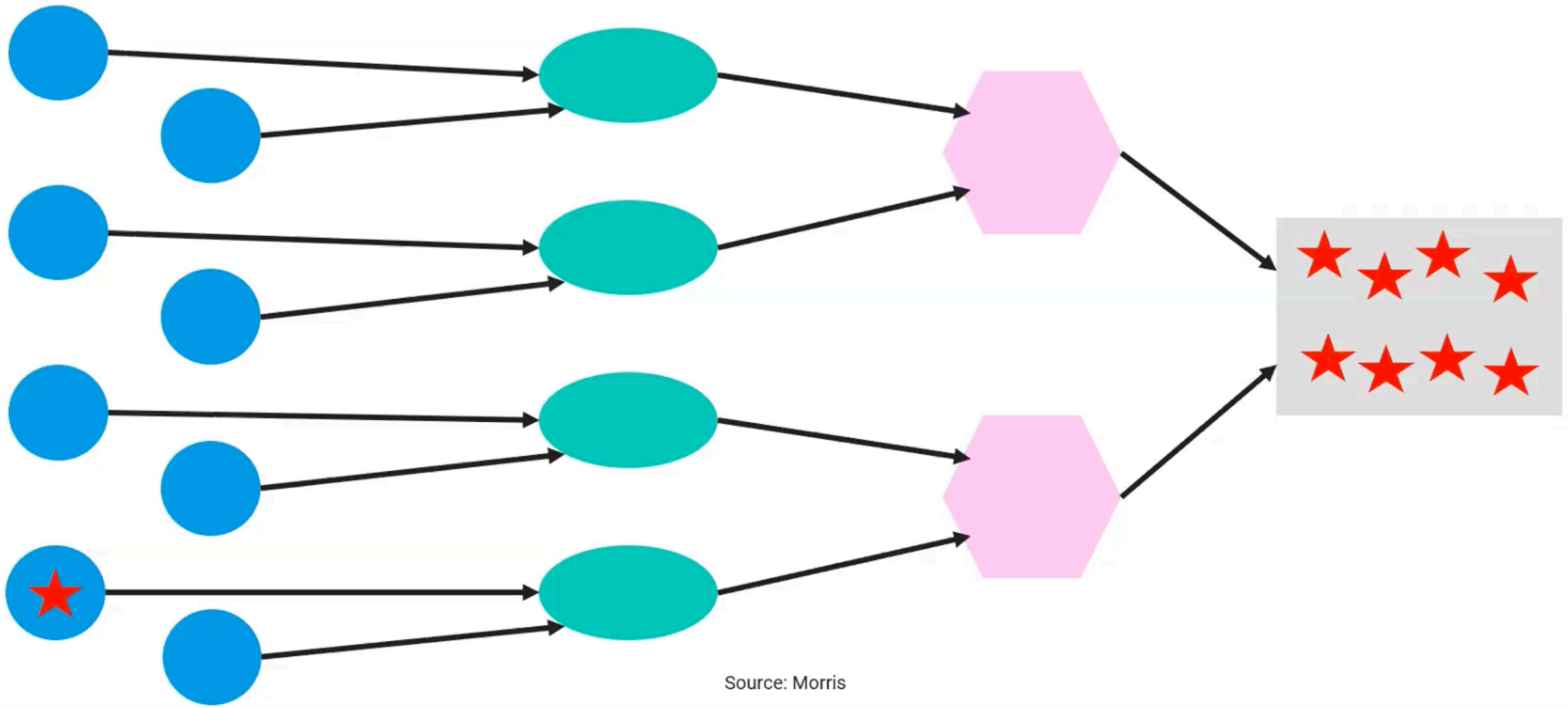
Everything has an LD_{50}

Lethal dose 50%:

- Amount of a substance that is lethal to 50% of a population of animals
- Common unit: mg substance/kg body mass
- Data is extrapolated to predict effects on humans.

RHJPhtotoandilustration/Shutterstock.com

Biomagnification



Source: Morris

MCQ Practice

A rodenticide has an LD_{50} of 50 mg/kg. A typical male rat has a mass of 0.5 kg. Which of the following methods would best convert the LD_{50} to mg per rat?

A 50 mg/kg x 50% x 0.5 kg/rat

B 50 mg/kg x 50% x 1 rat

C 50 mg/kg x 0.5 x 0.5 kg/rat

D 50 mg/kg x 0.5 kg/rat

LD_{50} allows for toxins to be compared

1. Amount of chemical that is lethal to 50% of a population
2. Measured by unit of body mass so comparisons can be exact
3. Effects extrapolated to humans
4. Helps to explain outcomes of biomagnification

TOPIC 8.13

Dose Response Curve

Required Course Content

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.B

Evaluate dose response curves.

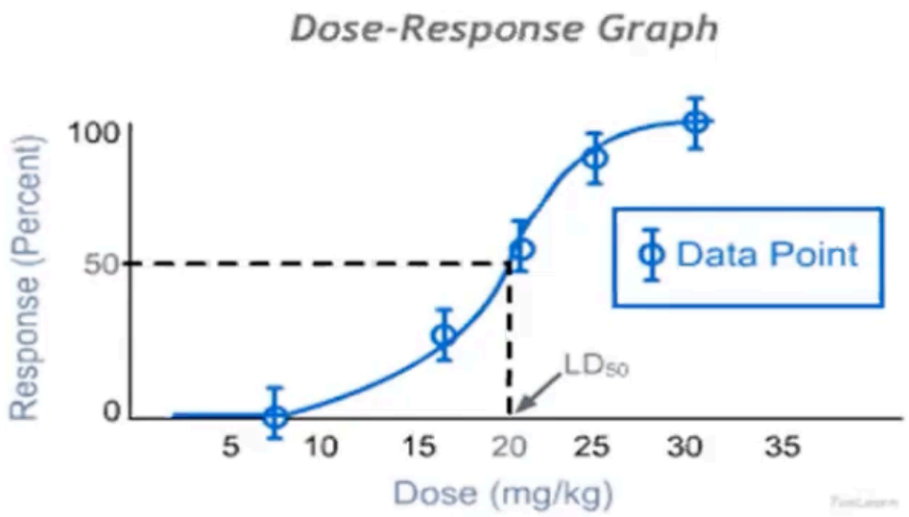
ESSENTIAL KNOWLEDGE

EIN-3.B.1

A dose response curve describes the effect on an organism or mortality rate in a population based on the dose of a particular toxin or drug.

Dose response curve

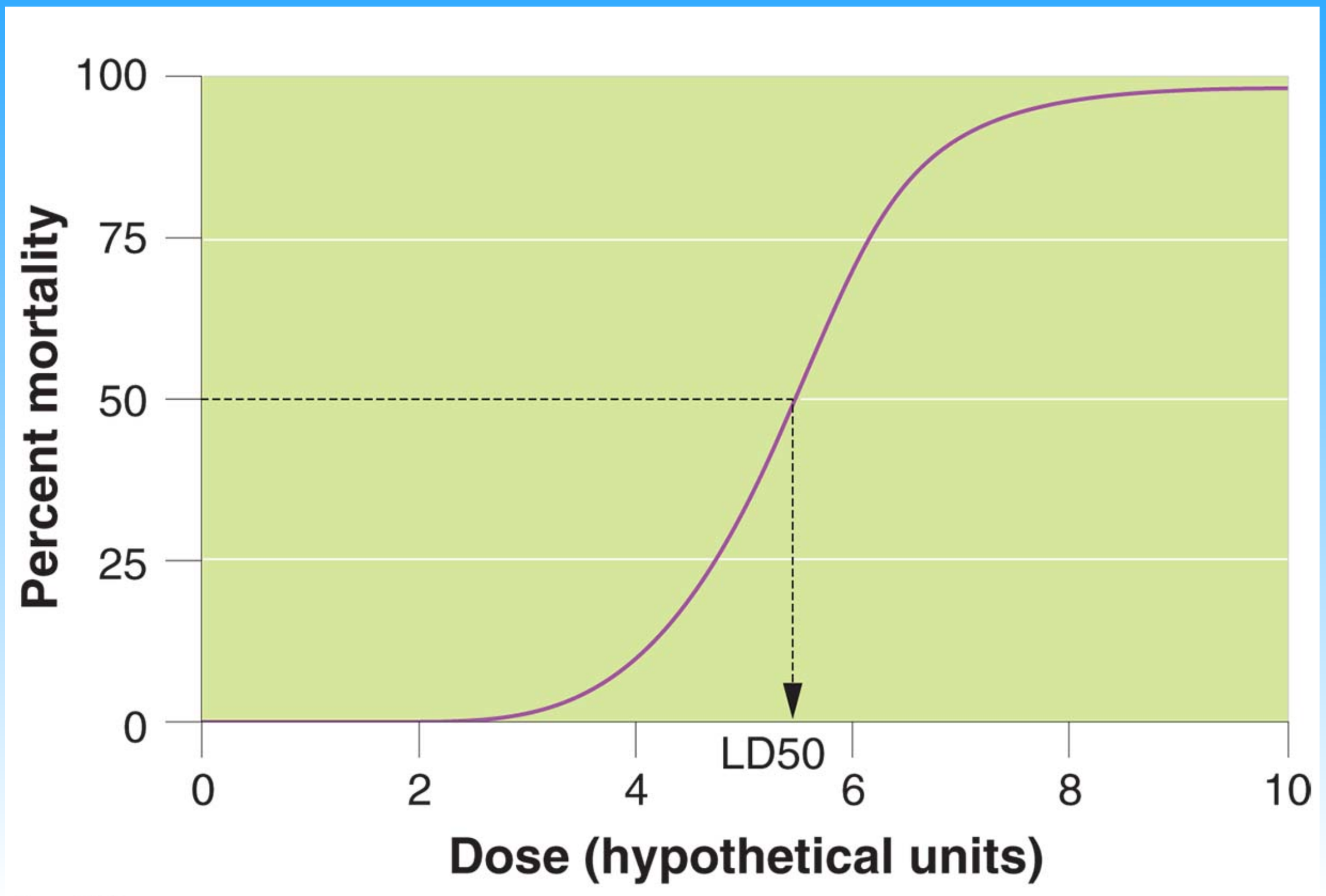
- Shows data collected while testing effect a toxin/drug has on a given population
- LD50 can be determined from graph
- Threshold dose can be determined from graph
- Effects of toxin/drug on humans can be extrapolated from graph



"Mg/kg" refers to the amount of the chemical in milligrams per kilogram of body weight of the subject.

Courtesy of the US National Library of Medicine

LD50 studies. To determine the dose of a chemical that causes a 50 percent death rate, scientists expose animals to different doses of a chemical and determine what proportion of the animals die at each dose. Such an experiment typically produces an S-shaped curve.



Dose Response Studies

- **Sublethal effect** The effect of an environmental hazard that is not lethal, but which may impair an organism's behavior, physiology, or reproduction.

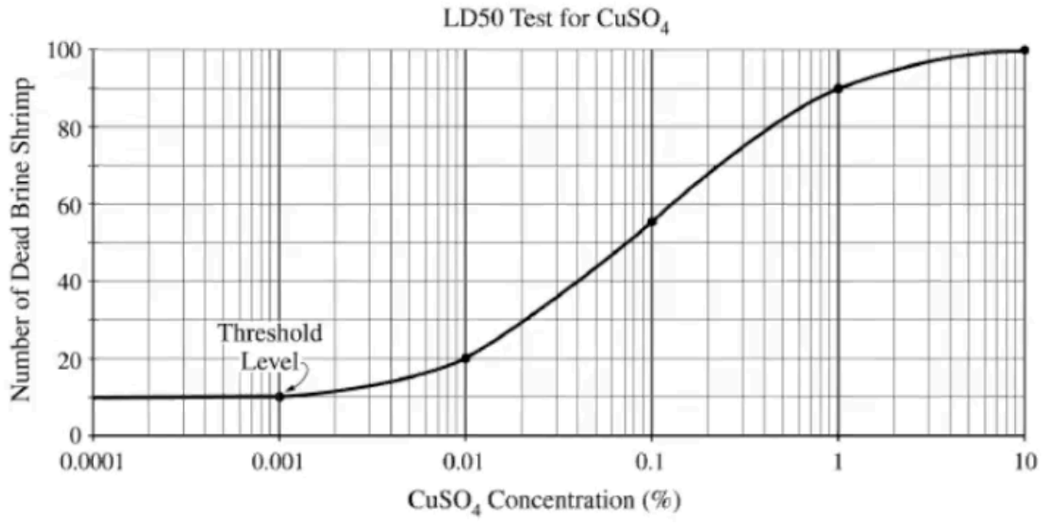
- **ED50** The effective dose of a chemical that causes 50 percent of the individuals in a dose-response study to display a harmful, but nonlethal, effect.

- Conducting LD50 and ED50 studies would be unethical so mice and rat values are used to determine safe guidelines for humans

- In short mice/rat LD50 and ED50 values are divided by 1000 to determine human values

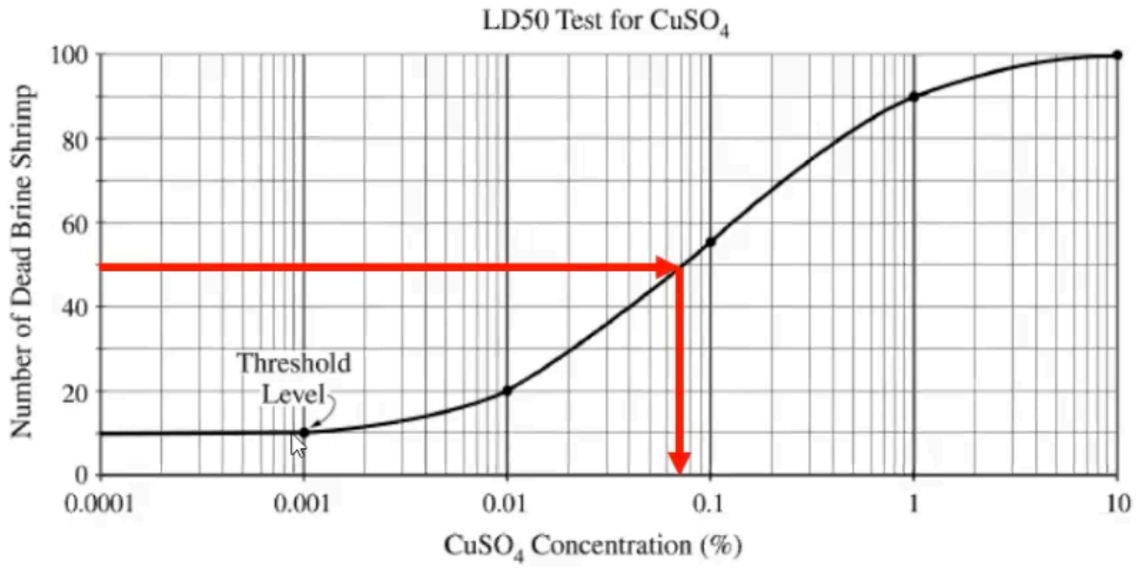
Released FRQ Practice

An experiment is performed to test the toxicity of copper sulfate ($CuSO_4$) using brine shrimp as a test organism. Six different concentrations of $CuSO_4$ solution are prepared in separate petri dishes, and 100 brine shrimp are placed in each dish. After 48 hours, the number of brine shrimp that have died is counted and recorded. The results have been plotted on the graph below.



a. **What is** the LD_{50} concentration for brine shrimp?
b. **Explain** the meaning of the term "threshold level of toxicity."

Released FRQ Practice



Explain the meaning of the term "threshold level of toxicity."

The dose below which no toxic/lethal effects are observed and/or above which the toxic/lethal effects are apparent.

Dose response curves show trends

1. Specific data points can be determined: threshold dose, LD_{50} dose.
2. Overall shape of curve can be interpreted.
3. Dose response curves can be compared between substances.

Pollution and Human Health

Required Course Content

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.C

Identify sources of human health issues that are linked to pollution.

ESSENTIAL KNOWLEDGE

EIN-3.C.1

It can be difficult to establish a cause and effect between pollutants and human health issues because humans experience exposure to a variety of chemicals and pollutants.

EIN-3.C.2

Dysentery is caused by untreated sewage in streams and rivers.

EIN-3.C.3

Mesothelioma is a type of cancer caused mainly by exposure to asbestos.

EIN-3.C.4

Respiratory problems and overall lung function can be impacted by elevated levels of tropospheric ozone.

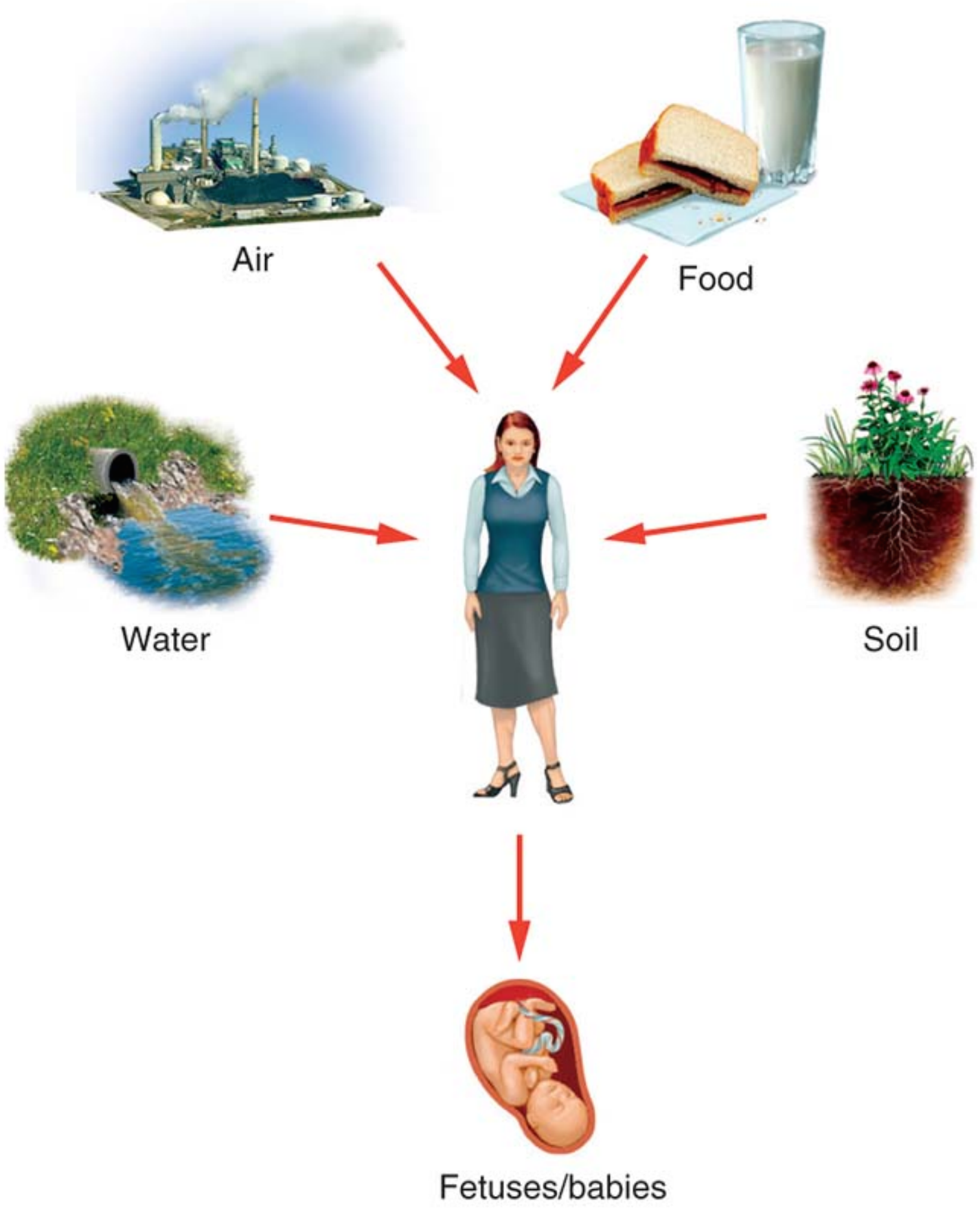
Diverse exposures

It can be difficult to establish a cause and effect between pollutants and human health issues because humans experience exposure to a variety of chemicals and pollutants:

- Food
- Water
- Air
- Building materials and household items

There are health issues, however, that are clearly linked with certain environmental conditions or exposures.

If you haven't already watched videos for Topics 8.12 & 8.13, consider doing so as they explore how toxicities are determined.



Routes of Exposure

Routes of exposure. Despite a multitude of potential routes of exposure to chemicals, most chemicals have a limited number of major routes.

Dysentery

Joe Souza / Shutterstock.com

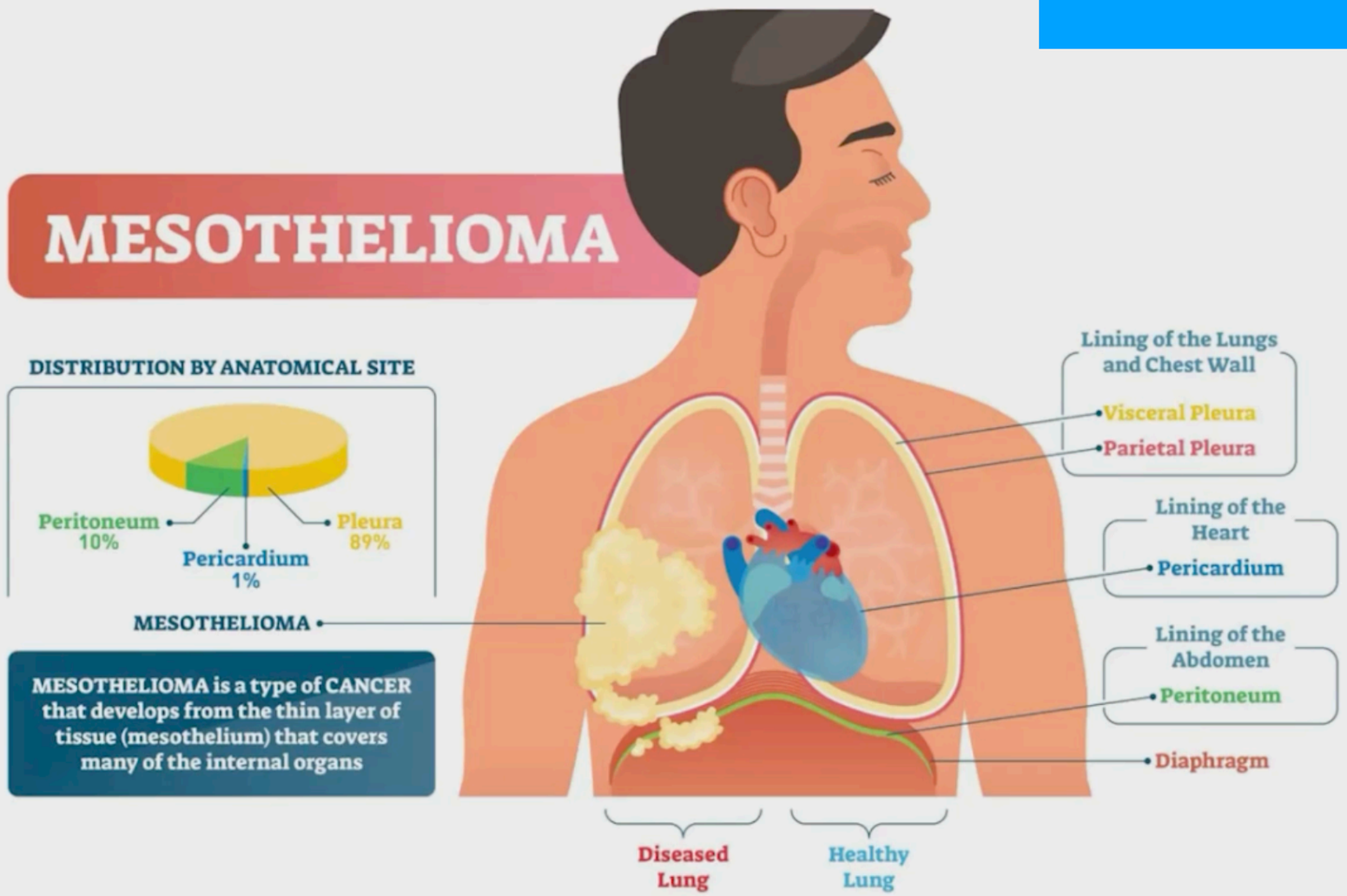
Dysentery is inflammation of the intestines caused by bacteria or parasites. People can experience bloody diarrhea and abdominal cramping.

Dysentery is caused by untreated sewage in streams and rivers. Contamination can be detected by sampling for fecal coliform in water sources.

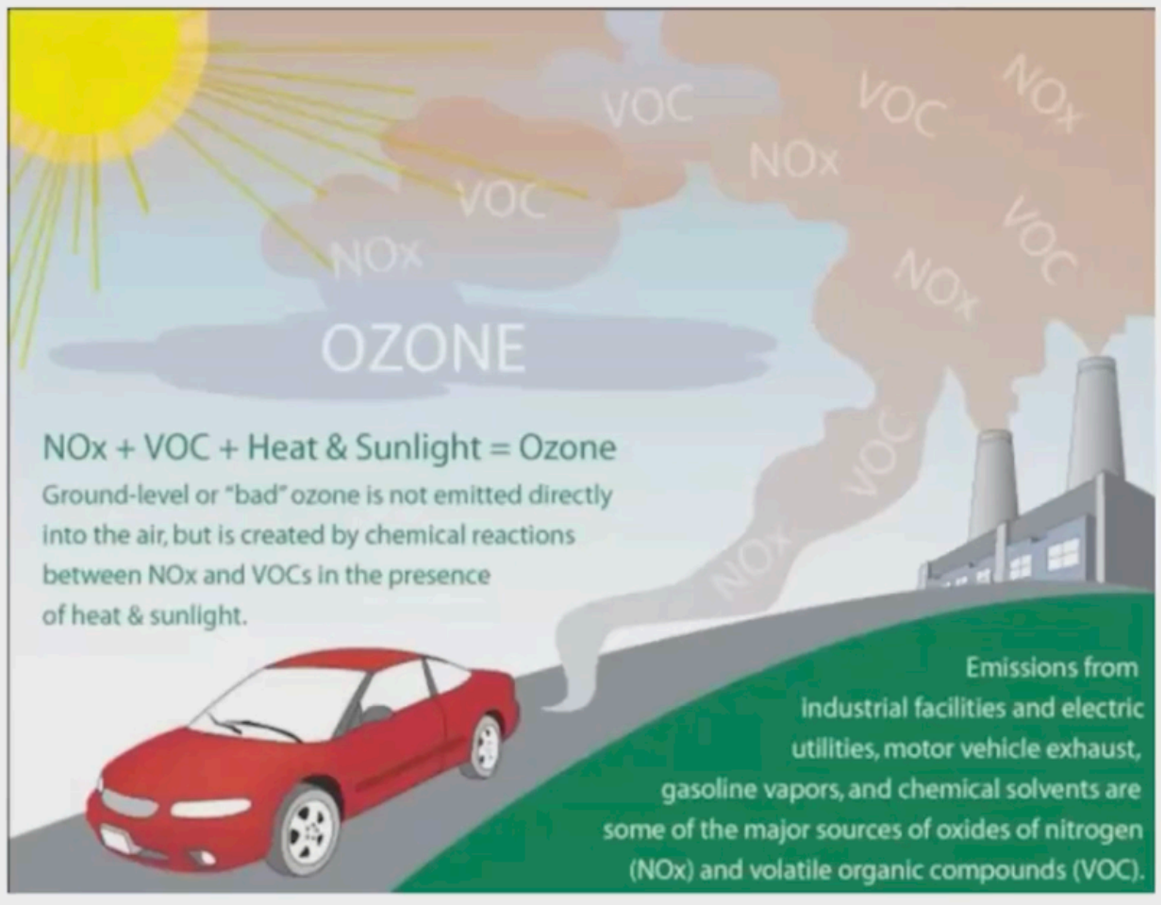
Mesothelioma

Exposure to asbestos, a type of insulation material, can result in this type of cancer.

Asbestos is a natural mineral made of tiny glass-like fibers that are easily inhaled. Over time, this inflammation damages the cells lining the lungs, heart, and abdomen.



Tropospheric ozone causes respiratory issues



Ground level ozone is a secondary air pollutant that is formed from volatile organic compounds, nitrogen oxides, and sunlight.

EPA's Air Quality Index (AQI) can help communities notify people, especially those already at risk of respiratory conditions like asthma, when air quality is a threat to health.

Lung function can be compromised

Ozone can constrict the
muscles in our airways.
This traps air in the alveoli
of the lungs causing shortness of breath.

Ozone can also inflame and damage
airways while also making lungs more
susceptible to infections.

Ideas to take away

- Humans are exposed to many chemicals and pollutants and at varying levels, so it is not always easy to show a direct cause and effect relationship, although they do exist.

- Dysentery is characterized by bloody diarrhea and is caused by bacteria in untreated sewage in water sources.

- Asbestos can cause mesothelioma, a cancer mainly in the lungs, but can include the linings of the heart and abdomen.

- Ground level ozone can inflame and damage people's airways and lungs.

Describe an aspect of a research method, design, or measure used.

A small, remote community in rural Alaska is hoping to upgrade their wastewater treatment facility by adding an additional step of UV light exposure before discharging treated water. UV light destroys the DNA of disease-causing microbes so they cannot reproduce. They will be testing three different lengths of time the water is in contact with the UV light. This is called contact time. After UV exposure, bacterial sampling will take place.

In the experiment above, what would be an appropriate control?

A. A control would be to keep the contact time the same for all samples.

B. A control would be wastewater that has no contact time with the UV light.

C. A control would be the type of bacteria tested.

D. A control would be to use a different type of light besides UV for the contact time.

Ecotoxicology

- Dilution Paradigm is not valid
  - "Dilution is the solution to pollution"
- Boomerang Paradigm is accepted
  - "What you throw away can come back and hurt you"
- Ecotoxicology
  - The study of contaminants in the biosphere and their harmful effects on ecosystems
  - Helps policy makers determine costs and benefits of industrial and technological "advances"

TOPIC 8.15

Pathogens and Infectious Diseases

ENDURING UNDERSTANDING

EIN-3

Pollutants can have both direct and indirect impacts on the health of organisms, including humans.

LEARNING OBJECTIVE

EIN-3.D

Explain human pathogens and their cycling through the environment.

ESSENTIAL KNOWLEDGE

EIN-3.D.1

Pathogens adapt to take advantage of new opportunities to infect and spread through human populations.

EIN-3.D.2

Specific pathogens can occur in many environments regardless of the appearance of sanitary conditions.

EIN-3.D.3

As equatorial-type climate zones spread north and south in to what are currently subtropical and temperate climate zones, pathogens, infectious diseases, and any associated vectors are spreading into these areas where the disease has not previously been known to occur.

EIN-3.D.4

Poverty-stricken, low-income areas often lack sanitary waste disposal and have contaminated drinking water supplies, leading to havens and opportunities for the spread of infectious diseases.

EIN-3.D.5

Plague is a disease carried by organisms infected with the plague bacteria. It is transferred to humans via the bite of an infected organism or through contact with contaminated fluids or tissues.

continued on next page

LEARNING OBJECTIVE

EIN-3.D

Explain human pathogens and their cycling through the environment.

ESSENTIAL KNOWLEDGE

EIN-3.D.6

Tuberculosis is a bacterial infection that typically attacks the lungs. It is spread by breathing in the bacteria from the bodily fluids of an infected person.

EIN-3.D.7

Malaria is a parasitic disease caused by bites from infected mosquitoes. It is most often found in sub-Saharan Africa.

EIN-3.D.8

West Nile virus is transmitted to humans via bites from infected mosquitoes.

EIN-3.D.9

Severe acute respiratory syndrome (SARS) is a form of pneumonia. It is transferred by inhaling or touching infected fluids.

EIN-3.D.10

Middle East Respiratory Syndrome (MERS) is a viral respiratory illness that is transferred from animals to humans.

EIN-3.D.11

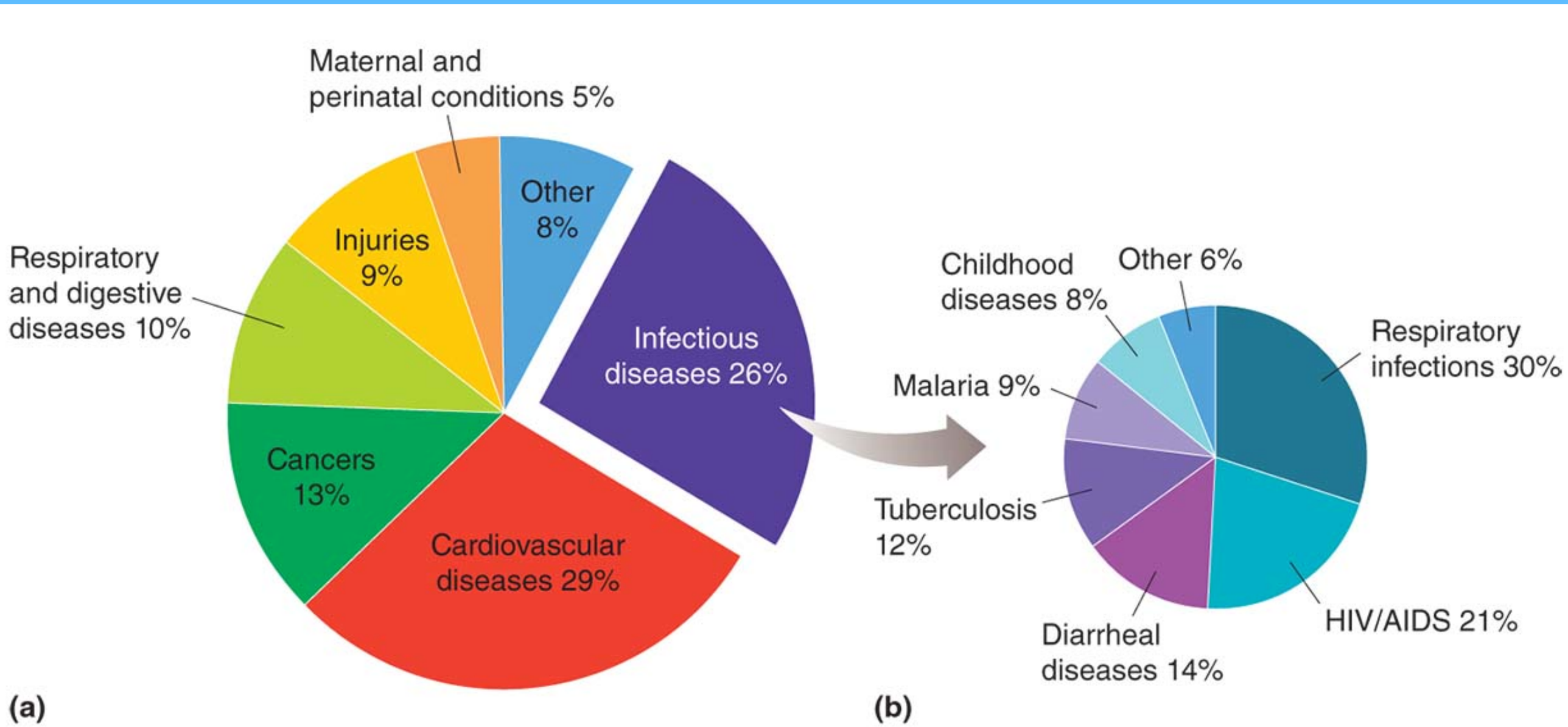
Zika is a virus caused by bites from infected mosquitoes. It can be transmitted through sexual contact.

EIN-3.D.12

Cholera is a bacterial disease that is contracted from infected water.

Types of Human Diseases

Leading causes of death in the world. (a) More than three-quarters of all world deaths are caused by diseases, including respiratory and digestive diseases, various cancers, cardiovascular diseases, and infectious diseases. (b) Among the world's deaths caused by infectious diseases, 94 percent are caused by only six types of diseases.



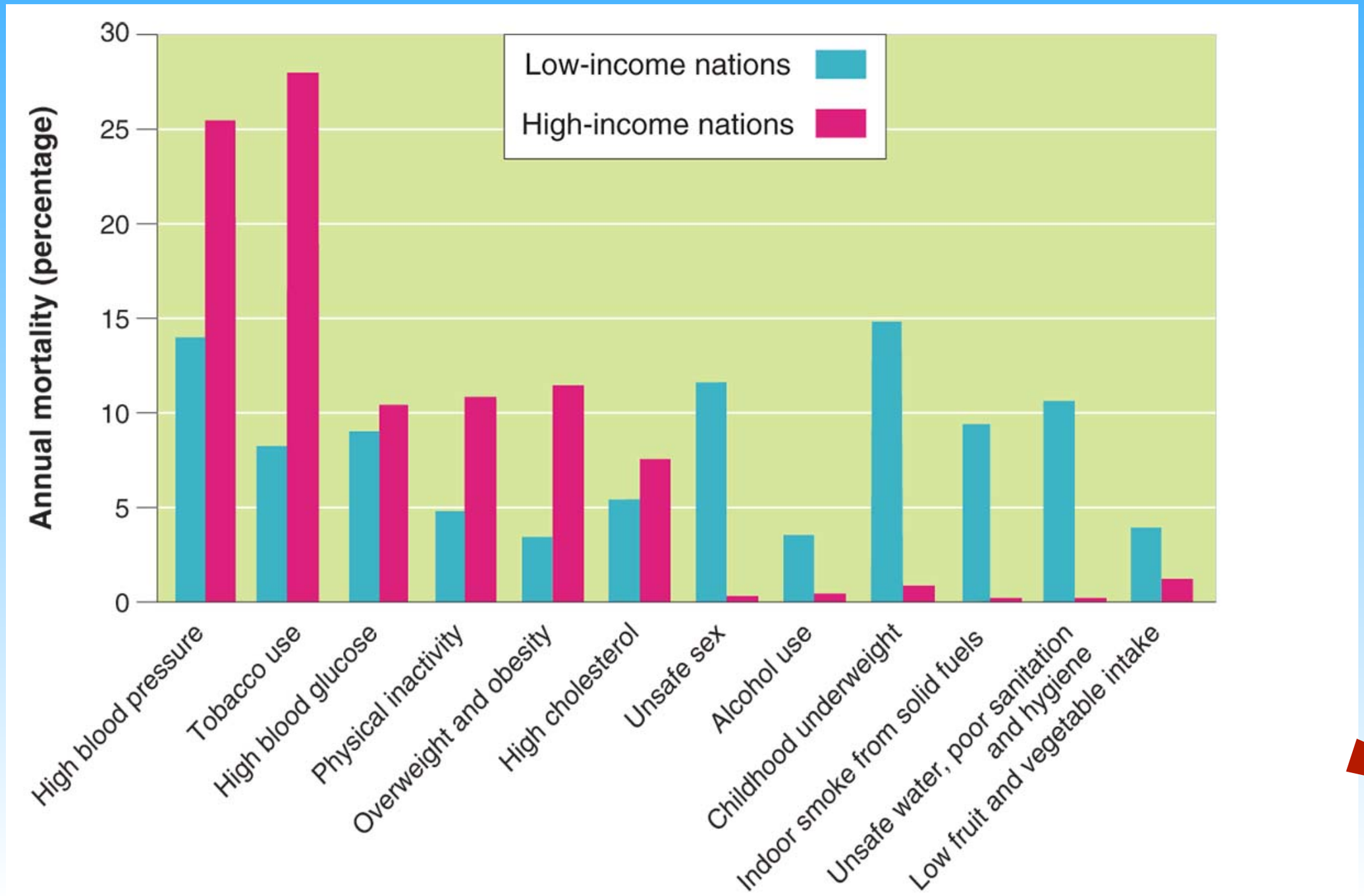
Numerous risk factors exist for chronic risk factors in humans

- In low-income countries, the top risk factors leading to chronic disease are associated with poverty, including unsafe drinking water, poor sanitation, and malnutrition.

- Risk factors for chronic disease in high-income countries include increased availability of tobacco, and a combination of less active lifestyles, poor nutrition, and overeating that leads to high blood pressure and obesity.

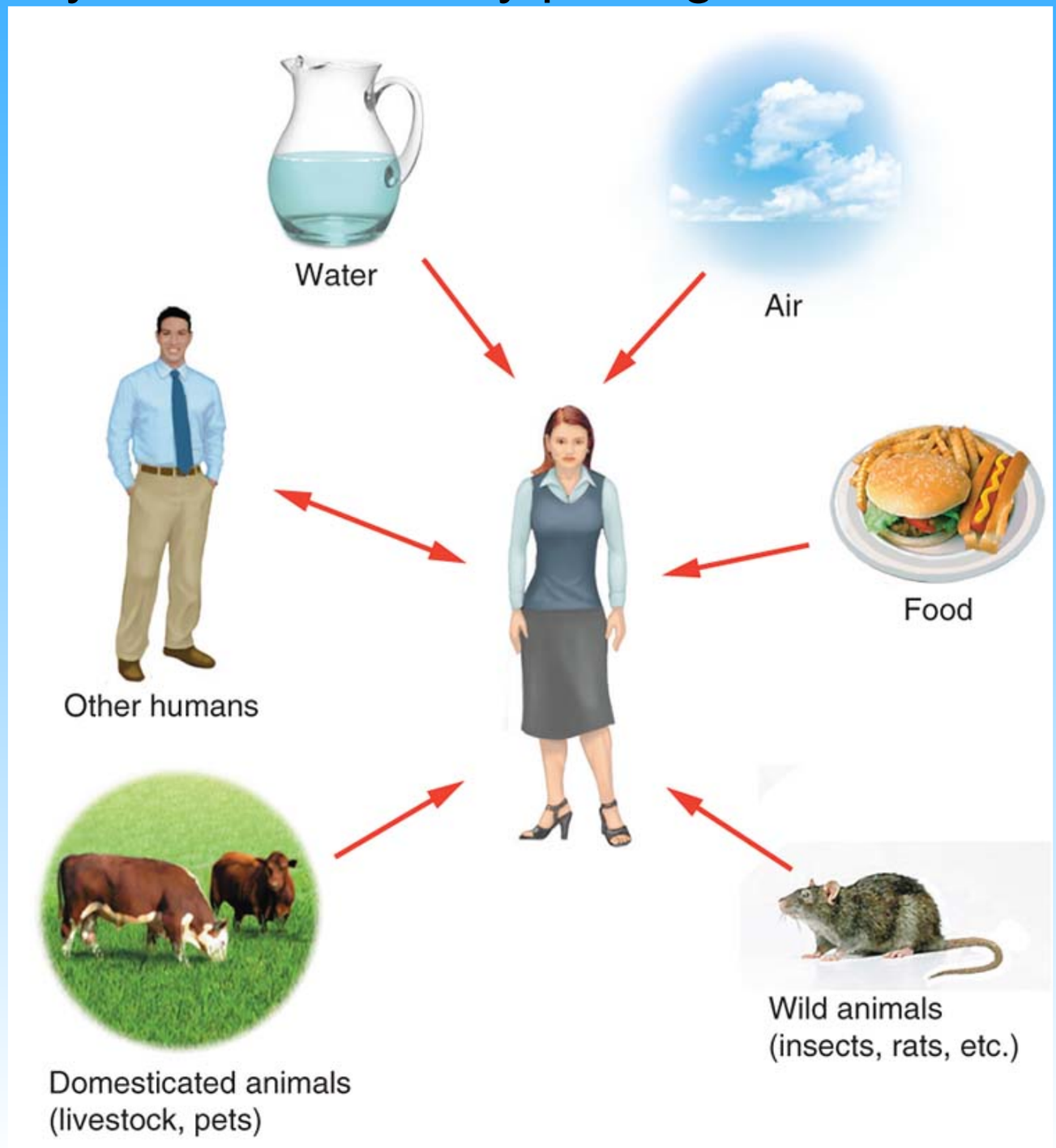
Chronic Risk Factors in Humans

Leading health risks in the world. If we consider all deaths that occur and separate them into different causes, we can examine which categories cause the highest percentage of all deaths. The leading health risks for low-income countries include issues related to low nutrition and poor sanitation. The leading risks for high-income countries include issues related to tobacco use, inactivity, obesity, and urban air pollution.



Some infectious diseases have been historically important

- Environmental scientists are interested in diseases that have environmental causes, especially those caused by pathogens such as fungi, bacteria, and viruses.



Pathways of transmitting pathogens. Pathogens have evolved a wide variety of ways to infect humans.

Pathogens cause disease

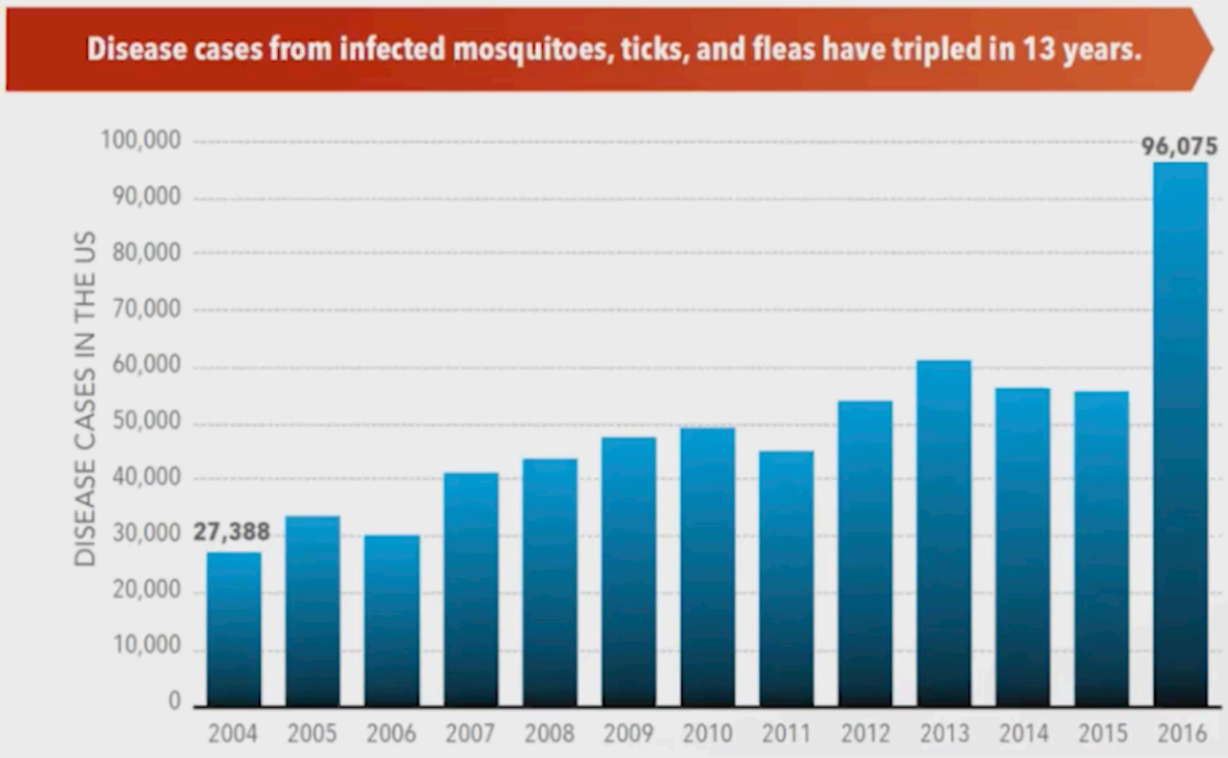
Any organisms can produce a disease:

- Viruses
- Bacteria
- Protozoans
- Worms
- Fungi

We call them germs or infectious agents.

Pathogens can occur in many environments **regardless** of the appearance of sanitary conditions.

Pathogens adapt



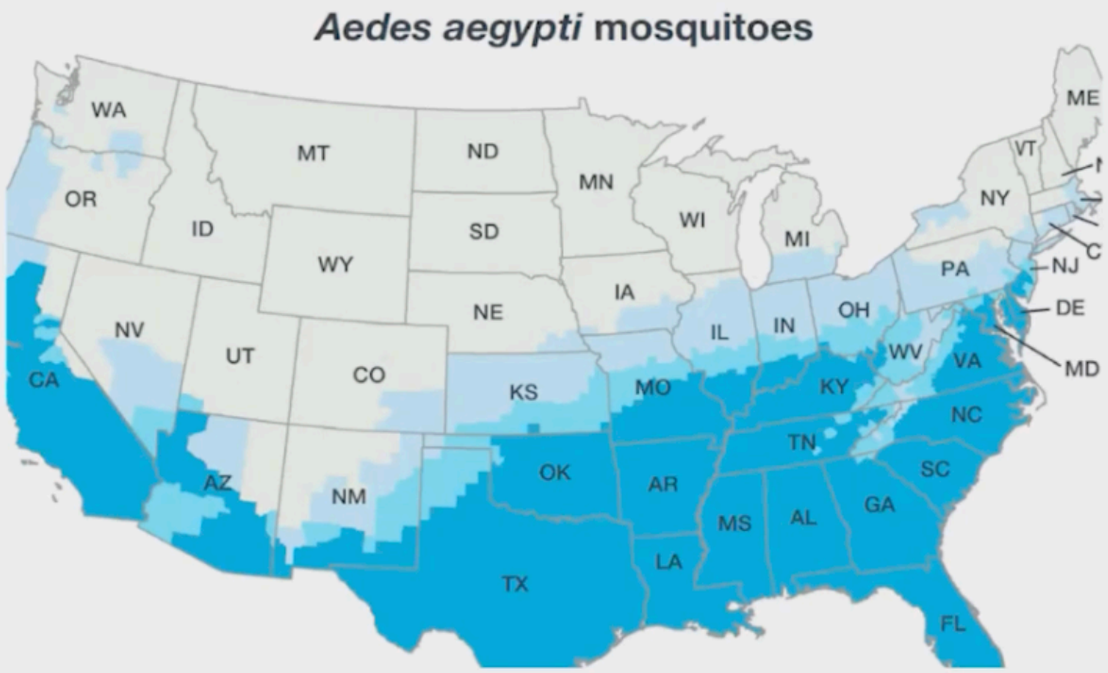
https://www.cdc.gov/other/agencymaterials.htm

Pathogens can infect and spread through human populations.

As our climate shifts, opportunities for movement of pathogens are created.

As equatorial-type climate zones spread north and south from the equator, pathogens and the vectors that carry them are showing up in places they've never been before.

Vectors can spread pathogens



In this case, the mosquito is a vector that carries the pathogen to areas where it might never have been prevalent before.

A **vector** is an organism that can transmit diseases between humans and between animals and humans.

Pathogens cycle through environments

Pathogens can spread in many ways:

- airborne particles
- skin contact
- bodily fluids
- contact with feces
- touching surfaces that an infected person has touched
- bite of a vector like mosquito or tick

The next two videos in Topic 8.15 will go into more detail about specific diseases.

Ideas to take away:

- Pathogens adapt to new conditions, allowing spread and infection to occur through human populations.

- Pathogens can occur in environments, regardless of the appearance of sanitary conditions.

- Shifts in climate are resulting in diseases associated with equatorial regions turning up for the first time in subtropical and temperate climate zones.

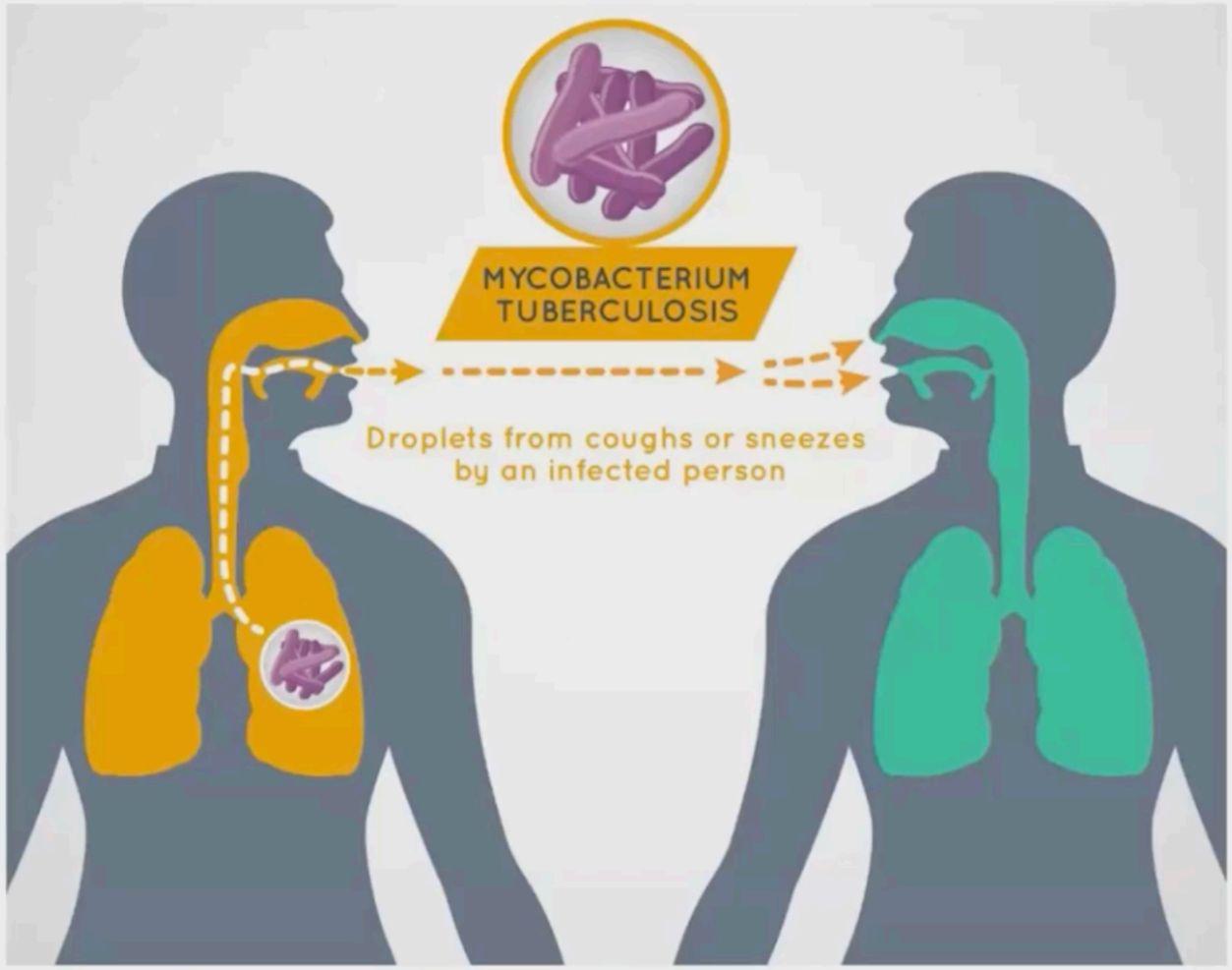
Contaminated water can transmit disease

Poverty-stricken areas often lack sanitary waste disposal, leading to contaminated drinking water and the easy spread of infectious diseases.

Cholera is a bacterial disease contracted from infected water.

Severe diarrhea and dehydration can result in death if left untreated.

Airborne droplets can transmit disease



Tuberculosis is caused by bacteria and attacks the lungs.

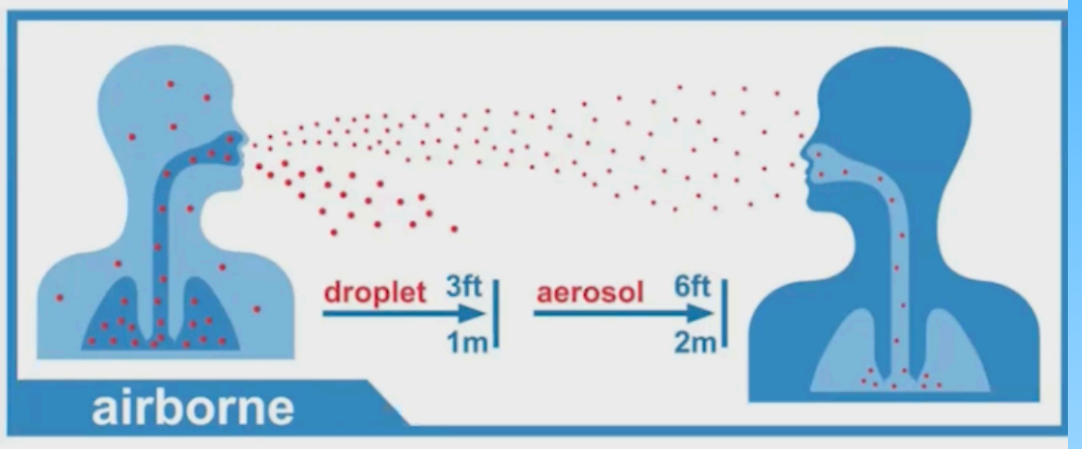
Droplets from the coughs and sneezes from an infected person transmit the disease through the air, where others breathe in the pathogen.

Airborne droplets and aerosols transmit disease

Severe acute respiratory syndrome (**SARS**) and Middle Eastern respiratory syndrome (**MERS**) are respiratory diseases caused by **coronaviruses.** These viruses are identified as SARS-CoV and MERS-CoV.

The disease **COVID-19** is also caused by a coronavirus and is identified as SARS-CoV-2.

Severe respiratory distress and pneumonia can be caused by these viruses as they spread from person to person.

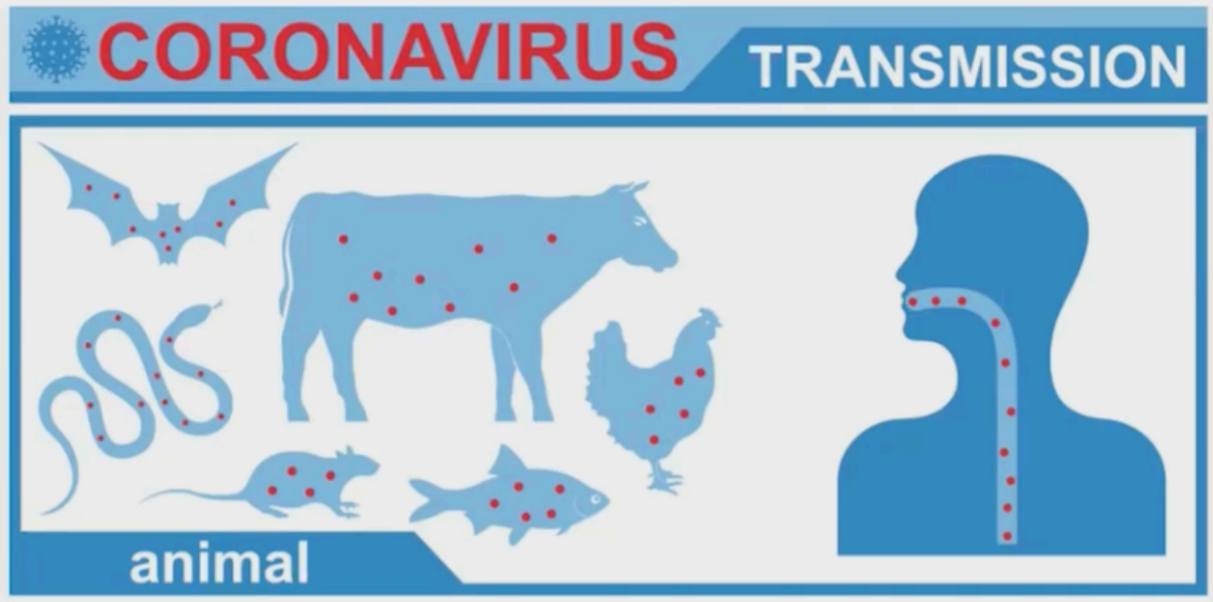


Pathogen spillover

When a disease originates in animals and then spreads to humans, it is called a spillover event.

SARS-CoV and MERS-CoV originated in bats and then spread to animals that were closer to people, like civets and camels.

Like these other coronaviruses, SARS-CoV-2 is thought to also have originated in bats, and investigations continue to learn more about its transmission.



OnD / Shutterstock.com

Ideas to take away

- Bacteria that causes cholera can be spread through contaminated water sources.

- Wastewater treatment can prevent this spread.
- Bacteria that causes tuberculosis can be spread through inhaling the airborne droplets of those people already with the respiratory disease.

- Coronaviruses that cause SARS, MERS, and COVID-19 are spread through airborne droplets and aerosols from people already infected.

- Spillover events are when viruses, like coronaviruses, jump from their animal host to humans.

Plague is caused by bacteria

Credit: Marisa Lubeck, U.S. Geological Survey. Public domain

People contract the Sylvatic plague from the bacteria *Yersinia pestis* after being bit by an infected flea.

Fleas that carry the disease are often found on mammals, particularly rodents.

Antibiotics allow us to control the plague in humans. In wildlife, it can still be a problem. Here, a National Park Service veterinarian is checking a prairie dog for fleas.

Mosquitoes are vectors

Mosquitoes are a common vector of bacteria, viruses, and parasites that cause disease.

Zika

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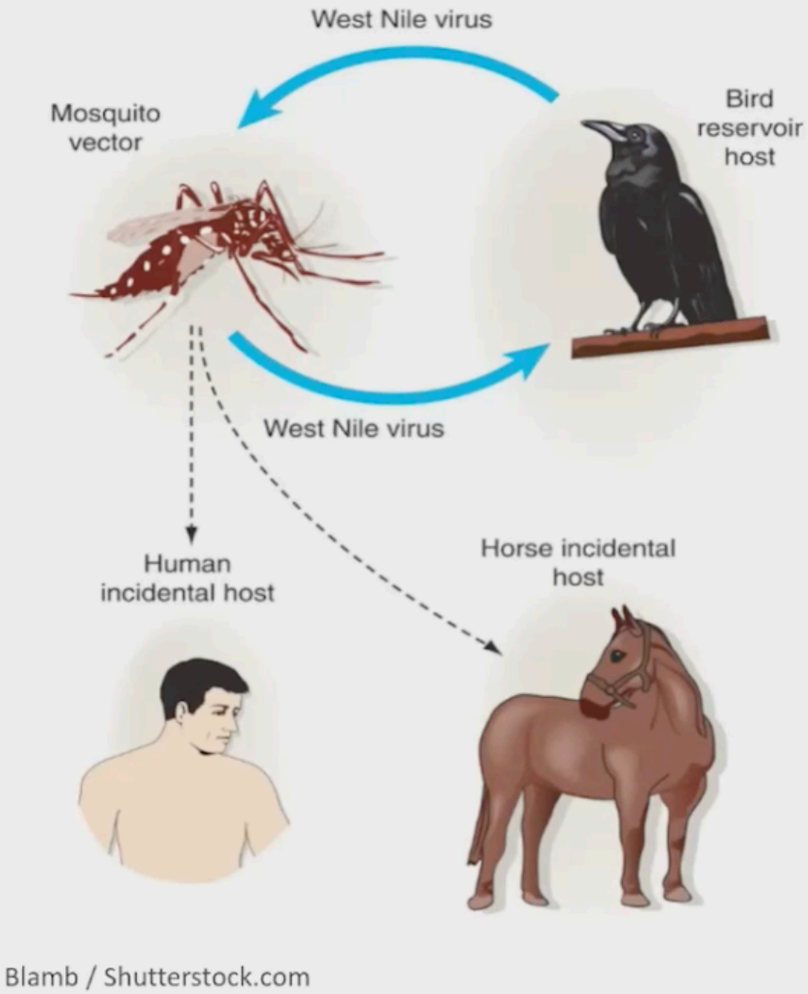
The Zika virus can
be spread to humans
by infected mosquitoes.

People can also contract the virus from
sexual contact with an infected person.

For most people, the disease symptoms
are mild.

If pregnant women are infected,
however, the virus can cause a severe
birth defect called microcephaly and
other severe fetal brain deformities.

West Nile Virus



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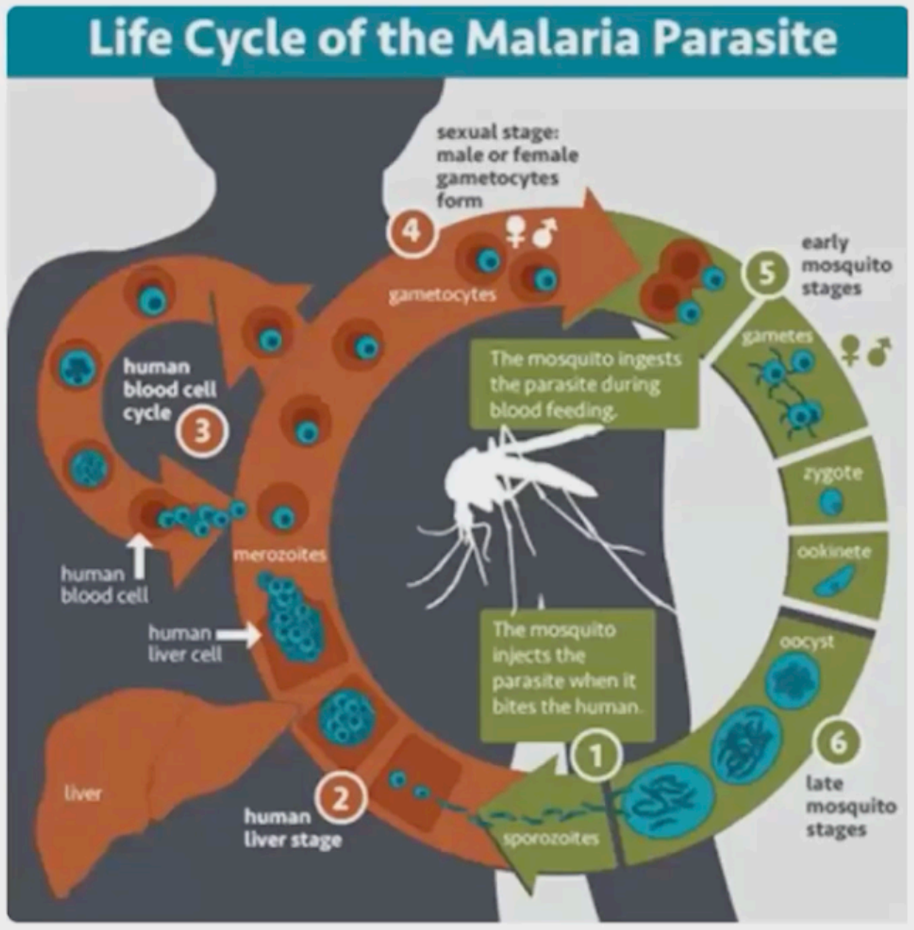
West Nile Virus was first found in the United States in the late 1990s and has spread from the east coast to across the country.

The virus spreads to humans and other animals, like horses, through mosquito bites.

Most people have few and mild symptoms from the virus such as fever, rash, and fatigue.

In severe cases, the virus can cause encephalitis, meningitis, and other issues of the central nervous system.

Malaria



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Malaria is caused by Plasmodium, a single-celled parasite. There are 5 species that cause malaria.

It is transmitted through mosquito bites.

The parasite infects your red blood cells and causes them to burst. If left untreated, people can develop severe complications and die.

Hundreds of millions of people, many children, die each year due to malaria. This disease is found mostly in sub-Saharan Africa.

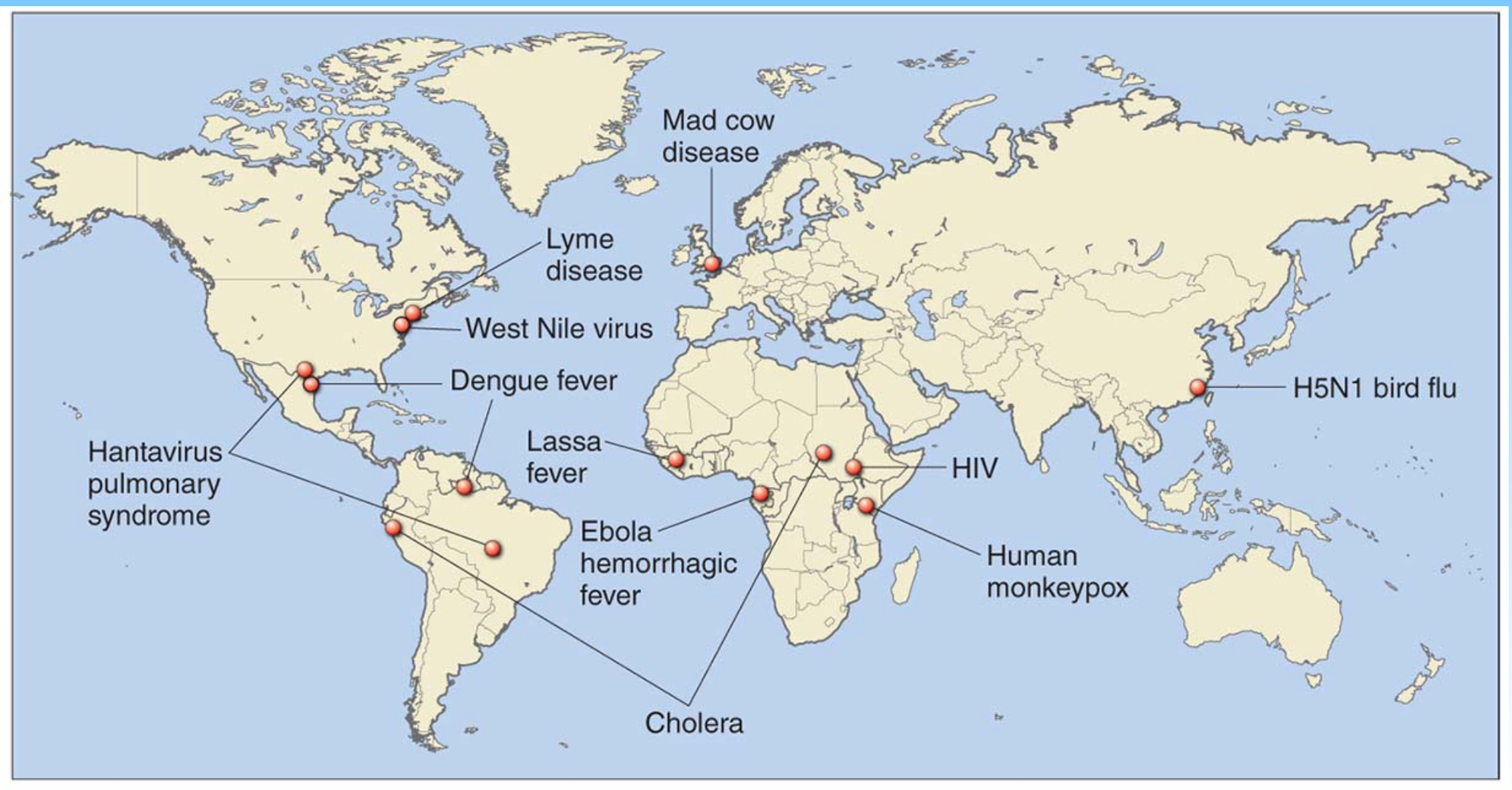
Ideas to take away:

- Plague can be spread by the bites from fleas that live on rodents.
- Zika and West Nile Virus are viruses spread by mosquitoes and can cause issues with the central nervous system.
- Also spread by mosquitoes, malaria is caused by a single-celled parasite that infects red blood cells.

Emergent infectious diseases pose new risks to humans

- **Emergent infectious disease** An infectious disease that has not been previously described or has not been common for at least 20 years.

The emergence of new diseases. Since the 1970s, new diseases, or diseases that have been rare for more than 20 years, have been appearing throughout the world at a rate of approximately one per year.



Emergent Infectious Diseases

- Acquired Immune Deficiency Syndrome (AIDS)
- An infectious disease caused by the human
- immunodeficiency virus (HIV).

- **Human Immunodeficiency Virus (HIV)** A type of virus that causes Acquired Immune Deficiency Syndrome (AIDS).

- **Ebola hemorrhagic fever** An infectious disease with high death rates, caused by the Ebola virus.

Emergent Infectious Diseases

- **Mad cow disease (bovine spongiform encephalopathy)** A disease in which prions mutate into deadly pathogens and slowly damage a cow's nervous system.

- **Prion** A small, beneficial protein that occasionally mutates into a pathogen.

- **Swine flu** A type of flu caused by the H1N1 virus.

- **Bird flu** A type of flu caused by the H5N1 virus.

Emergent Infectious Diseases

- **Bird flu** A type of flu caused by the H5N1 virus.
- has the potential to become more deadly
- a type of flu virus that originates in Asia
- moves from birds to humans

Reasons for Emergence/ Reemergence

- Evolution of disease so it transitions to human host
- Evolution of antibiotic resistance in disease
- Urbanization and overcrowding
- Increased pop. of elderly - susceptible to disease
- Pollution and environmental degradation
- Growth in international travel and commerce
- Poverty and social inequality

Addendum

Many types of chemicals can harm organisms

Table 57.1 Some chemicals of major concern

Chemical	Sources	Type	Effects
Lead	Paint, gasoline	Neurotoxin	Impaired learning, nervous system disorders, death
Mercury	Coal burning, fish consumption	Neurotoxin	Damaged brain, kidneys, liver, and immune system
Arsenic	Mining, groundwater	Carcinogen	Cancer
Asbestos	Building materials	Carcinogen	Impaired breathing, lung cancer
Polychlorinated biphenyls (PCBs)	Industry	Carcinogen	Cancer, impaired learning, liver damage
Radon	Soil, water	Carcinogen	Lung cancer
Vinyl chloride	Industry, water from vinyl chloride pipes	Carcinogen	Cancer
Alcohol	Alcoholic beverages	Teratogen	Reduced fetal growth, brain and nervous system damage
Atrazine	Herbicide	Endocrine disruptor	Feminization of males, low sperm counts
DDT	Insecticide	Endocrine disruptor	Feminization of males, thin eggshells of birds
Phthalates	Plastics, cosmetics	Endocrine disruptor	Feminization of males