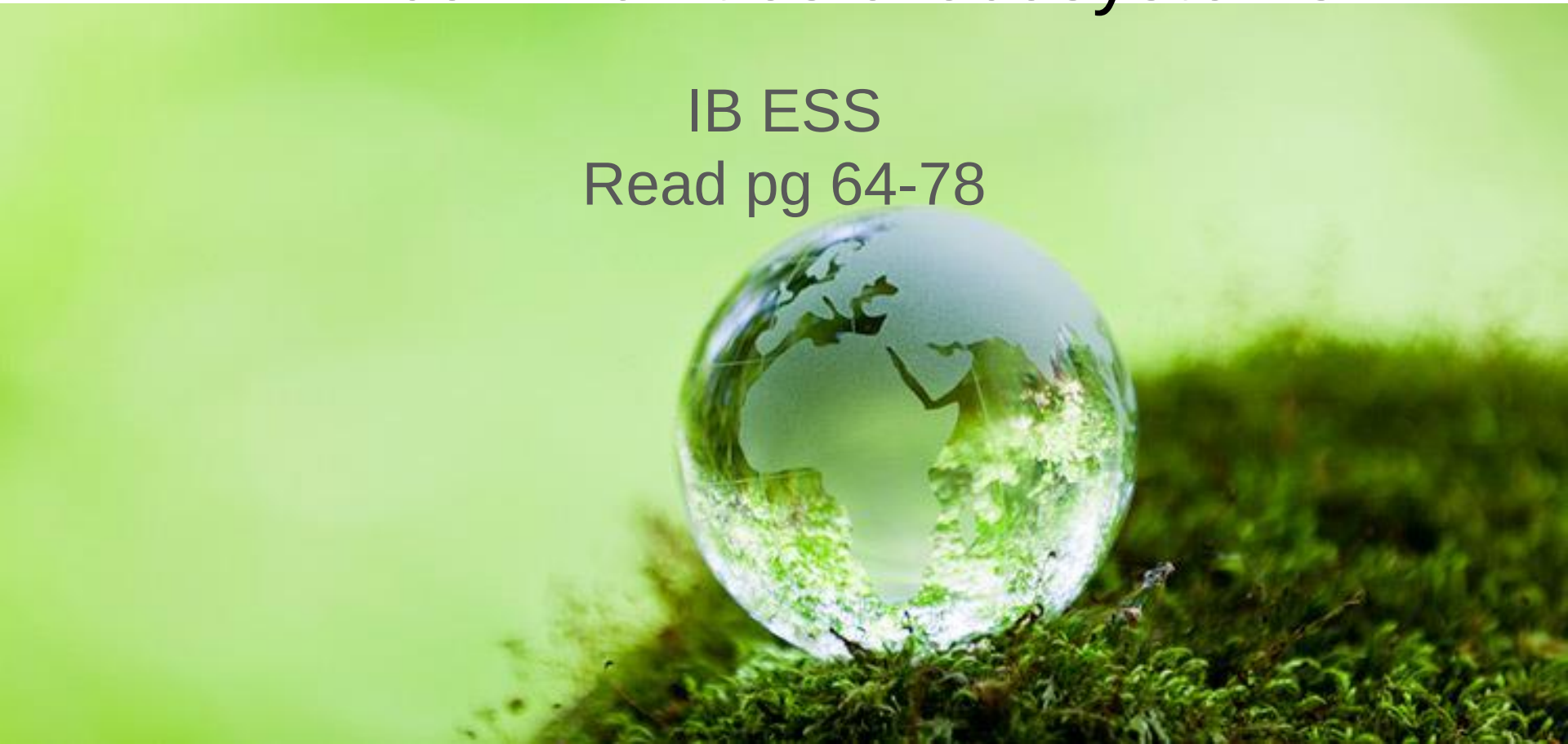
# 2.2 communities & ecosystems

IB ESS

Read pg 64-78



# Learning Objectives

- Define the terms ‘ecosystem’ and ‘community’
- Outline how ecosystems may vary in size and complexity
- Describe the roles of producers, consumers and decomposers in an ecosystem
- Explain how feeding relationships are modeled using food chains, webs & ecological pyramids

# Key Questions

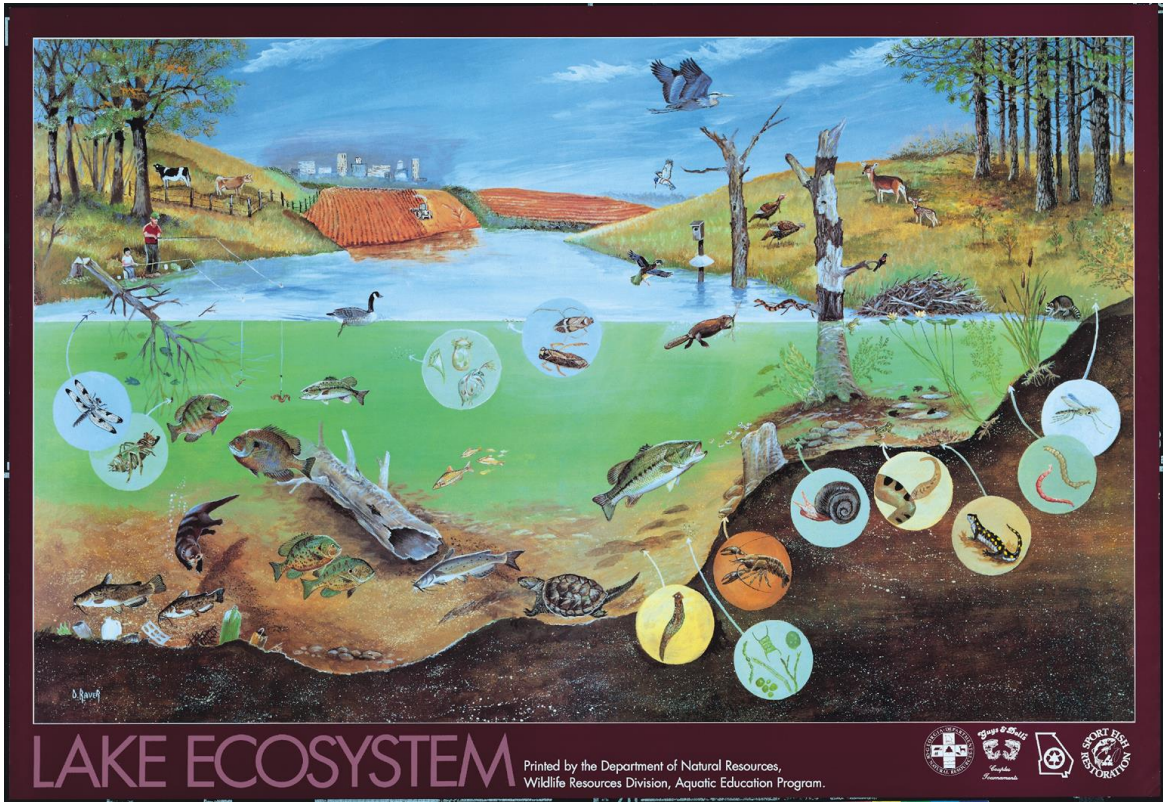
1. How do interactions between species result in energy flow and nutrient cycling?
2. How are photosynthesis and respiration important in the flow of energy?
3. How are models used to show feeding relationships in an ecosystem?

# Ecosystem

- Community of interdependent organisms & their abiotic environment

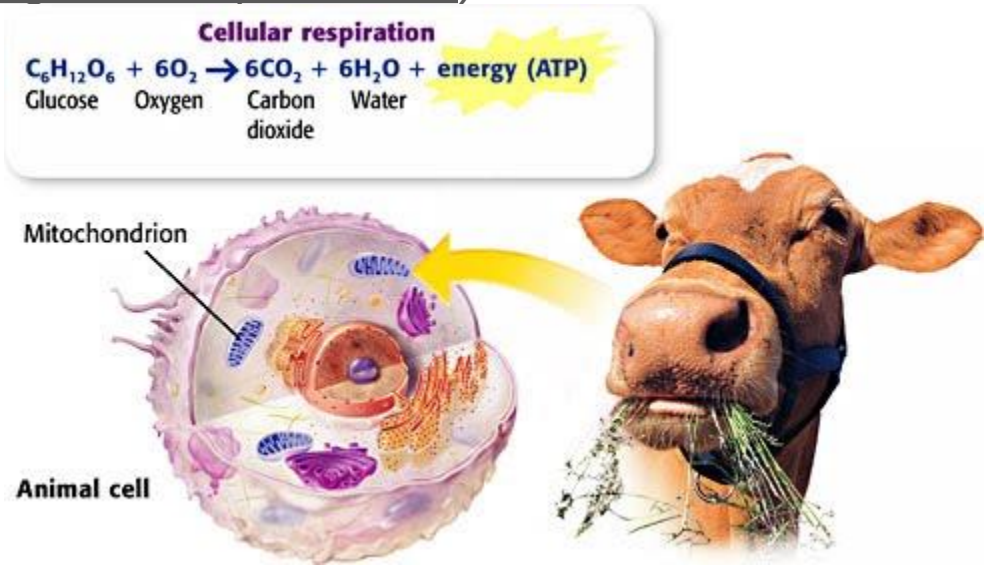
# Community

- Group of populations living & interacting in same area
- Interlinked by food sources & organisms that feed on them
- Food chains & food webs
  - Begin with light energy from sun (photosynthesis)



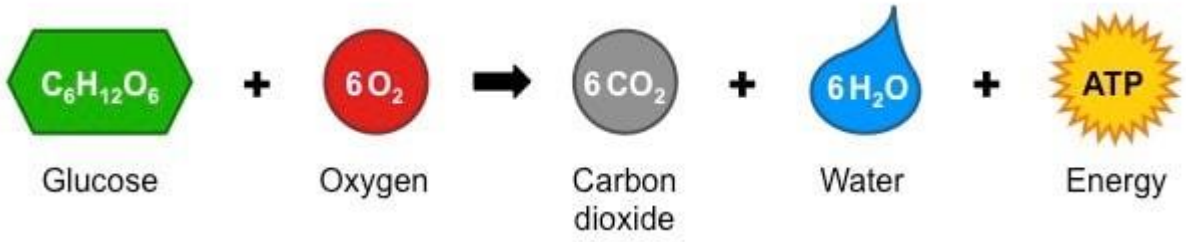
# Respiration

- Process in which food, often in the form of glucose, is broken down to release the energy it contains
- ALL living things respire to stay alive and maintain their life processes (movement, growth, reproduction)



# Respiration

- Series of inputs, energy transformations & outputs
- Complex series of chemical reactions controlled by enzymes




INPUTS

OUTPUTS

# Respiration

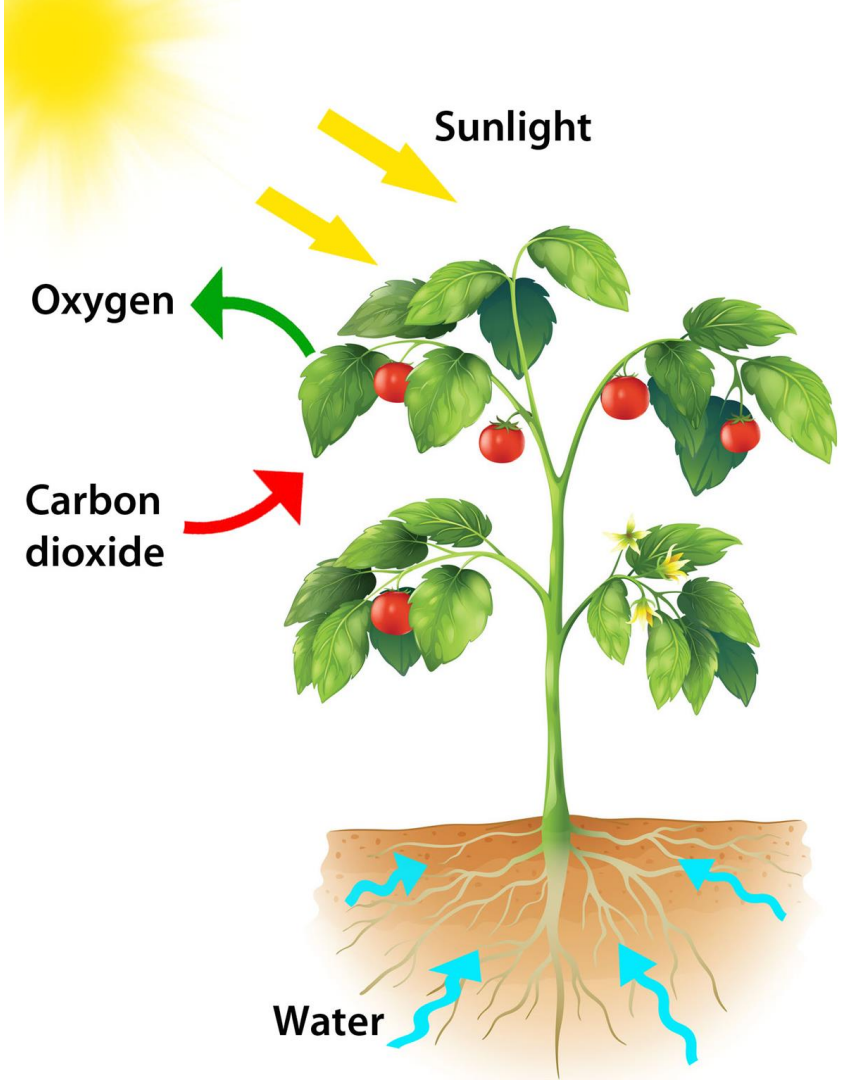
- Takes place in ALL living cells
- Stored chemical energy in bonds of glucose transformed and used for movement, growth and other life processes
- **Aerobic respiration** (oxygen present)
  - Outputs = energy + carbon dioxide & water
- **Anaerobic respiration** (without oxygen)
  - Releases less energy inside body cells
  - Yeast Outputs = carbon dioxide & ethanol
  - Animals outputs = lactic acid
  - Mud-dwelling worms in low-oxygen environments
  - Whales when they dive to great depth
  - Humans during vigorous exercise (but build up of lactic acid = cramps)

# Respiration

- Essential
  - provides energy needed to build an organism's body
  - Keeps the molecules used in a well ordered (low entropy) state
- Large amounts of heat lost (2nd law of thermodynamics)
  - Exercise vigorously = increase rate of respiration = hot
  - Heat not useful form of energy for other organisms
  - Heat said to increase entropy in the ecosystem
  - **Entropy** - the way a system is arranged & a measure of the disorder of its components

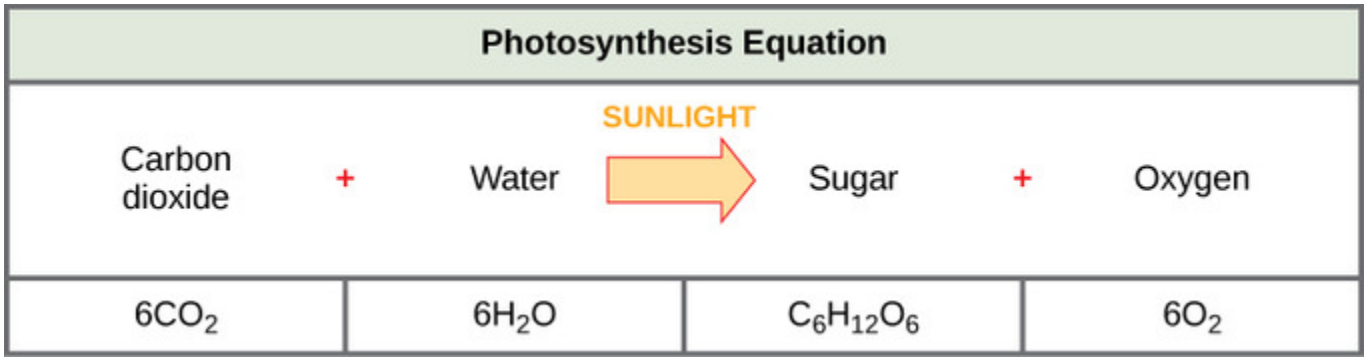
# Photosynthesis

- Process by which green plants make their own food using water and carbon dioxide
- Light energy from sun splits water & combines it with carbon dioxide to produce sugar glucose



# Photosynthesis

- Series of inputs, energy transformations & outputs
- Complex series of chemical reactions catalyzed by enzymes




INPUTS

OUTPUTS

# Photosynthesis

- Light energy captured by chlorophyll (green pigment)
  - Red & blue wavelengths of the light spectrum are best absorbed (maximum rate of photosynthesis)
  - Green parts of the spectrum reflected (unused)
- Energy used to bond H atoms from water with carbon dioxide molecules to form glucose
- Light energy converted to stored chemical energy (bonds of glucose molecules)
- Glucose - organic compound
  - Plant can go on to convert into other substances (starch or protein)
- Photosynthesis = process that leads to accumulation of biomass

# Trophic Levels (food chains & food webs)

- Position that an organism occupies in a food chain as a result of its feeding habits.  (can be position of a group of organisms that feed at the same position in their food chain)
- Hierarchy of feeding relationships impacting the way nutrients & energy pass through every ecosystem
    - Series of feeding levels (trophic levels)
    - Arrows = energy & nutrient flow direction
    - Producers → consumer → secondary consumer

# Trophic Levels (food chains & food webs)

- Few consumers rely on only 1 food
  - Ecosystems contain many interlinking food chains (food web)
- Longer food chains that include more carnivores (quaternary consumers) also possible
- Can be used to predict consequences of changes that may occur
  - A change in one species can affect many others

# Producer

- (autotroph) - organism that converts light energy into chemical energy
- Classification based on the way they feed (obtain energy)
- Play key role in every ecosystem
- EXAMPLES: green plants, algae & some bacteria
- Produce the **biomass** (living material such as leaves & fruits) that supports all the consumers in the food chains/webs for an ecosystem
- Via photosynthesis

# Consumer

- (heterotroph) - organism that feeds on other organisms
- Cannot make own food
- Must feed on others to get nourishment/energy
- Break down complex organic molecules in food (digestion)
  - Releases minerals & nutrients
  - Respired to fuel activity and build up their body
- Types:
  - Herbivore - feed on plants
  - Omnivore - feed on both plants & animals
  - Carnivore - feed on other animals
  - Detritivore - feed on decomposing plant & animal material (help speed up decay process)

# Types of Consumers

Type of Consumer: HERBIVORE
What It Eats: Plants

A grasshopper eats grasses and other plants.

Type of Consumer: CARNIVORE
What It Eats: Animals

A mole eats insects in the soil.

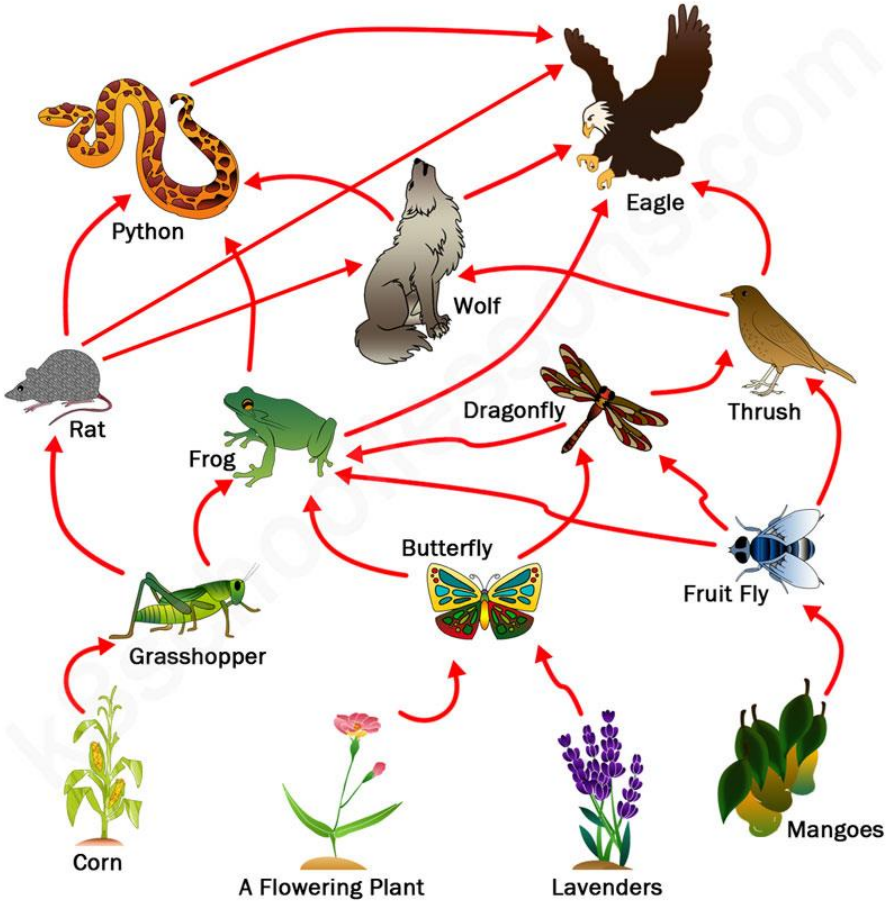
Type of Consumer: OMNIVORE
What It Eats: Plants and animals

A raccoon eats seeds, nuts, fruits, worms and fish.

# Decomposer

- (heterotroph) - break down organic material at a microscopic level to provide nutrients and release inorganic materials into the soil
  - Plants able to pull in inorganic material from soil through their roots
- Soil decomposers (enzymes digest) & detritivores (feeding) = feed on dead leaves & bodies of dead animals
  - Vital to soil fertility
  - Part-digested material = humus
    - Influences drainage of soil
- Vital to recycling nutrients in ecosystem
- Provide food for other decomposers
- Form 1st link in decomposer food chains

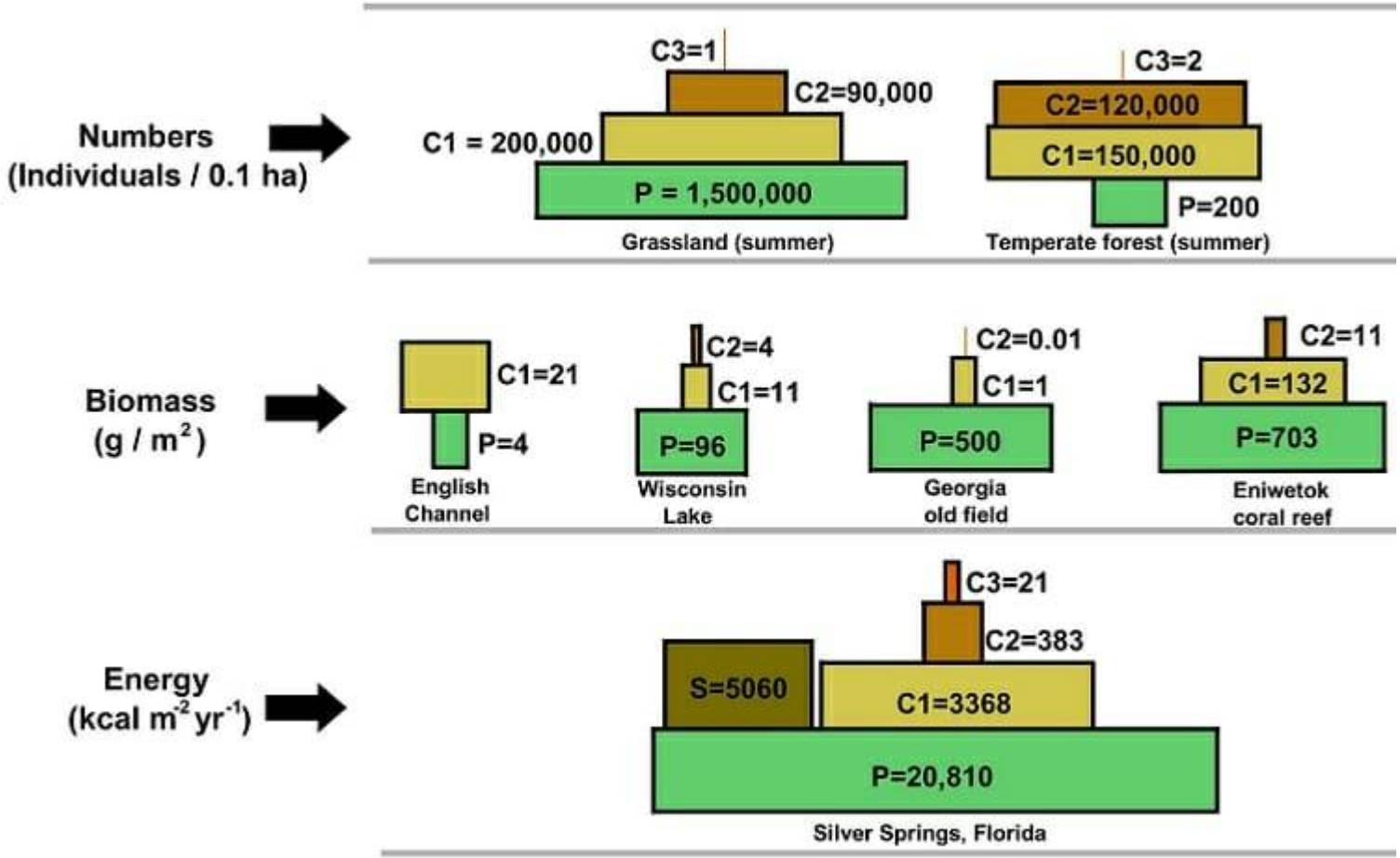
# A Food Web

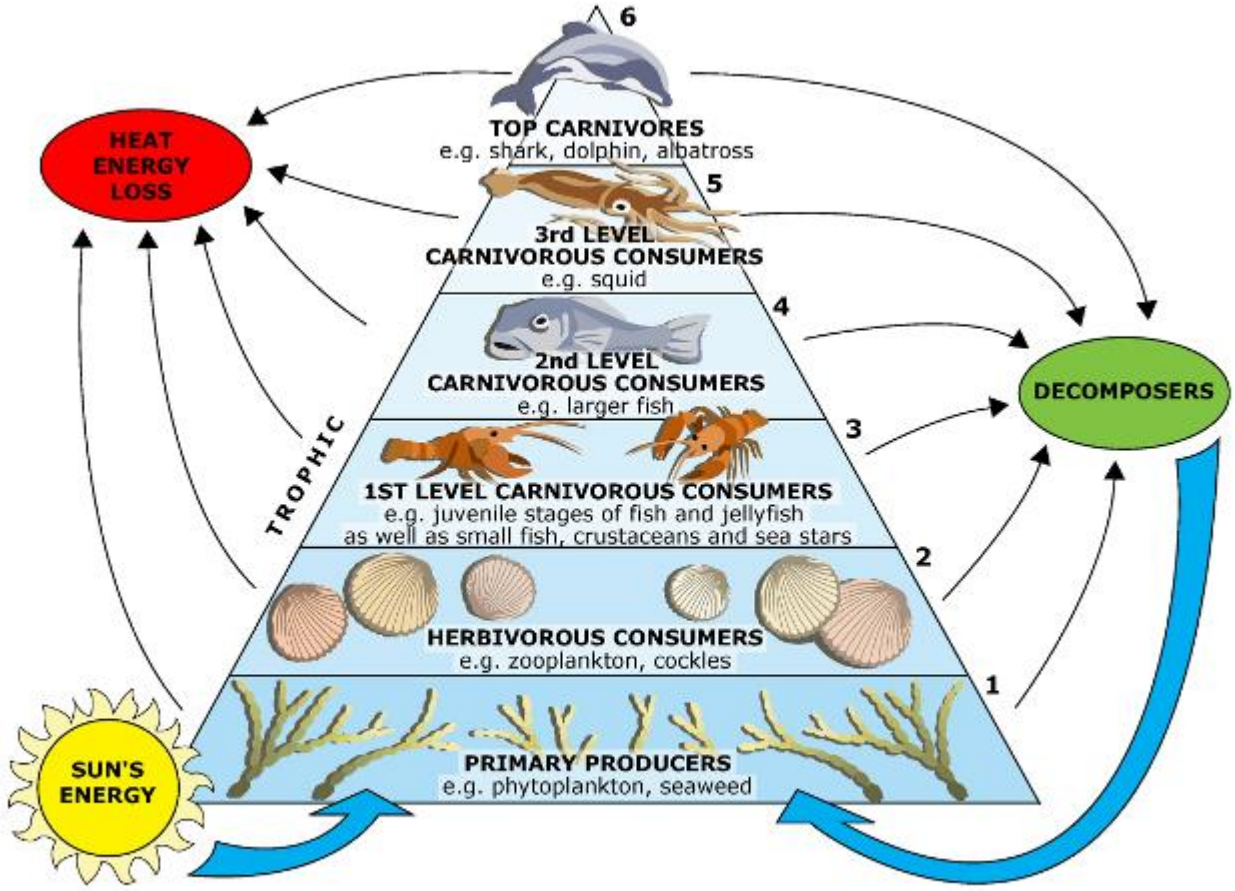

Python
Eagle
Wolf
Rat
Frog
Dragonfly
Thrush
Butterfly
Fruit Fly
Grasshopper
Corn
A Flowering Plant
Lavenders
Mangoes

# Ecological Pyramids

p. 71

- Diagrams that ecologists use to provide a picture of the quantities of organisms present at each trophic level in an ecosystem
- Show a visual form of how different trophic levels relate to one another
- Problem:  many species feed at more than 1 trophic level which can affect results
- TYPES:
  - Pyramid of numbers
  - Pyramid of biomass
  - Pyramid of productivity (energy)


Numbers
(Individuals / 0.1 ha)
C3=1
C2=90,000
C1 = 200,000
P = 1,500,000
Grassland (summer)
C3=2
C2=120,000
C1=150,000
P=200
Temperate forest (summer)
Biomass
(g / m²)
C1=21
P=4
English Channel
C2=4
C1=11
P=96
Wisconsin Lake
C2=0.01
C1=1
P=500
Georgia old field
C2=11
C1=132
P=703
Eniwetok coral reef
Energy
(kcal m⁻² yr⁻¹)
C3=21
C2=383
S=5060
C1=3368
P=20,810
Silver Springs, Florida

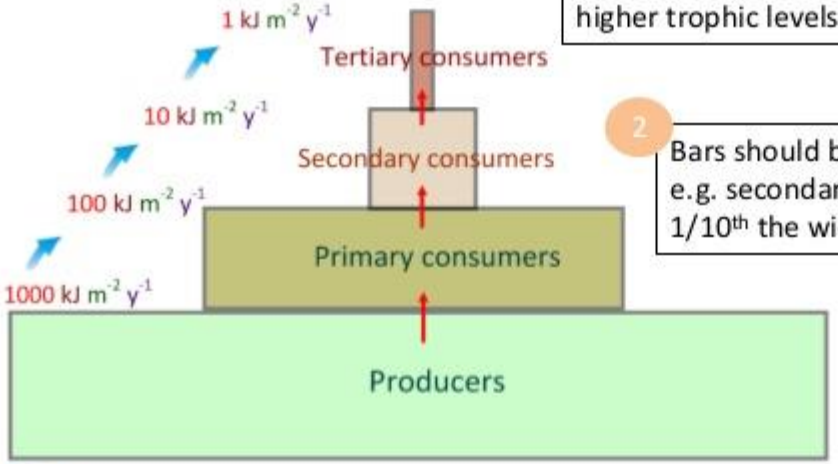


# Drawing pyramids of energy

Measured in units of energy per unit area per unit time: $kJ\ m^{-2}\ y^{-1}$

Transfer of energy is never 100% efficient.

1. Pyramids of energy always get smaller at higher trophic levels due to the loss of energy.



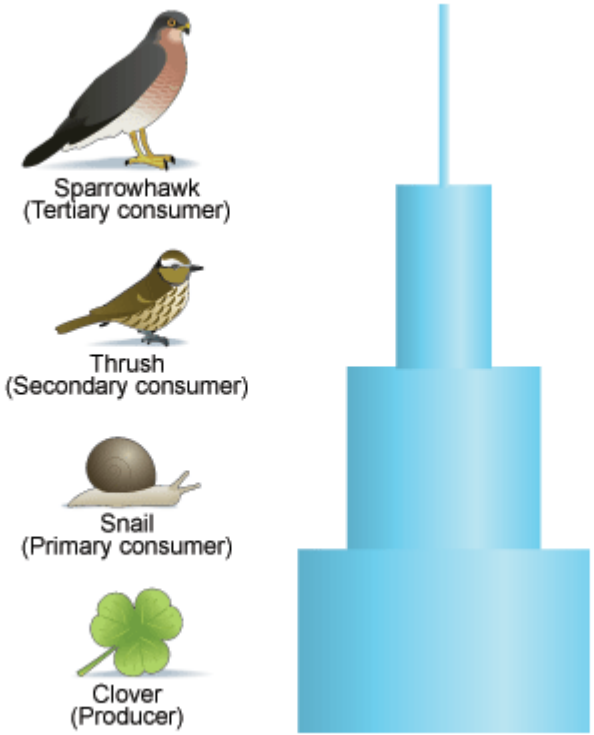

2. Bars should be roughly drawn to scale, e.g. secondary consumers should be 1/10th the width of primary consumers.

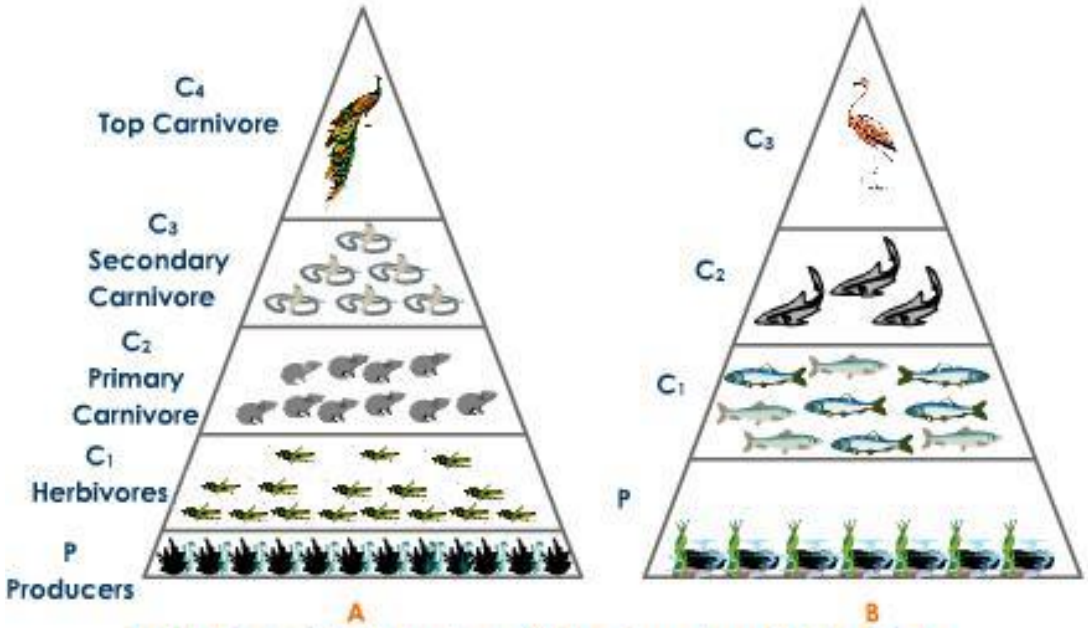
3. The bottom level will always represent the producers, with subsequent levels representing consumers (primary, secondary, etc.)

Image from http://www.slideshare.net/gurustip/communities-and-ecosystems

# Pyramid of numbers

- Constructed by counting # of organisms at each trophic level
- Info for each level drawn to scale (represented in diagram)
- Counting every individual usually impossible
  - Samples from measured areas then multiplied to represent whole system
- Give good approximate representation but…
  - Can be misleading (cannot account for size of organisms)
  - EXAMPLE: 1 large tree can support 100s of small herbivorous insects & birds (may not look like pyramid shape)
  - EXAMPLE: single-celled diatom in pond counts as 1 just like a large water lily




Upright Pyramids of Numbers. (A) In a Grass Land (B) In a Pond

# Upright pyramid

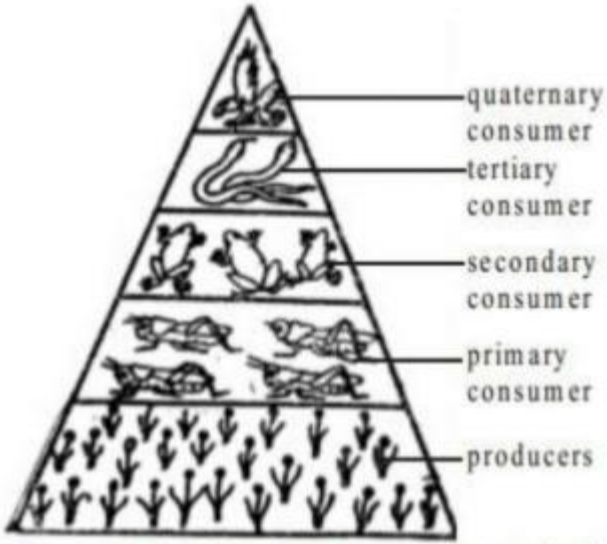
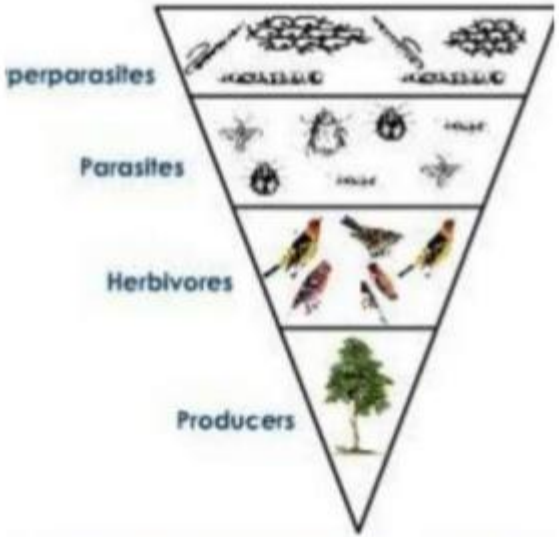



Fig. Pyramid of numbers in a grassland

# Inverted pyramid

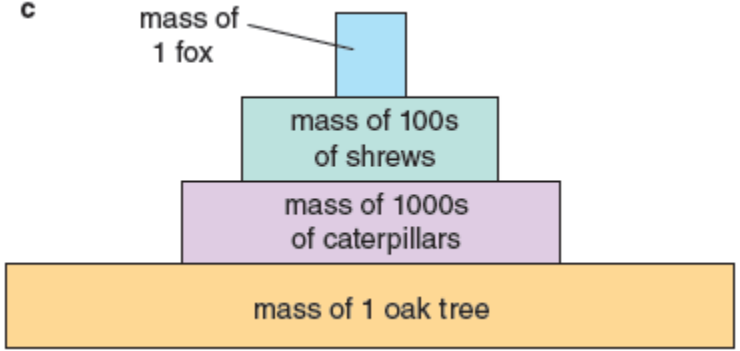


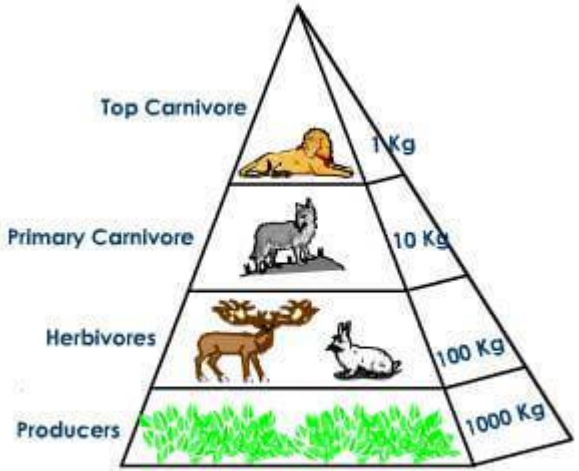

Inverted pyramid of number

# Pyramid of biomass

- Overcome some of the problems of pyramids of #s
- **Biomass** - measure of mass of all organisms at each trophic level
- Ecologists estimate biomass at a particular moment in time
  - Recorded as total dry mass x # organisms for each trophic level in a given area
  - Biomass calculated in units of …
    - mass per unit area (gm^-2 or kg m^-2)
    - Energy per unit area (Jm^-2)
    - *water is excluded because it has no energy value
- Usually pyramid shaped
  - ***At each trophic level the portion of energy & biomass that can be transferred reduces***
    - Some energy used by the organism (isn't transferred)

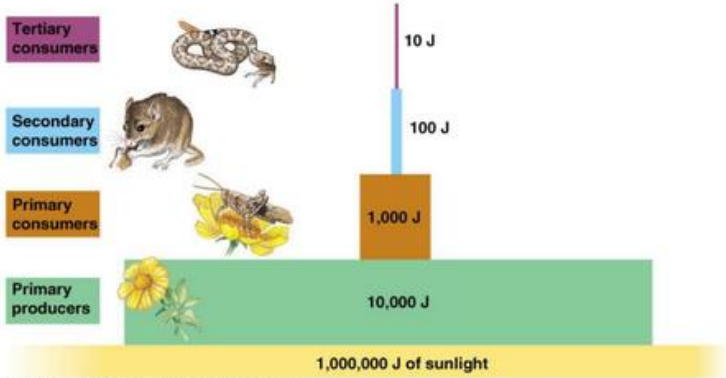
c




Upright Pyramid of biomass in a Terrestrial Ecosystem

## Pyramids of numbers and biomass



# Pyramid of biomass

- Cannot take into account seasonal variation in populations' biomass
  - EXAMPLE: certain times of the year phytoplankton (small green aquatic plants) in a pond grow quickly as temps increase & light levels rise
    - This extra biomass provides more food for primary consumers
    - Allows for burst of reproduction in small fish, snails & insects
    - As phytoplankton are consumed, its biomass falls rapidly
    - Sampling during phytoplankton abundance give a pyramid-shape diagram
    - Sampling during consumer reproduction give an inverted pyramid

# Pyramid of productivity

- Most accurate way to model an ecosystem
- Show flow of energy in an ecosystem over period of time (usually a year)
- Each level = energy per unit area per unit time
- Measured in mass or energy per square meter per year ($g/m^2/yr$ or $kJ/m^2/yr$)
- Show how quickly organisms are accumulating biomass
- Each trophic level has shorter bar than the one below
    - Energy is used at each level to keep the organism alive
    - **Only ~10% of the energy passed to next trophic level**

# Advantages & disadvantages of pyramids

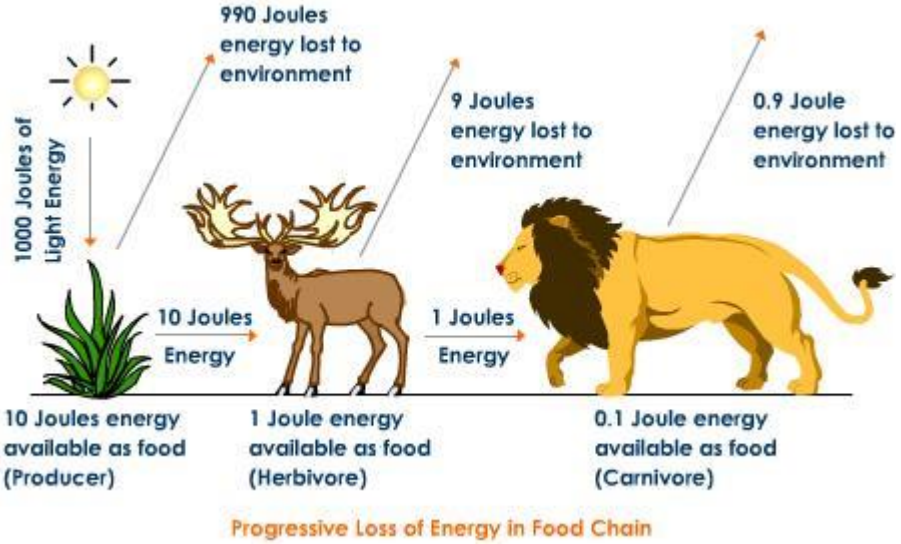
| Type of pyramid | Advantages | Disadvantages |
|---|---|---|
| **Numbers** | • Gives a quick overview<br>• Useful for comparing pop #s in different seasons | • No account taken of size of organisms<br>• Pyramids with large producers are inverted |
| **Biomass** | • Takes account of size of organisms<br>• Overcomes problems of pyramids of #s | • Difficult to measure accurately as sampling involves killing organisms<br>• Seasonal variation leads to inverted pyramids<br>• Some animals have a lot of bone/shell which can distort results |
| **Productivity** | • Shows energy transferred over period of time, allowing for different rates of production<br>• Ecosystems can be compared easily<br>• Pyramids are never inverted | • Data difficult to collect as rate of biomass production over time must be measured<br>• Many species feed at more than one trophic level which can affect results (true for all pyramids) |

# Energy transfers

- On land = food chains seldom more than 4 trophic levels
- In water = food chains may be 5 or more trophic levels
- Each time energy transferred from 1 trophic level to next = energy ‘lost’ to living organism
  - Used for growth, movement, life processes like respiration and lost as heat
  - Second law of thermodynamics
    - Energy is not destroyed but converted
    - Converted to heat (not useful to sustain the lives of organisms)

# Energy transfers

- On land = energy used to keep animals warm & support their bodies
  - Energy runs out after 4 transfers and not enough to support another consumer
- In water = animals often cold-blooded & use water to support them
  - More energy remains at each trophic level to pass to the next...so food chains can be longer

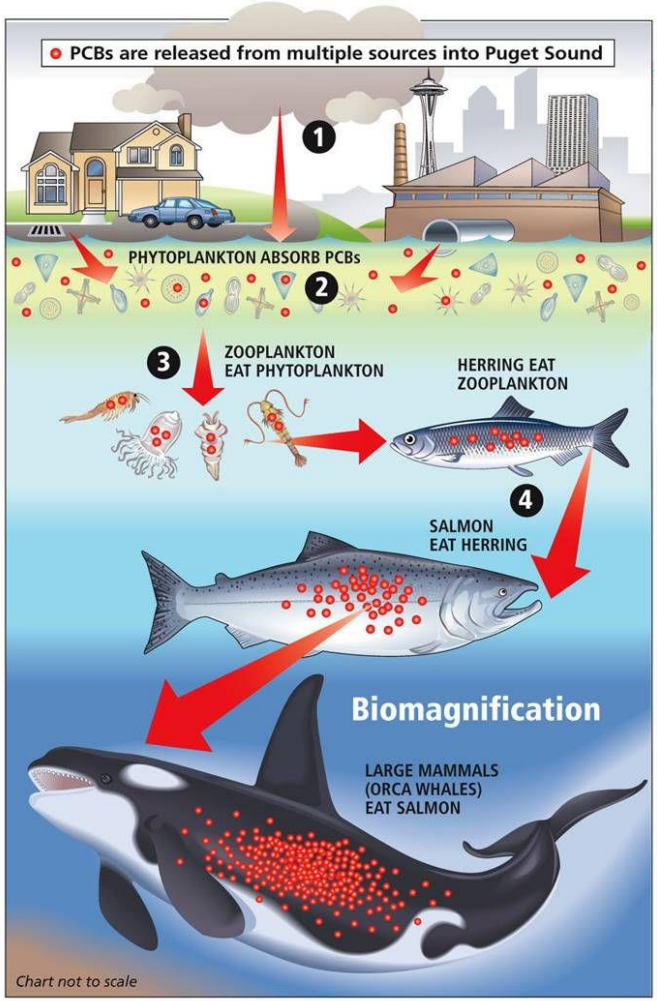


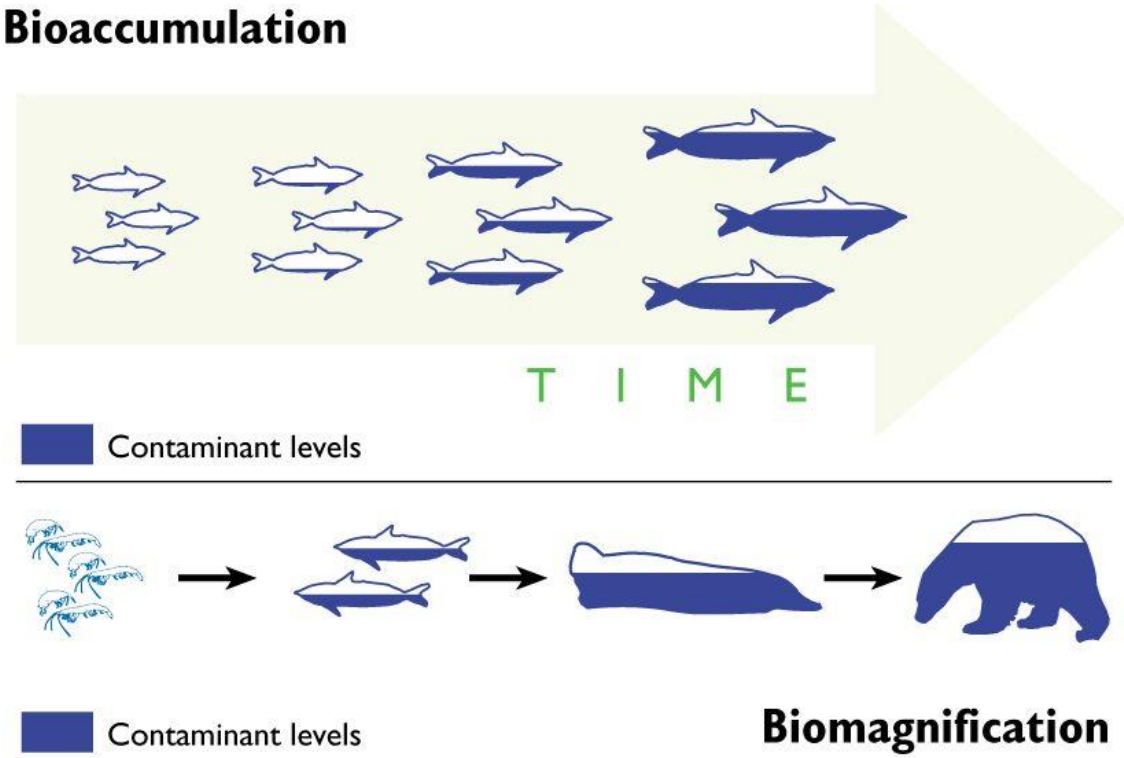
# Accumulated pollutant in an ecosystem

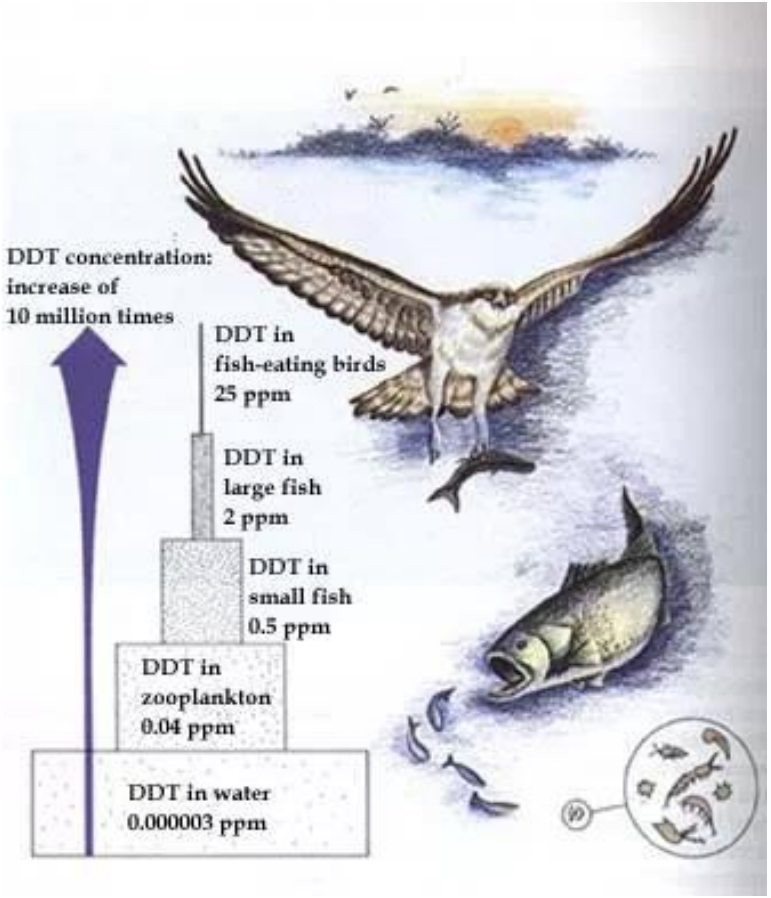
- Pollutant not biodegradable
  - Do not break down easily in environment or in organisms' bodies
- Higher trophic levels = increase in concentration
  - Carnivores tend to feed on many smaller animals
- **DDT** - insecticide historically used by farmers to reduce losses & maximize crop yields
  - **Non-biodegradable** - pollutants that cannot be broken down within an organism or trophic level
  - Remained poisonous in environment for long time
  - Low concentrations used...but bioaccumulated
    - Bioaccumulation - build up of a persistent pollutant within an organism or trophic level because it is nonbiodegradable

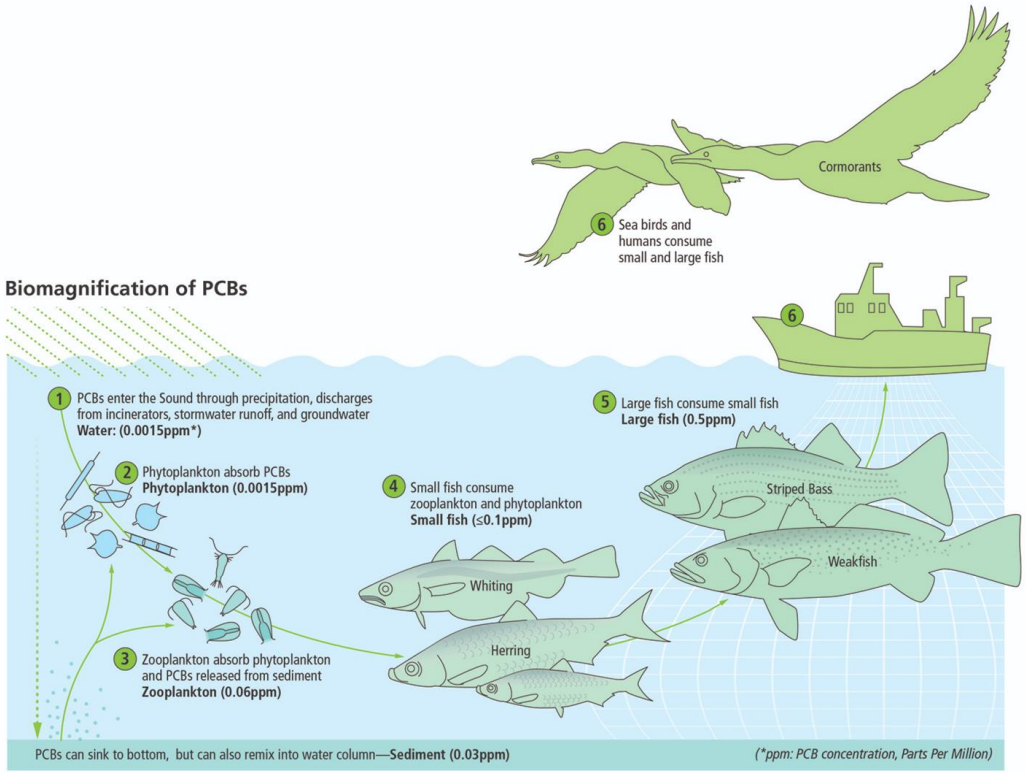
# Biomagnification (example DDT)

- Primary consumers eat many small plants containing poison
  - Accumulated and concentrated DDT into their body fat
- Secondary & tertiary consumers eat many smaller animals
  - DDT increased many thousands of times at each link in food chain
    - Called biomagnification - increase in concentration of persistent pollutants along a food chain
- Effect to top carnivores caught attention…#s plummeted (predatory birds)
- DDT banned for use in agriculture during 1970s and 1980s
  - But in 2004 Stockholm Convention permitted DDT to control malarial mosquitoes (signed by more than 170 countries and endorsed by most environmental groups)


PCBs are released from multiple sources into Puget Sound
1
PHYTOPLANKTON ABSORB PCBs
2
3
ZOOPLANKTON
EAT PHYTOPLANKTON
HERRING EAT
ZOOPLANKTON
4
SALMON
EAT HERRING
Biomagnification
LARGE MAMMALS
(ORCA WHALES)
EAT SALMON
Chart not to scale

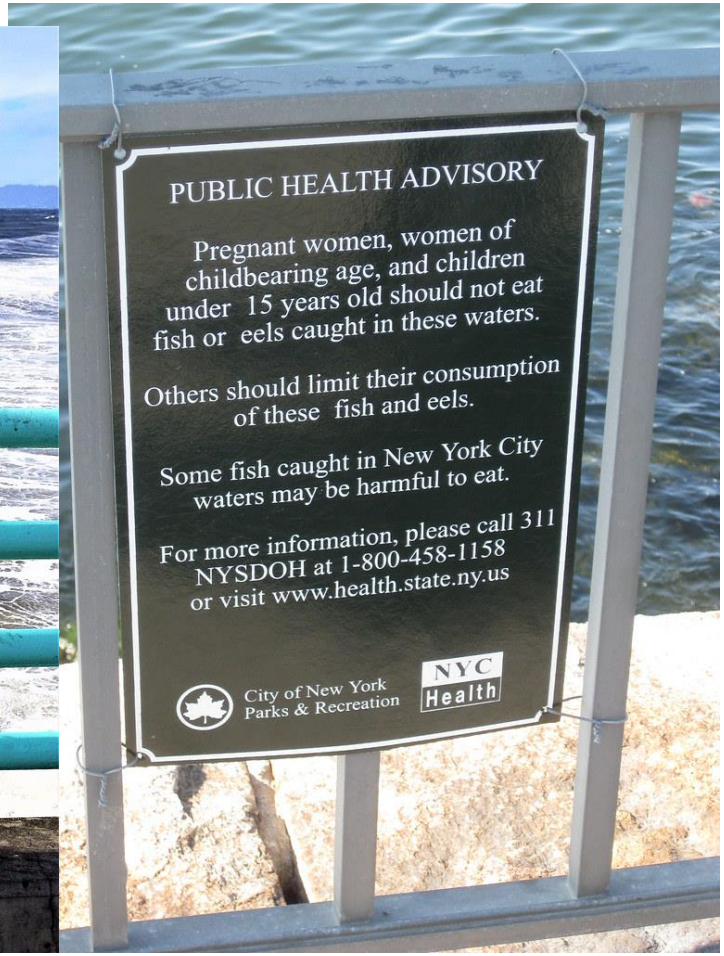

Bioaccumulation
T I M E
Contaminant levels
Contaminant levels
Biomagnification


DDT concentration:
increase of
10 million times
DDT in
fish-eating birds
25 ppm
DDT in
large fish
2 ppm
DDT in
small fish
0.5 ppm
DDT in
zooplankton
0.04 ppm
DDT in water
0.000003 ppm


Biomagnification of PCBs
Cormorants
6 Sea birds and humans consume small and large fish
6
1 PCBs enter the Sound through precipitation, discharges from incinerators, stormwater runoff, and groundwater
Water: (0.0015ppm*)
2 Phytoplankton absorb PCBs
Phytoplankton (0.0015ppm)
3 Zooplankton absorb phytoplankton and PCBs released from sediment
Zooplankton (0.06ppm)
4 Small fish consume zooplankton and phytoplankton
Small fish (≤0.1ppm)
5 Large fish consume small fish
Large fish (0.5ppm)
Striped Bass
Weakfish
Whiting
Herring
PCBs can sink to bottom, but can also remix into water column—Sediment (0.03ppm)
(*ppm: PCB concentration, Parts Per Million)


DO NOT EAT THE FISH
This area is part of the Do Not Eat Fish Advisory issued by the State of Michigan due to high amounts of PFAS found in fish.
Enjoy swimming, boating, and catch and release fishing. Touching the water is not a health concern.
For more information, call MDHHS at 1-800-648-6942 or visit www.michigan.gov/pfasresponse
MDHHS
DEQ


Do Not Eat Contaminated Fish
¡No Coma Pescado Contaminado!
White Croaker
Corvineta blanca, Roncador blanco
Barred Sand Bass
Cabrilla de arena
Black Croaker
Corvineta negra, Roncador negro
Topsmelt
Pejerrey
Barracuda
Barracuda
Choose healthy fish; check your local advisory.
Coma pescados saludables; infórmese con su asesor local.
www.pvsfish.org


PUBLIC HEALTH ADVISORY
Pregnant women, women of childbearing age, and children under 15 years old should not eat fish or eels caught in these waters.
Others should limit their consumption of these fish and eels.
Some fish caught in New York City waters may be harmful to eat.
For more information, please call 311 NYSDOH at 1-800-458-1158 or visit www.health.state.ny.us
City of New York Parks & Recreation
NYC Health