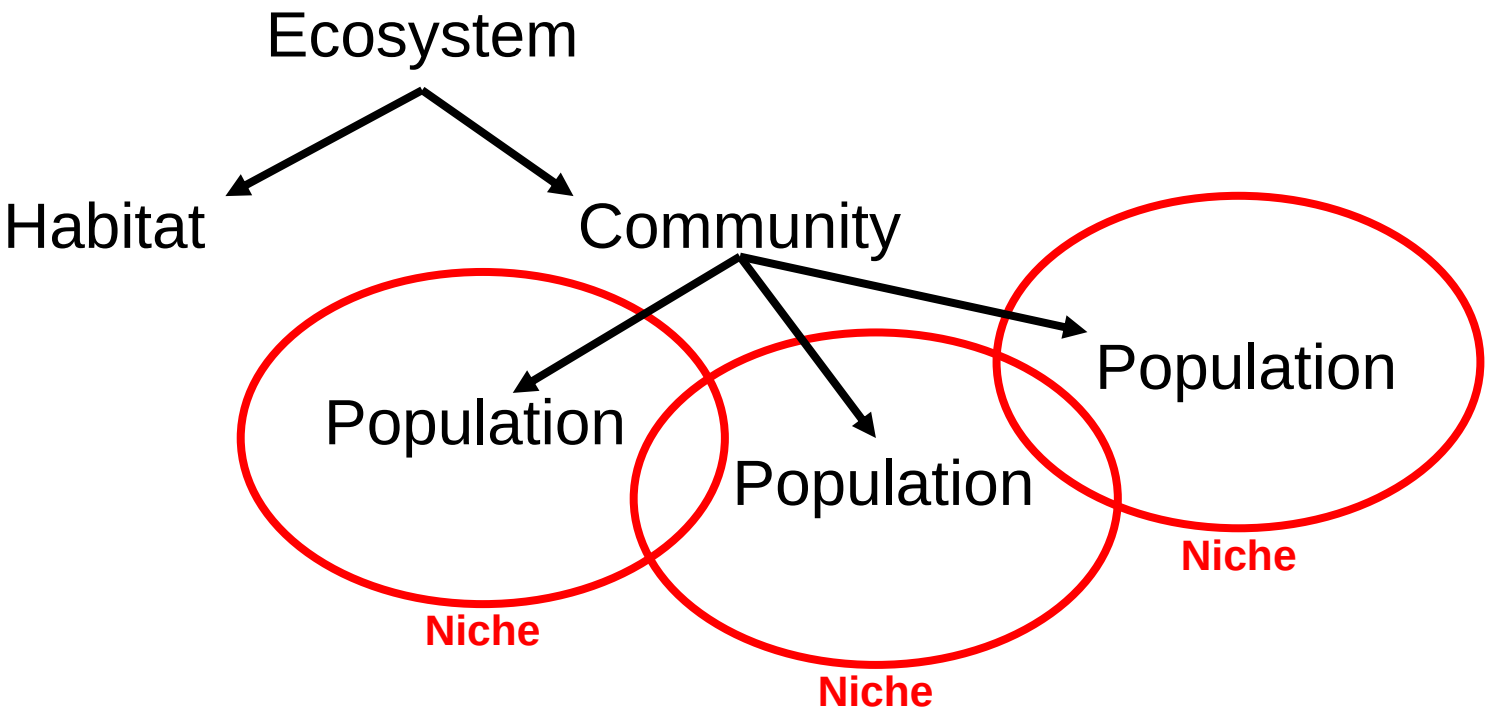
Ecosystems & Sustainability

- Define an ecosystem
- Describe how energy is transferred between trophic levels
- Explain how we can manipulate these energy transfers
- Describe the role of microbes in an ecosystem
- Describe the role of decomposers within an ecosystem.

What is an Ecosystem?

- A group of living & non-living things occurring together



Factors affecting organisms

- An organism's environment may be divided into two main parts:
  - Biotic (living) environment.
  - Abiotic (non-living) environment.

- These factors both influence the distribution & behaviour of an organism.

Biotic Factors

- Competition
- Predation
- Antibiosis
- Disease
- Food supply
- Human influence

Abiotic Factors

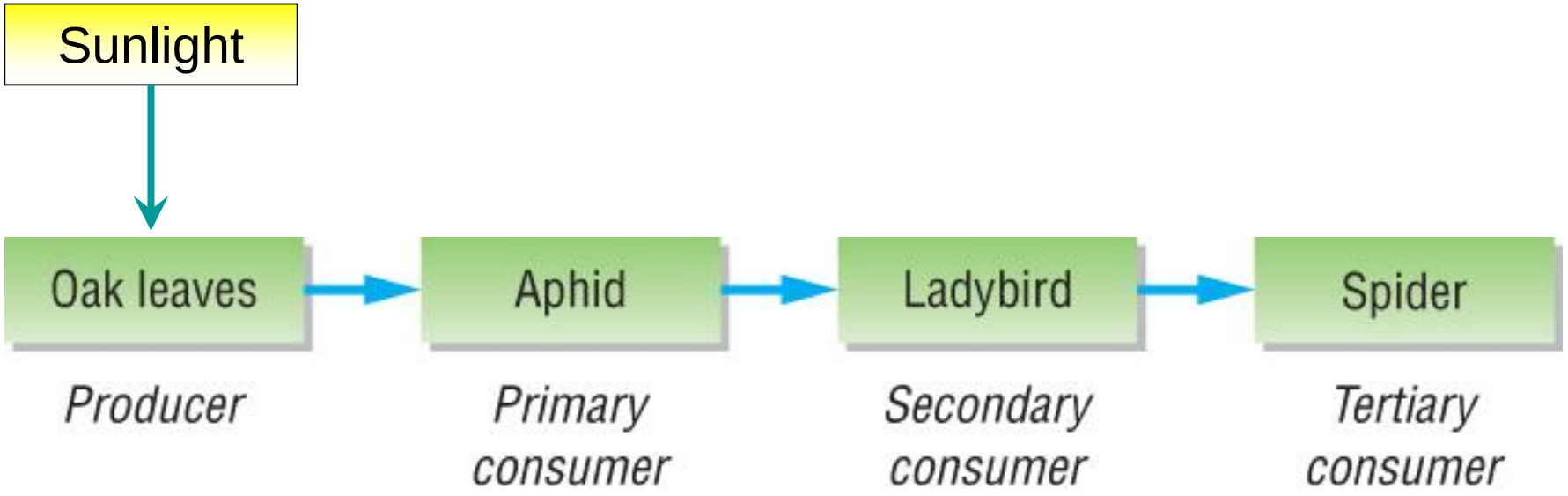
- Light
- Temperature
- Water
- pH
- Humidity
- Soil nitrogen levels

Ecosystems are Dynamic

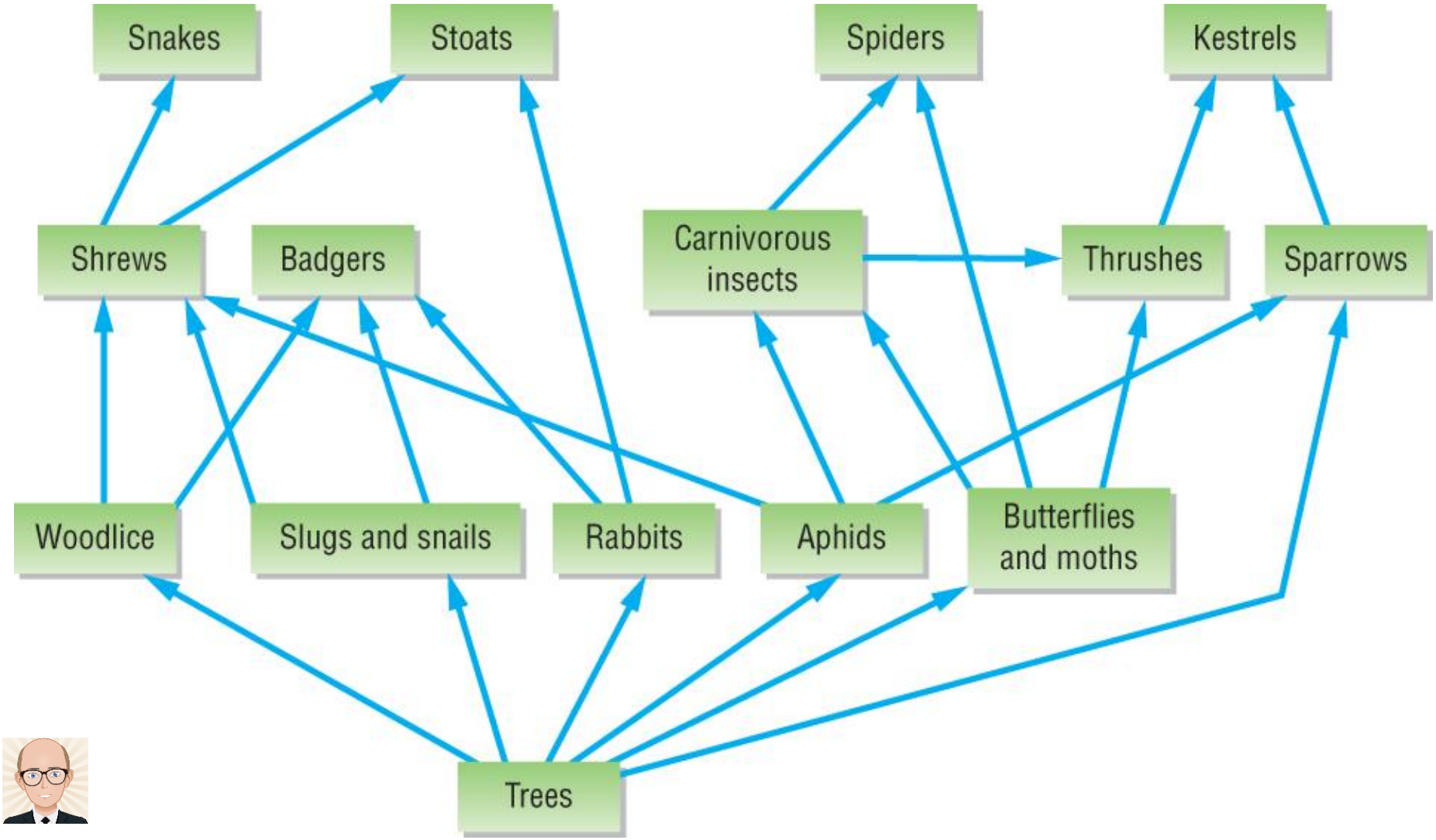
- Any change in any biotic or abiotic factor can have effects on the sizes of populations within the ecosystem.

Energy flows through an ecosystem

- Food chains show how energy is transferred:

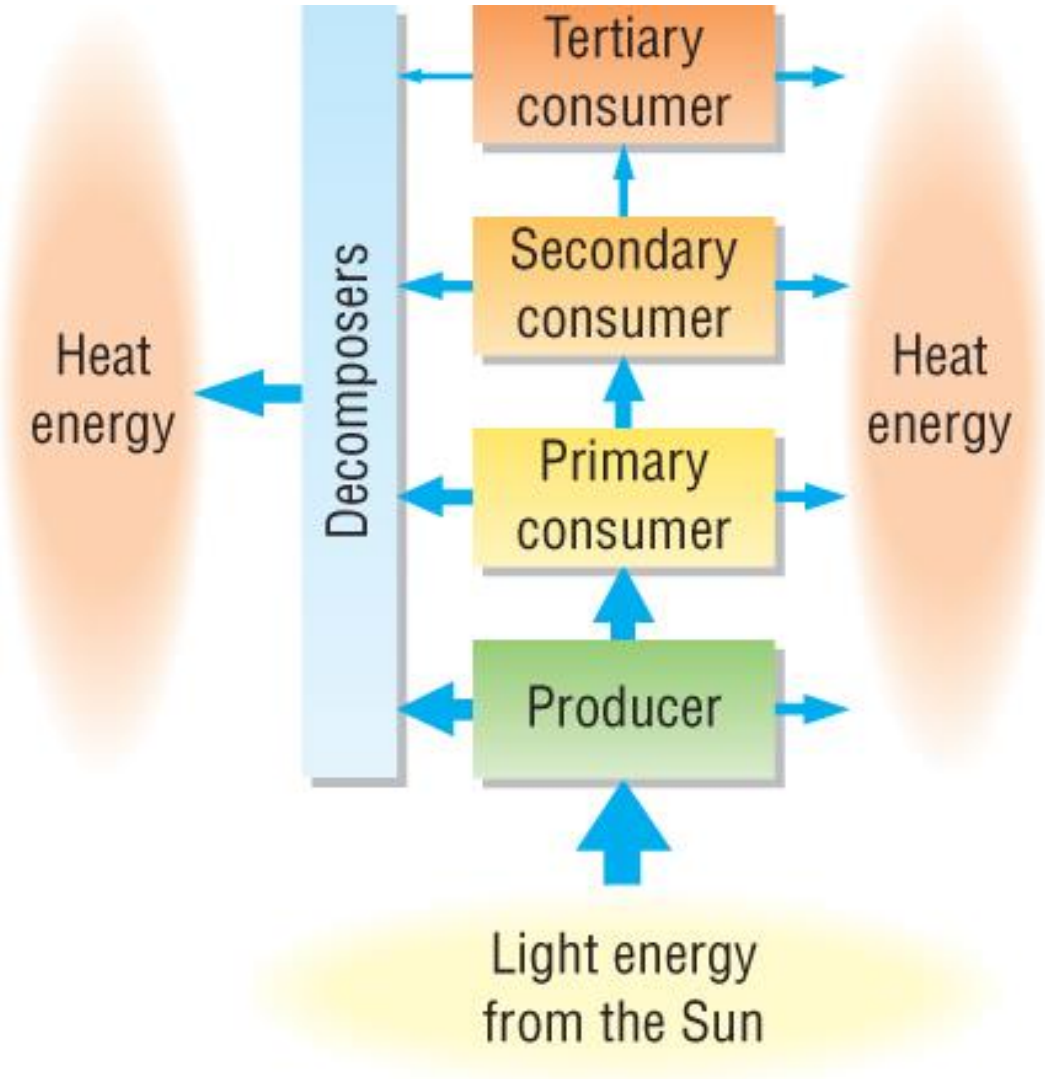


Most food chains are part of a food web



Energy loss

- At each trophic level, energy is lost to the environment.

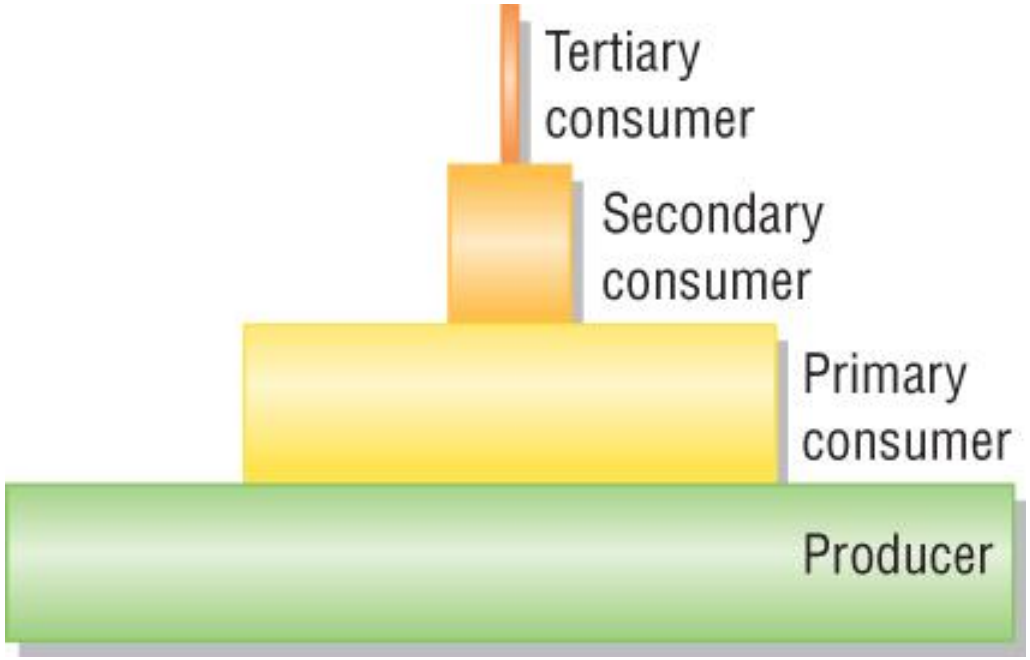


Measuring energy transfer

- 4 main methods:
  - Pyramids of number
  - Pyramids of biomass
  - Pyramids of energy
  - Productivity

Pyramids of number

- Counting the number of organisms at each trophic level in an ecosystem.
- Simple & quick
- Not always accurate



Pyramids of biomass

- Areas of bars are proportional to biomass at each trophic level.

- A more accurate measure.

- Destructive method
- Species vary in their chemical composition

Pyramid of energy

- Burning the organisms in a calorimeter.
  - Heat energy is measured from an increase in temperature of a given volume of water.

- More realistic measure of energy content at each trophic level

- Destructive & time consuming
- Just a snapshot in time

Productivity

- The rate at which energy flows through each trophic level per unit area per unit time.

- Primary Productivity – the productivity of plants.
  - Measured in MegaJoules per square metre per year ($MJ.m^{-2}.yr^{-1}$)

Primary Productivity

- Gross Primary Productivity
  - The rate at which plants convert light energy into chemical energy.
    - Difficult to measure

- Net Primary Productivity
  - GPP minus the energy used by the plants for respiration.
    - Often simply measured as above-ground dry biomass per area per time

Improving NPP

- Crop plants typically have a NPP of 1–3% of the total visible light energy provided to the by the sun.

- By manipulating various factors we can make energy conversion more efficient and increase crop yields.

Light

- Plant crops early to provide a longer growing season.

- Grow crops under artificial light.

Temperature

- Increased temperatures = increased reaction rates.
  - Provided the enzymes are not denatured.

- Greenhouses can be used.

Water

- Irrigation
- Breeding drought resistant crops

Minerals

- Crop rotation
- Plant nitrogen fixing crops (peas, beans) between cycles

Pests

- Insects/caterpillars eat crop plants.
- Pesticides can reduce the effect.
- GM crops can be produced that are resistant to pests.

Disease

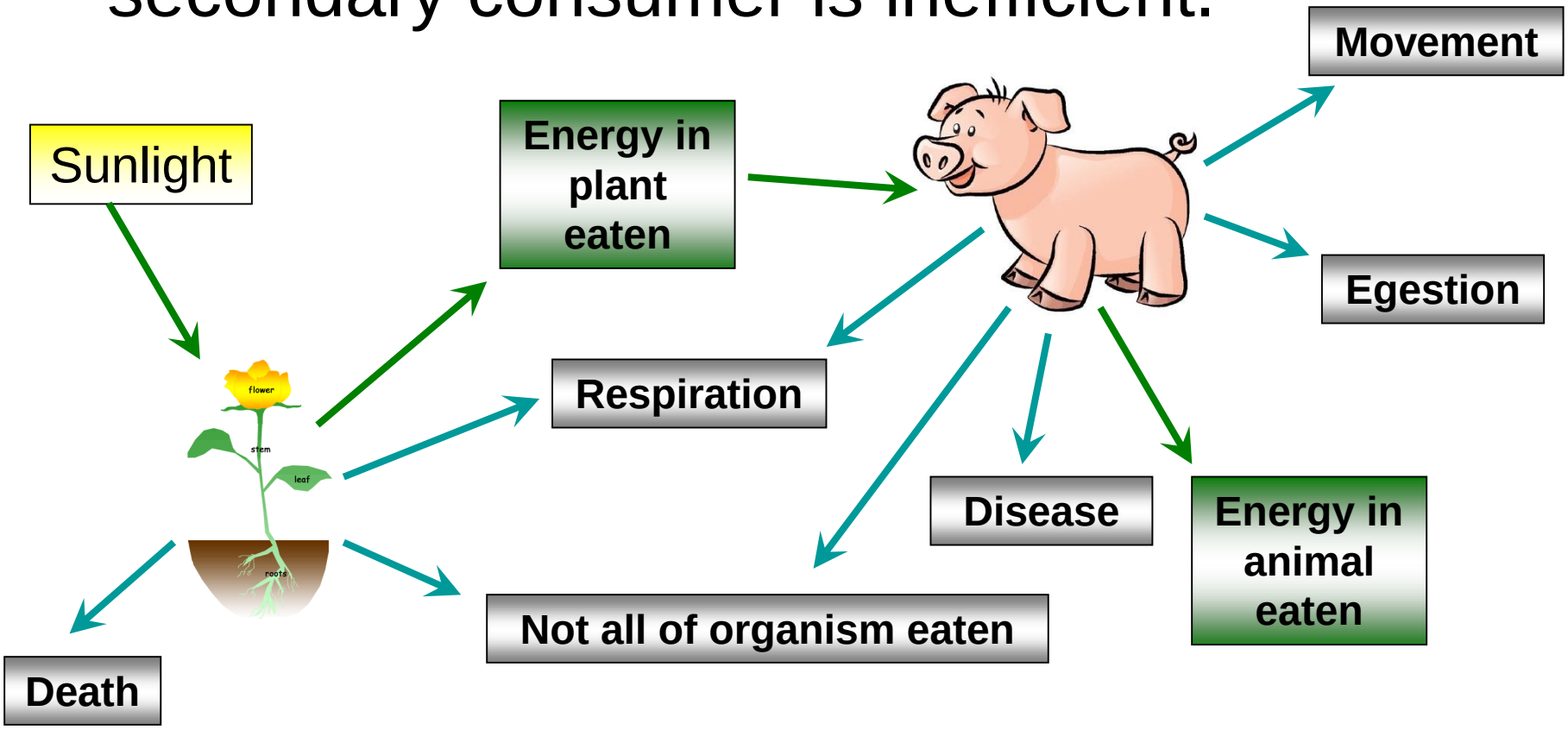
- Fungal diseases damage crop plants.
  - Damage to roots, xylem, leaves
- Fungicides can reduce the effect.
- GM crops can be produced that are resistant to fungal infections.

Competition

- Weeds compete with crops for minerals, water, light.
- Herbicides can reduce the number of weeds.

Improving secondary productivity

- Energy transfer from producer to consumer and then from consumer to secondary consumer is inefficient.



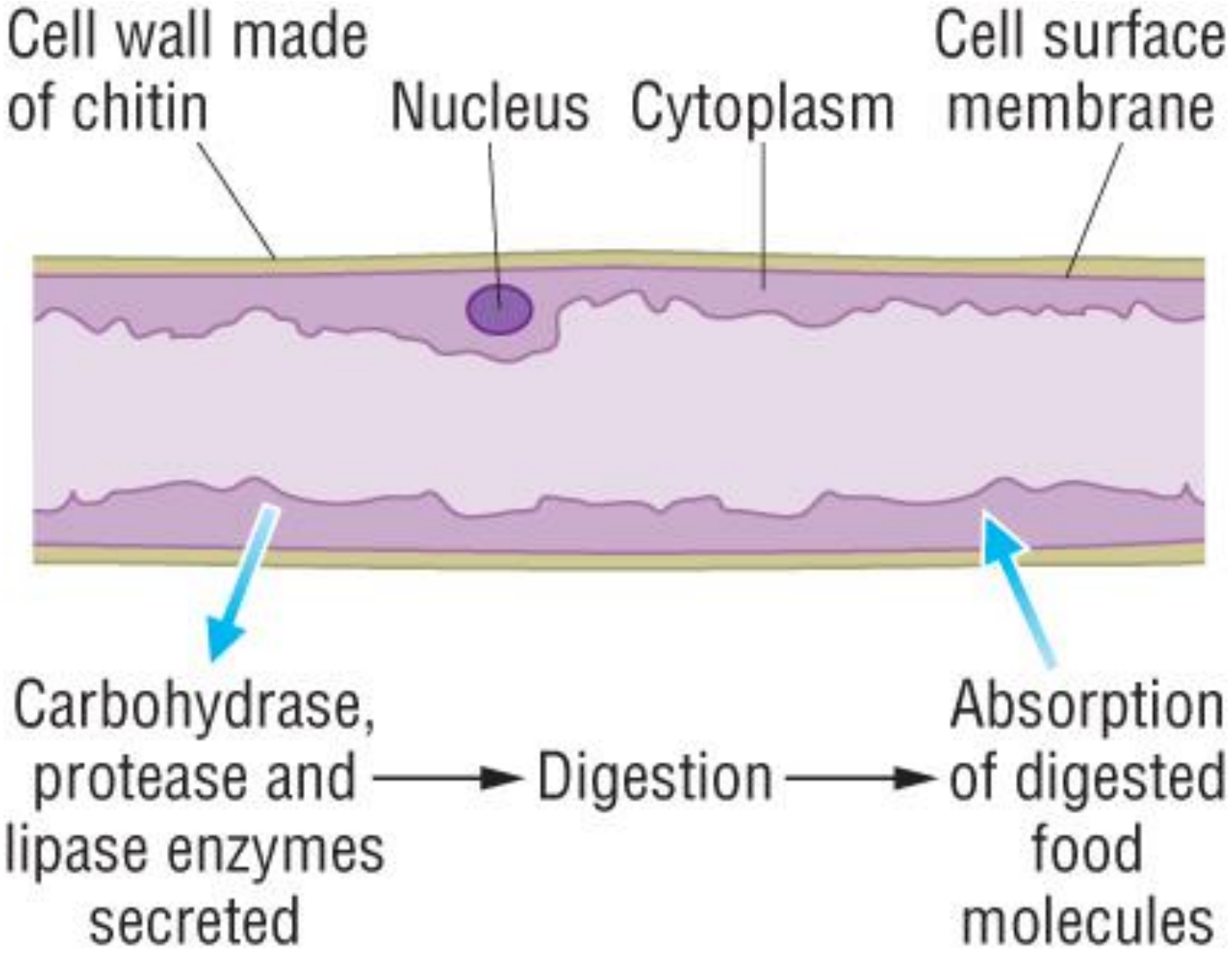
We can…

- Harvest the animal before adulthood.
  - Young invest more energy into growth.
- Selectively breed faster growing animals.
  - Or high yielding milk/eggs.
- Treat with antibiotics
  - Reduces energy loss to parasites/pathogens.
- Rear animals in cages.
  - Reduces energy loss in movement & maintenance of body temperature.

Decomposers & Recycling

- Decomposers:
  - Microorganisms such as bacteria & fungi.
  - Feed Saprotrophically.
    - Saprotrophs secrete enzymes onto dead/waste material.
    - Enzymes break digest material.
    - Digested substances absorbed into organism.

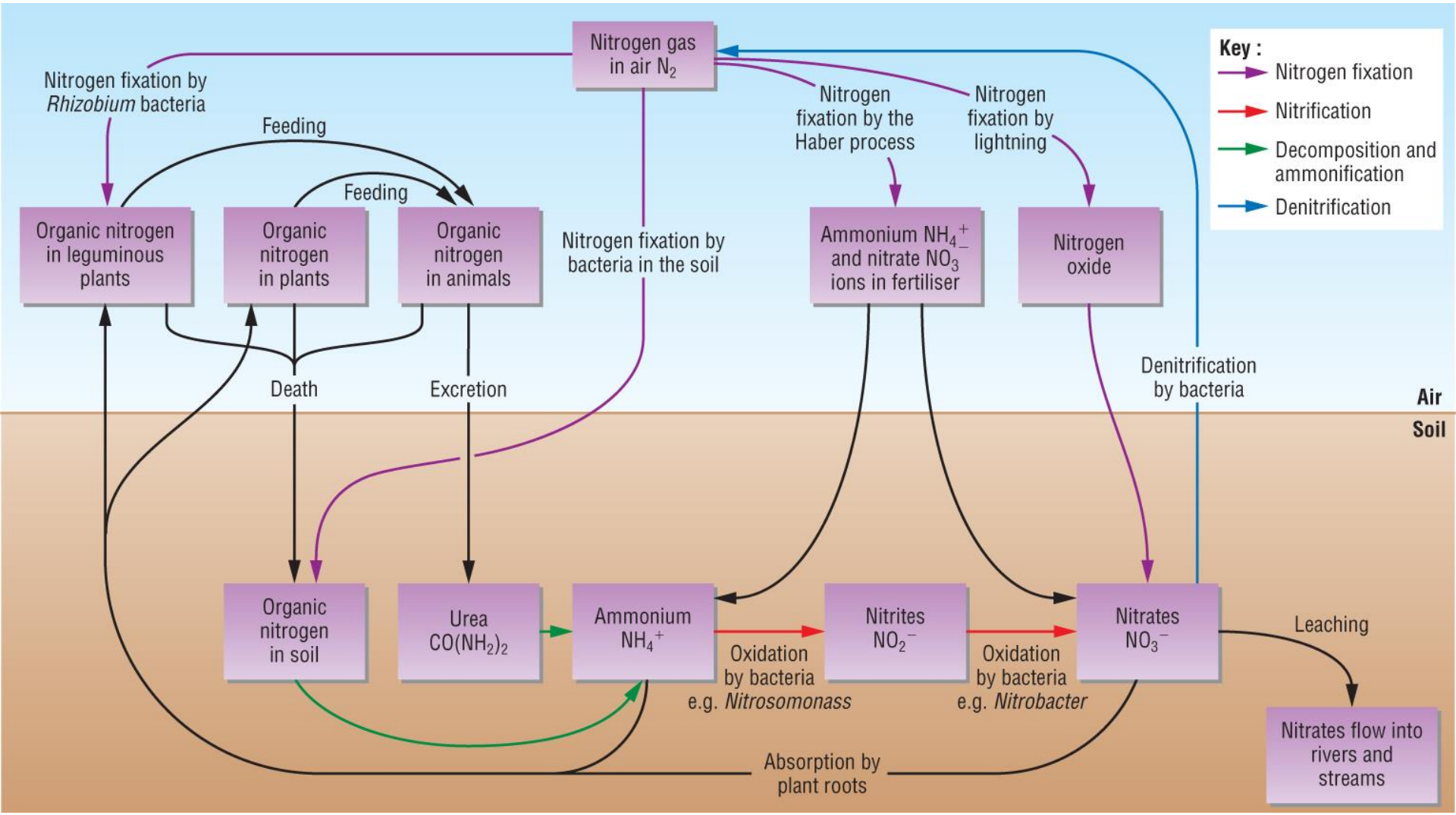
Saprotrophic feeding



Nitrogen Cycle

- Nitrogen is used by living organisms to:
  - Make DNA/RNA
  - Make Proteins

Process	Bacteria	Details
Decomposition/ Ammonification	(lots)	
Nitrogen Fixation		
Nitrification		
Denitrification		


Nitrogen gas in air N_2
Nitrogen fixation by *Rhizobium* bacteria
Feeding
Feeding
Nitrogen fixation by the Haber process
Nitrogen fixation by lightning
Organic nitrogen in leguminous plants
Organic nitrogen in plants
Organic nitrogen in animals
Nitrogen fixation by bacteria in the soil
Ammonium NH_4^+ and nitrate NO_3^- ions in fertiliser
Nitrogen oxide
Key :
Nitrogen fixation
Nitrification
Decomposition and ammonification
Denitrification
Death
Excretion
Denitrification by bacteria
Air
Soil
Organic nitrogen in soil
Urea $CO(NH_2)_2$
Ammonium NH_4^+
Nitrites NO_2^-
Nitrates NO_3^-
Oxidation by bacteria e.g. *Nitrosomonass*
Oxidation by bacteria e.g. *Nitrobacter*
Leaching
Absorption by plant roots
Nitrates flow into rivers and streams

Ammonification

- Basically:
  - Any process that produces ammonia.

- Ammonium ions produced by:
  - Bacteria that cause decay to organic matter.
  - The industrial Haber process.
    - Chemical fertilisers often contain ammonium nitrate.

Nitrogen Fixing

- Nitrogen gas is very unreactive.
  - Fixed Nitrogen (NH_4^+, NO_3^-) can be used by plants.
  - 10% fixed by Haber Process & lightning.
  - 90% fixed by Nitrogen fixing bacteria.
- Nitrogen Fixing bacteria:
  - Occur in soil.
  - Rhizobium is found inside root nodules of leguminous plants.

Nitrification

- Chemoautotrophic bacteria get energy by oxidising ammonium ions into nitrites or by oxidising nitrites into nitrates.

Ammonium ions + Oxygen —(**Nitrosomonas bacteria**)→ **Nitrites**

Nitrites + Oxygen —(**Nitrobacter bacteria**)→ **Nitrates**

Denitrification

- Some bacteria in anaerobic conditions use nitrates as a source of oxygen.
  - These produce Nitrogen gas.

Nitrates ⟶ **Nitrogen gas + Oxygen**