

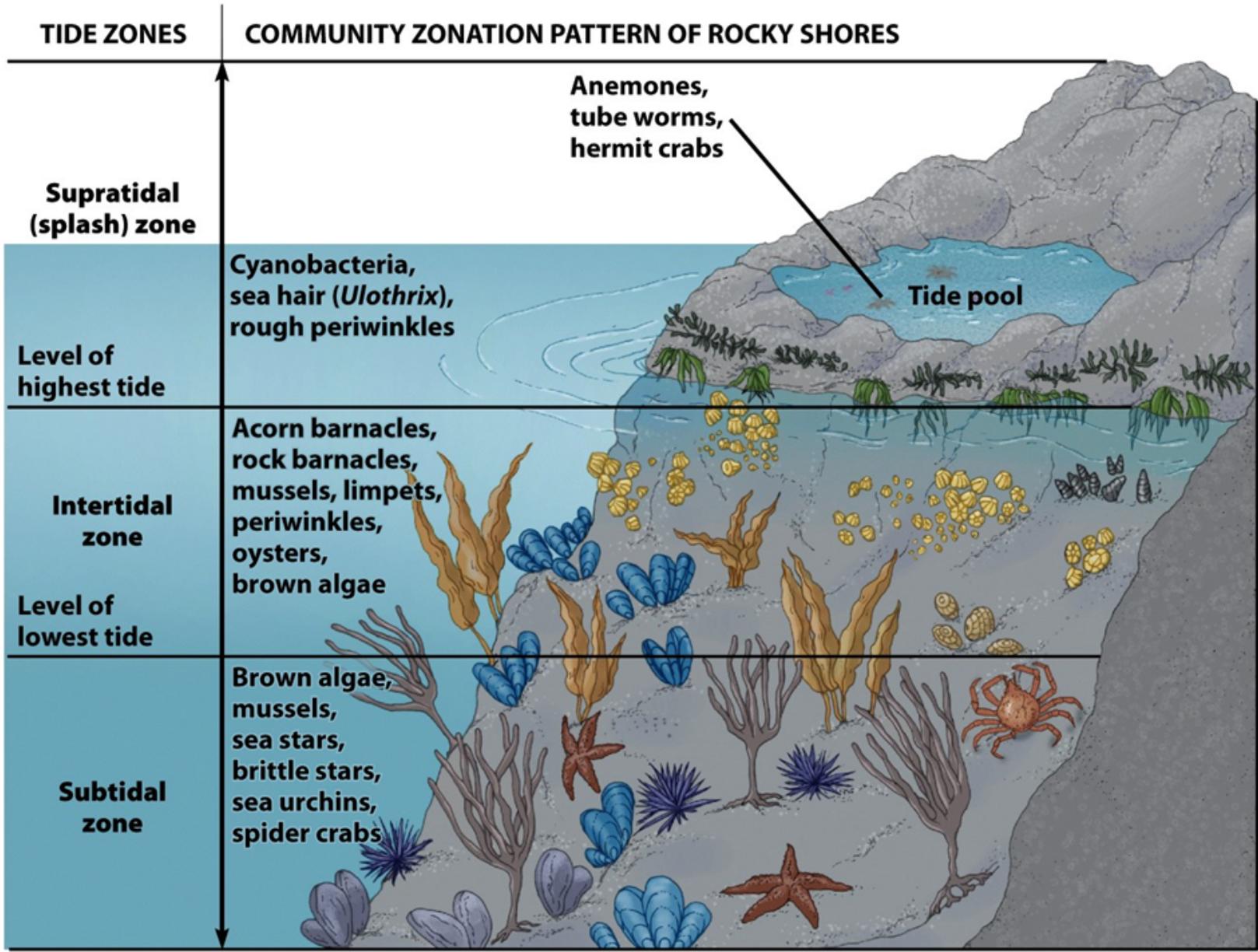
ESS 2.5.1

Zonation and Succession

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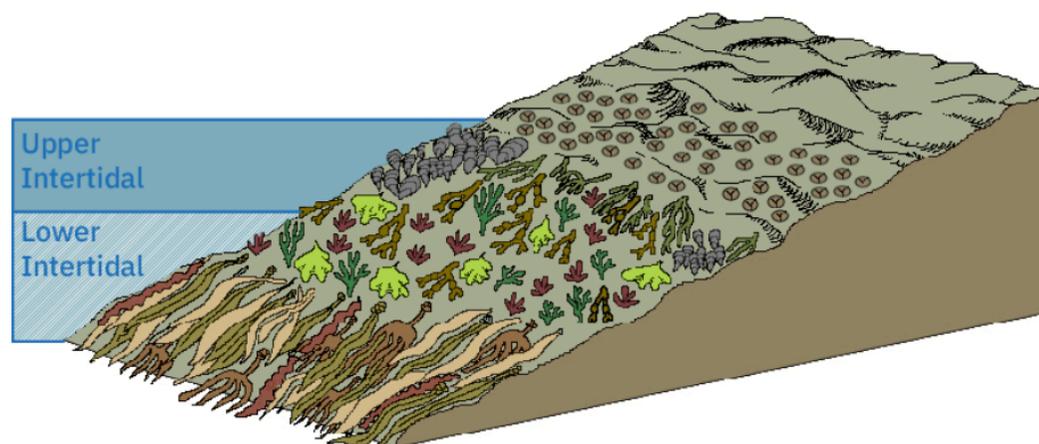
Learning Objectives

1. Describe the term zonation
2. Outline the use of transect to investigate zonation
3. Describe the process of succession
4. Describe the term “seral stages” and “climax community”
5. Explain the changes in succession time



Part 1: Zonation = space occupied

- Zonation describes the variation in biological communities along an environmental gradient
- Example: Seaweeds, in particular, exhibit clear zonation patterns
- Species that are more resistant to water loss, such as channel wrack, thrive on the upper shore.
- Species that are less tolerant of desiccation, like kelp, are found on the lower shore, where they remain submerged for longer periods.



 Barnacles
 Mussels
 *Ascophyllum* sp.
 *Fucus* sp.

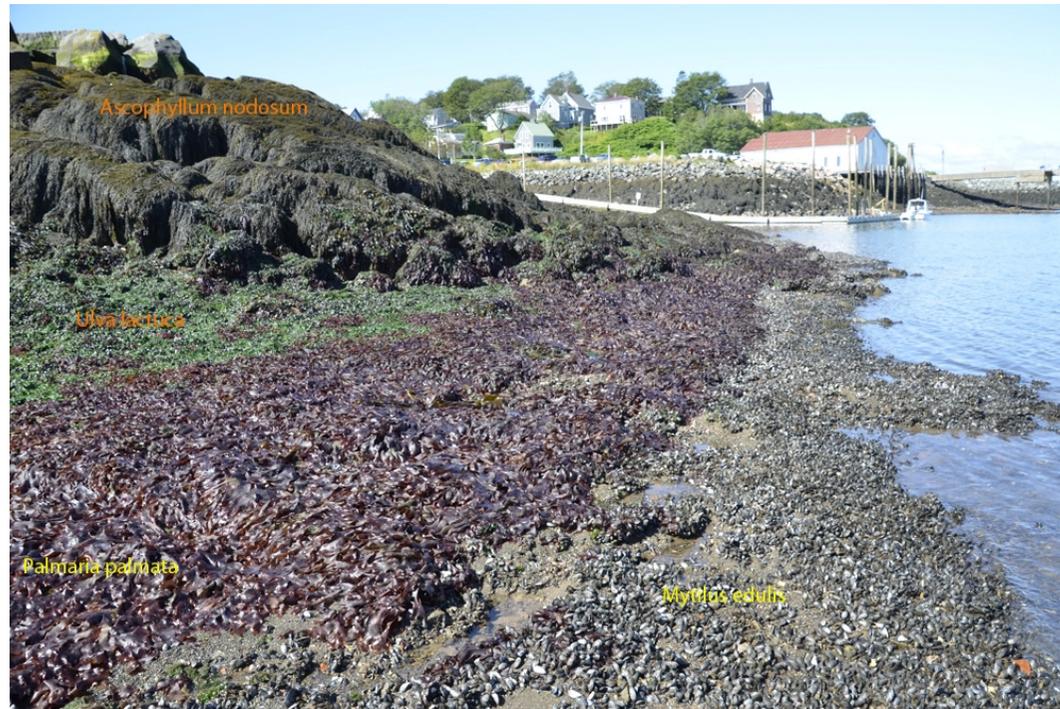
 *Chondrus* sp.
 *Codium* sp.
 *Ulva* sp.

 *Sacchoriza* sp.
 *Undaria* sp.
 *Laminaria* sp.
 *Grateloupia* sp.

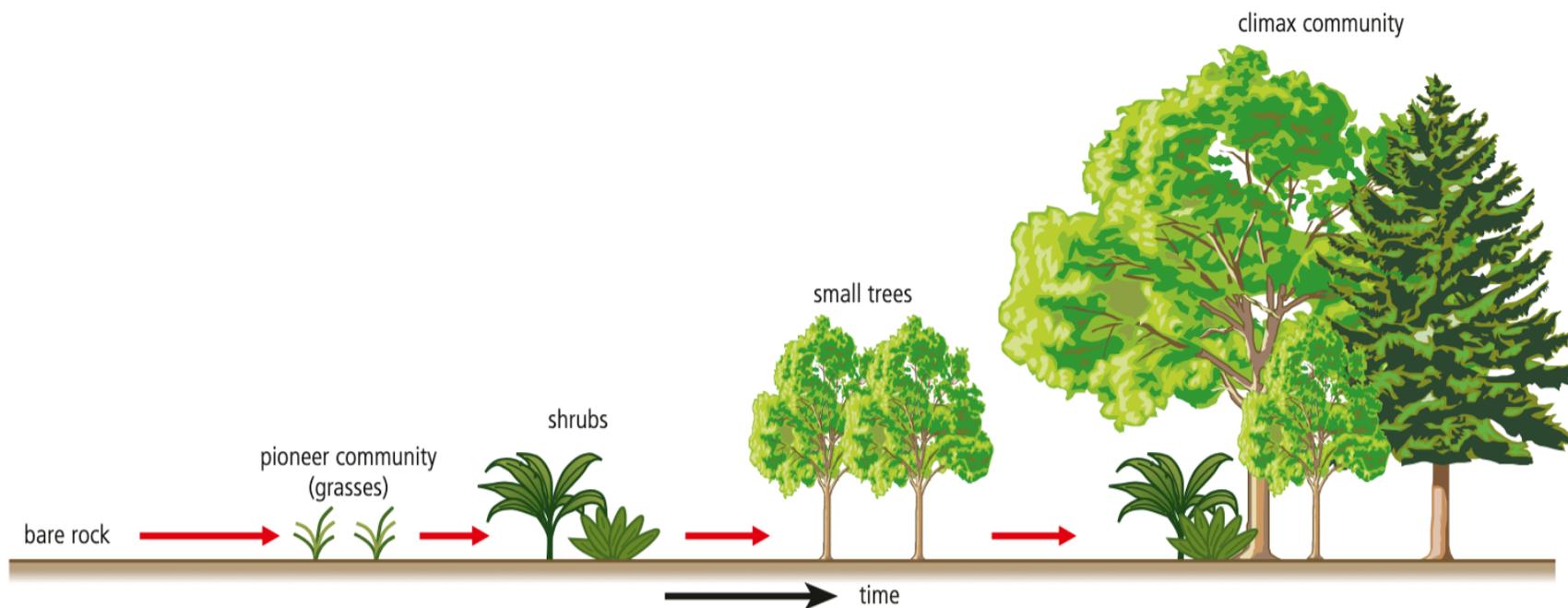
Using Transect to Investigate Zonation

- Zonation measurement involves recording biotic and abiotic factors at fixed heights along a transect.
- A transect is established using a long tape measure, running along the vertical gradient of study (across different zones).
- A cross staff is used to move a set vertical distance (e.g., 0.6 m) up the transect.
- The staff is placed vertically at each sample location, and a sighting point at 0.6 m above the ground is used to determine the next sampling point.
- Biotic and abiotic factors are recorded at each height interval along the gradient.

Zonation



Part 2: Succession = time to establish an ecosystem



What happens in the soil in terms of nutrient accumulation during succession?

- Increase in Organic Matter
 - Succession leads to the accumulation of organic matter in ecosystems.
- Decomposition Process
 - Dead plants and organisms break down, enriching the soil with nutrients.
- Role of Soil Organisms
 - Earthworms and other decomposers enhance soil structure and moisture retention.
- Fertile Soil Formation
 - Organic matter accumulation creates richer soil, supporting greater biodiversity.
- Succession as an Ecological Process
 - Gradually transforms ecosystems over time.
- Predictable Sequence
 - Involves species replacement, soil formation, and increasing biodiversity.
- Final Result
 - Ecosystems become more complex, stable, and resilient.
 - Climax Community → Represents long-term equilibrium and ecosystem maturity.

What happens in the soil in terms of nutrient accumulation during succession?

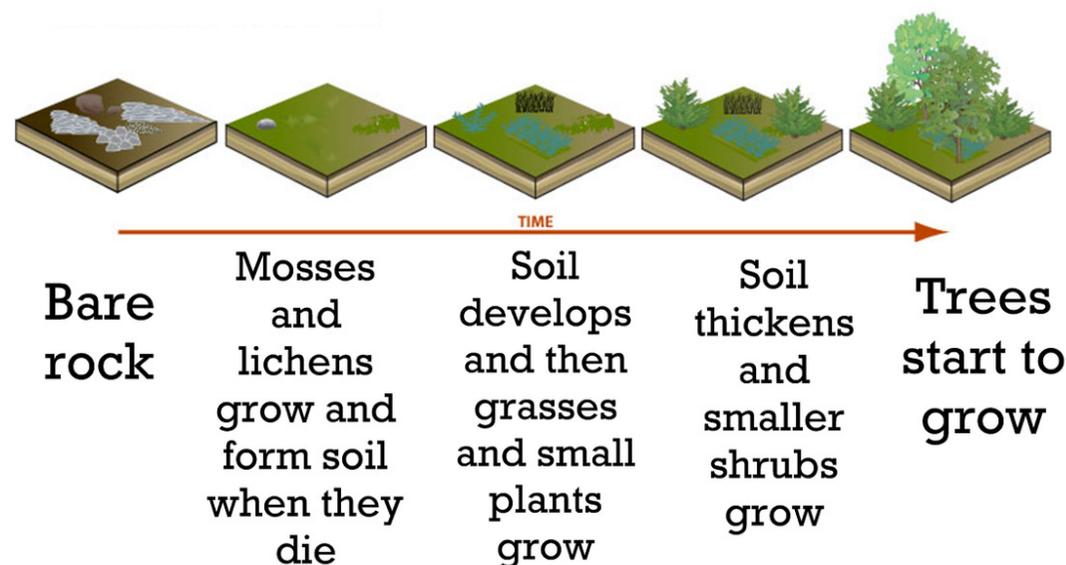
- Soil fertility increases
 - Succession leads to the accumulation of organic matter in ecosystems.
 - Dead plants and organisms break down, enriching the soil with nutrients.
 - Earthworms and other decomposers enhance soil structure and moisture retention.
 - Organic matter accumulation creates richer soil, supporting greater biodiversity.
- Succession as an Ecological Process
 - Gradually transforms ecosystems over time.
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- Final Result
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2 Types of Succession

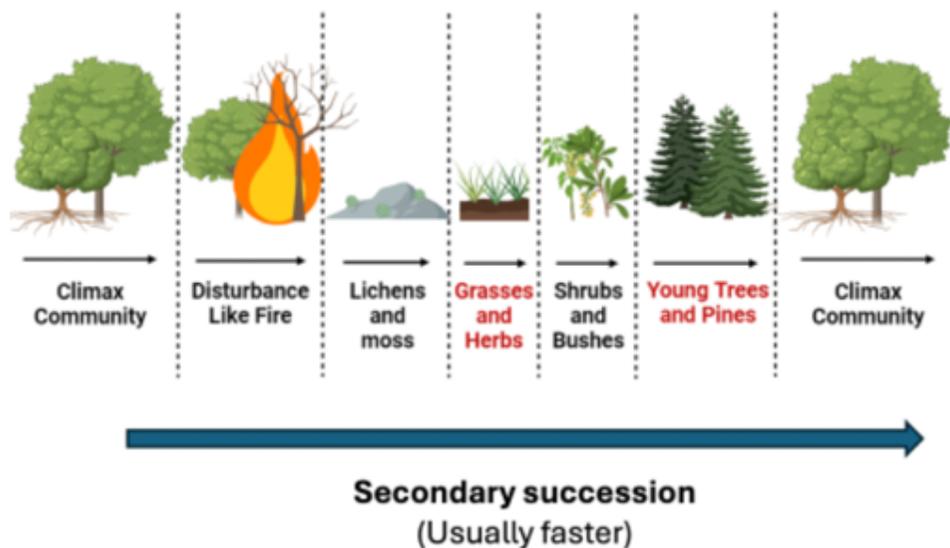
Primary Succession

- This occurs on **previously uncolonised surfaces**, such as newly formed volcanic rock or glacial deposits. In these environments, there is no pre-existing soil, and life begins with pioneer species like **lichens and mosses**, which can withstand harsh conditions.

Primary Succession (no life already existed here)



2 Types of Succession

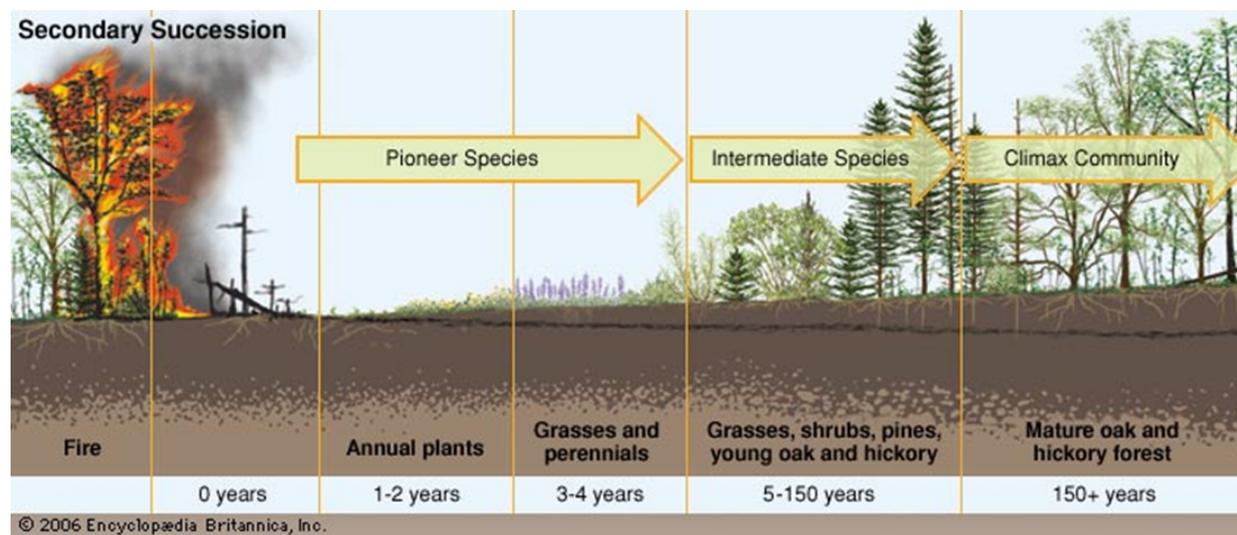


Secondary Succession

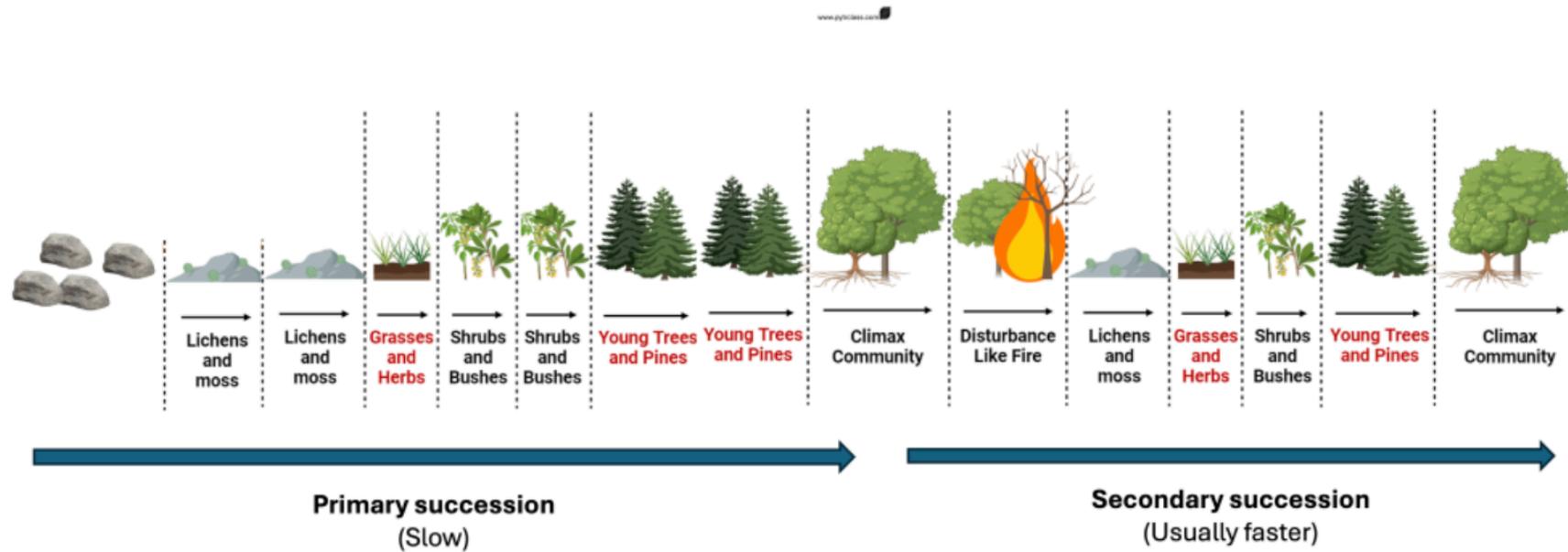
- This takes place in areas where an existing community has been **disturbed or destroyed**, such as after a forest fire, flood, or human activity. Since soil and seed banks are already present, secondary succession happens **much faster** than primary succession.

Secondary Succession

- Succession that begins in an environment following destruction of all or part of the earlier community
 - Ex: abandoned farmland, open area after fire
- Begins when natural community is disturbed BUT soil & sediment remains
- New vegetation can germinate from the seed bank
- In both cases (primary and secondary), succession focuses on vegetation changes



2 Types of Succession



Seral Stages and Climax Community

What are seral stages?

Seral Stages in Succession

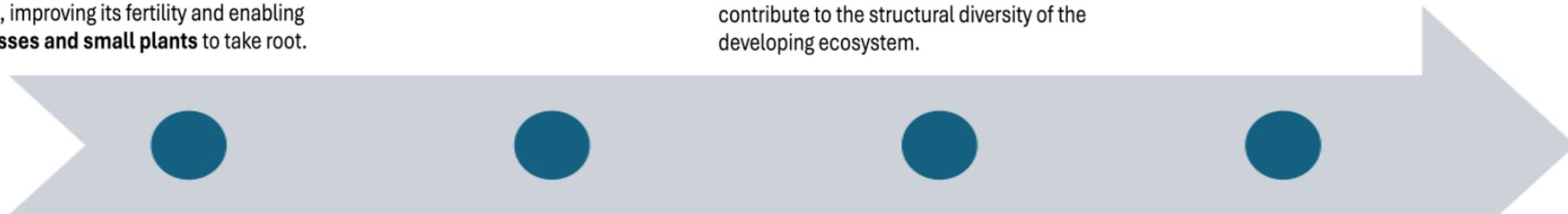
- Each transitional community within an ecological succession is known as a **sere**.
- As succession progresses, each **seral stage** modifies the environment in a way that facilitates the establishment of the next community.
- This transition occurs through **competition** between species, ultimately leading to the formation of a **stable climax community**.

Pioneer Species Establishment

- Bare rock or exposed land is colonized by **lichens and mosses**, which are well-adapted to survive without soil.
- These species trap wind-blown particles, retain moisture, and begin the process of **weathering the parent rock**, contributing to the formation of thin soil.
- When pioneer species die, their decomposition adds **organic material** to the soil, improving its fertility and enabling **grasses and small plants** to take root.

Shrub Growth and Increased Competition

- Over time, larger and more competitive species such as **bramble, gorse, and rhododendron** take over, further enhancing soil quality.
- These shrubs provide habitat for animals and contribute to the structural diversity of the developing ecosystem.



Development of Grasses and Herbaceous Plants

- **Grasses and ferns** outcompete mosses and lichens by growing taller, gaining better access to sunlight for **photosynthesis**.
- Their **root systems** stabilize the thin soil, reducing erosion and facilitating the accumulation of nutrients.
- As soil depth and fertility improve, **herbaceous plants** such as dandelions and goosegrass appear. These plants grow quickly and spread via **wind-dispersed seeds**, allowing them to dominate before larger plants can establish.

Formation of the Climax Community

- Eventually, trees grow, producing **dense shade** that limits the survival of shrubs and early-stage plants.
- Only **shade-tolerant species** persist on the forest floor, while deep-rooted trees dominate the upper canopy.
- This marks the establishment of a **climax community**, which represents a **stable, self-sustaining ecosystem** in balance with environmental conditions.

Pioneer Communities

- Lichens and Mosses
- Survive on nutrients in dust and rock
- Start soil formation
- Characterized by r-selected species

Roles:

1. Trap small particles
2. Produce organic material - photosynthesis
3. Chemically weather the rock
4. Patches of soil form



Characteristics of climax community

Characterized by K-selected species (better adapted to this stage of succession)

- Greater biomass
- Higher species diversity
- Improved soil conditions (e.g., increased organic matter and deeper soil)
- Enhanced soil structure, leading to better water retention and aeration
- Taller and longer-living plant species
- Increased community complexity and stability
- Diverse habitats
- Maintenance of steady-state equilibrium

Climax Communities and Ecosystem Stability

Ecosystem stability refers to an ecosystem's ability to withstand and recover from changes. Most ecosystems function as negative feedback systems, meaning they have built-in mechanisms that regulate ecological balance and prevent destabilisation.

Ecosystems that reach the later stages of succession tend to be more stable due to their greater species diversity and complex food webs. This complexity provides resilience, as species can switch to alternative food sources if their primary food supply declines. Additionally, as succession advances, organic matter accumulates, enriching the soil and supporting nutrient cycling in a self-sustaining manner.

A climax community maintains a state of steady-state equilibrium, where inputs and outputs of matter and energy continue, but the overall system remains relatively constant.

Alternative Stable States

There is no single climax community for a given ecosystem. Instead, ecosystems can exist in multiple stable states, influenced by factors such as climate, soil properties, and random natural events over time. These variables shape the final composition of a mature ecosystem, meaning that different regions may develop distinct climax communities under similar conditions.

Different types of succession occur depending on the specific environment being colonised:

- **Lithosere** – Succession that takes place on bare rock.
- **Hydrosere** – Succession occurring in freshwater habitats.
- **Xerosere** – Succession that develops in dry environments, such as sandy areas.

Pioneer Vs Climax Communities

- Construct a table to differentiate pioneer and climax communities
 1. Definition
 2. Species Composition
 3. Adaptations
 4. Biodiversity
 5. Soil Quality
 6. Nutrient Cycling
 7. Energy Flow
 8. Vegetation Structure
 9. Environmental Conditions
 10. Ecological Stability
 11. Timeframe

Pioneer Vs Climax Communities

Key Differences

- Pioneer communities are the first colonisers, whereas climax communities represent the final stage of succession.
- Pioneer species are simple and hardy, while climax species are diverse and specialised.
- Pioneer communities modify the environment, making it suitable for later species, whereas climax communities maintain long-term stability.

Key Similarities

- Both are essential parts of succession, contributing to ecosystem development.
- Both influence nutrient cycling, energy flow, and biodiversity in an ecosystem.
- Both play a role in maintaining ecological balance over time.

Climax Community and Stability

- A **climax community** represents the final stage of succession, where the ecosystem reaches stability.
- In some areas, disturbances like wildfires prevent ecosystems from reaching the climax stage, leading to **plagioclimax communities**.

Plagioclimax



Plagioclimax = a stable plant community that is maintained by ongoing human activity (such as grazing, mowing, burning, or cultivation) and would not persist in its current form if those human influences stopped.

Conceptual Qs

1. Explain the changes during succession time
2. Outline how succession increases resilience

Succession Increases Diversity

- Succession increases diversity, enhancing resilience and stability.
- Human interference can disrupt succession, reducing resilience and stability.
- Ecosystem Stability & Resilience is an ecosystem's ability to tolerate disturbances depends on its diversity and resilience.
- Resilience is defined as the capacity of a system to resist tipping points and maintain stability through equilibrium.
- Factors Influencing Resilience:
 - Human Impact: Reducing diversity and storages lowers resilience. Example – Tropical Rainforests:
- High biodiversity makes them resilient.
- Logging and fires reduce resilience, causing slow recovery.
- Example – Natural Grasslands:
 - Low diversity but high resilience due to underground nutrient storage.
 - Recover quickly after fires.
 - Fires and elephants help maintain grasslands by preventing forest encroachment

Explain the changes during succession time

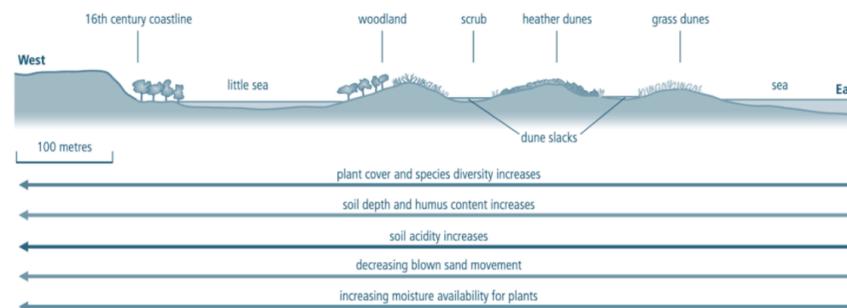
Soil consists of inorganic and organic components, water, and air. Inorganic materials come from rock weathering, while organic matter includes living organisms and decayed material. In primary succession, soil is initially absent. Pioneer plants break down rock and contribute organic matter as they decompose, forming the first soil layers. As succession continues, increased biomass enhances soil development, allowing larger plants to take root and stabilise the ecosystem.

In early succession, mineral cycling is an open system, with elements like carbon and nitrogen entering and leaving the ecosystem. As succession progresses, nutrient cycling becomes more closed, with minerals cycling within the system. Nutrients move from the soil to living organisms and return through decomposition, sustaining the ecosystem.

Changes during succession time

Factor	Early Succession	Late Succession
Soil Quality	Poor, little organic matter	Rich, high nutrient levels
Biodiversity	Low, dominated by a few species	High, diverse plant and animal species
Productivity	Low (less energy flow)	Higher (more biomass and energy transfer)
Microclimate	Harsh (extreme temperatures, little moisture)	More stable (moderate temperature, more humidity)

Explain the changes during succession time



Feature	Pioneer community	Climax community
GPP	low	high
NPP	high	low
total biomass	low	high
niches	few	many
species richness	low	high
diversity	low	high
organic matter	small	large
soil depth	shallow	deep
minerals	external	internal
nutrient cycles	open system	closed system
mineral conservation	poor	good
role of detritus	small	large