4.Mangroves- Environment

Mangroves' Cells Help Plants Survive in Saltwater. A New Study Reveals That Mangroves Tolerate Extreme salinity primarily through structural cellular adaptations—specifically small epidermal cells and thick cell walls—rather than by modifying stomata. These insights into salt exclusion and secretion mechanisms offer a blueprint for developing salt-tolerant crops and underscore the critical role of mangroves as high-efficiency "Blue Carbon" sinks and coastal defenders.

Cellular Adaptations in Mangroves

Context- A new study published in the journal *Current Biology* has shed light on the specific cellular mechanisms that allow mangrove species to thrive in high-salinity environments. Unlike previous assumptions focusing on stomata, this study highlights structural cellular adaptations, offering a blueprint for developing salt-tolerant crops in the future.

Key Highlights of the Study

Cellular Traits (Structural Adaptation)- The study reveals that mangroves do not rely on having smaller or more numerous stomata (pores for gas exchange) to manage water loss or photosynthesis. Instead, they utilize unique structural defenses

Small Epidermal Cells- They possess unusually small leaf epidermal pavement cells.

Thick Cell Walls- These small cells have thickened walls which provide enhanced mechanical strength.

Purpose- This structural rigidity allows the cells to withstand the low osmotic potential caused by high salt concentrations, preventing cell collapse under stress.

Salt Management Strategies

Mangroves have evolved two distinct mechanisms to handle the excess salt in their environment-

Strategy	Mechanism
Salt Exclusion	Specialized waxy layers in the roots act as ultra-filtration systems, physically blocking salt from entering the plant while allowing water absorption. (Filters out ~90% of salt).
Salt Secretion	Some species absorb the salt but actively expel it through specialized glands on their leaves (salt crystals often visible on leaf surfaces).

About Mangroves

Definition and Classification

Nature- Mangroves are small trees or shrubs that grow in intertidal zones (coastlines), thriving in salty sediments and often submerged conditions.

Taxonomy- They are flowering trees belonging to diverse families including Rhizophoraceae, Acanthaceae, Lythraceae, Combretaceae,Arecaceae

Unique Features & Adaptations

Saline Environment Survival- Capable of surviving in extreme conditions of high salinity and tidal immersion where ordinary plants would perish.

Root Filtration- The root systems are highly efficient filters, excluding up to 90% of salt from the surrounding brackish water.

Respiration (Pneumatophores)- Underground tissues in waterlogged soil face low oxygen (hypoxic) conditions. Mangroves possess specialized aerial roots (pneumatophores) that grow upwards to absorb oxygen directly from the atmosphere.

Water Storage (Succulence)- Similar to desert plants (xerophytes), mangroves have thick, succulent leaves to store fresh water.

Vivipary (Reproduction)- Mangroves exhibit viviparous germination. Seeds germinate into seedlings (propagules) while still attached to the parent tree. This ensures the seedling is mature enough to survive the harsh saline water when it eventually drops.

Major Mangrove Regions in India

The Sundarbans (West Bengal)- The largest mangrove forest in the world. Designated as a UNESCO World Heritage Site.

Bhitarkanika Mangroves (Odisha)- The second largest mangrove forest in India. A designated Ramsar

Site (Wetland of International Importance). Formed by the estuarine confluence of the Brahmani and Baitarani rivers.

Ecological and Economic Importance

Natural Coastal Defence

Wave Energy Reduction- A mature mangrove belt (50 years old, 100–1,000m wide) can reduce wave energy by 7–55%.

Disaster Mitigation- They act as bio-shields, significantly lowering the impact of cyclones, storm surges, and coastal flooding compared to undefended coastlines.

Biodiversity Hotspots- India's mangroves are rich ecosystems supporting approximately 4,011 species, comprising 920 plant species. 3,091 animal species.

Climate Change Mitigation (Blue Carbon)- Mangroves are highly efficient carbon sinks. They store 7.5 to 10 times more carbon per acre than terrestrial tropical forests, sequestering it in the biomass and sediment (known as Blue Carbon).

Livelihood and Economic Security- Support millions of people globally.

Sectors- Fisheries (nurseries for fish), aquaculture, eco-tourism, and sustainable restoration activities.

Cost-Effective Nature-Based Solutions- They provide a "triple dividend" by combining

1. Disaster Risk Reduction
2. Biodiversity Conservation
3. Climate Change Adaptation (Carbon Sequestration)

They serve as a low-cost, high-impact alternative to expensive engineered coastal defences (like sea walls).

Source- https-//www.thehindu.com/sci-tech/science/how-mangroves-cells-helps-plants-survive-in-saltwater/article70375660.ece