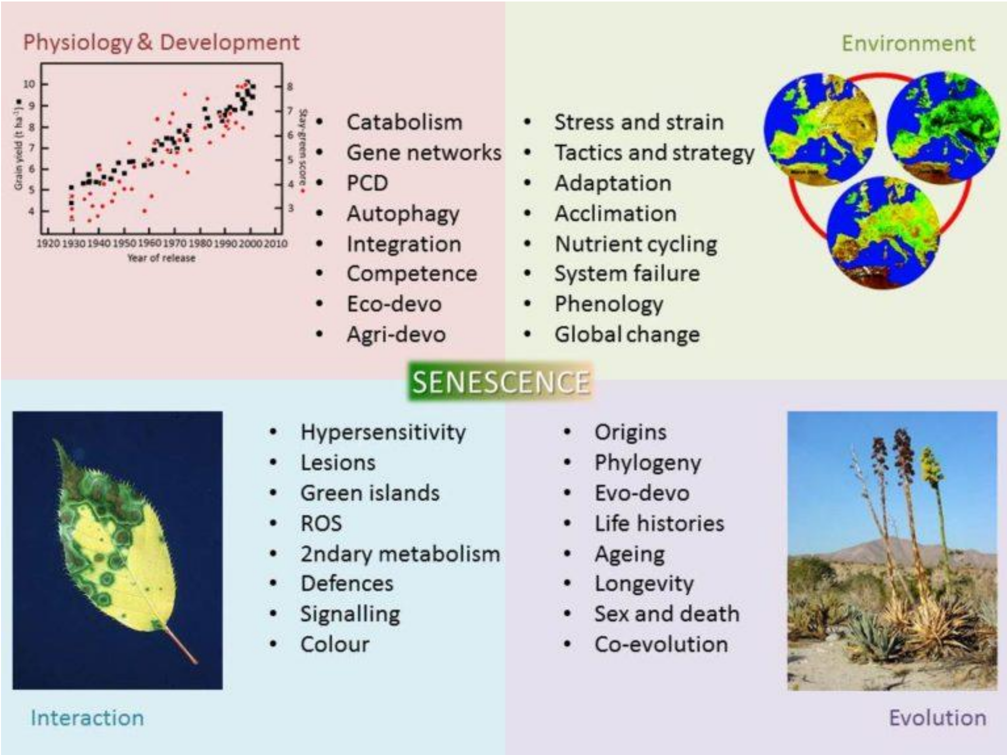
The how and why of plant senescence

Senescence is a critical built-in module in the plant life-cycle. Here are some of the intrinsic cell biology activities underlying the senescence syndrome and the biotic, abiotic and evolutionary interactions in which senescence is a leading player.



Some senescence FAQs, with answers:

How does senescence enable plants to survive in a testing environment?

Senescence is a terminal developmental event that usually, but not invariably, results in the death of the plant or its parts

Stress (non-optimal environment) is a way of life for plants and selective senescence is one of the main ways they deal with it

Senescence is a pervasive biological process that dominates many ecosystems and, as satellite imaging shows, can be seen from space

Autumnal senescence of temperate forests is an example of senescence deployed strategically to deal with regularly recurring stresses

Senescence is often a tactical response to unscheduled challenges such as unseasonal drought

Internal nutrient recycling during senescence attunes individuals and communities to the nutritional status of the soil environment

Physiological collapse, where stress exceeds adaptive and acclimatory capacities, is a failure, rather than a result, of senescence

Senescence in the life-cycle is a critical phenological metric and a sensitive indicator of biosphere response to global change

How and why did senescence arise in plant evolution?

Senescence is an assemblage of processes that arose at different times in evolution

The origins of the components of the senescence syndrome can be reconstructed by phylogenetic analyses

Molecular studies of phylogenetic distribution show carotenoid and chlorophyll metabolism in senescence to be evolutionarily ancient

Building senescence into the developmental repertoire has contributed to the diversification of structures, functions and lifeforms

The physiologies of senescing leaves, ripening fruits and developing floral organs are variations on a common theme

To understand plant life-cycles and ecophysiologies, we need insights into the relationship of senescence to ageing

Organisms that reproduce once and die are termed semelparous; monocarpic plants are semelparous

Iteroparous organisms reproduce repeatedly throughout their lifespan; polycarpic perennial plants are iteroparous

Plants represent a unique perspective on the central biological question of how reproduction and senescence are related

Monocarpic species exemplify the concept of death as the price paid for sex but polycarps do not conform to this principle

The nature of ageing in plants is a challenge to models of biological ageing coming out of gerontology and medical sciences

What part does senescence play in a plant's relations with other living organisms?

The nature and expression of senescence in plants are outcomes of coevolutionary influences from biotic factors in the environment

Pathogens commonly invoke senescence-like hypersensitive, chlorotic and necrotic responses in their hosts

Green islands often form when a pathogen attempts to turn senescing host tissue into a zombified source of nutrition

Biotic and abiotic interactions have driven the evolution of distinctive senescence-specific metabolism

Reactive oxygen species (ROS) and secondary pathways are common to senescence physiology and defences against pathogens and predators

The characteristic yellows, oranges, reds and purples that often develop during senescence are symptoms of novel metabolism

The molecular basis and function of some colour changes in senescence are well established: e.g. de-greening and chlorophyll breakdown

Because intermediates are photosensitizers, chlorophyll catabolism takes place via a kind of detoxification pathway

Controlled removal of chlorophyll during senescence makes chloroplast thylakoid proteins available for recycling

The significance of changes in carotenoid and phenylpropanoid pigments in senescing leaves is incompletely understood

Some hypotheses propose that the reds and yellows of senescing leaves are visual signals to interacting insects

There is evidence that colour changes protect senescing tissue from damage by light or other abiotic stresses

It is possible that the colours of senescing tissues invite aesthetic responses in humans but have no intrinsic function

What goes on inside a senescing plant, and how does it help to know?

As well as chlorophyll catabolism, pathways for remobilization and salvage of nutrients (N,P,S) are activated during senescence

There have been significant recent advances in knowledge of the cell biology of protein recycling in senescing tissues

Details of nucleic acid, lipid and other metabolic pathways during senescence remain to be determined

Vast numbers of senescence-associated genes and regulatory elements have been described

Efforts to build senescence-associated genes into meaningful regulatory networks are at an early stage

Plant senescence is often classified as a member of the programmed cell death (PCD) family of terminal processes

The relationship between senescence and other instances of programmed autolysis, such as autophagy, is a fertile research area

At the level of whole-plant development, senescence is integral to the regulatory cross-talk between sources and sinks

Plants and their parts must achieve competence before they can senesce in response to internal and environmental signals

Competence to senesce is associated with phase-change, the juvenility-maturity transition, and epigenetic factors

Plant development is not only origami (morphogenesis and growth); it requires scissors (selective deletion through senescence) too

Senescence is an essential element in eco-Devo, genotype-phenotype studies of functioning individuals and evolving plant populations

By analogy with eco-Devo, senescence is critical for Agri-Devo, the study of crop development, yield and survival

Senescence is a primary target for economically and environmentally expensive agricultural inputs (fertilizer, pesticides, water)

Senescence sets limits on crop adaptability and resource capture

Agriculture is largely concerned with keeping crops alive long enough and in a physiological condition to yield a harvest

Many modern staples have been selected for delayed senescence (stay-green) and efficient nutrient recycling

Understanding how and why plants senesce is necessary if we are to address global ecological and agricultural challenges