

Definition

Gerotype

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A gerotype is the measurable aging phenotype of a biological entity at a given biological age. It is the integrated, multilevel state of regulatory variables that indexes the entity's position along an aging trajectory.

Phenotype refers to all observable features of an organism. Gerotype refers to the subset of features that vary as a function of biological age. Genotype is fixed at conception and constrains what is possible. Gerotype is dynamic and reversible in principle.

Etymology. Greek γέρων (*gerōn*, "old age") + τύπος (*typos*, "type, kind, impression"). Constructed in parallel to *phenotype* and *genotype*.

Operational content

A gerotype is specified by joint measurements across at least four layers:

1. transcriptional and methylation dispersion at the single-cell level (variance metrics in scRNA-seq and single-cell methylation data);
2. variance and set-point drift of regulatory feedback at the network level (kinetic decoherence in stress-response networks; baseline drift in metabolic homeostasis networks);
3. cell-identity fidelity at the tissue level (occupation of on-lineage versus off-lineage states);
4. recovery capacity following perturbation at the system level (return time, overshoot, feedback gain).

The gerotype is what aging clocks measure indirectly. It is what rejuvenation interventions modify. Within the cybernetic attractor decay (CAD) framework, the gerotype is the empirical face of attractor decay.

Properties

Multi-scale. A gerotype can be specified at the cellular, tissue, organ, or organismal level. The operational measurements differ by scale. The underlying construct is the same: the state of a regulatory system along its aging trajectory.

Reversible in principle. A gerotype is a state, not a property. The same biological entity occupies different gerotypes at different times. Partial reprogramming, fasting-refeeding, senolytic intervention, and developmental-program reactivation are operations on gerotype.

Vector-valued. A gerotype is multidimensional. Biological age is a scalar projection of this vector. Two entities can share the same biological age and occupy distinguishable gerotypes.

Distinction from related terms

- vs **phenotype**: gerotype is the aging-relevant subset of phenotype. Hair colour is phenotype but not gerotype. Methylation variance at PRC2-bound sites is gerotype.
- vs **genotype**: genotype constrains possibility and is heritable. Gerotype is dynamic and lies within the space genotype permits.
- vs **biological age**: biological age is a scalar. Gerotype is the underlying vector from which such scalars are derived.
- vs **hallmarks of aging**: hallmarks are a catalogue of features that accompany aging. Gerotype is the integrated regulatory state from which such features emerge. It is treated as a state to be reset, not as a list of items to be addressed individually.
- vs **senescence**: cellular senescence is a discrete cell-state transition. Gerotype is continuous and applies across all cells, not only those that have entered the senescent program.

Worked example

A 65-year-old liver tissue and a 65-year-old skeletal muscle share a chronological age and may share a single-scalar biological age. Their gerotypes are nevertheless distinguishable. The liver gerotype is dominated by set-point drift in metabolic feedback (insulin signaling, AMPK-mTOR balance). The muscle gerotype is dominated by kinetic decoherence in stress-response networks and erosion of myogenic identity. A single intervention can move both, but it moves them along different axes. The gerotype framing makes this difference explicit. A hallmark catalogue does not.

Declarations

Potential competing interests: No potential competing interests to declare.