The Hallmarks of Aging

Scientists have identified 12 biological processes — called the "Hallmarks of Aging" — that drive how and why we age. These include things like DNA damage, cellular stress, epigenetics, and inflammation. There may be additional hallmarks we have not yet discovered.

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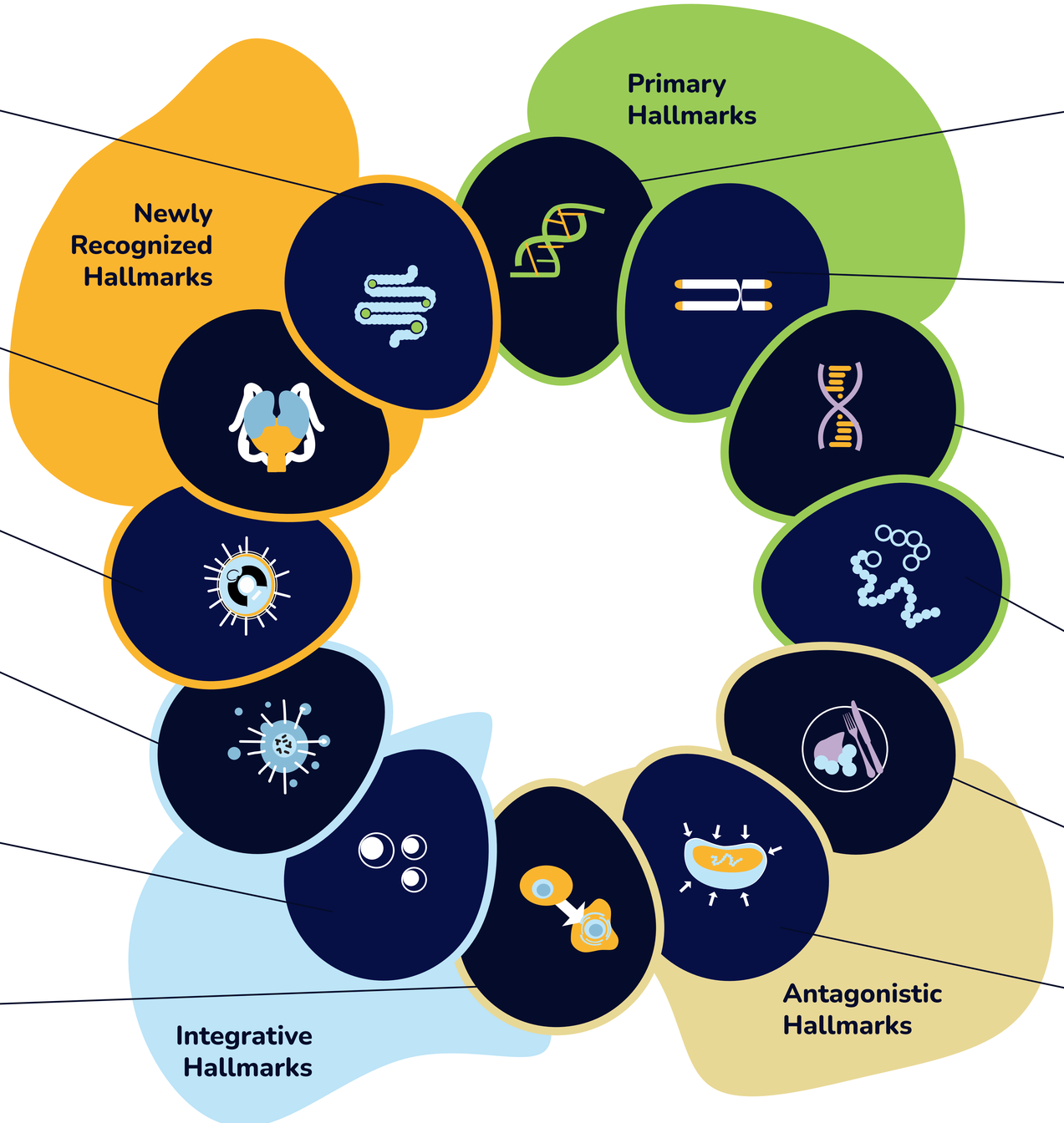

MICROBIOME DYSBIOSIS

Some cells stop dividing and become "senescent"—they don't die, but they can't function properly either. Worse, they release harmful signals that damage nearby healthy cells and tissues.

CHRONIC INFLAMMATION

Stem cells help repair and renew our tissues. As we age, they lose their ability to regenerate, which makes it harder for our bodies to heal and maintain themselves.

DISABLED MACROAUTOPHAGY

Cells constantly send signals to each other to coordinate body functions. Aging disrupts this communication, often increasing harmful inflammation and reducing repair signals.

ALTERED INTERCELLULAR COMMUNICATION

Cells have a recycling system called autophagy that clears out damaged parts. In aging, this cleanup process becomes less effective, leading to a buildup of cellular junk.

STEM CELL EXHAUSTION

Low-level, chronic inflammation increases with age—even without infection or injury. This "silent fire" contributes to many age-related diseases like heart disease and diabetes.

CELLULAR SENESCENSE

The community of microbes in our gut changes with age, often becoming less diverse and more harmful. This imbalance can affect digestion, immunity, and even brain health.

GENOMIC INSTABILITY

Over time, our DNA—the instruction manual for our cells—accumulates damage from things like radiation, toxins, and normal cell activity. This damage can disrupt how our cells function and lead to age-related diseases.

TELOMERE ATTRITION

Telomeres are protective caps at the ends of our chromosomes, like the plastic tips on shoelaces. As cells divide, telomeres shorten, and when they get too short, the cell stops working properly or dies.

EPIGENETIC ALTERATIONS

Our genes are controlled by chemical tags that act like switches, turning genes on or off. With age, these tags can become scrambled, leading to cells behaving in the wrong way.

LOSS OF PROTOSTASIS

Proteins need to be folded correctly to do their jobs in the cell. As we age, our ability to maintain healthy proteins declines, leading to clumps and dysfunction that are seen in diseases like Alzheimer's.

DEREGULATED NUTRIENT SENSING

Our cells use nutrient signals to manage energy and growth. Aging throws off this balance, leading to problems like insulin resistance and slower cell repair.

MITOCHONDRIAL DYSFUNCTION

Mitochondria are the "power plants" of our cells, making the energy we need to live. With age, they become less efficient and produce harmful byproducts, like cellular exhaust fumes.