Can we Biohack Aging?

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ABSTRACT

Aging is a universal biological process that affects all living organisms. New findings in cellular and molecular biology show that aging is not just a passive decline. It's an active process and is highly regulated. It includes key pathways like mTOR, sirtuins, and NAD^+ metabolism. This article looks at new interventions that aim to delay aging and extend healthspan by targeting specific pathways. Traditional Indian medicine, particularly Ayurveda, has long advocated practices for promoting longevity. Here, we examine how modern science is beginning to support these ancient ideas and how Indian labs are playing a pivotal role in helping the world understand and alter the biology of aging.

INTRODUCTION

Why do we get older? Can we alter it or slow it down? In the past, these inquiries concerned myths and philosophy. Today, researchers worldwide are asking it again, but with the aid of microscopes, molecular assays, and model organisms. Research on human populations and model organisms demonstrates that aging is more than a random decline; it is a complex process. Rather, it adheres to particular cellular signalling pathways. Some pathways are evolutionarily conserved, including sirtuin activity, NAD^+ metabolism, and the mechanistic target of rapamycin (mTOR). They also respond to things like stress, poisons, and diet. Although aging is inevitable, focusing on these pathways may increase healthspan, or the amount of time spent free from illness.

Molecular Mechanisms of Aging

Aging is a universal process, but not a uniform one. Some people reach 90 with sharp minds

and strong limbs, while others experience illness and decline decades earlier. Scientists are discovering that this variation may depend less on the calendar and more on the body's internal code. At the centre of this code lies a handful of well-studied molecular systems.

The mTOR Pathway

The mechanistic target of rapamycin (mTOR) is a central regulator of cellular growth, metabolism, and protein synthesis (Kennedy & Lamming, 2016). When nutrients are abundant, mTOR promotes anabolism, cell division, protein synthesis, and metabolism. However, if this same pathway is persistently triggered, it can hasten cellular aging, promote tumour growth, and raise the risk of metabolic disorders.

Remarkably, it has been demonstrated that rapamycin, a medication that inhibits mTOR activity, can increase a mouse's lifespan by up to 30% (Bitto *et al*., 2016). The well-known treatment of calorie restriction, which prolongs life in rodents, worms, flies, and yeast, also partially functions by inhibiting mTOR signalling.

Fuel and Fire: Sirtuins and NAD^+

Another class of molecules closely linked to aging is sirtuins (Imai & Guarente, 2014). These enzymes support mitochondrial health, DNA repair, and inflammation regulation. However, sirtuins don't function by themselves. They rely on Nicotinamide adenine dinucleotide, or NAD^+, whose levels drastically decrease with age. Neurodegeneration, immunological dysfunction, and exhaustion are all associated with low NAD^+ levels. Muscle strength, heart function, and cognitive function have all improved in mice when NAD^+ is restored using precursors such as NMN (nicotinamide mononucleotide) or NR (nicotinamide riboside). To find out if these advantages persist in humans, several human trials are currently in progress.

The Problem of "Zombie" Cells

The buildup of senescent cells is another indicator of aging. These are the cells that continue to be metabolically active even though they are no longer dividing, causing pro-inflammatory cytokines and tissue damage in the process. The senescence-associated secretory phenotype (SASP) is a process that leads to both functional decline and chronic inflammation (Coppé *et al.,* 2010). Senolytics are substances that specifically destroy senescent cells and have demonstrated promise in preclinical models. (Zhu *et al*., 2015).

Ancient Insights, Modern Tools

Ayurveda, India's traditional medical system, recognised that aging could be postponed long before Western biology discovered these molecules. It provided rasayana therapies, which are interventions meant to bring back longevity, vitality, and resilience (Wujastyk, 2017). These included herbal remedies or plant based formulations such as Guduchi (*Tinospora cordifolia*), Amalaki (*Phyllanthus emblica*), and Ashwagandha (*Withania somnifera*) (Balasubramani *et al*., 2011)

Using contemporary pharmacological instruments, researchers are now reexamining these herbs. It has been demonstrated that compounds in ashwagandha lower cortisol levels and alter stress pathways. Phyllanthus emblica exhibits strong antioxidant activity. Tinospora has been shown to strengthen the immune system. These effects are currently being verified in controlled trials by a number of Indian labs.

Today, some of these herbs are being examined in labs. For instance, extracts of ashwagandha have been shown to reduce stress hormones and inflammation. Guduchi has antioxidant properties that may protect

cells from damage. Researchers are now exploring whether these effects could influence aging-related pathways like mTOR or sirtuins.

India's contribution to aging science

In India, research on aging is accelerating. Neuroscientists at the Indian Institute of Science (IISc), Bangalore, are examining the effects of aging-related alterations in brain metabolism on cognition. To find genetic and epigenetic indicators of longevity, the Institute of Genomics and Integrative Biology (IGIB) is analysing the DNA of Indian centenarians. The Central Council for Research in Ayurvedic Sciences (CCRAS) is investigating the effects of traditional formulations on biological aging markers, while the National Institute of Nutrition (NIN) is assessing dietary interventions for age-related diseases.

This integration of tradition and technology, where genome-wide studies meet herbal pharmacology, offers a uniquely Indian approach to longevity science (Ashok & Ali, 2003)

A Longer Life, or a Better One?

This is a controversial question. Some scientists argue that aging should be treated like a disease, a process with causes, symptoms, and treatments. Despite the buzz around biohacking, most scientists agree that aging is not a disease to be cured but a process to be understood. The goal isn't immortality, it's more years of good health, free from disability and disease. This concept is called healthspan, which both sides agree on, how long a person lives without suffering from a serious illness. That is the true objective. Researchers want to help people stay active and independent into their 70s, 80s, and beyond, rather than striving for immortality. While we wait for anti-aging pills to become real, some habits seem to support healthy aging:

- Sleep well. It helps repair tissues and balance hormones.
- Eat mindfully. Diets rich in plants and low in processed sugars reduce inflammation.
- Move daily. Exercise boosts mitochondria, the energy-makers of cells.
- Take breaks from food. Intermittent fasting has been linked to lower mTOR activity.

None of these will stop aging, but they may help you age better.

However, as we get closer to extending healthspan, we also need to address moral dilemmas. These interventions are available to whom? How can we control them? And how can we strike a balance between hype and promise?
We're just beginning to answer that question. Aging is complex, and no single molecule can reverse it. But by targeting the right pathways- mTOR, NAD^+, senescence- we might be able to slow the rate at which aging happens. Strong regulatory oversight, long-term safety studies, and public discussions regarding the dangers and boundaries of tampering with human biology are all recommended by experts.

The Path Ahead

There isn't yet a miracle anti-aging drug. But today, the path to a longer, healthier life is being paved with both molecular science and traditional roots. Recalling what previous generations understood- resilience, balance, and daily routines that support mental and physical well-being may be just as important to longevity as modifying our biology. The field is still in its infancy. There are numerous claims that precede the data, particularly in the supplement industry. Real progress is being made, though, despite the hype. And perhaps what's most exciting is the possibility of blending ancient knowledge with

modern methods. India's history of looking at health holistically may offer valuable ideas, not just for treating disease, but for extending our lives.

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