



# Aging and Epigenetic Clocks: Unlocking Molecular Markers of Biological Age

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## DESCRIPTION

Aging is a complex process influenced by both genetic and environmental factors. While chronological age the number of years a person has lived has long been used as a measure of aging, it does not necessarily reflect an individual's biological condition. People of the same chronological age can age at very different rates depending on lifestyle, genetics and other factors. In recent years, scientists have turned their attention to a new tool for measuring aging: Epigenetic clocks. These molecular biomarkers provide a more accurate representation of biological age, offering insights into how the body is aging at the cellular and molecular levels.

## Understanding epigenetics: How the environment shapes our genes

Epigenetics refers to the study of changes in gene expression that occur without altering the underlying DNA sequence. These changes are often mediated by chemical modifications to the DNA molecule or the proteins associated with DNA, such as histones. The most well-known form of epigenetic modification is DNA methylation, in which a methyl group is added to specific sites on the DNA molecule, often silencing the expression of the associated gene.

## What are Epigenetic clocks?

Epigenetic clocks are molecular tools that estimate biological age based on the pattern of DNA methylation across the genome. Researchers have identified specific regions of the genome where methylation levels change predictably with age. By analyzing the methylation status at these sites, scientists can calculate a person's biological age, which may be higher or lower than their chronological age.

Horvath epigenetic clock, measures biological age by examining methylation patterns at specific CpG sites in the genome. Since then, other epigenetic clocks have been developed, each focusing on different sets of methylation markers and offering various degrees of precision and applicability in different contexts.

Epigenetic clocks provide a more effective picture of aging, as they reflect the cumulative effects of lifestyle, environmental exposures and genetic predispositions. In essence, they offer a glimpse into the "biological wear and tear" on a person's body, allowing scientists to distinguish between individuals who are aging faster or slower than their chronological age would suggest.

## Biological age vs. chronological age

While chronological age is simply the number of years a person has lived, biological age is a reflection of the actual physiological and functional state of the body. A person's biological age can be younger or older than their chronological age depending on their health and lifestyle. For example, someone who exercises regularly, eats a healthy diet and avoids smoking may have a biological age significantly younger than their chronological age. Conversely, someone exposed to chronic stress, unhealthy habits, or illness might have an accelerated biological age.

## How epigenetic clocks work

Epigenetic clocks rely on DNA methylation, a chemical modification that influences gene expression without changing the underlying DNA sequence. As we age, certain regions of our genome undergo predictable changes in methylation patterns. These age-related changes can either increase or decrease the expression of specific genes involved in cellular processes like metabolism, inflammation and stress responses.

## The role of epigenetic clocks in aging research and medicine

Epigenetic clocks are revolutionizing our understanding of aging and have significant potential applications in both research and medicine. Some of the key areas where epigenetic clocks are proving valuable include:

**Predicting health outcomes:** Epigenetic age can serve as a biomarker for predicting an individual's risk of developing age-related diseases. Studies have shown that individuals with an accelerated epigenetic age where their biological age is older than

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their chronological age are more likely to develop conditions such as cardiovascular disease, diabetes and Alzheimer's disease. This information could be used to identify individuals at higher risk and implement early interventions to improve their health outcomes.

**Evaluating longevity and lifespan:** Biological age, as measured by epigenetic clocks, has been shown to be a strong predictor of lifespan. Individuals with a slower epigenetic aging rate tend to live longer and remain healthier in old age. This insight can help researchers explore the factors that contribute to longevity and develop strategies for promoting healthy aging.

**Monitoring the effects of interventions:** Epigenetic clocks provide a valuable tool for measuring the effectiveness of anti-aging interventions. Whether its lifestyle changes, medications, or experimental therapies, researchers can use epigenetic clocks to monitor how these interventions affect biological age over time. For example, studies have begun exploring how diet, exercise and certain drugs like metformin can slow down epigenetic aging.

**Personalized medicine:** The ability to measure biological age through epigenetic clocks opens up new possibilities for personalized medicine. By assessing an individual's biological age, healthcare providers could offer customized interventions aimed at reducing age-related risks and extending healthy

lifespan. This could involve customized dietary plans, exercise regimens, or pharmacological treatments designed to target the underlying mechanisms of aging.

### Challenges and limitations

While epigenetic clocks represent a innovative advance in aging research, there are still some challenges and limitations to their use. One challenge is that different epigenetic clocks may yield slightly different estimates of biological age, depending on the specific methylation sites they target and the tissues used for analysis. Additionally, while epigenetic clocks provide valuable information about biological age, they do not directly measure all aspects of aging, such as telomere shortening, mitochondrial dysfunction, or oxidative stress, which also play significant roles in the aging process.

### CONCLUSION

Epigenetic clocks are transforming our understanding of aging by providing a more accurate measure of biological age than chronological age alone. These molecular biomarkers offer valuable insights into how lifestyle, environment and genetics influence the aging process. On research we can expect to see even more innovative applications in personalized medicine, longevity research and therapeutic interventions aimed at slowing or reversing biological aging.