TruDiagnostic

Reveal Your TruAge™

Collection Results Report

Hi Jane,

Thanks so much for taking the TruAge™ test by TruDiagnostic™. TruDiagnostic™ is a company that has been built on *one premise*. We want to be able to read your DNA methylation patterns so that we can help you live longer, better quality life. In the report below, we will explain everything about our test including why it is important and how you can use this metric to live a healthier life.

By purchasing TruAge™, you have now unlocked a lifetime of information about yourself. As we get better at reading each methylation spot on your DNA, and the outcomes that each spot is correlated to, we will continue to update you on the information and what it tells us about you. You are one of the first to have your DNA read and interpreted by our innovative algorithms. We are thankful to you for adding to the growing science and innovation around these areas.

Hopefully this will be the first of many times we report our hard work to you and help you unlock a longer, healthier life.

Thanks,
The TruDiagnostic™ Team

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WHAT IS EPIGENETICS

and how is it different than genetics?

Epi - is a greek prefix for "above". ***Genetics*** is the study of our DNA. Together, epigenetics means the study of things above and beyond the genome. This means we are studying the changes to your DNA and how it actually affects the body instead of what the DNA could possibly do or mean.

It is often more useful than genetics because it allows us to see how the genetic material in your body behaves instead of just seeing what it contains. Traditional genetics is like looking at a light bulb and its components but not knowing if the bulb is producing light. Epigenetics lets us know if the light bulb is on or off.

The link between epigenetics and health has been linked through biological age. ***This is important because aging is THE leading risk factor for multiple chronic diseases and disorders.*** Therefore, finding a way to slow the biological aging process is essential. Through epigenetics, TruAge™ does just that. Our epigenetic clock is the most accurate measurement of biological age and age-related disease risk!

Epigenetic aging can be reversed, so it is crucial to understand DNA methylation changes through utilizing TruAge™. Since we know that it can be reversed, we can apply changes to our lifestyles and use TruAge™ to show that we are reducing YOUR risk of incidence of disease and death.

Genetic Testing **VS** Epigenetic Testing

	23andMe and Similar Testing	TruAge™
Measures the Genetic Code	✔	
Reports Health Risks	✔	✔
Measurement of How Genes Are Expressed		✔
Able to Influence with Lifestyle Changes		✔
Unique Algorithms For Health Insights		✔
Measures a Value that You Can Improve Over Time		✔

WHAT IS BIOLOGICAL AGE

and why is this important to know?

Everyone knows their chronological age. Chronological age is the number of candles that are on top of your cake and the birthdays that you celebrate (or sometimes don't!). However, developments in science have created another measurement of age called biologic age. This measurement of age is based on years of statistical research which can predict how healthy you are and even when you might pass away.

The novel DNA biomarker uses markers on your DNA called methylation to predict your age. Your biological age is more accurate at predicting health span (how healthy you are) and lifespan (how long you will live) than any previous molecular biomarker, and can be correlated to aging-related conditions such as Alzheimer's disease and cancer. Ideally, everyone would want their biological age to be less than their chronological age. This means that you are living a lifestyle that is healthy and will help you stay free of sickness and disease longer.

It is a single metric that takes all the important health data (weight, sex, medication, exercise frequency, etc.) about an individual and is able to report back in one single metric how healthy you are!

CHRONOLOGICAL AGE

The number of years that have passed since birth. This cannot be influenced by lifestyle and eating habits

BIOLOGICAL AGE

How old our cells really are, therefore, our real age. This can be reversed by attending to your health.

WHY IS THIS IMPORTANT?

When we are born, all of our cells have the same DNA. The cells in your eyes have the same DNA as the cells in your hair. ***So what makes our cells different?***

The answer is each cell chooses to turn on some genes and turn others off. Your eyes express different genes than your hair. This is called expression, and it is controlled by the markers we measure with our TruAge™ test. Unfortunately, as we age, expression can become much harder to regulate. The genes which should be expressed in your eyes aren't regulated as well and you start to lose function. In fact, aging is defined as the progressive loss of function as you age! So what does this have to do with biological age measured by TruAge™?

TruAge™ can report how old your cells and DNA look. Meaning you can measure how likely you are to develop disease or how long you might live!

Often, knowing how to be the healthiest you can be is difficult. Doctors measure blood levels like cholesterol, inflammation, and blood sugar. They perform tests such as colonoscopies, vision tests, and physical function tests. Now, with this single measurement, you can link your health and longevity to a single, simple test which can help you and your doctor know the best way to address your health concerns in a personalized way!

Why are **METHYLATION MARKERS** a better measurement of Biological Age than other factors?

A recent review six types of potential biological age estimators:

- Epigenetic Clocks
- Telomere Length
- Transcriptomic-Based
- Proteomic-Based
- Metabolomic-Based
- Composite Biomarkers

The study concluded that the ***epigenetic clock is the most promising molecular estimator of biological age.***[1]

Similarly, a comparative review of different ***forensic methods for age estimation concluded that DNA methylation is the most promising age-predictive biomarker.***[2]

Source:

1. Jylhävä, Juulia, et al. "Biological Age Predictors." EBioMedicine, vol. 21, 2017, pp. 29–36., doi:10.1016/j.ebiom.2017.03.046.

2. Lee, Hwan Young, et al. "Forensic DNA Methylation Profiling from Evidence Material for Investigative Leads." BMB Reports, vol. 49, no. 7, 2016, pp. 359–369.

HOW WAS THIS TEST CREATED and is it accurate?

WE LOOK AT OVER 850,000 PLACES ON THE DNA. HOW DO WE MAKE SENSE OF WHAT WE FIND?

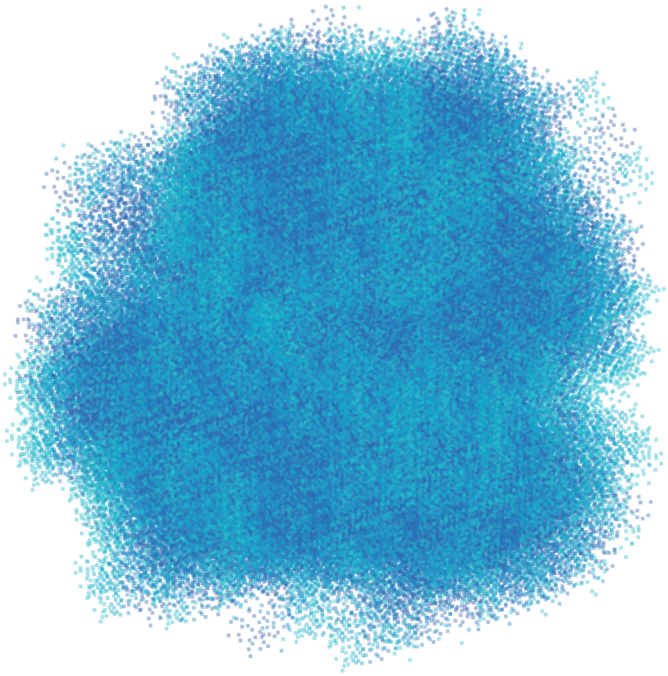
We have the most robust testing available in the world for biological age. The data we get from your DNA is 40,000 times larger than many competitors. But how do we know how this data applies to your health?

The answer is we use confusing mathematical models built by computer learning and artificial intelligence. This model helps to design a powerful algorithm. It does this by looking at all the data points we feed it. Thus far, we have given it almost a million data points from over 5,000 patients. We also feed it other variables such as blood tests, imaging data (such as MRI), genomic data, proteomic data, transcriptomic data and even other bits of health history.

By looking at all of this data, it is able to find correlations with incredibly high accuracy and link these variables to health outcomes. If 2000 patients show methylation on their DNA at the same place, and 1999 of those patients develop Alzheimer's, we can say with a high degree of certainty that that location on the DNA can help predict risk of Alzheimer's.

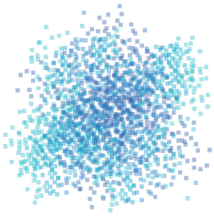
These mathematical calculations have been performed with biological aging. By comparing the biological age and chronological age of a person we can predict their risk of many many different diseases and even when they might die themselves!

850,000 PLACES ON THE DNA



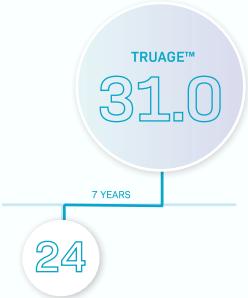
VS

2,500 POINTS COMPETITORS LOOK AT

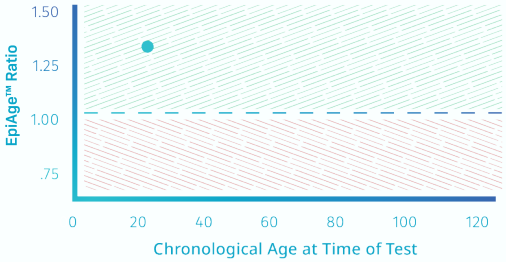


YOUR TRUAGE™

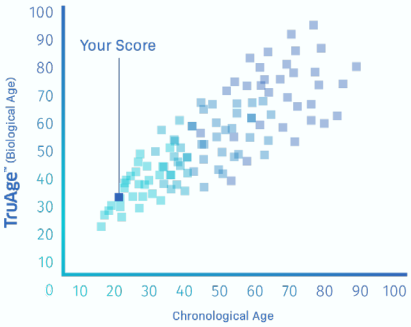
Summary



Your biological age vs chronological age



Your EpiAge™ Ratio



Your TruAge™ Compared to the General Population

Read further to see explanations for each of your results!
Also, see your TruAge™ Treatment Framework on pg 63.

YOUR TRUAGE™

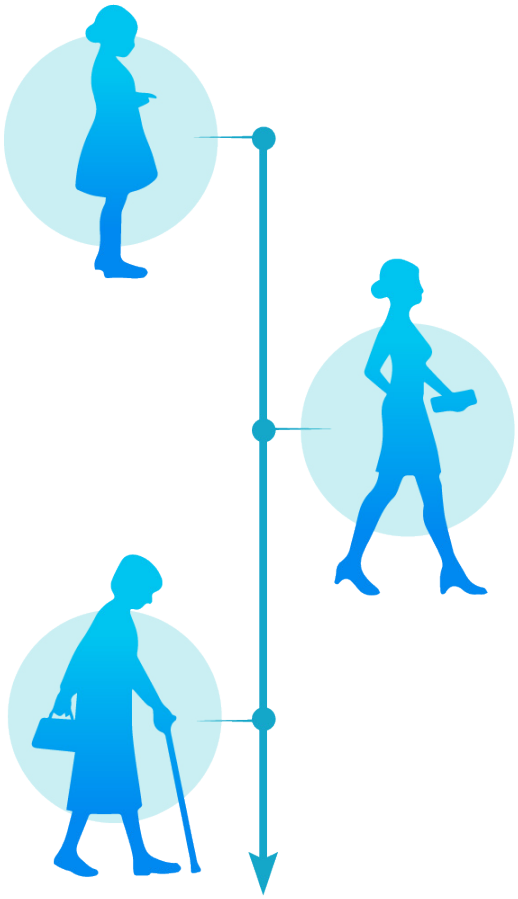
Biological Age vs Chronological Age

Your biological age is higher than your chronological age.

This is the first of hopefully many tests to measure the status of your DNA. You are more than your DNA. While tests like 23andMe might predict risk of certain diseases, TruAge™ can see how much your DNA can be changed through proper lifestyle changes.

If your TruAge™ is much higher than your chronological age, don't worry! There are plenty of things you can do to slow your aging. If your TruAge™ is under your chronological age, don't stop doing what you are doing, but maybe add things which could make it even better!)

TERMS YOU SHOULD KNOW



ADVANCED EPIGENETIC AGING

Advanced Epigenetic aging is having an EpiAge™ ratio above one. This means through the lens of your DNA methylation, you are aging quicker than you should! This is ultimately what we want to avoid as advanced epigenetic age is correlated to aging diseases and more negative health outcomes.

IEAA (INTRINSIC EPIGENETIC AGE) AND THE LINK TO IMMUNOSENESCENCE

As we age, we have other changes than what happens epigenetically on our DNA. One of the biggest changes to our health and body is called immunosenescence. Immunosenescence is when our immune system becomes weaker and less functional as we age. This is often seen in the blood by having a fewer number of naive T cells and a higher number of senescent T Cells. There are other changes in the number and percentage of cells that make up the blood as well but because of these changes that we see health consequences like older individuals being more likely to die from the flu or COVID-19! [53]

Because the DNA of these cells are found in unequal proportions as we age, we often want to control for this.

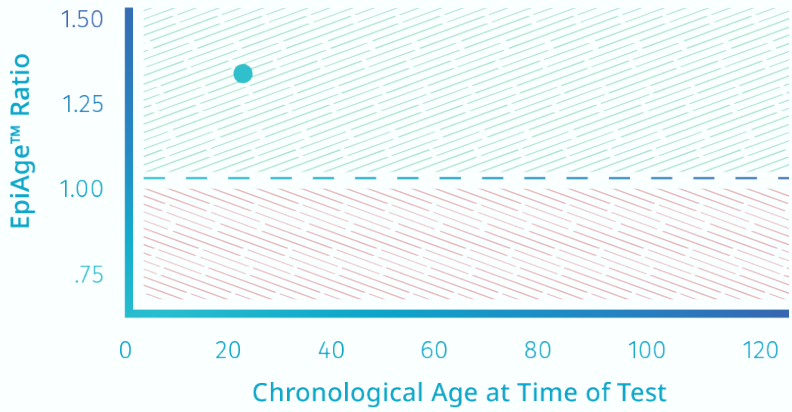
Therefore, IEAA or Intrinsic epigenetic age is when we factor the change of these cell types out of the equation. In scientific terms, the measure of intrinsic epigenetic age acceleration (IEAA) measures "pure" epigenetic aging effects that are not confounded by differences in blood cell counts. [Okazaki et al. 2019]

EEAA (EXTRINSIC EPIGENETIC AGE)

Extrinsic Epigenetic Age is also important. This is when we factor immune cells back into the equation. Scientifically put, EAA tracks both age-related changes in blood cell composition and intrinsic epigenetic changes. [11]

In the rest of this report you will see these two terms mentioned as they are both useful makers for health. Although intrinsic measures seem to exhibit greater consistency across cell types and organs, extrinsic measures seem to be better suited for assessing age-related decline of tissue performance as they exhibit stronger predictive associations with time to death than intrinsic measures of age acceleration.

YOUR EPIAGE™ RATIO



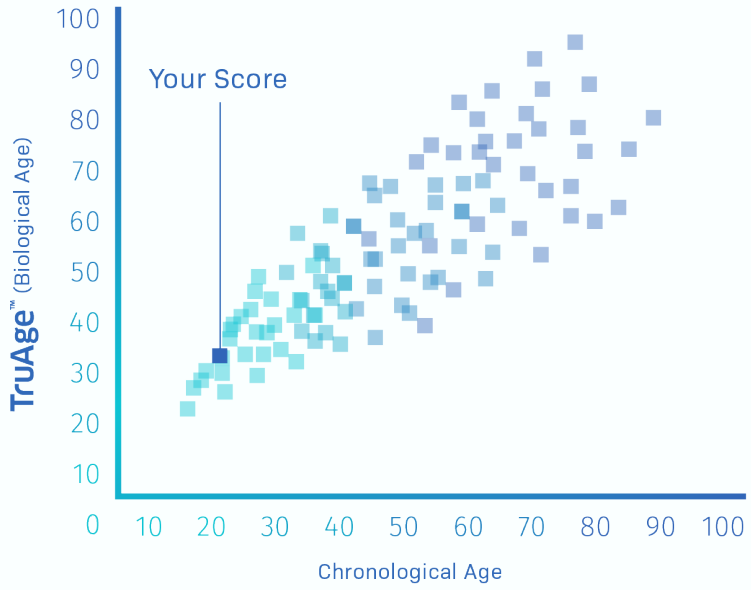
$$\frac{\text{Biological}}{\text{Chronological}} = \text{EpiAge™} \quad \Big| \quad \frac{31}{24} = 1.29$$

You show accelerated aging

Your EpiAge™ ratio is faster than your chronological age. individuals whose epigenetic age was greater than their chronological age (i.e., individuals exhibiting epigenetic "age acceleration") were at an increased risk for death from all causes, even after accounting for known risk factors.

Your EpiAge™ ratio is 1.29. This means you age 129% for every year. If you lived 20 more years at this rate your age would be X when you are X.

HOW DO YOU COMPARE
to the general population?



Your TruAge™ Compared to the General Population

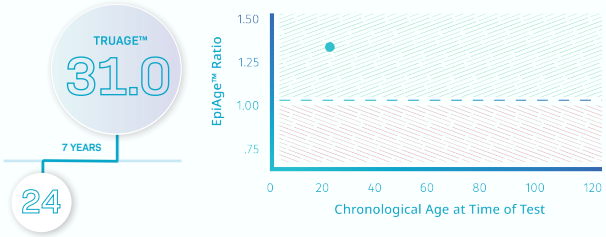
This graph shows you where most people would fall on the graph when comparing their chronological age versus their TruAge™.

One thing to remember is that a majority of our patient population are receiving this test in a preventative, integrative, functional medical community. As a result, our population metrics might be slightly different than those of the general population. That is because often, the individuals who are being tested can afford the test and are most likely interested in aging in a healthy manner. In order to avoid this bias, TruDiagnostic™ actively recruits participants outside of this population to make sure we have a good snapshot of all variables such as socioeconomic status, race, gender, nationality and many others. If you have a connection to a under represented group who would like to be involved in this research please let us know!

YOUR TRUAGE™ OVER TIME

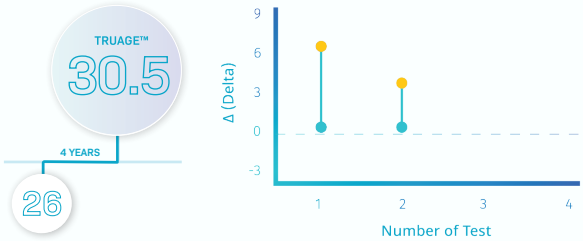
How to measure your progress

Your 1st TruAge™ & EpiAge™ Ratio Results:



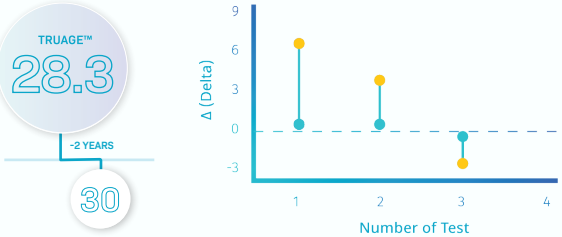
Your EpiAge™ ratio is **1.29**. This means you age 129% for every year. If you lived 20 more years at this rate your age would be 51 when you are 44.

Your 2nd TruAge™ & EpiAge™ Ratio Results:



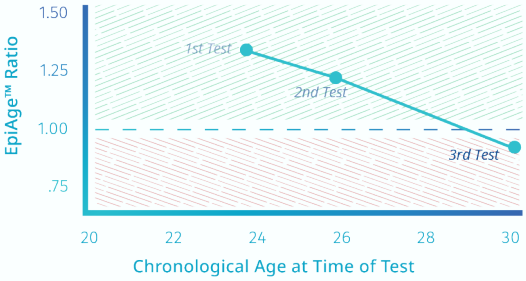
Your EpiAge™ ratio is **1.15** This means you age 112% for every year. If you lived 20 more years at this rate your age would be 50 when you are 46.

Your 3rd TruAge™ & EpiAge™ Ratio Results:



Your EpiAge™ ratio is **.94**. This means you age 94% for every year. If you lived 20 more years at this rate your age would be 48.8 when you are 50.

Your TruAge™ Ratio Over Time



Key:

- **Blue Dot:** Chronological Age
- **Yellow Dot:** TruAge™

IS AGING A DISEASE?

Most scientists and medical professionals describe aging as *"a persistent decline in the age-specific fitness components of an organism due to internal physiological degeneration."* -[24] The longstanding question if old age is itself a disease has been addressed since ancient times, starting from the Roman playwright Terentius, who claimed "senectus ipsa est morbus" (old age itself is a disease), and Cicero who some decades later argued in De Senectute: "pugnandum, tamquam contra morbum sic contra senectutem" (we have to fight against aging, as we do against a disease). These quotations elegantly summarize a long-held view of aging and old age!

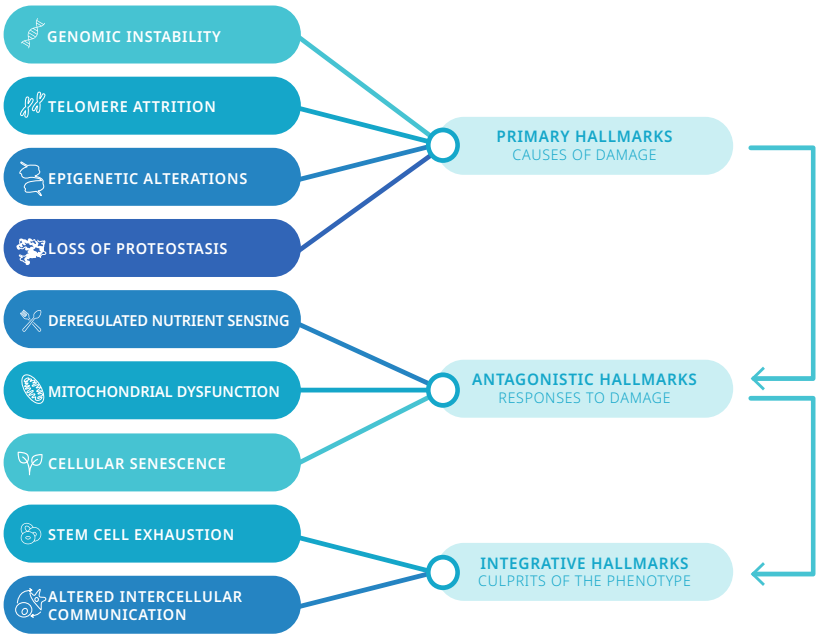
Aging is the predominant risk factor for most diseases and conditions that limit healthspan. Accordingly, interventions in animal models that end up in an extension of lifespan often prevent or delay many chronic diseases. Why? For many years the explanation was that aging per se is a physiological condition, which favors the onset of many diseases. However, their relationship is likely much more complex. Usually scientists say this relationship is related via 8 (or 9) hallmarks of aging. [43]

Hallmarks of Aging: TruDiagnostic™ is actively investigating how all of these hallmarks might affect the TruAge™ Epigenetic aging rate.

Due to the fact that aging is the predominant risk factor for most diseases and conditions the limit lifespan, using this as a target of optimal health makes sense!

Additionally, the specificity and accuracy of epigenetic tests make this a reliable metric to judge health by limiting aging and therefore reducing the major risk factors for disease. Even the world health organization recently added a code to identify diseases linked with aging!

We don't believe that aging is required, and that you can affect the aging process in your own body. We want to help you with that process.



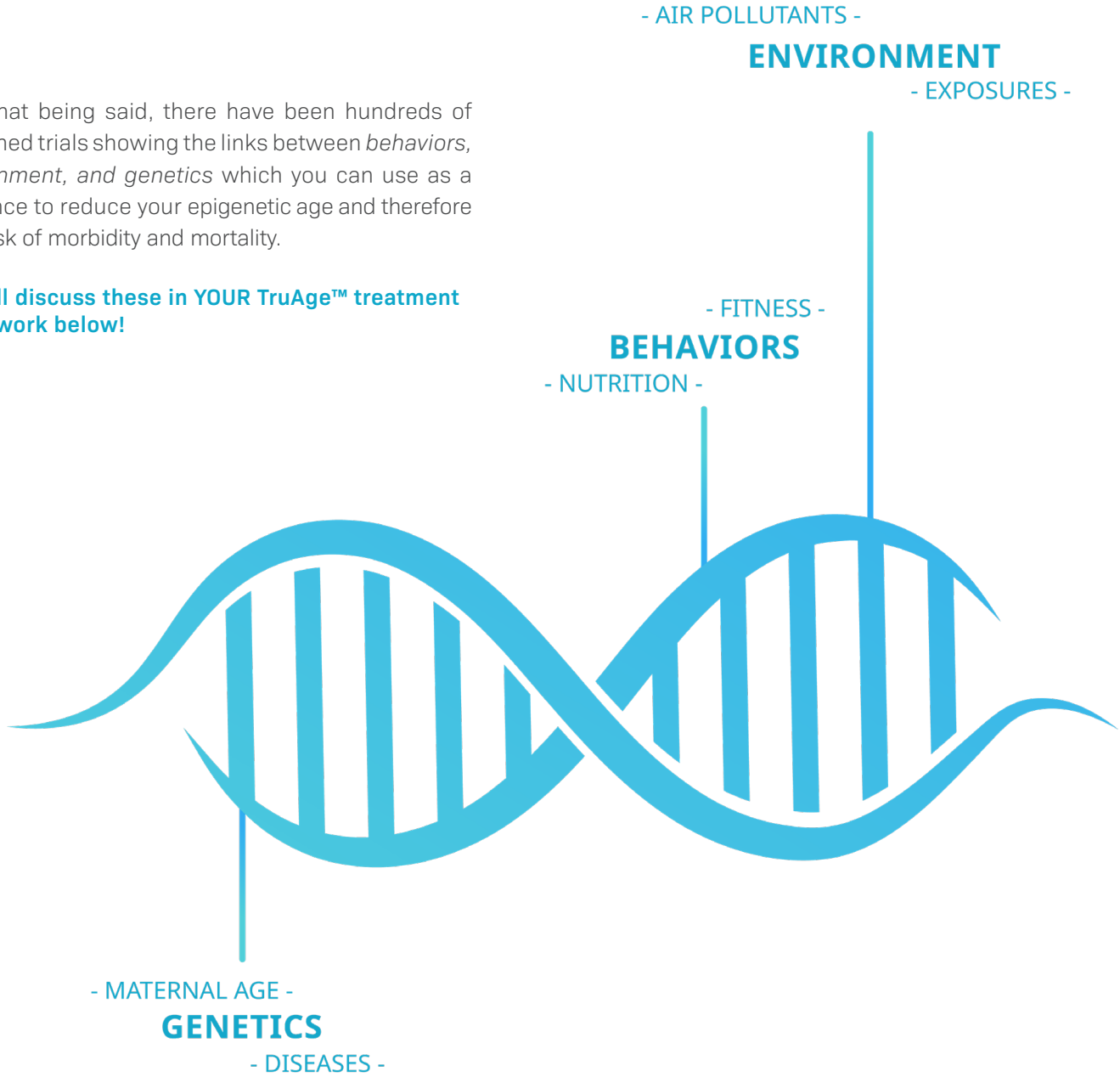
HOW DO I SLOW MY AGING?

WHAT DOES THE DATA SAY?

Unfortunately, the data around slowing epigenetic age is very, very new. While this means you are on the cutting edge of medical therapy, it also means that interventions to help reverse your epigenetic age are still being investigated.

With that being said, there have been hundreds of published trials showing the links between *behaviors, environment, and genetics* which you can use as a guidance to reduce your epigenetic age and therefore your risk of morbidity and mortality.

We will discuss these in YOUR TruAge™ treatment framework below!



THE TRUAGE™

Treatment Framework

"60% of the determination of the aging rate is due to factors that you can control!**"**

We have created the TruAge™ framework to let you see the biggest areas that affect your EpiAge™ ratio! Much like your epigenetics, this framework is constantly updating and changing. We will continue to update your treatment framework with new results that comeout and try and give you suggestions on how to age better. *Together, we will use this framework to tell you what the literature says about the best way to age slowly.*

Inner Circle - Intrinsic Aging - The Thread of Life - Genetics, Predispositions

Unfortunately, there are some aspects of your epigenetic aging that aren't within your control. Usually these things have to do with your underlying genetic predispositions or the epigenetic traits passed on by your parents and even grandparents. While often times there is little to do about these

THE TRUAGE™
Treatment Framework

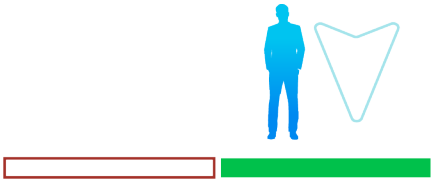
The Impact To You - Where you Stand

Throughout the rest of this report, you will see the graphic above! This will be a quick signal to let you know how your demographic information trends according to the data.

The Red Side: Factors Increasing Your Epigenetic Age

This means that the answers you provided us, and the results we extrapolated from your epigenetic test are associated with higher epigenetic aging. Oftentimes, this is associated with negative health outcomes.

In the paragraphs of text, we will review the impact and the evidence which has been described in the literature so that you can judge the effect of this trend in yourself and how you might be able to address this in your TruAge™ Treatment Framework.



The Green Side: Factors Decreasing Your Epigenetic Age

This means that the answers you provided us, and the results we extrapolated from your epigenetic test are associated with lower epigenetic aging. Oftentimes, this is associated with positive health outcomes.

This is good news! We still encourage you to read the information next to these images. Often, there is a middle ground or "goldilocks zone" with these metrics. This means that some behaviors might be good generally, but bad when done too often. By reading the explanations, or talking to your physician, you can see exactly what activities, history, or actions are beneficial to make efforts to continue this trend!

THE TRUAGE™

Treatment Framework

Genetics

Genetics regulate many of the epigenetic modifications the body has. For instance, the epigenomes of identical twins are known to be more similar than those of fraternal twins [78]. This shows that your own genetic make-up is partly responsible for the way that your body makes methylation changes to itself. Since you can't affect or change it, it is considered an intrinsic form of epigenetic aging.

Epigenetic Inheritable Changes "The Middle Ground of Nature vs Nurture"

Parental experiences:

Everyone knows that your DNA is 50% of each of your parents. But did you know you also inherit some of their experiences?

Experiences of earlier generations can modify regulatory factors affecting gene expression such that the DNA sequence itself is not changed but the individual's physiology and behavior are substantially influenced.[13]

Instinct and predispositions:

An animal mind is not born as an empty canvas: Bottlenose dolphins know how to swim and honey bees know how to dance without ever having learned these skills. Little is known about how animals acquire the instincts that enable such innate behavior. Instincts are widely held to be ancestral to learned behavior but *increasing evidence is showing that these might be epigenetic features passed through the germ line. [5]*

For example, when a mouse has experienced fear of something, changes in DNA methylation and chromatin structure in neurons of the hippocampus help stabilize long-term changes in neural circuits. These changes help the mouse to remember what has been learned and support the establishment of new behavioral responses.

Evolutionary changes in epigenetic mechanisms may sculpt a learned behavior into an instinct by decreasing its dependence on external stimuli in favor of an internally regulated program of neural development. There is evidence for such epigenetically driven evolutionary changes in behavior. For example, differences in innate aggression levels between races of honey bees can be attributed to evolutionary changes in brain gene expression that also control the onset of aggressive behavior when threatened. Another example of this intrinsic epigenetic regulation is female puberty. Currently a few studies have related epigenetic mechanisms to female puberty regulation, supporting the notion that the activation of neuroendocrine pubertal components is mediated, at least in part, by epigenetic mechanisms. [73]

THE TRUAGE™

Treatment Framework

Epigenetic Age in Utero

You can actually already have age acceleration when you are in the womb. As almost every child seems to age at a different rate, many studies have looked into the epigenetic age of children. *The results have told us a lot!*

For instance,
Some findings have shown that accelerated epigenetic age when children are in the womb are associated with higher birth weight and birth length as demonstrated previously and that this difference persisted up to approximately 9 months of age. From age 9 months onwards, these differences continued to attenuate and eventually reversed for weight, resulting in approximately 0.6 kg lower weight at age 10 years per week greater gestational advanced aging. [52]

The amount of touch and coddling you get as a child can affect your aging rate. We know that coddling can affect your age acceleration but we aren't quite sure what implications that this has yet! [60]

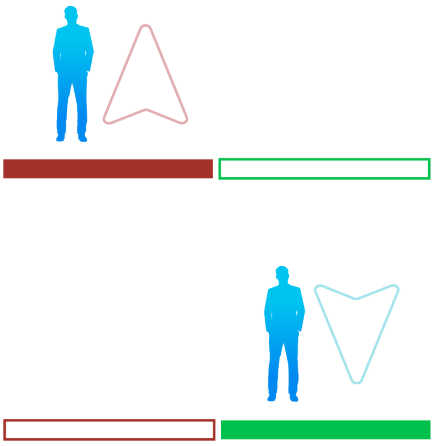
Did your mother smoke or use nicotine products while she was pregnant with you?

The risk of fast aging in children is about 3 times higher in mothers who smoked versus the risk in nonsmokers.

Did you or your mother have any pregnancy complications?

Prenatal adverse environment is associated with epigenetic age deceleration at birth and hypomethylation at the hypoxia-responsive EP300 gene. P300 gene revealed cg19011939 to be differentially methylated in association with prenatal adversity. This can lead to increased epigenetic age acceleration. [66]

The Impact To You



THE TRUAGE™

Treatment Framework

The Impact To You

Age of parents?

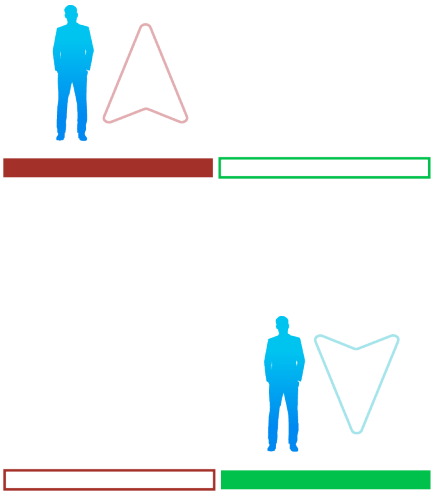
Parental experiences:

Many studies have linked higher paternal age to reduced benefits in longevity. [82]

Maternal Age:

Unfortunately, maternal age has been documented to be a big influence on several epigenetic changes.

One of the well-described changes occurs in a gene called a carbohydrate N-acetylgalactosamine 4-O sulfotransferase 8 (CHST8). This has some important implications for fertility. CHST8 is predicted to be maternally imprinted and encodes an enzyme necessary for the synthesis of luteinizing hormone (LH).



An LH surge is responsible for triggering ovulation and development of the corpus luteum. This finding may provide additional support for the hypothesis that increased maternal age results in decreased fertility in adult daughters via epigenetic modification of critical target genes.

LHX8 is one of 2 genes which are related to maternal age and obesity as well. In addition to LXH8's key role in reproduction, is an expression marker for metabolically active brown fat. The other gene linked to brown fat is PRDM16.

Brown fat mass and BMI have been reported to have an inverse association in adults. Meaning the more brown fat you have the lower your BMI.

Additionally, we find an inverse association between maternal age and the adult daughter BMI – a relationship that we confirmed in the full Sister Study cohort. Meaning that the older mom you have the more likely you are to have a higher BMI.

While the associations between maternal age and offspring cardiometabolic health may be modified by many other factors, the biologic underpinning for these relationships may include epigenetic modifications at LHX8 and PRDM16. [61]

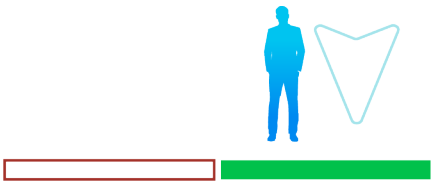
THE TRUAGE™

Treatment Framework

The Impact To You

Socioeconomics of your parents at birth

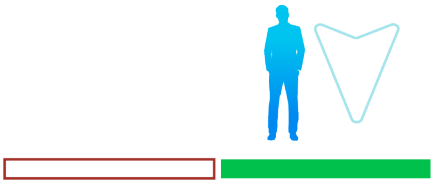
Lower SES was associated with higher methylation age for children at birth. SES was negatively and significantly associated with methylation age at birth. [8]



Childhood events:

Did you have experience stress as a child such as abuse, financial stress or a parent with a mental illness?

It seems that there are times throughout development where we are particularly sensitive to different stimuli. There are several examples of this.



One study found evidence for sensitive periods during early and middle childhood, when the association between adversity exposure and epigenetic aging appears to be particularly strong. This finding aligns with human studies showing the importance of sensitive periods in epigenetic programming [19, 21, 57].

It seems therefore plausible that the epigenetic age of cells is influenced by environmental inputs in a similar time-susceptibility manner. The current findings further emphasize the importance of attending to possible time-dependent effects when studying the effects of adversity on cellular aging, including DNAm and other cellular-based measures of accelerated aging.

The sex-stratified analyses revealed that adversity could differentially affect epigenetic age acceleration in boys and girls. Some of these associations were particularly notable; for example, by age 7.5, girls who were exposed to abuse at age 3.5 were biologically older than their unexposed peers by almost 2 months.

Childhood Abuse [45], financial stress [74], and parental psychopathology [7,45], are all associated with accelerated epigenetic aging in adulthood.

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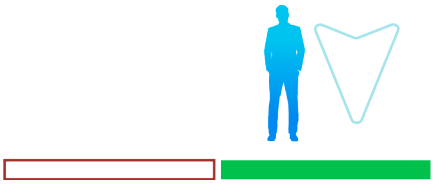
Treatment Framework

The Impact To You



Semi-Centenarians: Anyone over 100 in your family?

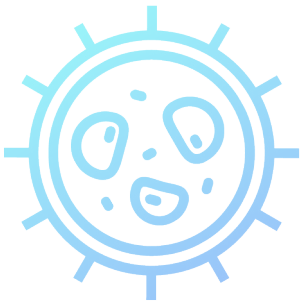
It isn't just bad behavior that is passed through genes. Good behavior and results can also heritable. Semi- supercentenarians (subjects who reached an age of 105-109 years) arguably represent the gold standard of successful human aging because they managed to avoid or postpone the onset of major age-related diseases. If you have had one of these individuals in your family, you are more likely to age much slower!

Further, the offspring of centenarians age more slowly than age matched controls according to Age Accel and intrinsic age acceleration. [33]

Infectious inheritance

In April of 2020, a study came out showing the first example of an infection epigenetic inheritance in men. This study from Walter and Eliza Hall Institute in Australia showed an infection of toxoplasmosis in males can result in epigenetic changes being transmitted to subsequent generations. [79]

Toxoplasma is one of the world's most common parasites, estimated to be carried by between 25 and 80 percent of the global population. Toxoplasma infection can cause an initial mild illness in most people, however, pregnant women, babies and people with weakened immunity experience more severe infections.



The published study documented that Toxoplasma infection in male mice caused changes in levels of 'small RNA' molecules contained in their sperm, potentially altering gene expression in the resulting offspring which could affect development and behavior. Even viral exposure in previous generations could affect your epigenetic age. [79]

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Treatment Framework

Your Selected Ethnicity

Middle Eastern/North African

The Impact of Sex, Race, and other demographics

What best describes your ancestry/ethnicity?

Race seems to have a significant impact on epigenetics. We are unsure at the moment how much this affects different health outcomes but studies have shown the following:

- Infants from mixed race/ethnicity origin had significantly higher methylation age and higher frequency of fast aging rate than that in African-origin black people. [38]

- African Americans have indications of a significantly younger immune system age than Caucasians after controlling for gender, educational level, diabetes status, and Hypertension. [35]

- According to measures of extrinsic epigenetic age acceleration, Hispanics have a significantly older extrinsic epigenetic age than Caucasians and fewer naïve CD4+ T cells.

- This pattern of fewer naïve CD4+ T cells is even more pronounced for Tsimane, who experience repeated acute infections and elevated, often chronic, inflammatory loads. [35]

- In one famous study, there were three variables linked to extrinsic epigenetic age acceleration: race/ethnicity, hypertension, and gender. However, this significant association between extrinsic epigenetic age acceleration and hypertension, type II diabetes status is only found in Caucasians; not in African Americans. [35]

- The lower level of intrinsic epigenetic age acceleration in Hispanics echo the finding that Hispanics in the US have a lower overall risk of mortality than Caucasians despite having a disadvantaged risk profile. The fact that Hispanics have typically had lower intrinsic epigenetic aging but not lower extrinsic epigenetic aging might reflect that Hispanics have higher levels of metabolic/inflammatory risk profiles and that Hispanics have a lower relative CD4+ T cell percentage than Caucasians. [35]

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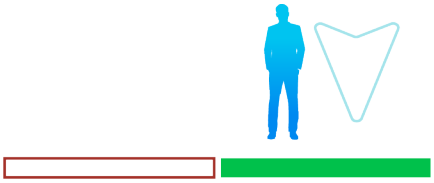
Treatment Framework Cont.

The Impact To You

What is your Biological Sex?

Sex morbidity–mortality paradox

The sex morbidity–mortality paradox was first described in the 1970s. It refers to the observation that women have a lower mortality rate compared to men despite being more likely to suffer from other diseases and co-morbid conditions. It has always been assumed that this might be due to behavioral traits such as lifestyle factors or that they might be less likely to go to a doctor in order to be diagnosed with a disease or condition. [44]



However, we still see differences in health after accounting for differences in work-related behavior, smoking, obesity, and other behaviors. We also see this in epigenetic testing.

Although there is only one study which has really dived into the differences between sexes. It showed that epigenetic aging markers show a large and consistent male-biased vulnerability in multiple tissues (blood, brain, and saliva) across all racial groups.

Men have higher IEAA and EEAA than women even when controlling for education, diabetes, and hypertension. [35]

However, this difference wasn't found in all races. According to the studies evaluation of EEAA, Caucasian men are epigenetically older than Caucasian women, but there was not a significant difference in other groups such as African Americans or central African populations.

Despite the inclusion of race, it is still clear that some of the processes which lead to advanced epigenetic aging are affecting Men more. Additionally, it might have a larger effect on extrinsic aging because Men have fewer naïve CD4+ T cells than women in three racial/ethnic groups: Caucasians; Tsimane; and African Americans. [35]

Sex also effects aging of the brain

All tissues have different epigenetic aging rates! However, the impact of sex and tissues aging is still seen in the brain. While sex did not have a significant effect on the epigenetic age of the cerebellum, the study found that other brain regions from men exhibit a significantly higher age acceleration than those from women. [35]

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Outer circle - Extrinsic aging

Environmental exposures such as nutrition, disease, stress, activity, medications, and drugs can alter DNA methylation at various stages in your life. These are considered extrinsic factors and are the focus for any health conscious individuals because these are the things you can fix and change! [2]

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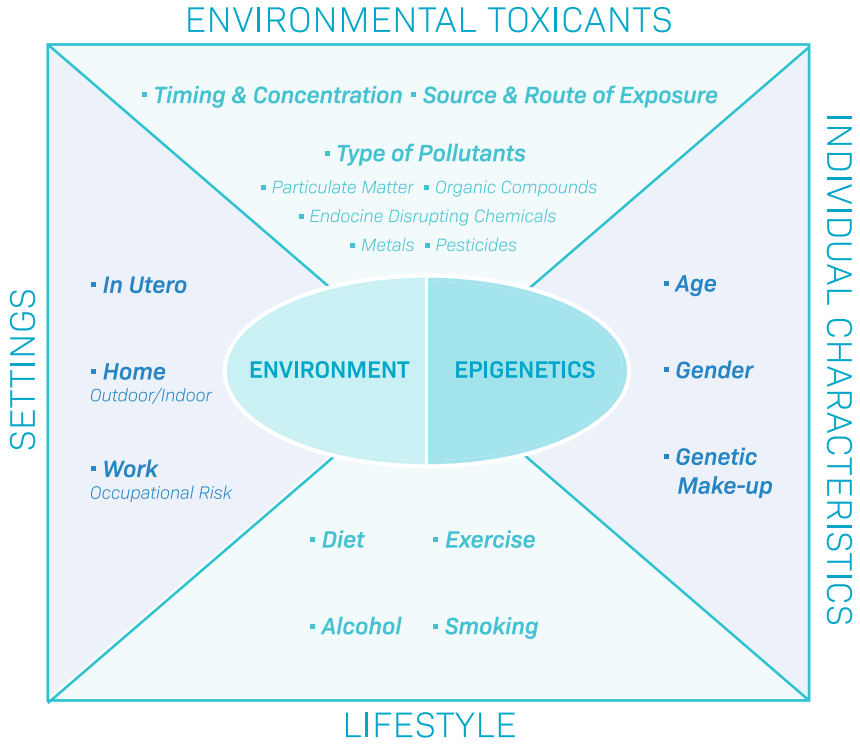
Treatment Framework

Environmental Exposures

The Trouble with Testing and the Twin Solution:
When setting up a good scientific experiment, one of the most important things to do is to have very few variables. By doing this, scientists are able to calculate just how much one independent variable can affect the outcome they are measuring. Unfortunately, this is often hard to do. It is especially hard to do with the epigenetics of methylation because so much can change this pattern. That is why most valuable studies are done with large numbers of people and in similar populations.

It is similarly difficult judging which things in the environment of a person change their epigenetic aging rate. Even just defining what should be included in the environment can be incredibly difficult. You might consider pollution, but do you account for humidity? One way to solve this is to look at individuals who do just about everything in the same fashion except for one of two variables. That is why identical twins can be so helpful! Identical twins share the same DNA and oftentimes share the exact same environment growing up. It is as close to a controlled experiment as you can get for such a complicated field of research like epigenetics!

Thankfully, many of these experiments have been done and they tell us a lot about the environmental effects of aging. [40] **In one study looking at two popular clocks, they estimated that 40% of the determination of the aging rate was due to the factors you can't control like your DNA or the influences and lives of your parents. However, this means that 60% is changeable! This means you're able to greatly affect your own aging!**



Correlations to Toxic Exposures

Oftentimes, methylation epigenetics doesn't have enough data yet to be a stand alone diagnostic. However, we are able to help narrow down the scope of diagnosis. One of the ways we can do that is by looking at the correlated changes of the DNA methylation to different types of diseases or exposures.

Environmental exposures are a good example of this. Below is a list of some environmental toxins which can help shape the epigenome. If you are concerned you have been exposed to these things please let us know and we will work to read your DNA and let you know the likelihood of exposure! [56]

Exposures	Global Methylation	Gene-Specific Methylation	Exposure-Associated Health Impact
Aflatoxin B1	Hypomethylation associated with exposure	71 CpG sites associated with prenatal exposure	Hepatocellular carcinomas, reduced growth, immune deficiencies
Air pollution	Hypomethylation typically associated with exposure in adults, prenatal exposure is associated with both hypo- and hypermethylation	MAPK pathway members, ACE, iNOS, ICAM-1, TLR2, IL-6, TET1	Accelerated lung aging, loss of lung capacity, asthma, bronchitis, emphysema, and cancer
Arsenic	Hypomethylation associated with exposure with sex-specific directionality shown as well	KCNQ1, SQSTM1, sex-specific profilese	Cancer lung conditions and diabetes in adults; prenatal exposure is associated with increased incidence of infection, neurocognitive effects, and increased neonatal mortality
Bisphenol A	Hypomethylation associated with exposure in females, potential nonmonotonic dose responses	SNORD, SULT2A1, COMT	Neurocognitive effects, increased incidence of cancer, and heart conditions from prenatal exposure
Cadmium	Hypomethylation associated with exposure	DNMT1	Cancer, lung, bone, and kidney disease, developmental toxicity
Chromium	Hypomethylation associated with exposure	Not assessed at present	Cancer
Lead	Not assessed at present	Alterations in imprinted genes, sex-specific response	Neurotoxicity, developmental toxicity
Mercury	Not assessed at present	EMID2, sex-specific profiles	Neurotoxicity
Polycyclic Aromatic Hydrocarbons	Hypomethylation associated with exposure	HIN1, ESR1, TWIST1	Cancer
Persistent Organic Pollutants	Nonmonotonic association with exposure	IGF2, TNF-α, NR3C1	Various health effects
Tobacco Smoke	Hypomethylation associated with exposure	AHRR, CNTNAP2, MYO1G	Cancer, developmental toxicity, cardiovascular disease, chronic respiratory conditions
Nutritional Factors	Hypermethylation associated with exposure	IGF2, RXR-α, PLAG1	Proper development
Non Chemical Stressors	Not assessed at present	BDNF, IGF2	Various health effects

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Air Pollutants

Everyone knows that due to environmental changes and increased activity, the air is becoming more polluted! To objectively measure the amount of pollution in the air scientists have created a term called PM2.5. PM2.5 refers to atmospheric particulate matter (PM) that have a diameter of less than 2.5 micrometers, which is about 3% the diameter of a human hair.

Commonly written as PM2.5, particles in this category are so small that they can only be seen with a microscope. Since they are so small and light, fine particles tend to stay longer in the air than heavier particles. This increases the chances of humans and animals inhaling them into the bodies. Owing to their minute size, particles smaller than 2.5 micrometers are able to bypass the nose and throat and penetrate deep into the lungs and some may even enter the circulatory system.

Studies have found a close link between exposure to fine particles and premature death from heart and lung disease. Fine particles are also known to trigger or worsen chronic disease such as asthma, heart attack, bronchitis and other respiratory problems.

A study published in the Journal of American Medicine suggests that long-term exposure to PM2.5 may lead to plaque deposits in arteries, causing vascular inflammation and a hardening of the arteries which can eventually lead to heart attack and stroke. Scientists in the study estimated that for every 10 micrograms per cubic meter (µg/m3) increase in fine particulate air pollution, there is an associated 4%, 6% and 8% increased risk of all-cause, cardiopulmonary and lung cancer mortality, respectively. [17]

In addition to those health effects, we also see changes in the epigenome and in the epigenetic age rate!

In a study with almost 600 men from the Northeastern USA enrolled in the Normative Aging Study (NAS), a 1 µg/m3 increase in one-year PM2.5 exposure was significantly associated with a 6-month increase in their epigenetic age. [63] In a similar study using 1,777 German participants of the Cooperative Health Research in the Region of Augsburg (KORA) study, a 0.97 µg/m3 increase in long-term exposure to PM2.5 was associated with a 0.33-year increase in extrinsic epigenetic age acceleration. [16] In addition to PM2.5 mass, associations with a particular clock have been observed with specific PM2.5 components such as ammonium and sulfate. [16]

Pollution and particles are negative for your aging and you can wear a mask to prevent this when traveling. Particularly, due to pollution's specific effect on extrinsic epigenetic aging, it might be related to decrease immune functioning!

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Treatment Framework

Metal and Pesticide Exposures

Two studies have examined associations between metal exposures and epigenetic aging to date.

A study of urinary cadmium in 40 non-smoking women from Thailand and a study of blood cobalt and chromium levels resulting from chronic exposure due to metal on metal hip replacements found no associations between any of the metals examined and Epigenetic age. It seems that this doesn't have an effect on these variables. [76]

In a study of three organochlorine pesticides – (4-chlorophenyl)-1,1-dichloroethene (DDE), hexa- chlorobenzene (HCB), and trans nonachlor (TNC) – in the plasma of 967 Swedish individuals. All three exposures were positively associated with larger differences between chronological and epigenetic ages, with TNC having the strongest association. [49]

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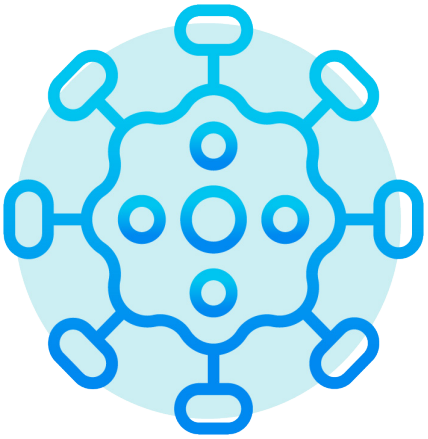
Infectious Exposures

As mentioned earlier with toxoplasmosis, we know that viruses can have an effect on epigenetics. However, how do some common viruses affect epigenetic aging?

Of all of the infectious agents studied for their relationship with epigenetic age, Human Immunodeficiency Virus (HIV) is the most widely examined.

In one study HIV positive individuals were found to have brain and blood samples that were 7.4-years and 5.2-years higher, respectively, compared to controls.

What's more, is that the load of the virus was associated with higher aging rates. Adult male cases with detectable viral load (>35 HIV copies/mL) had a 3.6-year higher methylation age as compared to adult male cases with an undetectable viral load. [32]



In addition to HIV, H.Pylori (an abnormal bacteria from the gut), and cytomegalovirus (CMV) have both been linked to changes in epigenetic aging. [80]

In a study of 1509 German adults who had documented *H. pylori* infections, were all associated with increases in epigenetic methylation age of 0.4, 0.6. and 1-year, respectively, independent of white blood cell distributions. [16] In peripheral blood cells from 122 nonagenarians (a person who is from 90 to 99 years old) and 21 young healthy controls from a sub-cohort of the Finland Vitality 90+ study, ***epigenetic methylation age was 2.5-years higher in CMV positive individuals versus those without disease.*** [41]

The underlying mechanisms connecting infections and DNAm-age have yet to be elucidated, and alterations in blood cell composition may play an important role, though other mechanisms are needed to explain associations in non-blood tissues and those that appear to be independent of assessed blood cell proportions.

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Psychosocial Exposures

Psychosocial exposures such as stress, adversity, and socioeconomic status, may also impact epigenetic aging.

In Hugo's fictional work Les Misérables, an extreme stressor causes the main character, Jean Valjean, to undergo accelerated aging, depicted as rapid whitening of his hair. This dramatic depiction is just one among innumerable examples—found in literary works, movies, and folklore legends—of individuals whose "biological clocks" appear to tick fast in the face of life adversity. Beyond fiction, however, the connection between psychosocial stress and rate of biological aging is also seen in everyday life and clinical practice.

> ***It was he [Jean Valjean] in fact. The clerk's lamp illuminated his countenance. He was pale and he trembled slightly. His hair, which had still been gray at his arrival [to the court], was now entirely white; it had turned white during the hour he had sat there.***
>
> - Victor Hugo,
> *Les Misérables*

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Treatment Framework

Adrenal Stress and Fatigue

Rate your Lifetime stress 1-10?

An important risk factor for accelerated aging and aging-related diseases is psychological stress. Although stressors are ubiquitous in nature and necessary for survival, excessive and chronic stress has been associated with accelerated cellular aging and increased risk for aging-related disease phenotypes, including cardiovascular disease, immune dysregulation, and late-life neuropsychiatric disorders. Furthermore, stressors occurring during sensitive developmental periods, such as childhood maltreatment, have been linked with later development of aging-related diseases. Lastly, stress-related psychiatric disorders, including major depression and post-traumatic stress disorder (PTSD), are themselves risk factors for such diseases.

The Impact To You

In a 2015 study by Zannas et al, the authors showed that cumulative lifetime stress may accelerate epigenetic aging. They also hypothesized that these effects could be driven by glucocorticoid-induced (cortisol) epigenetic changes. Cortisol is the hormone that is upregulated during stress and can cause people to put on weight. [84]

Glucocorticoids, a class of endocrine signaling hormones which includes cortisol, are a component of the biological response to stress. In particular, ***85 of the 353 loci that comprise the epigenetic clock are located near glucocorticoid receptor elements, and 110 loci showed altered DNA methylation after exposure to dexamethasone, a glucocorticoid receptor agonist.*** [84]

Researchers have proposed biological mechanisms that may connect stress to epigenetic alterations and DNA methylation age/aging in particular. Accordingly, stress-inducing psychosocial exposures are frequently associated with epigenetic age.

Limiting stress and this hormone might be a good way to avoid advanced epigenetic aging.

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Stress, Trauma, & Post-traumatic Stress Disorder (PTSD)

In a study of 392 adults recruited from urban hospitals, the relationship of life stress was associated with higher epigenetic age, an observation which was more prominent in older participants and those who experienced minimal childhood mistreatment. In this particular study, however, epigenetic age was not related to childhood trauma, current stress, depressive symptoms or PTSD symptoms.

Combat-related trauma and PTSD have been associated with increased epigenetic age in a few studies of veterans. In veterans of the Iraq and Afghanistan conflicts (N = 281) lifetime PTSD was related to increased epigenetic age.

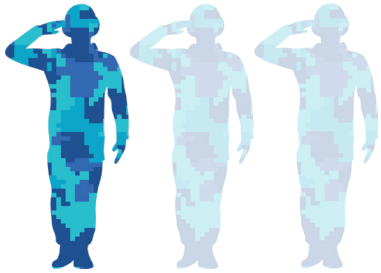
In 339 middle-aged, trauma-exposed veterans, hyperarousal PTSD symptoms were associated with increased epigenetic age. [84]

In a longitudinal study, epigenetic age was determined in 96 Dutch military personnel deployed to Afghanistan, from blood draws conducted before and 6 months post-deployment. ***Combat-related trauma was significantly associated with an increase in epigenetic age of about 2 years over the course of deployment.***

A meta-analysis of 9 cohorts (n = 2186, civilian and military) found modest associations of accelerated epigenetic age with exposure to child trauma, and with lifetime PTSD severity. [Dhingra et al. 2018]

22%
of veterans suffer from PTSD or depression

34%
of veterans suffer from other mental concerns



1 OUT OF 3
veterans seek help

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Childhood Adversity and Trauma

Studies of childhood and adolescent adversity have been the first to use biological epigenetic aging as a potential measure of intervention efficacy, or effect modification by intervenable factors.

Using 399 parent and child pairs from rural Georgia, USA one study aimed to assess if parental depressive symptoms at child age 11 forecast epigenetic age at child age 20, and the potential of an intervention program, the Strong African American Families program (SAAF), which aimed to improve supportive parenting and family relationships, to moderate observed associations.

Among the control group, elevated parental depressive symptoms were associated with future increased epigenetic age in children, but the association was abolished in those receiving the SAAF intervention. Similarly, a longitudinal study of 616 African American youths (16–17 years old at recruitment) in rural Georgia found an ameliorating effect of a supportive family environment on the relationship of epigenetic age to experience of racism. ***Among youth with a less supportive family exposure to higher levels of racial discrimination during early adulthood was associated with higher epigenetic age.*** [16]

In a separate study of 101 children (age 6–13 years) from a primarily low income, highly traumatized neighborhood populations in Atlanta, Georgia, direct experience of violence was significantly associated with increased epigenetic aging, and there was a suggestive ($p < 0.10$) association between witnessing violence and epigenetic aging. [16]

Associations of childhood adversity and trauma with biological age measures appear consistently adverse, unless moderated by an ameliorative co-exposure, whether preexisting or the product of intervention.

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Treatment Framework

Socioeconomic Status and Hardship

The largest study of socioeconomic status (SES) to date has shown us some interesting findings. Using a meta-analysis of cohort specific associations, low SES was associated with a 0.99-year greater epigenetic aging rate when comparing the highest to lowest SES categories. [25]

The trajectory of a socioeconomic life course has consistent effects on epigenetic age.

Two studies of epigenetic age were conducted in African-American adolescents residing in rural Georgia and examined the direct or modifying impact of economic hardship on epigenetic age using samples collected around the Great Recession.

One study examined the impact of economic hardship during the 2007–10 economic recession on epigenetic age in 330 African American adolescents (mean age 16.6 years in 2007). ***Adolescents exhibited a mean 1.42-year increase in epigenetic age with each as categorical measures of economic adversity increased.*** These findings are mirrored in observations of increased allostatic load and decreased self-reported overall health with increased epigenetic age. [10]

A second study noted that while self-control was associated with several favorable psychological outcomes (e.g., lower rates of depressive symptoms, substance use, and aggressive behavior), among low SES youths better self-control was associated with an increased biological age of 2.27-years. In contrast, among less-disadvantaged subjects, better self-control was associated with a 2.14-year deceleration. [16]

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Do you have Allergies and Asthma?

"We know that the prevalence of allergies and asthma has been increasing over the past decade. The genome hasn't changed, but some of the ways that the environment is interacting with our genomes may have. - Dawn DeNeo, MD, MPH"

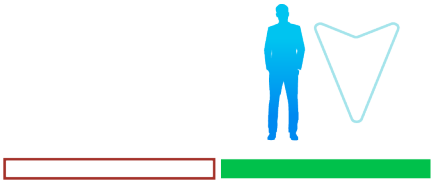
At mid-childhood (mean age, 7.8 years) in Project Viva, epigenetic age and age acceleration were cross-sectionally associated with greater total serum IgE levels and greater odds of atopic sensitization.

Every 1-year increase in intrinsic epigenetic age acceleration was associated with a 1.22, 1.17, and 1.29 greater odds of atopic sensitization and environmental and food allergen sensitization. [70]

Extrinsic epigenetic age acceleration was also cross-sectionally associated with current asthma at mid-childhood. Biological age and age acceleration at birth and early childhood were not associated with mid-childhood allergy or asthma.

Because the epigenetic clock might reflect immune and developmental components of biological aging, the Project Viva study suggests pathways through which molecular epigenetic mechanisms of immunity, development, and maturation can interact along the age axis and associate with childhood allergy and asthma by mid-childhood. [70]

The Impact To You



Epigenetic age acceleration assessed at mid-childhood is **associated with mid-childhood allergy & asthma** in children *in Project Viva*

Prenatal/Early Life Environment

↓

Changes in epigenetic modifications of age-associated methylation sites

↓

Epigenetic age acceleration
(i.e., epigenetic age is older than chronological age)

↓

Childhood Phenotypes
(mean age 7.8 years)

- ↑ **Food Allergen Sensitization** OR = 1.29 (95% CI [1.12-1.49])
- ↑ **Atopic Sensitization** OR = 1.22 (95% CI [1.07-1.39])
- ↑ **Asthma** OR = 1.11 (95% CI [0.95; 1.31])
- ↑ **Environmental Allergen Sensitization** OR = 1.17 (95% CI [1.03-1.34])

Abbreviation:
IgE: Immunoglobulin E
OR = odds ratio (for every 1 yr increased in epigenetic age acceleration)

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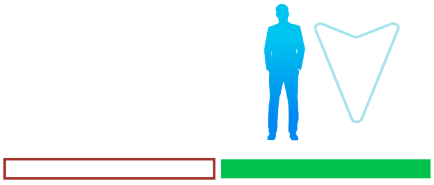
The Impact To You



Education Level:

Higher education has been a demographic variable that has been linked to many positive health outcomes including reductions in morbidity and mortality risk.

How is it correlated to Epigenetic aging?

It seems that it has a significant effect on the extrinsic epigenetic aging rate of a person according to a 2017 study. *In this study it was correlated that those with more education have less advanced aging.* This doesn't mean that getting an education will reduce your epigenetic age, it just means that it is correlated to that outcome with the populations studied.

This study also looks into fitness and nutrition which we will discuss later! [72]

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Treatment Framework

Nutrition

Nutrition is always a hard topic to discuss and there are many differing opinions out there about what is the best diet. Some focus on macronutrients such as carb intake, others focus on the timing of meals, and there are very vocal advocates on all sides. However, epigenetic testing gives us a very objective metric to look at how some diets and supplements can affect the aging process!

The Mediterranean Diet

The Mediterranean diet, which is considered by UNESCO as a heritage of humanity, is a well-balanced mix of nutrients, antioxidants, and anti-inflammatory molecules. This diet has demonstrated favorable effects on cardiovascular risk, blood pressure, cancer, inflammation, or frailty status, and it has been observed that it can impact methylation of inflammation-related genes in peripheral blood cells.

Mediterranean Diet

The role of the Mediterranean diet in promoting healthy aging has been recently investigated in a new European project abbreviated NU-AGE for "New dietary strategies addressing the specific needs of elderly population for an healthy aging in Europe". The aim of NU-AGE project is to investigate how an intervention based on the Mediterranean diet, specifically tailored according to the nutritional needs of people over 65 years of age, can impact on age-related diseases and functional decline, possibly modulating inflammation and its outcomes.

Baseline and after the 1-year intervention, and results achieved so far in the framework of this study have demonstrated a beneficial effect of the Mediterranean-like diet on global cognition and episodic memory, osteoporosis, immune function, and cardiovascular health, as well as on the proteasomal proteolysis.

There still remains little evidence on the biomarkers associated with the Mediterranean diet. However, one study looked at the effect of 100+ participants and the effect of their epigenetic aging.

Their study observed a trend towards the epigenetic rejuvenation of participants after the nutritional intervention. The effect was statistically significant in the group of Polish females and in subjects who were epigenetically older at baseline.

Together, these findings suggest that the Mediterranean diet can promote epigenetic rejuvenation but with country-, sex-, and individual-specific effects, thus highlighting the need for a personalized approach to nutritional interventions. [30]

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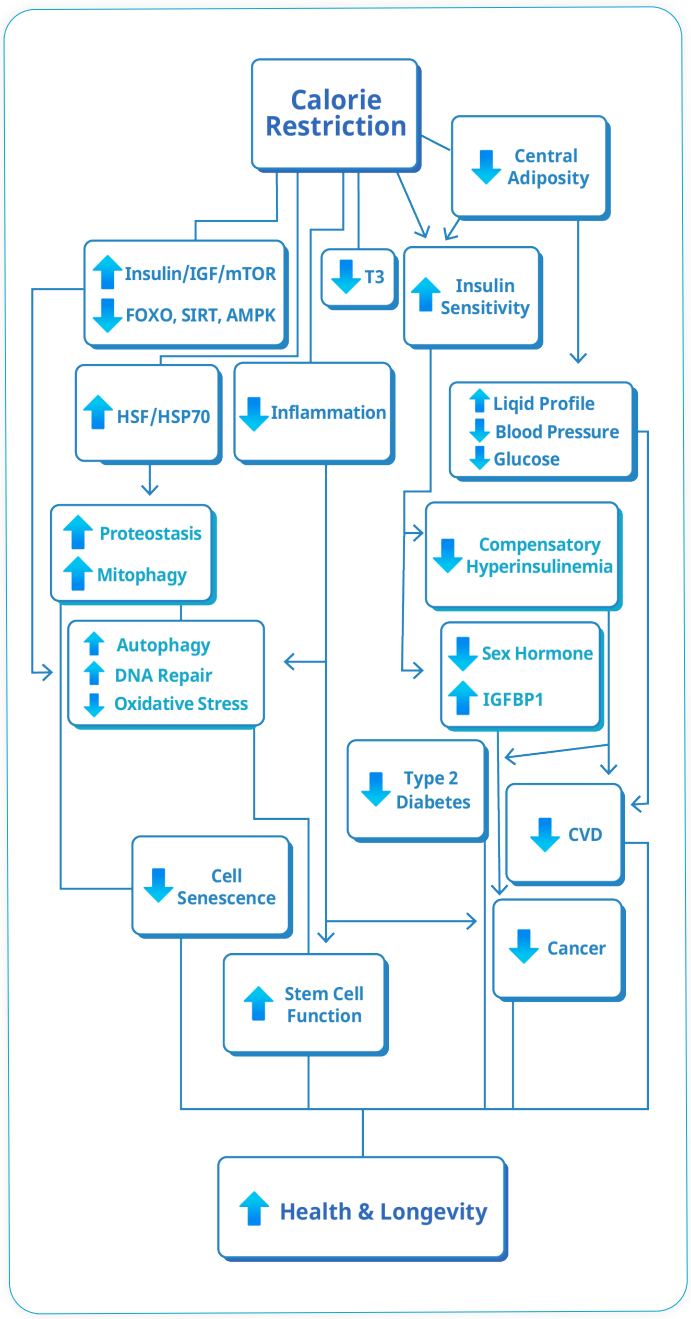
Calorie Restriction

Calorie restriction (CR) without malnutrition is the most studied and robust non-genetic non-pharmacological experimental intervention for extending healthspan and lifespan in multiple animal models!

In budding yeast, fruit flies, and worms, CR can dramatically extend lifespan (2–3 fold). [77] ***A 20 to 50% reduction in caloric intake, without malnutrition, in some strains of rats and mice prolongs median and maximal lifespan up to 50% and prevents or delays the onset of many chronic diseases, such as obesity, type 2 diabetes, cancer, nephropathy, cardiomyopathy, neurodegeneration, and multiple autoimmune diseases.*** [62]

Hundreds of preclinical studies have shown that dietary restriction, by inhibiting key nutrient-sensing and inflammatory pathways, activates multiple molecular pathways that promote proteostasis, genome stability, stress resistance, and stem cell function. Data collected in non-human primates indicate that calorie restriction in combination with diet quality modifications markedly decreases the incidence of cardiovascular disease, cancer, diabetes, and attenuates age-related neurodegeneration, sarcopenia, and auditory loss.

Finally, data from human studies show that calorie restriction remains the cornerstone in the prevention and treatment of obesity and its complications. Moderate CR achieved through intermittent fasting or restricting feeding in combination with regular physical activity most likely exerts additional beneficial health effects even in non-obese individuals. However, a general facet of modern life in the developed world is the near-constant availability of food. So some researchers have developed some diets to mimic fasting or calorie restriction! [62]



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Treatment Framework

Dr. Valter Longo's Fasting Mimicking Diet

One of the most popular calorie-restricting diets is the Fasting Mimicking Diet (FMD) popularized by Dr. Valter Longo. The longevity diet Valter Longo developed consists of two parts: the "fasting" phase and the "whole foods" phase. The fasting phase isn't necessarily complete fasting. Rather, it involves consuming a series of packaged herbal teas, soup blends, energy bars, oils, and drinks.

They are to be rationed over the course of five days. After those five days, the dieter can go on to the whole foods phase. During the whole foods phase, the dieter can go back to eating "normal" food that they can get at the grocery store. They do have to make healthy eating choices, though, or all the space freed up during the fasting phase will be put to waste. There's a wealth of research on how intermittent fasting might help with longevity and youthfulness. Intermittent fasting, they say, can reset our bodies and our genes. [50]

While there is not yet a trial published on this at the moment, there is a highly popularized anecdotal trial on this by the radiant Gwenyth Paltrow and her company, Goop Lab. Here Gwenyth and two of her team members test whether different diets can make your body younger, and therefore healthier, by reducing their epigenetic age. Gwenyth, 46 years old at the time of filming, was prescribed the most extreme of the test diets, the fasting mimicking diet. Following this five-day cleanse, her biological age was 44.2. Goop's chief content officer, Elise Loehnen, 40 years old, was put on a three-week Mediterranean-style diet. Her biological age was 37.9 after the pescatarian, mostly plant-based diet. Wendy Lauria, Goop's vice president of marketing, 49.5 years old, was assigned a three-week vegan diet of plant-based meals, excluding all animal products like meat, fish, milk, and eggs. Lauria had a biological age of 48.4 after her given diet.

In conclusion, Gwenyth came out on top in the final test results, which showed that her fast-mimicking regimen shaved 1.7 years off her biological age, bringing her to a youthful 42.5 (compared with her actual age of 46 years). The results of her experiment have been backed up by some data from mouse clinical trials. A 2017 study from the Max Planck Institute for Biology of Ageing looked at dietary restriction in mice and its effect on genome wide methylation. While they didn't directly address epigenetic age, they found that dietary restriction is generally strongly protective against age-related changes in DNA methylation. During aging with dietary restriction, DNA methylation becomes targeted to gene bodies and is associated with reduced gene expression, particularly of genes involved in lipid metabolism.

Overall their results revealed that dietary restriction remodels genome-wide patterns of DNA methylation so that age-related changes are profoundly delayed, while changes at loci involved in lipid metabolism affect gene expression and the resulting lipid profile. [31]

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Treatment Framework

Bioactive Compounds and Longevity

Although calorie restriction has been shown to have a beneficial role in aging, calorie restriction therapy has several limitations or potential side effects, such as infertility, menstrual irregularities, hypertension, and depression. For these reasons, recent studies have aimed to identify bioactive compounds that may mimic calorie restriction and provide therapeutic anti-aging effects.

Unfortunately, direct evidence shows the linkage between bioactive compound consumption and longevity is scarce. However, several studies have reported beneficial effects of natural compounds on age-related phenomena, mainly in providing anticancer and anti-inflammatory effects. [31]

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Treatment Framework

Resveratrol

Resveratrol is the most characterized bioactive polyphenolic compound in anti-aging diets. Dietary polyphenols have antioxidant capacity and protect against age-related degenerative diseases. They can activate endogenous defense systems and modulate cellular signaling processes. Resveratrol is found in grapes, grape-based red wine, as well as strawberries and blueberries. [67]

The possible role of resveratrol in extending the life span recently gained worldwide attention. Resveratrol has been identified as a potent SIRT1 activator that mimics the effects of calorie restriction and regulates longevity from lower organisms to humans. In 2003, Howitz and colleagues showed that resveratrol increases the deacetylase activity of SIRT. A number of studies showed that resveratrol induced SIRT1 activity in several species. Resveratrol mimics calorie restriction effects, which may result in an increased life span.

Although the effects of resveratrol and SIRT1 on longevity are still debated, resveratrol clearly appears to improve metabolism and attenuate the risk of age-related chronic diseases in animal models. For example, increased SIRT1 activation from resveratrol improves energy expenditure and prevents diet-induced obesity and other metabolic diseases. [36]

In addition, middle-aged mice on a high-calorie diet that were treated with resveratrol showed health and longevity benefits. In humans, resveratrol supplementation induces metabolic changes in obese humans, mimicking the effects of calorie restriction. In addition to metabolic regulation, resveratrol has an intrinsic antioxidant capacity and induces the expression of antioxidant enzymes, which reduces oxidative stress. To date, little is known about the underlying epigenetic mechanism by which resveratrol improves longevity and aging-related metabolism. Research suggests that resveratrol may target metabolism-related pathways, such as AMP-activated protein kinase and peroxisome proliferator-activated receptor-gamma coactivator 1 a. [6]

In addition to resveratrol, you may see other research on several bioactive components of which beneficial effects are mediated by epigenetic modifications, namely, sulforaphane, epigallocatechin-3-gallate (EGCG), quercetin, and genistein. All of these have been highlighted for their epigenetic effect on aging. [69]

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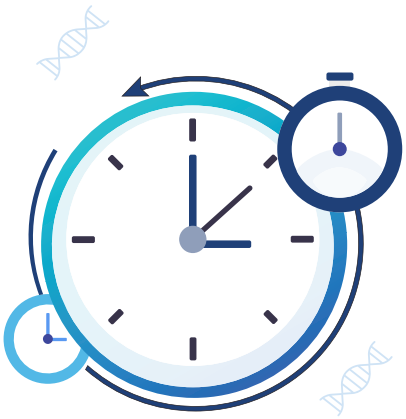
Treatment Framework

Eating Fish and Chicken

In the same study that looked at the dietary effects of alcohol, they also looked at how the consumption of fish and chicken affected epigenetic aging. Those who had fish more frequently were less likely to have a higher extrinsic epigenetic age acceleration. This is consistent with prospective studies suggesting that fish consumption is protective against various age-related diseases. The benefits of fish intake may be mediated in part through the omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which stimulate the synthesis of anti-inflammatory cytokines. ***This was further supported by the authors' findings that CRP—a well-known marker of inflammation—was the most significant explanatory biomarker of extrinsic epigenetic age acceleration.***

This suggests that one reason higher fish consumption may lower extrinsic epigenetic age acceleration is because it has beneficial anti-inflammatory or metabolic effects.

Similarly, the same study found that poultry consumption was associated with a decreased intrinsic age rate and lower BMI after adjusting for potential confounders. [72]



Extrinsic Epigenetic Age	Intrinsic Epigenetic Age
↓ Fish	↓ Poultry
↓ Fruits & Veggies	↓ HDL Cholesterol
↓ Moderate Alcohol	↑ Insulin & Glucose
↓ Edication & Income	↑ C-Reactive Protein
↓ Exercise	↑ BMI & Waist-to-Hip Ratio
↓ HDL Cholesterol	↑ Triglycerides
↑ Insulin & Glucose	↑ Systolic Blood Pressure
↑ C-Reactive Protein	
↑ BMI & Waist-to-Hip Ratio	
↑ Triglycerides	
↑ Systolic Blood Pressure	

Blue Arrow: Decreases Epigenetic Age
Red Arrow: Increases Epigenetic Age

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Treatment Framework

Alcohol

While many might instinctively think that alcohol might decrease epigenetic age, the one study conducted on this actually showed the opposite!

They found that alcohol consumption was negatively associated with extrinsic epigenetic age acceleration even after adjusting for potential confounders such as socioeconomic status! This is consistent with prospective studies which have identified light to moderate alcohol intake as a protective factor against all-cause and CHD-related mortality. It is even supported by a recent publication that also found an inverse association between epigenetic age and alcohol intake in Caucasian and African American individuals.

In a study from UCLA, researchers found that one monthly drink had a positive effect. It remained consistent when adding weekly and daily intake levels as well.

The association appears to be driven by wine consumption though there is also a trend towards association with beer. This is consistent with other studies that have suggested that wine may have added benefits compared to light alcohol consumption.

It has been postulated that this may also be related to the anti-inflammatory effects of light alcohol consumption, which are associated with decreased circulating levels of inflammatory markers such as IL-6 and CRP. [72]

Alternatively, this may be the result of reverse causation, whereby those with health issues abstain from alcohol consumption due to their illness, however, other interventional studies support a protective effect of moderate alcohol consumption.

Do not change drinking habits without talking to your physician.

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Treatment Framework

What is your alcohol consumption?

Some studies which have been published have found that alcohol consumption can help reduce your aging rate. Particularly, it can help reduce your extrinsic epigenetic aging rate even after adjusting for potential confounders such as socioeconomic status.

This finding is consistent with prospective studies which have identified light to moderate alcohol intake as a protective factor against all-cause and CHD-related mortality and are supported by a recent publication that also found an inverse association between epigenetic age and alcohol intake in Caucasian and African American individuals

In the same study, they also found that the potential benefits of alcohol consumption are *observed using a threshold of more than one serving per month. But the effect is extended to a drink once weekly and once daily. The association appears to be driven by wine consumption though there is also a trend towards association with beer.* This is consistent with other studies that have suggested that wine may have added benefits compared to light alcohol consumption.

This finding may also be related to the anti-inflammatory effects of light alcohol consumption, associated with decreased circulating levels of inflammatory markers such as IL-6 and C-Reactive Protein (CRP). [72]

The Impact To You

Do you smoke?

Tobacco

Tobacco smoking is a major public health problem, associated with substantial preventable morbidity globally. In particular, active smoking in adults accounts for a large proportion of age-related diseases, including various forms of cancer, respiratory, and cardiovascular diseases. Recent studies have demonstrated the role of DNA methylation, one of the main forms of epigenetic modification, in the pathways of smoking and smoking-induced diseases via regulating gene expression and genome stability.

An increasing number of smoking-related CpG sites in various genes, such as *AHRR, F2RL3, and GPR15,* have been discovered by epigenome-wide association studies (EWASs) based on whole blood samples, and have been shown to be useful as quantitative biomarkers of current and past smoking exposure and predictors of smoking-associated health risks. This means you might be able to have a blood test in the future which quantifies how much you have smoked in life!

Despite many changes in the epigenome, smoking isn't necessarily correlated to increased epigenetic age which highlights that not every poor lifestyle choice is associated with an increased epigenetic aging effect in blood tissue. [29]

Illicit Drugs

Not many studies have yet been done on illicit drugs, however, there are many in development!

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Treatment Framework

Pregnancy

Have you been pregnant?
Pregnancy also affects aging. One study suggests that Pregnancy (gravidity) predicts shorter telomeres and epigenetic age acceleration, measures of mitotic and non-mitotic aging, respectively, among young women.

Unfortunately, this supports other data showing the cost of reproduction from pregnancy in humans as it relates to age. [75]

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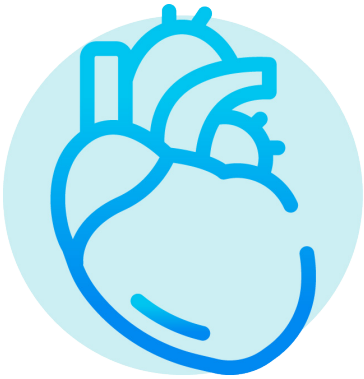
Treatment Framework

Diseases



CHD

DNA methylation is associated with the risk of developing coronary heart disease (CHD), using methylation levels at 52 CpG sites determines one's risk of developing CHD. CHD events include unstable angina, heart attack, coronary revascularization, and coronary death.

Your race/ethnicity, chronological age, and sex are related to your susceptibility to developing CHD. Biomarkers of epigenetic aging can address the mortality rates of coronary heart disease and how epigenetic rates of aging are found to be significantly associated with race, sex, and chronological age.

In the first-ever study to use epigenetic measures as an estimate for aging rates amongst gender and ethnic groups found differential mortality rates across these groups. The study used thousands of participants across these ethnic groups: 1387 African ancestry, 2932 caucasian, 657 Hispanic, 127 east Asians, and 59 Tsimane Amerindians.

Finding that women have lower rates of mortality than men despite having higher rates of morbidity. Hispanics and Tsimane have lower intrinsic epigenetic age acceleration (IEAA) and longer life expectancies but higher extrinsic epigenetic aging rates than Caucasians. African Americans have lower extrinsic epigenetic age acceleration (EEAA) than Caucasians and Hispanics.

Notably IEAA is not associated with CHD risk factors, but EEAA was positively correlated with CHD risk factors like triglyceride and creatinine levels. [35]

Large-scale studies show that risk factors for CHD include smoking, obesity, hypertension, serum lipids, and type-2 diabetes are all linked to differences in leukocyte DNA methylation. The largest longitudinal study of its kind, with 11,461 participants found pathways to CHD, including calcium regulation, kidney function, and gene regulation mechanisms that involve non-coding RNAs.

Associations between leukocyte DNA methylation and risk of CHD are clinically relevant. These associations have the potential to present novel avenues for targeting disease pathways and developing therapeutic interventions. Several of the 52 CHD associated CpG sites map to genes with roles in calcium regulation and kidney function. [1]

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Treatment Framework

Downs Syndrome

Individuals with the genetic disorder, Down syndrome, have an increased risk of having chronic diseases that are associated with older age. The disorder is interpreted as segmental progeria affecting at least two different tissues and is characterized by rapid aging starting in early childhood.

Not only is this an intellectual disability but it is also linked to the clinical manifestations of rapid aging. Trisomy 21 is linked to the acceleration of the biological age of tissues and significantly increases the ages of blood and brain tissue.

A method that predicts adults with Down's syndrome's biological age is based on DNA methylation at 353 CpG sites. These sites are strong indicators for these individuals' biological age. Using CpGs associated with Downs syndrome status and age acceleration helps determine the specific set of conditions associated with accelerated aging.

The early onset of epigenetic changes is linked to Downs syndrome pathologies which include premature wrinkling, greying of hair, hypogonadism, early menopause, hypothyroidism, declining immune function, and Alzheimer's disease. [34]

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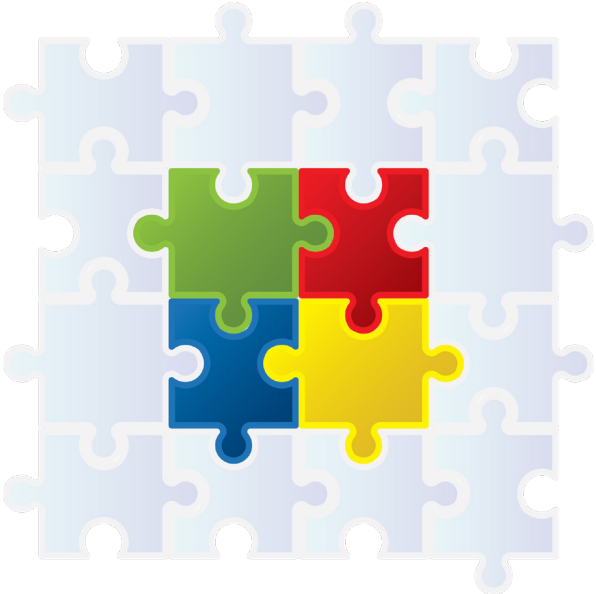
Treatment Framework

Autism

The prevalence of autism spectrum disorder has been increasing over the past 20 years. Autism spectrum disorder is a clinical grouping of neurodevelopmental disorders characterized by debilitated social communication and repetitive behaviors. Many children and adults diagnosed with autism have comorbid health problems and are three to ten times more likely to die prematurely. The biological makeup of people with autism spectrum disorder is linked to other illnesses such as epilepsy, gastrointestinal, and respiratory disorders. [68]



"Comorbidity is to be expected in autism spectrum disorders- directly or indirectly. Comorbid conditions may be markers for underlying pathophysiology and request a more varied treatment approach."

-Jorn Isaksen et al., 2012 *'Children with autism spectrum disorders: The importance of medical investigations.'*

Genetic discoveries of autism spectrum disorder provide evidence of a strong inherent component for many cases of individuals with the disorder. Multiple genetic hits for autism spectrum disorders located in numerous genes support that genetic risk for autism spectrum disorder will likely lie in immune-related genes. But genetic inheritance is not the only cause for the pathology of the disorder.

Impairments of microglial function explain the mechanisms that react to environmental influences on the developing brain's DNA methylation. Individuals with autism spectrum disorders exhibit age-related changes in the trajectory of microglial and synaptic function, suggesting a genetic risk for autism can influence regional cortical gene expression.

Epigenetic dysregulation of synaptic genes at the transcriptional level contributes to autism susceptibility. Abnormal epigenetic modifications, known as epimutations in DNA, can be acquired throughout life. Impaired methylation is evident in environmental factors' role in autism risk. High levels of impaired methylation are common in people affected by autism compared to other groups and it has a pathological role in the development of autism spectrum disorder. [58]

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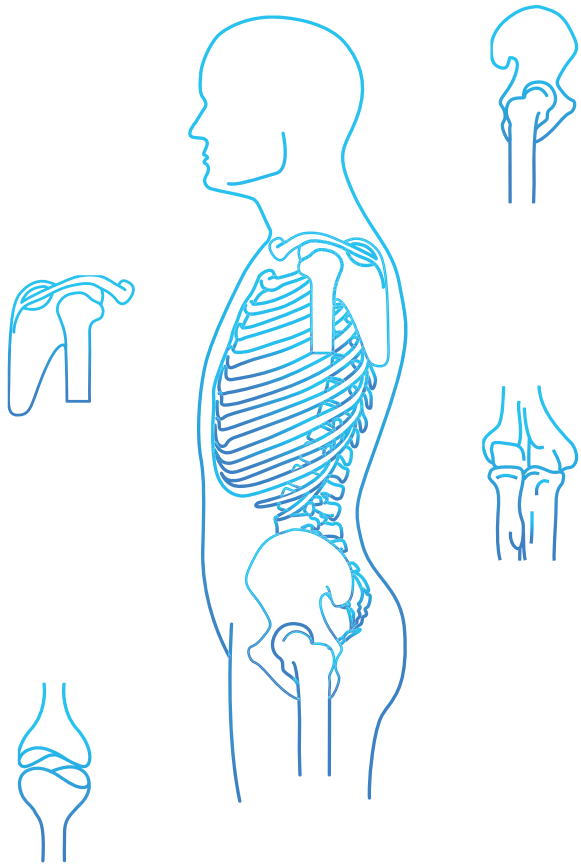
Treatment Framework

Osteoporosis

Osteoporosis is an age-related progressive bone disease characterized by the reduced bone formation and the accumulation of adipocytes in the bone marrow compartment, causing the bones to become porous and weak. Epigenetic mechanisms play a significant role in the activity of bone cells.

Diseased patients suffer from changes in the way their DNA is methylated, causing the acceleration of the disease. Those who have an accelerated epigenetic age are more likely to experience the disease, notably, age is the most important risk factor for osteoporosis.



Adipocytes are derived from mesenchymal stem cells, these stem cells are important for making and repairing skeletal tissue. At the expense of bone formation, osteoporosis aberrant lineage allocation of mesenchymal stem cells leads to the overwhelming accumulation of marrow adipose tissue. The over-accumulation of marrow adipose tissue occurs in states of low bone density and can be harmful to the overall health of the diseased individual.

Marrow adipose tissue influences mesenchymal stem cell lineage decisions, the bone responds to various environmental cues during aging. Epigenetic regulation of mesenchymal stem cell lineage specification plays a role in osteoporosis, resulting in a mesenchymal stem cell shift from osteolineage to adipocytes. These changes can lead to a bone matrix that becomes thin and porous.[83]

Bone tissue samples from patients with osteoporosis and healthy patients uncovered inhibitors of bone formation with methylation levels being significantly different between osteoporotic and control patients. Epigenetic events may have a profound effect on the differentiation and activity of the cells within the bone marrow environment and consequently may contribute to the pathophysiology of age-related bone loss. [46]

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Treatment Framework

Hypertension

Hypertension is a complex condition with no single causative agent, remaining one of the world's leading health problems. It is high blood pressure characterized by the long-term force of the blood against the artery walls able to cause major health problems, such as heart disease.

Evidence supports that epigenetic modifications are just as important as any genetic predisposition for the development of hypertension. The interaction between genetic and environmental systems can determine an individual's risk for hypertension.

Different degrees of DNA methylation has been correlated with the onset, timing, and severity of hypertension. Age acceleration in terms of the differences between age predicted by DNA methylation and chronological age is an independent predictor of all-cause and cause-specific mortality in patients with hypertension.

Global genomic DNA methylation can be quantified by measuring the amount of the 5-methyl cytosines present in a DNA sample. A study found a correlation between the decreased levels of 5-methylcytosine in peripheral blood with an increase in hypertension grade severity. Global DNA methylation levels decreased as the severity of hypertension increased [81].

The most sound data involving the methylation in blood pressure regulation performed a genome-wide association and replication study. Their results show the roles of DNA methylation in blood pressure regulation. They identified genetic variants at 12 new loci that correlated with blood pressure modulation in 320,251 individuals of East Asian, European, and South Asian ancestry. At some of the loci, they identified DNA methylation may lie on the regulatory pathway linking sequence variation to blood pressure [42].

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Treatment Framework

Diabetes Mellitus

Type 2 diabetes is characterized by chronic hyperglycemia due to impaired insulin secretion. As a result of a worldwide aging population and increasing prevalence of obesity, the number of patients with type 2 diabetes has rapidly increased. Genome-wide association studies have shown that an individual's genetic background can influence the risk of this disease.

Epigenetics may affect the pathogenesis of type 2 diabetes. To determine the epigenetic basis of type-2 diabetes a study analyzed DNA methylation at 479,927 CpG sites in human pancreatic islets, which are regions of the pancreas that produce endocrine cells, from 15 type 2 diabetic donors and 34 non-diabetic donors.

They ran an analysis to find absolute differences in DNA methylation that was greater than 5%. 1,649 CpG sites had absolute differences in methylation between the diabetic and non-diabetic islets. Of these CpG sites 97% showed a decrease in DNA methylation within the diabetic islets compared to the non-diabetic islets. The majority of the CpG sites that showed decreased DNA methylation in the diabetic islets had an intermediate degree of methylation, with 20-70% being methylated, and were more dynamic to change in human islets.

The study also found that islet expression involved in de novo DNA methylation correlated negatively with age. Age was associated with differential DNA methylation of 28 CpG sites and ~92% of CpG sites exhibited differential DNA methylation due to increasing age. These findings suggest that increased aging affects DNA methylation of CpG sites in the diabetic islets. [14]

It has been suggested that epigenetic changes can contribute to the occurrence of comorbid diseases. Another study found that epigenetic changes, especially after stress, can be of importance in the pathogenesis of both type 2 diabetes and depression.

Alterations in gene expression were found in postmortem specimens from a person with type 2 diabetes compared to controls without diabetes. There is a possibility for epigenetic mechanisms to explain the increased risk of dementia among individuals with diabetes. Epigenetic mechanisms explain the increased prevalence and incidence of depression among persons with diabetes as well [3].

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Treatment Framework

Schizophrenia

The majority of deaths in schizophrenic patients have been attributed to age-related diseases that are primarily independent of the brain, such as cardiovascular and respiratory diseases. Due to accelerated biological aging in the schizophrenic population, there is an increased prevalence of these age-related disabilities and morbidities.

A study on epigenetic aging in blood affected by schizophrenia found that the change in age is significantly altered by this severe mental disorder. They used a novel blood-based DNA methylation test to be a strong predictor of morbidity and mortality, it found that epigenetic age is accelerated in late adulthood for schizophrenic individuals.

Based on the biological age indicated by their genome-wide DNA methylation, schizophrenic patients were on average 1.55 years older than their chronological age.

Surprisingly they found that individuals diagnosed with schizophrenia displayed epigenetic age deceleration in young and mid-adulthood. Between these age groups of young and middle-aged adults, schizophrenic patients were on average 0.7 years younger in their biological age indicated by the level of methylation within their DNA.

Age-specific effects in schizophrenia can yield new insights that might otherwise be missed. Blood-based epigenetic aging is a heritable trait and a predictor of a wide variety of phenotypes for this population of individuals vulnerable to age-related diseases and excess mortality [65]. Understanding the epigenetic mechanisms that occur between the period of middle adulthood and late adulthood is pertinent to combatting the acceleration of aging in schizophrenic people.

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Treatment Framework

Insomnia

Insomnia is a common sleep disorder that makes it hard to fall asleep and stay asleep; its symptoms are connected to a multitude of age-related conditions. Accelerated biological aging may be a mechanism through which sleep influences risk for age-related disease and early mortality.

Insomnia symptoms are associated with an increased vulnerability to declines in mental and physical health, elevated inflammation, and age-related morbidity and mortality including risk for coronary heart disease and cancer. ***Cross-sectional data suggests that insomnia is linked to shorter leukocyte telomere length, which is a biomarker of aging and predictor of age-related disease risk.***

Another biomarker for aging is based on DNA methylation. Using DNA methylation as a biomarker of age can examine the role of environmental factors contributing to the accelerated rate of aging and sleep disturbances.

Extrinsic epigenetic age acceleration is the deviation between DNA methylation and chronological age. Insomnia symptoms are significantly associated with the extrinsic measure of age acceleration.

Sleep duration and disturbances are associated with increased epigenetic age of blood tissue and higher counts of late CD8+ T cells. These findings link insomnia with accelerated epigenetic aging and are evidence of an aged immune system. The importance of aging biology for late-life chronic diseases, there is a growing demand to address the sleep disturbance. [9]

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Treatment Framework

Dementia

The current public health priority, dementia, is distinguished by the structural decline in the brain. Due to the disease's wide list of symptoms, cognitive and behavioral tests don't provide a definitive diagnosis of dementia which addresses the importance of biomarkers able to indicate the disease state.

Age-related changes in brain structure are the focus of dementia research. Increasing age is significantly associated with the increasing prevalence and incidence rates of dementia. Finding the link between age-acceleration propagated by DNA methylation and the onset of dementia is significant for targeting therapies that can prevent the disease.

Epigenetic disruptions in the brain are observed in individuals with dementia. DNA methylation markers can reflect the biological processes that occur in the early stages of dementia. DNA methylation changes have been observed in individuals with dementia. [28]

Epigenetic evidence suggests that dementia is not a suddenly occurring and sharply delineated state, but rather it is a gradual change of crucial cellular pathways going into a dysfunctional state. Locating the physical pathway for gene-environment interactions that lead to dementia is vital.

A case using two monozygotic twins found they had very different DNA methylation in brain cortical neurons. The twin with dementia had lower methylation than the healthy twin. Reduced DNA methylation is an overall trend in brain samples of dementia patients compared to people without the disease.

Evidence suggests that epigenetics can detect, prevent, and reverse such processes before clinical dementia is detected. A study found that individual epigenetic variation is not time-bound and that epigenome differences correspond to environmental influences, such as smoking. Likewise, DNA methylation changes that occur in response to stress often occur later in life. [54]

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Treatment Framework

Alzheimer's Disease

Aging is tied to a number of neurodegenerative diseases that cause cognitive decline. ***Alzheimer's disease is the most common form of dementia, accounting for ~70% of all dementia cases.*** After the age of 65 the risk for developing Alzheimer's disease doubles every 5 years. The pathogenesis of Alzheimer's disease involves gene-environment interactions that can be captured by the epigenome. Patterns of DNA methylation are investigated to uncover its relationship with Alzheimer's disease.

DNA methylation levels are used to measure the age of human tissues; also its variant levels of methylation are linked to the pathology of Alzheimer's disease. Aging is associated with the rapidly increasing susceptibility to Alzheimer's disease. Using DNA methylation as an indicator for the rate of disease progression we can understand that people diagnosed with Alzheimer's disease will have a higher DNA methylation age than their chronological age.

Epigenetic age acceleration, which is the change between epigenetic age and chronological age, captures the biological age of brain tissue. Alzheimer's disease patients have biologically older brains than non-diseased individuals.

In a recent study, age indicated by methylated DNA is associated with cognitive decline among people with Alzheimer's disease. Variance in global cognitive function and episodic memory change is much higher in individuals with Alzheimer's disease than those without it. It has also been determined in this study that individuals with Alzheimer's disease experience far more cognitive aging changes than non-diseased individuals.

Alzheimer's disease is currently not treatable once patients are diagnosed, but it is definitely a preventable disease. Dietary supplements and lifestyle changes are the best measures to take when combatting Alzheimer's disease. Understanding the mechanisms that drive the acceleration of aging which contributes to the symptoms of Alzheimer's disease is pertinent when addressing the treatment and prevention of this disease. [48]

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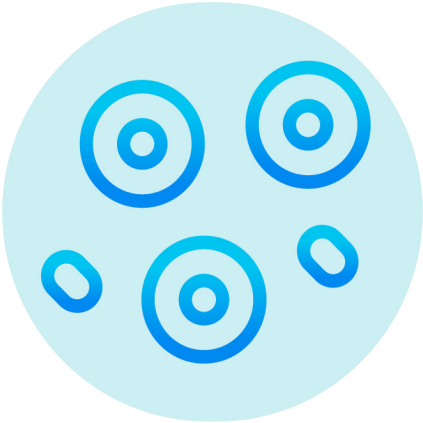
Treatment Framework

Cancer Risk

As we have mentioned, the epigenetic aging rates of all tissues are different. This is true with cancer as well as epigenetic age does not always parallel chronological age, particularly in tumor samples.

This is often referred to as biological age or the EpiAge™ ratio. Furthermore, since the methods for measuring epigenetic age incorporate loci in pathways related to both cancer development and aging in general (e.g., DNA damage, cellular proliferation, and oxidative stress), it is highly possible that biological age can be a predictive biomarker for cancer risk, metastasis, and mortality in addition to serving as an indicator of aging.



With further study and refinement, the concept of epigenetic age may also be useful for improving our understanding of mechanisms by which age and cancer are related. However, no longitudinal analysis has yet evaluated how blood epigenetic age changes overtime prior to cancer diagnosis or cancer-related death, and whether blood biological age can predict future risk of cancer incidence and mortality.

In one study though, they investigated patients' epigenetic markers and their cancer progression. What they found was interesting. About 3–5 years before cancer onset or death, biological age was associated with cancer risks in a dose-responsive manner and a one-year increase in biological age was associated with increased cancer incidence and mortality.

Participants with smaller biological age and decelerated epigenetic aging over time had the lowest risks of cancer incidence (P = 0.003) and mortality (P = 0.02).

This isn't enough to have a conclusive link for prediction but it was concluded that blood epigenetic age may mirror epigenetic abnormalities related to cancer development, and might potentially serve as a minimally invasive biomarker for cancer early detection. [85]

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Treatment Framework

The Impact To You

Have you been through menopause and do you have AA?

Breast cancer's link:

Increased breast cancer risk has been correlated to increased epigenetic aging rate in women who are postmenopausal (particularly intrinsic epigenetic aging rate) in a 2017 study. Another reason to try and slow your aging rate. [20]

Do you have a history of lung cancer?

Lung Cancer incidence

A separate study by Levine et al in 2015 also showed a correlation between lung cancer risk and intrinsic epigenetic aging. [47]

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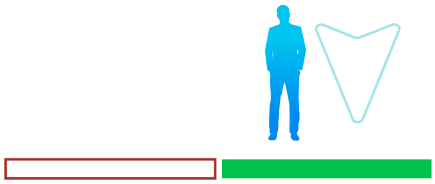
Treatment Framework

The Impact To You



Medications

GH, DHEA, Metformin (The Famous TRIIM Study)

Are you taking Growth Hormone or a Growth Hormone secretagogue?

In mammals, the thymus supports the maturation of thymocytes into T-cells and to maintain immunological tolerance. This is an important part of what makes your immune system work.

The thymus continually atrophies after childhood, it's epithelia is replaced by adipose tissue, and it has been hypothesized that at least some immune dysfunction associated with aging is caused by the loss of thymus tissue. For example, infants whose thymus was removed during cardiac surgery at 18 years after surgery have immune cell populations more reminiscent of 65-70 year olds.

Multiple factors have been tested preclinically to try and regenerate the Thymus. However, only one study has been shown to help regrow the thymus for immune benefit. [39]

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Treatment Framework

THE FIRST HUMAN CLINICAL TRIAL DESIGNED TO REDUCE EPIGENETIC AGE

In what may be the first human clinical trial designed to reverse aspects of human aging, the TRIIM (Thymus Regeneration, Immunorestoration, and Insulin Mitigation) study was conducted to address the thymus regeneration and therefore help with epigenetic aging! The decision to use GH, DHEA, and metformin.

The scientific justification for using GH to regrow thymic tissue when it has not completely atrophied is extensive, as the thymic epithelia not only express GH receptors but secrete GH in a positive feedback loop.

Fahy et al. treated 9 subjects in this uncontrolled Phase I trial with GH. Because GH induces hyperinsulinemia, GH was supplemented with metformin, an AMPK activator that increases glucose tolerance and DHEA, an endogenous steroid hormone that decreases gradually in adults, that can act as a precursor to testosterone, estrogen, as a neurosteroid that Fahy has stated to have anti-diabetic properties, but there is little reported evidence for this.

After treatment of 9 patients for 12 months, the thymic fat-free fraction (TFFF) (a measure of functional thymus tissue) increased significantly in 7 out of 9 participants, in many cases almost doubling from 20% to ~35%. The two nonresponders were actually participants who had the highest TFFF at the start of the trial. These results were considered statistically significant but suffer from the underpowered number of participants.

The most significant immune changes observed were decreases in total and CD38+ monocytes which were statistically correlated with the TFFF. The reduction led to an increase in the lymphocyte-to-monocyte ratio (LMR), which reached ratios similar to younger adults. ***These changes are consistent with restored thymic function.***

Because GH acts predominantly through induction of IGF-1, Fahy et al. wanted to ensure that they did not accelerate aging. Currently, various DNAm age clocks are the best correlated biomarkers available for chronological age, phenotypic age and mortality. To their surprise, DNA age using leukocytes at 12 months of treatment was reversed in all four clocks studied with a mean change using regression on all 4 clocks of -2.5 years. These included the Horvath clock[9] which can predict chronological age for a large number of tissues (-2.5 years), the Hannum clock (- 3 years) which is based on leukocytes in whole blood, the phenoage DNAm clock (-3.5 years), which is better correlated with aging phenotype and the GrimAge DNAm clock (-2 years) which predicts human life expectancy. After cessation of treatment all of the clocks resumed ticking, except the Grimage clock which did not advance. The rates of decline increased in the last 9-12 month period which could indicate further gains are possible with longer treatment

It is interesting that two of the three factors decrease with age (GH and DHEA) as might be expected for factors that help maintain homeostasis! It also might give some credence to hormone replacement therapies. [23]

THE TRUAGE™

Treatment Framework

The Impact To You

Are you taking Metformin?

Metformin, an FDA approved first-line drug for the treatment of type 2 diabetes, has known beneficial effects on glucose metabolism.

Evidence from animal models and in vitro studies suggest that in addition to its effects on glucose metabolism, metformin may influence metabolic and cellular processes associated with the development of age-related conditions, such as inflammation, oxidative damage, diminished autophagy, cell senescence, and apoptosis. As such, metformin is of particular interest in clinical translational research in aging since it may influence fundamental aging factors that underlie multiple age-related conditions. [4] Also, in the hallmark Fahy trial, it was part of the drug cocktail which was wildly successful in reducing the epigenetic aging rate. [23]

So does Metformin have an effect on epigenetic aging? Unfortunately the answer is probably not.

In one study, no significant differences were found for the two metformin groups, and in most cases those currently on Metformin had a somewhat higher epigenetic aging rate than those who would be prescribed Metformin in the future.

Also, the study's results for the extrinsic epigenetic aging rate show very little difference between those who start Metformin between first and second blood draw and those who don't. [72]

THE TRUAGE™

Treatment Framework

Death

No one likes to talk about death…but it is an important outcome metric when considering your health and preventative health. This is also an outcome that many have focused on in the field of Epigenetic aging.

There are multiple studies that link aging rates and the risk of death. ***Soon, TruDiagnostic™ will have a mortality predictor to help determine your risk.*** In the meantime, we have summarized some of the findings from the literature below!

General correlations:
"Increased Age Acceleration has been associated with increased risk of mortality, and these associations, albeit small, were independent of known mortality risk factors, including a large number of demographic, lifestyle, and anthropometric variables, and medical conditions." [18]

Both intrinsic and extrinsic measures of epigenetic age acceleration in the blood are associated with an increased risk of death from all-natural causes even after accounting for known risk factors.(111)

The different types of tests:
There are many algorithms that can help you predict death risk. The good news is that almost all measures are pretty good at predicting life expectancy.

A meta-analysis of blood DNA methylation data from more than 13,000 individuals found that all measures of age acceleration considered were able to predict life expectancy.

Intrinsic versus extrinsic:
Generally, intrinsic measures of epigenetic age exhibit much weaker associations with lifestyle factors and markers of inflammation, which probably reflects the fact that it relates to an innate aging process that doesn't capture other comorbidities. As a result, extrinsic age tends to be more predictive of death.

The measure of extrinsic age acceleration also reflects aspects of immunosenescence. This is because, by construction, it correlates with age-related changes in blood cell composition, such as T lymphocyte populations, which underlie much of the age-related decline in the protective immune response. [22]

THE TRUAGE™

Treatment Framework

It also means that the highly predictive significance of EEAA for all-cause mortality probably reflects the fact that it assesses multiple aspects of the biological age of the immune system including both changes in the blood cells.

This data also suggests that intrinsic epigenetic age acceleration is reflective of an intrinsic epigenetic clock that is associated with mortality independent of chronological age, changes in blood cell composition, and traditional risk factors of mortality.

This means that it also is probably indicative of a process of aging not related to cell composition and is still useful. For instance, IEAA but not EEAA is predictive of lung cancer. [47]

Additionally, IEAA is also related to centenarian status. [33]

Methylation + Biomarkers = better death prediction capabilities:
Methods of biological testing which use biological methylation markers and other covariates such as blood levels such as fasting glucose and albumin tend to be even better at predicting death than just looking at methylation alone. Currently, the best biomarkers seem to be C-reactive protein, insulin, fasting glucose, triglyceride, and high-density lipoprotein (HDL) cholesterol levels.

Methylation Biomarkers + Demographics:
Even more recently, in 2019, a test called GrimAge was published by Dr. Steve Horvath (One of the creators of the original Biological age clocks). This is probably the best death prediction calculator to date.

Instead of using biomarkers in his calculation, he trained blood biomarkers against the epigenetic data. In short, he created Biomarkers that could be read from methylation data. This was a vast improvement and allowed for the best measurement of death prediction.

Beyond lifespan prediction, Age Acceleration with GrimAge (and several of its underlying surrogate biomarkers including DNAm PAI-1) relate to many age-related conditions (multi-morbidity, metabolic syndrome, markers of inflammation) in an expected way, i.e. high values are associated with a bad risk profile.

Soon TruAge™ will have a similar test!

JANE'S TRUAGE™

Treatment Framework

Fitness

- Regularly perform physical (aerobic and resistance) exercise
- This is more important the older you are as epigenetic changes are more likely as you are older
- Epigenetic age changes are correlated with the level of activity.

Nutrition

- Increase fish and poultry consumption
- Consider a Mediterranean diet with the help of a nutritional professional
- Consider a calorie restriction diet with the help of a nutritional professional
- Consider increasing consumption of polyphenols such as trans-resveratrol, sulforaphane, epigallocate chin-3-gallate (EGCG), quercetin, and genistein.

Medications

- Ask your doctor about growth hormone optimization to regenerate the thymus
- Consider asking your doctor about DHEA and metformin
- Rapamycin and other senolytics might be considered in the future as well as sirtuin activators
- Stem cell or young plasma apheresis procedures

Drugs/Alcohol

- Consider regular consumption of small quantities of wine and beer.
- Avoid all other recreational drugs

Exposures (Toxins, Pollution)

- Wear a mask in highly polluted areas
- Spend more time in nature
- Avoid exposure to pesticides and pesticide treated foods without washing

Psychosocial

- Reduce physical and emotional stress
- Seek a counselor for any PTSD related events

Comorbidities

- Avoid behaviors which increase risks of viruses
- Avoid type 2 diabetes and obesity
- Avoid insomnia by creating good sleep habits

CURRENT QUESTION

And Our Investigations Into The Answers!

The study of epigenetics is very new. Thus far only 2 studies have documented how interventions can reverse epigenetic age. However, we want to change that!

Below we have documented some questions and the studies we are completing to find out the answers!

NAD+

NAD+ is the second most popular cofactor in the human body. NAD+ activate PARPS, Sirtuins, and help with immune dysregulation and as a result has been viewed as an essential cofactor to help address the process of aging.

The clinical importance of maintaining cellular NAD+ levels was established early in the last century with the finding that pellagra, a disease characterized by diarrhea, dermatitis, dementia and death, could be cured with foods containing the NAD+ precursor niacin. Additionally, cellular concentrations of NAD+ have been shown to decrease under conditions of increased oxidative damage such as occur during aging . Altered levels of NAD+ have been found to accompany several disorders associated with increased oxidative/free radical damage including diabetes, heart disease, age-related vascular dysfunction, ischemic brain injury, misfolded neuronal proteins, and Alzheimer's dementia .

Interventions targeted at restoring NAD+ have been shown in animal models to support healthy aging and improve metabolic function, and dementia as well.

We have set up a trial as listed below:

Intravenous NAD+ and its effect on Immune Biomarkers and Epigenetic Aging.

In this trial, we will explore how NAD+ effects the bodies cellular immune responses and look how periodic IV administration can effect epigenetic age.

Senolytics

Cellular senescense is considered to be another of the 8 hallmarks of aging. Senescence is defined as stable cell growth arrest. Usually this is essential to ensure that damaged or transformed cells do not perpetuate their genomes. However, when large quantities of cells do this, they can display a Senescence Associated Secretory Phenotype which can cause a process called inflammaging. This process is highly correlated with most age related diseases.

Several products have shown to help clear senescent cells from the body and several have been shown to increase lifespan. One of these products is Rapamycin. We are investigating if this product can help reduce inflammatory biomarkers and epigenetic age!

We have set up a trial as listed below:

The Safety and Effectiveness of Rapamycin on the Epigenetic Aging Rate in Healthy Individuals

We have seen evidence that Rapamycin slows cell proliferation and decelerates aging and the risk of age-related diseases. The aim of our pilot study is to evaluate the safety, efficacy and feasibility of Rapamycin as an effective treatment option to improve clinical care of healthy individual's biological age thus prolonging longevity.

CURRENT QUESTION

And Our Investigations Into The Answers!

Testosterone Replacement and Bariatric Surgery

Andropause is the slow decline in hormone levels in men. Many men try and treat this condition with hormone replacement therapy. Additionally, as we have detailed it the this report, weight loss is correlated to changes in epigenetic age. As a result, we will be looking at how both of these things can address epigenetic age both together and independently through the following study.

#14169, Prospective randomized comparative study to learn if lean muscle catabolism be prevented in bariatric patients by the use of Hormone Replacement Therapy (HRT) vs patients receiving Standard of Care (SOC) and how does bariatric surgery with/without HRT impact DNA methaylation-based biomarkers for aging

Young Plasma

Several decades ago, several studies were published showing that when old and young mice were connected together to share blood, the older mice has several aging benefits and that vice-versa, Young mice became a little older. A recent revival of this approach confirmed this observation and demonstrated beneficial effects on muscle, heart, brain, and numerous other organs. Recently, this effect has been investigated in mice by transferring young mice plasma to older mice and showed that it reduced epigenetic age (less in the brain) in most systems.

This procedure has also been done by one of our Scientific advisory board members to investigate cognitive function in humans. We will be conducting some of these procedures again and measurements of sensecence, immune function, and biological age in the study below!

"Safety and efficacy of Young Plasmapheresis in elderly patients and its effect on cognitive function and Epignetic biological age"

CURRENT QUESTION

And Our Investigations Into The Answers!

Mitochondrial Function

The role of mitochondria in aging was first proposed more than 40 years ago. This theory, the free radical theory of aging, suggested that accumulation of cellular damage with increasing age results from reactive oxygen species (ROS) and mitochondria are one of the most important sources and targets of ROS and could function as an 'aging clock'.

Since then, a growing body of evidence has shown that mitochondrial dysfunction contributes to aging in multiple model organisms and that several factors cause increased mitochondrial dysfunction with chronological age including accumulation of somatic mtDNA mutations, enhanced oxidative damage, decreased abundance and quality of mitochondria, as well as dysregulation of mitochondrial dynamics.

As mitochondrial dysfunction is one of the hallmarks of aging, we want to look at the effects of mitochondrial peptides such as SS-31 and MOTS-C have on epigenetic aging.

We will be using these products in patients for 6 months and looking at the effects of mitochondrial functioning and epigenetic age!

"Mitochondrial peptides and their effect on biomarkers, mitochondrial function, sarcopenia, and biological aging"

Chronic Inflammatory Response Diagnostic (CIRS)

Chronic Inflammatory Response Syndrome (CIRS) is a multi-symptom, multi-system illness caused by exposure to biotoxins, or neurotoxins produced from a biological source. Often, this test is hard to diagnosis. As a result, we will be investigating biomarkers correlated to patients diagnosed with this disease in order to develop methylation markers which might correlate to disease and disease progression. We hope to be able to find highly correlative markers that could diagnosis this disease at a fraction of the cost of conventional testing.

"Investigation of methylation biomarkers of Chronic inflammatory Response Syndrome versus the normal population"

HELP US DESIGN A BETTER TEST

and get your report and analysis for FREE!

One of the best parts about our test is the amount of data we look into! By getting one of the largest glimpses of your DNA methylation data available, we are able to correlate these to health outcomes and provide you more insight into your markers! ***However, in order to create new markers, we need your help!***

If you submit any of the following markers, ***we will give you a $10 credit toward a future test.***

We will also give you ***a free report*** if we use your help in developing any additional test.

If you have any of the following testing done within 6 months of our test, please upload it to your patient portal!

- **VO2 Max**
- **Skin Glycosylation Measurements**
- **MRI Imaging**
- **Genomic Sequencing**
- **Telomere Testing**
- **Blood and Hormone Levels**
- **Microbiome Analysis**
- **Proteomic Data**

FUTURE TEST

- Telomere Estimation
- Cardiovascular Disease Risk
- Senescence Burden Estimation
- Cancer Risk
- Alzheimer's Risk
- Best Fitness and Diet Estimator

KEY TERMS
& Abbreviation

CMV (cytomegalovirus): a common virus that typically only causes problems for immunocompromised and pregnant individuals

CpG: regions of DNA where a cytosine (C) nucleotide is next to a guanine (C) nucleotide. It is sited in the DNA where methylation does occur.

CR (Calorie Restrictive): type of diet when you reduce the average daily caloric intake below what is normal for that particular individual

CRP (C-Reactive Protein): a protein made by the liver, measuring amounts of it in the blood is used to detect inflammation

DHA (docosahexaenoic acid): an omega-3 fatty acid that's a structural component of the brain, cerebral cortex, skin, and retina

DHEA (dehydroepiandrosterone): an endogenous steroid hormone that decreases gradually in adults, that can act as a precursor to testosterone, estrogen, as a neurosteroid

DNA Methylation: where methyl groups are added to the DNA and can change the expression of that segment without altering the sequence

EGCG (epigallocatechin-3-gallate): compound used for preventing certain diseases by targeting epigenetic alterations

EEAA (Extrinsic epigenetic Age Acceleration): aims to measure aging in immune-related components; it also relates age-associated changes in blood cell composition.

EPA (eicosapentaenoic acid): an omega-3 fatty acid that is prescribed to reduce triglyceride levels

Epigenome: all of the chemical modifications to DNA that regulates the expression of genes

EWAS (epigenome-wide association studies): analyzes epigenetic markers, typically a DNA methylation marker, to derive epigenetic variations and a particular phenotype

FMD (fasting Mimicking diet): developed by Dr. Valter Longo, it is a 5-day diet that guides the body into a fasting state, similar to long fasts, while eating quantified meals

GH (growth hormone): a peptide hormone that stimulates growth, development, cell reproduction, and cell regeneration

HDL (high-density lipoprotein): known as the "good" cholesterol because it removes other forms of cholesterol from the body

HIV (human immunodeficiency virus): this is a family of viruses that damage to the immune system, which inhibits the body to fight off infections

Hypogonadism: the testes are no longer to produce testosterone, sperm, or both

Hypothyroidism: a condition where the thyroid gland doesn't produce enough of the body's essential hormones

IGF-1 (Insulin-like growth factor-1): a hormone that promotes bone and tissue growth

KEY TERMS
& Abbreviation

IEAA (Intrinsic Epigenetic Age Acceleration): a measure of the "pure" epigenetic aging effects in blood cells that are not confounded by differences in blood cell counts

ORA (Cooperative Health Research in the Region Augsburg): a regional-research platform for population-based studies in epidemiology and health care research

LMR (lymphocyte-to-monocyte ratio): reflects systematic inflammation in several tumors

NAS (Normative-aging Study): a longitudinal study on the effects of aging covering a variety of health issues

Metformin: a diabetes medication that regulates blood sugar levels

Nephropathy: a kidney disease caused by damage to the small blood vessels

PAI-1 (Plasminogen activator inhibitor-1): a biomarker for multiple age-related conditions

PM2.5 (PM2.5 PM2.5): refers to atmospheric particulate matter (PM) with a diameter less than 2.5 micrometers

Polyphenols: micronutrients packed with antioxidants and other health benefits

PTSD (post-traumatic stress disorder): mental health disorder that is triggered by a terrifying event that an individual either experienced or witnessed

Resveratrol: a group of polyphenols; acts like antioxidants by protecting the body against damage that puts one at risk for diseases like cancer and heart disease

SAAF (Strong African American Families Program): an intervention program meant to improve supporting parent relationships

Sarcopenia: syndrome marked by the general loss of skeletal muscle mass and strength

Segmental progeria: a rare hereditary disease that's symptoms resemble enhanced aging; most who are diagnosed don't live past their teens

Senescent cells: a state where certain cells are no longer able to divide; this arrest mechanism acts as a protectant against cancer

SES (Socioeconomic Status): social standing or class of an individual; combines education, income, and occupation

TFFF (thymic fat-free fraction): measures the functional thymus tissue

Toxoplasmosis: a disease that results from infection with the toxoplasma gondii parasite, which is one of the world's most common parasites

Triglyceride: a chemical ester of glycerol and three fatty acids

TRIMM study (Triggers and Mechanisms of Myocardial Infarction): a study of the factors associated with the transition from chronic coronary artery disease to acute myocardial infarction

UNESCO (United Nations Education, Scientific, and Cultural Organization): this is a specialized agency of the United Nations

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