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Human Biology and Astrophysics

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Chapter 1: Introduction

This work includes studies which are under the umbrella of the Natural Sciences. Areas of study such as Biology, Physics, and Astronomy all strive to better understand the natural world. When we wish to understand a particular phenomenon, it is often helpful to observe it through the lens of more than one discipline because they are interrelated and often interdependent. Physics, Astronomy, and Biology are interwoven throughout this project. In fact, some cited sources herein are co-authored by a biologist and a physicist. Astrophysicist, Neil DeGrasse Tyson, puts it this way, "Sciences, like people, undergo phases as they mature. What we know, and how we know it, changes at the same time. Until the 19^{th} century, for example, biologists primarily concerned themselves with cataloging the species of life on Earth; today, on the other hand, they care about the molecular and physical processes that govern life. Biology, in other words, has absorbed chemistry and physics into its ranks (Tyson and Trefil 2021, 57)."

Three areas of Natural Sciences were Studied

Three primary areas have been studied. First, space habitats with a focus on the biological effects of reduced gravity fields on humans in space. Second, anti-aging and healthy aging research with a concentration on epigenetics. Third, Theoretical Physics with an intent to better understand Space, Time, and Gravity, and the incompatibly of the General Theory of Relativity and Quantum Theory. These areas will be summarized with what was previously learned and concluded. Previous research in these areas will be referenced and cited in that process. Then, additional findings and conclusions will be added.

Chapter 2: Space Habitats and the Risks to Humans from Reduced Gravity Fields

Plans are in the works by NASA and private businesses for humans to travel to the Moon and Mars. Some of those plans, with SpaceX in particular, include long term habitation and colonization on Mars. This raises the concern of what effects reduced gravity fields will have on humans over extended periods of time. The Moon has roughly 17% of Earth gravity and Mars about 38%. Earth gravity is typically referred to as 1g. So, using that measure, the Moon has 0.17g and Mars has 0.38g. The International Space Station (ISS) and its inhabitants experience microgravity or, for practical purposes here, we will refer to it as 0.0g.

The ISS has had constant human presence since 2000 with crews staying on board from a few months and up to one year. That has provided over twenty years of experience and data on the effects of 0.0g on human health. Bluntly stated, 0.0g is devastating to human health. My past coursework has researched this in some detail. Muscle atrophy, bone weakening, inner ear loss of balance function, and bodily fluid shifts which put pressure on the eyes and brain, are just some of the hazards. Astronauts aboard the ISS take prescribed supplements and exercise at least two-and one-half hours every day in an effort to mitigate some of the bone and muscle loss. Yet upon returning to Earth most cannot walk and need rehabilitation. In fact, if one of the ISS exercise machines breaks down it is considered a medical emergency because they must be constantly mitigating the harmful effects of 0.0g (Dawson, Reduced Gravity Experiment 2020, 6).

By contrast, Earth provides us with 1.0g of gravitational force for which we humans have evolved and adapted to over thousands of years. From previous research, “It is easy to underestimate how much our bodies are acclimated to normal earth gravity (1g), and are dependent upon it in order to maintain health. The 1975 NASA Design Study describes it in section 3 of Human Needs in Space, “On Earth, gravity subjects everyone continuously and uniformly to the sensation of weight. Evolution occurred in its presence and all physiology is attuned to it (H. Johnson, Space Settlements A Design Study Electronic Access 1977).” (Dawson, Reduced Gravity Experiment 2020, 5)

Human biology performs well in 1.0g but not 0.0g. That understanding is well established. However, there is very little data on how gravity in the range between those values will affect human health, such as on the Moon and Mars. The only actual human experience in space with reduced, but not zero, gravity is from the Apollo program decades ago when a handful of humans spent a few days each on the Moon. However, ambitious plans are currently being made to send humans to Mars for extended periods of time, even colonization. Concerns expressed from previous research, “My background in the biomedical sciences has taught me that the human body can be resilient to stressors in the short term, but unpredictable and vulnerable in the long term, such as in months or years. One could speculate that, because Mars and the Moon have some gravity, the harmful effects might be somewhat less than microgravity. That may or may not be true. There could be some threshold which the force of gravity must reach before it is any better than microgravity; as referenced on page 7, any level below 0.40 g may be insufficient (Dawson, Reduced Gravity Experiment 2020, 6).

There is enough gravity on Mars so that humans could walk on the surface. This leads to an assumption by many in the general public that it will be sufficient for survival. In fact, many people do not seem to give it a thought when dreaming about traveling to Mars. The focus is more on how to get there and all the other concerns for survival. To be sure, there are numerous challenges for travel to and survival on Mars. There has even been talk of terraforming Mars. The idea is to make it more Earthlike by adding an atmosphere and getting some greenhouse effect going to warm it up. That is a daunting and unlikely project, but conceptually valid. But what about gravity? Gravitational strength is related to mass so, even if Mars is terraformed in every other way, it would still have only 0.38g.

Previous research concluded that tests of reduced gravity effects should be conducted before sending humans into space for long periods of time and distances, such as to Mars. However, that is easier said than done because the tests cannot be done in an objective way on earth. There have been some piecemeal Earth-based tests but the effects of Earth gravity confound the results. They must be done in space for realistic results (Dawson, Reduced Gravity Experiment 2020, 45-51). A 0.0g environment is needed, such as in Earth orbit. Once in that environment, artificial gravity (AG) could be introduced to the desired level for the experiment. AG has been proposed often in the past for space habitats that would create a gravity experience by rotating the craft which would generate centrifugal force. From previous research,

> Conceptions of rotating free space colonies can be found in science and science fiction dating back centuries. In the early 1900's Konstantin Tsiolkowski, considered to be the founder of Russian astrophysics and cosmonautics, wrote about it with some serious intent in his novel, Beyond the Planet Earth. Over the years four fundamental shapes for such stations have been considered. They are, a sphere, a cylinder, a torus, and a dumbbell (Johnson 1977).

> In the 1950's Dr. Werhner von Braun, who was a famous rocket scientist as well as the first director of NASA's Marshall Space Flight Center, brought specific science to the concept. He proposed a donut, or torus, shaped station rotating to create artificial gravity. Also, in 1968 the movie, 2001 A Space Odyssey, portrayed a rotating station similar to von Braun's with inspiring video animation (Lockwood 1968). The movie was science fiction but was a very impactful movie ahead of its time.
>
> It is understandable that the concept has been considered throughout history because artificial gravity is based on the simple physics of centripetal and centrifugal force. (Dawson, Investigations into Space Habitats 2019, 3)

More on space stations later but a test is needed. For a human-rated experiment, a rudimentary station could be built and placed into Earth orbit. The rotation rate could be adjusted to achieve the gravity level desired for the test. Mars gravity would be a relevant one to test. It also needs to be done for the long term such as months or years. That kind of test would be ideal but the costs and commitment needed to build such a test station have, so far, been prohibitive. Because of that current limitation, I have proposed and detailed a miniaturized reduced gravity experiment that could be performed in the 0.0g environment of the ISS (Dawson, Reduced Gravity Experiment for the ISS 2020, 22-44).

Confidence in that proposed experiment and the need for it still stands. However, after contacting sources at NASA, the enormous complexity of actually putting it onto the ISS was discovered.

> The purpose of this paper was to present the concept of a reduced gravity experiment on the ISS and the reasons it is important. Hopefully that has been accomplished. The process of submitting an application to get it onto the ISS was also explored. However, it became apparent that the process is beyond the scope of this course. The downloaded 24 page ISS application outline is attached as appendix A. Those 24 pages could easily become several times that length as each section is completed and templates are filled. Much more time along with the expertise of others would be needed. Engineers would be needed for the technical section and business/financial experts would be needed for the budget section, just to name a couple.

> I emailed a question on this topic to Dr. John Harlander, former SCSU professor. He clarified that he has worked on space-based instruments on satellites and the space shuttle, but not the ISS. However he is very familiar with how projects are selected by NASA. He confirmed that it is a very involved process. Proposers are responsible for designing, building hardware, directing measurements, and analyzing the data. Most projects involve large teams of people and can take years of work. (Dawson, Reduced Gravity Experiment 2020, 57)

Tests on reduced gravity fields are important so that humans are not exposed to unknown risks. Given the resources needed to create such tests, perhaps the large firms who plan to send humans to Mars could be the ones who fund it.

Building Entire Spacecraft with 1.0 g

Another solution for long term space habitation, which was presented in recent past coursework, is to build entire spacecraft to rotate and create 1.0g. This could eliminate the many health risks associated with space travel while making the living quarters more comfortable and earthlike. They could be built small and basic for astronaut-explorers at first, and eventually large enough for space colonies. Imagine an entire city in space! This is not a new idea and the scientific community has considered it in past years. Proponents, including this author, suggest that colonizing space would be best done with rotating free space stations rather than on other planets. To be clear, travel to the Moon, Mars, and asteroids is important and exciting. But for the near future, it is recommended that exploration be limited to professional astronaut-explorers. Free space stations could provide more comfort and limit many risks. The first ones could be placed into Earth orbit where return time to Earth is just hours, or a day or two, as compared to Mars in which return is months or years away. From previous research,

> The prospect of exploring and colonizing space is exciting, challenging, and very complex. This study has expressed concern and caution about the unknown and untested risks of partial gravity such as on the moon and mars. It also discussed how microgravity is unacceptable for colonization because of the numerous and serious health effects it has on humans. An alternative has been proposed in the building of free space colonies which could provide normal earth gravity through rotation.
>
> A clear distinction was defined between colonization and exploration. Colonization implies humans living and reproducing in space for the long term and requires a high level of human safety and comfort. Exploration implies astronaut/explorers who are trained and conditioned risk takers, and who are willing and able to take whatever countermeasures are necessary to mitigate the unfavorable environments to which they are exposed. Exploring also implies a time limit to the mission and eventual return to earth.
>
> Finally, this study proposes the testing of partial gravity which represents a challenge because it cannot be thoroughly and reliably tested on earth. Reliable tests need to be created in microgravity so that the partial gravity created during the test is the only inertial force present. Such tests also need to be done for long duration such as months or years. (Dawson, Investigations into Space Habitats 2019, 29)

This discussion resulted in my proposed partial gravity experiment, previously mentioned, with the following conclusions,

> This research project raised concerns about the safety and comfort of reduced gravity fields for future space travelers. Many of those concerns will not be answered satisfactorily until a long-radius, human rated, space-based centrifuge is available. The scaled-down proposed reduced gravity experiment in this paper was intended to be a step in that direction. Studies herein found that reduced gravity fields are becoming a focus of current space research and testing. AG could be the solution to the known hazards of microgravity and the unknown risks of reduced gravity such as on Mars and the Moon.
>
> It is clear that AG will be used in the future of space travel. What is not clear is whether it will be used intermittently, as a countermeasure, or if entire spacecraft will be rotated to create 1g continuously. The conclusion from this study, as well as previous studies of mine, strongly support the later. Rotating an entire spacecraft comes with some challenges. However continuous 1g would all but eliminate the need for piecemeal mitigations such as intermittent centrifuging, supplementation, and drugs. Even if intermittent centrifuging is proven to mitigate common problems, such as muscle and bone atrophy, other unexpected biological problems could eventually occur at the molecular level. Intermittent centrifuging, in the opinion of this study, could be likened to determining the very least possible mitigation to keep astronauts alive. Why try to cheat death? Why not make continuous 1g as important as providing other human needs such

> as food, oxygen, and 1 atm pressurized quarters? As a bonus, it would almost certainly make for a more enjoyable work and living environment for space travelers. (Dawson, Reduced Gravity Experiment 2020, 61)

The figure 2.1, below, is a conception of the rotating torus design proposed by Dr. Werhner von Braun. 1.0g would be experienced at the interior wall of the outer rim.

Figure 2.1. *von Braun's Space Station 1952*. This artist concept by Chelsey Bonestell depicted Dr. Wernher von Braun's early space station concept, a 250-foot-wide wheel that would rotate to provide artificial gravity. Von Braun was the first center director at NASA's Marshall Space Flight Center in Huntsville, Alabama. Image Credit: NASA/MSFC (Bonestell 1952).

From previous research,

One individual who put a lot of hard science and calculations into the concept was Dr. Gerard K. O'Neill, a physicist from Princeton University. He invested years of planning and calculations into it during the 1960's and 1970's. His book, The High Frontier, Human Colonies in Space, is not a novel but rather his report on how these space habitats are possible as well as why they should be built (O'Neill 1977). His reasons of why were ahead of their time and are crucially important today.

His name is often referred to when people are discussing this type of space habitat. For example Jeff Bezos of Amazon and Blue Origin commented on February 23, 2019 in an interview with Business Insider, "I don't think we'll live on planets, by the way. I think we'll live in giant O'Neal-style space colonies" (Dawson, Investigations into Space Habitats 2019, 7).

O'Neill's work inspired the 1975 NASA/Ames summer study at Stanford University. He was also the technical director for the study. Their report grew out of a 10-week program in engineering systems design held at Stanford University and the Ames Research Center of the National Aeronautics and Space Administration during the summer of 1975. The project brought together nineteen professors of engineering, physical science, social science, and architecture, and two co-directors. This group worked for ten weeks to construct a convincing picture of how people might permanently sustain life in space on a large scale. Their work resulted in the report, Space Settlements, a Design Study (Johnson 1977). They concluded that such a space station was feasible with the technology they had at that time. (Dawson, Investigations into Space Habitats 2019, 8)

Before considering the technology, let's start with some benefits these stations could offer to humanity and earth. In chapter 2 of his book, The Human Prospect on Planet Earth, Dr. O'Neill stated four problems which relate to the limited size of earth: energy, food, living space, and population (O'Neill 1977). He was concerned, at that time, when he stated the world population is "just over four billion". He also talked about our planet reaching a "heat limit" (O'Neill 1977). How true his concerns relate to today's world where we are approaching a climate crisis and a world population of over 7.2 billion (Garland 10 Oct 2014)! Dr. O"Neill also envisioned taking heavy industry and manufacturing to space which would relieve earth of industry generated heat and pollution. These stations could help free earth of the pressures of pollution and overpopulation. Imagine if someday earth could be completely re-zoned "parks and residential." (Dawson, Investigations into Space Habitats 2019, 9)

Below, figure 2.2 depicts what the inside of a large station might look like.

Figure 2.2. *Illustration Inside Space Station.* Back in the 1970′s NASA did something a touch unusual. They commissioned a series of artists to create their visions of space stations of the future (NASA 2022).

Since O'Neiils work in the 1970's, others have furthered research on the concept. Notable is Theodore H. Hall. From previous research,

> Theodore H. Hall and other associates, have contributed a treasure of information for rotating space habitats. Hall's work is relatively recent and has built upon the work of Gerard O'Neill and the NASA Ames Research study from the 1970's. In fact his dissertation was titled, The Architecture of Artificial-Gravity Environments for Long-Term Duration Space Habitation (Hall 1994). He co-authored a study, Space Settlement Population Rotation Tolerance in 2015 (Hall-Globus 2015). He also published, Gravity as an Environmental System (T. W. Hall, Gravity as an Environmental System 2000). Hall has a long and impressive list of related publications and conferences which can be found

in his Curriculum Vitae (T. W. Hall, Theodore Hall Ciriculum Vitae 2020). (Dawson, Reduced Gravity Experiment 2020, 24)

Building rotating space habitats come with their own challenges. Humans inside a rotating system can experience discomforts caused by gravity gradients, Coriolis forces, and cross-coupled angular acceleration. These issues were described in previous research along with solutions (Dawson, Reduced Gravity Experiment for the ISS 2020). The above discomforts decrease as the diameter of the system increases. O'Neill and the 1975 NASA/Ames Study proposed a rotating torus shaped wheel about a mile in diameter which would rotate at just one revolution per minute. They concluded that it would provide maximum comfort for almost any human. One of that size would truly be a city in space capable of housing thousands of people.

So why hasn't one been built yet? The idea is conceptually valid. It is even feasible from an engineering standpoint which was established in the NASA Ames 1975 summer study. However, it represents an enormous effort and expense. Recall that there has not even been funding for a small rudimentary station located in earth orbit to test reduced gravity.

O'Neill's plan was to locate it in the Earth-Moon system and build it with materials mined from the Moon. Mining the Moon might happen someday but that technology has not yet been developed, which presents a huge obstacle for anything to happen soon. In addition, the amount of material needed for radiation shielding is enormous, especially with a structure of that size. Another limiting factor is that space endeavors in general have been limited and restricted to government funding. But that is changing. One only has to listen to current daily news to hear about private businesses entering the space business with intentions of tourism and colonization.

A large city in space has many potential benefits for humanity. However, something smaller and closer to Earth would be a more sensible beginning. Previous research came to that conclusion,

> With the knowledge and experience we have now it would seem reasonable that the first one should be in low earth orbit. Since the 1975 NASA study we have had thirty years of the Space Shuttle program and nineteen years with the ISS providing experience of going to and from low earth orbit.
>
> Another advantage of low earth orbit is that it is close enough to earth so that the earth's magnetic field would largely protect it from radiation, as is the case on the ISS, "The ISS has well-shielded areas. In addition, astronauts and the ISS itself are largely protected by the Earth's magnetic field because it is in low Earth orbit (NASA, NASA-Space Radiation 2019)." (Dawson, Investigations into Space Habitats 2019, 28)

Another realization that was becoming apparent in previous research is that somewhat higher rotation rates (angular velocity) are likely feasible. This greatly reduces the required station radius for achieving 1g and thus also reduces the size of the station. In regard to angular velocity,

> The cross-coupling of normal head rotations with the habitat rotation can lead to dizziness and motion sickness. To minimize this cross-coupling, minimize the habitat's angular velocity.
>
> Graybiel [1977] conducted a series of experiments in a 15-foot-diameter "slow rotation room" and observed:
>
> In brief, at 1.0 rpm even highly susceptible subjects were symptom-free, or nearly so. At 3.0 rpm subjects experienced symptoms but were not significantly handicapped. At 5.4 rpm, only subjects with low susceptibility performed well and by the second day were almost free from symptoms. At 10 rpm, however, adaptation presented a challenging but interesting problem. Even pilots without a history of air sickness did not fully adapt in a period of twelve days.
>
> On the other hand, Lackner and DiZio [2003] found that:
>
> sensory-motor adaptation to 10 rpm can be achieved relatively easily and quickly if subjects make the same movement repeatedly. This repetition allows the nervous system to gauge how the Coriolis forces generated by movements in a rotating reference frame

> are deflecting movement paths and endpoints and to institute corrective adaptations. (Dawson, Reduced Gravity Experiment 2020, 31)

Based upon the above information one could raise optimistic possibilities. What if a station could have a diameter of around 100 meters, as compared to O'Neill's, which had a diameter of about 1790 meters? Also, what if it needed little or no radiation shielding? Those two factors drastically reduce the cost and increase the chances that a station would be built sooner rather than later.

The Latest Research: Rotating Stations Made Easier

Shortly after completing that previous research, the recent work of Al Globus and Tom Marotta was discovered. First was their book *The High Frontier an Easier Way* (Globus and Marotta 2017). It proposed a smaller station in low Earth orbit, similar to this paper's earlier conclusion. Also provided is a related forty-six-page detailed report published in the National Space Society Journal (Globus, Covey and Faber 2017). An electronic version of the report can be accessed here, https://space.nss.org/wp-content/uploads/NSS-JOURNAL-Space-Settlement-An-Easier-Way.pdf This brings expert study of rotating stations into current times! They explain,

> The Moon and Mars also have a big problem for early settlers. Children raised there will almost certainly have very weak bones and muscles, and possibly other as-yet-unknown maladies. This is because Mars and the Moon have a surface gravity much less than Earth normal (1g). The lunar surface is roughly 1/6g and Mars about 3/8g. Muscles and bones develop in response to stress, and children raised in low-g cannot be expected to be strong enough to visit Earth except in extremis, or perhaps after an incredibly vigorous exercise program. Consider an individual who weighs 73 kg (160 pounds). If they went to a 2.7g planet, the equivalent of moving from Mars to Earth, they would weigh 194 kg (about 420 pounds) and probably could not get out of bed without assistance. (Globus and Marotta 2017, 12)

Their report also suggests smaller stations, with somewhat higher rotation rates, to be located in Earth orbit. Specifically, Equatorial Low Earth Orbit (ELEO) which maximizes radiation protection provided by the Earth and Earth's magnetic field. Interestingly, Globus co-authored a report, cited in my previous research, with Theodore H. Hall, *Space Settlement Rotation Tolerance* (Hall and Globus 2015). In many ways, Hall was the link between Gerard O'Neill's studies of the 1970's and today's studies currently being conducted by Globus. The abstract from the Globus report,

> To survive in the long run, we must settle beyond Earth. We are taking the first steps now, but there are major problems. Lunar or Martian settlements will be very far away and low gravity is a serious problem for children. Free-space settlement designs have typically been kilometer-scale spacecraft weighing millions of tons, requiring both large scale space construction and extraterrestrial materials processing infrastructure before the first settler moves in. To utilize extraterrestrial materials these designs are typically located in orbits very far from Earth, or at least as far as the Moon. Being so massive and distant makes construction impractical, at least for a long time to come.
>
> Things are about to change. Two recent discoveries regarding space radiation and human rotation tolerance suggest that the first free-space settlements may have a mass measured in kilotons, rather than megatons, with dimensions around 100 m rather than half a kilometer or more. First, space radiation computations suggest that Earth orbits below about 500 km and close to the equator have radiation levels so low that little or no radiation shielding is required [Globus 2017a]. Second, a careful examination of the literature suggests that permanent settlers can tolerate much higher rotation rates than was commonly thought, allowing much smaller settlements to provide 1g artificial gravity [Globus 2017b].
>
> Between these two studies, the mass of early free-space settlement designs can be hundreds of times less than previously believed and they can be located hundreds of times closer to Earth, vastly simplifying construction and logistics. Furthermore, extraterrestrial mining is no longer required to build the first settlements because of low mass and new, large reusable rockets under development. Also, the first space settlements may be very similar to large, advanced space hotels. Such facilities, in turn may be developed incrementally from smaller, less sophisticated hotels and stations starting with the ISS (International Spaced Station), perhaps even for a profit. If the results of this paper are confirmed by further research, a herculean task requiring monumental effort will instead become a difficult but surmountable engineering challenge. (Globus, Covey and Faber 2017)

His mention of the space hotel concept is very timely. As this paper is being written Blue Origin and Virgin Galactic sent individuals briefly into space with sub-orbital flights, and SpaceX sent three people into orbit for three days. All of these have an intent to carry paying customers. “For profit” businesses will accelerate development of space travel because progress will not be subject to delays in government funding approval. These businesses, however, receive cooperation and technical support from NASA, which is the best of both worlds.

Long term space travel and habitation will need some kind of mitigation for the 0.0g experienced during interplanetary travel as well as the 0.17g and 0.37g while on the surface of the Moon and Mars respectively. Short radius intermittent centrifuging was mentioned earlier in this paper as something that is being studied. The idea is to have individuals spend some time in a centrifuge on a regular basis. See Figure 2.3 below.

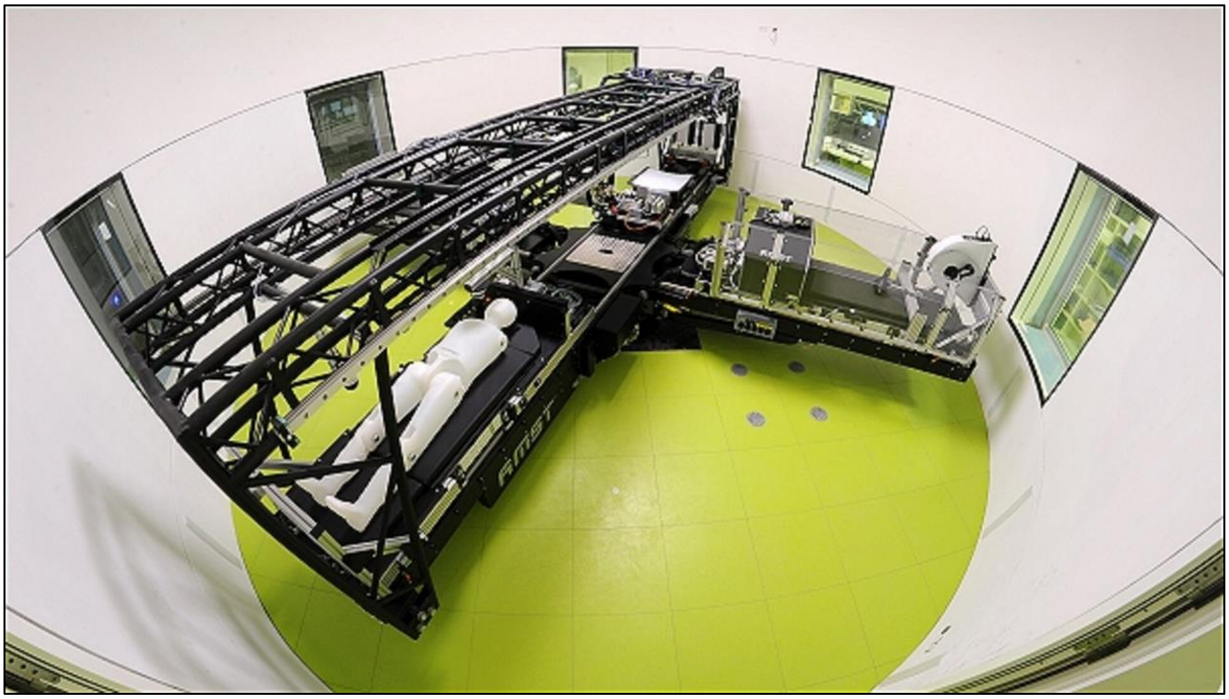

Figure 2.3. *Short Arm Centrifuge* (Agency 2022).

An individual would lay down with feet towards the outside edge. Note the white image in figure 2.3, above, depicting a human. The centrifuge would then be rotated to create artificial gravity (AG), probably 1g, to give the body the experience of gravity on Earth, and presumably, the health benefits. One study was testing if thirty minutes per day would provide significant mitigation. This was an Earth-based study which used inclined bed rest to simulate some of the negative effects of microgravity,

> Task Description: Investigate whether 30 minutes of artificial gravity (AG) per day, delivered either continuously or in six, five-minute intermittent blocks, mitigates changes that occur in a spaceflight analog environment. Aim 1) Determine whether 30 minutes per day of supine centrifugation +1Gz at the heart is effective at mitigating neurocognitive declines induced by 60 days of 6° head down tilt bed rest in comparison to a control group that is not exposed to AG. Aim 2) Determine whether centrifugation is more effective and better tolerated as a countermeasure when it is delivered continuously

> for 30 minutes or in six, five-minute sessions separated by breaks of five minutes each. Our approach utilizes cutting edge neuroimaging techniques and a broad ranging battery of sensory, motor, and cognitive assessments that we have found to be sensitive indices of bed rest—and in several cases—spaceflight induced performance decrements (Edwards 2019). (Dawson, Reduced Gravity Experiment 2020, 47)

Some benefits may be established but, at best, it would likely be regarded by space travelers as an unpleasant but necessary daily chore. At worst it may not mitigate all of the biological factors needed to maintain health. Some degree of centrifuging will almost certainly be needed for those who are on the surface of the Moon or Mars. It may be a mitigating option for trained and conditioned astronaut-explorers, but unpopular for the general public.

It is prudent to note here that my research has only addressed the challenge of the reduced gravity field of Mars. Other challenges include securing water, food, oxygen, and indoor pressurized habitats on or below the surface. Keep in mind that colonists who wish to walk outside will need to wear pressurized space suits. Initially that experience could be quite a thrill but it will not be like a walk in the park here on Earth.

Human Adaptation vs. Evolution

A fair question that could be asked is: Could humans adapt or evolve to tolerate a Mars reduced gravity field? First, let's consider the difference between adaptation and evolution.

Adaptation

For our purposes here lets loosely define adaption as something we can become accustomed to without significantly changing our physiology. We can learn to ride a bike rather than walk. We can become acclimated to various climates and environmental conditions within human biological limits. I, myself, have spent time living on a boat. Adapting to living and walking on, and driving, something that is on water and which always has some movement is often described as “getting our sea legs”. Most humans can do that. Adapting back to land always felt relatively easy, if not mundane. Adapting to rotating space habitats is a similar concept but could require more time than the boating example. The relevant point is that we are able to adapt to some things, such as rotating habitats, without changing the biology of who we are as a species. Surviving in a different gravity field over the long term, however, is biologically beyond the concept of adaptation.

Evolution

Some have suggested that, once living on Mars, humans may “evolve” to having Mars gravity be the normal for them. However, evolution is an entirely different thing. The idea is conceptually valid but extremely unlikely. This would require a significant change in human physiology and genetics over time, and perhaps the creation of a new species. When considering evolution, we are talking about the survival of the fittest through natural selection over hundreds, or thousands, or millions of generations. It certainly would not come as quickly, or as easily, as some would assume. It may not happen at all because evolution would need survivors from each successive generation. With our current limited knowledge, it is not known if there would be any survivors at all from the very first generation on Mars. As previously stated, the human body can be resilient in the short term but unpredictable and vulnerable in the long term. More research is needed before it would be safe or ethical to send large numbers of humans to Mars for long term colonization.

The Best Way to Become a Space Faring Civilization

For brief commercial suborbital and orbital flights, the effects of microgravity should not be a concern. The experience of weightlessness can offer a thrill to first timers in addition to having a view of Earth from space. However, for longer periods of time in space, all of my research on the topic suggests that rotating space stations with 1g offer the best option for health and comfort of humans. A lot could be learned from building a basic first station in Equatorial Low Earth Orbit such as proposed by Al Globus (Globus and Marotta, 2017). If one is successful, more and larger stations could be built in Earth orbit. Space tourism and eventually space manufacturing could provide untold benefits and opportunities. Our civilization could colonize the Earth-Moon system with numerous stations. People would be able to transfer between space stations as well as to and from Earth with relative ease. All of this could be done without an unsurmountable stretch of our current knowledge and technology.

What about Mars? Eventually rotating stations, future technology permitting, would not be limited to Earth orbit. What better way to travel to Mars than in a habitat that has many comforts of home including 1g! A station, or more than one, could be placed into Mars orbit to provide the benefits of 1g. Transfer vehicles could take travelers to Mars surface for exploration or exciting tourist excursions. Mars reduced gravity level should not be a concern for trips to the surface if there is a timely return to the 1g of the orbiting station. This would also provide the opportunity to truly test the effects of Mars gravity, in real time and in the real place, on humans. Perhaps a few trained astronauts could stay on Mars surface for an extended period of time so data could be obtained on the health effects. Once their experiment is complete, or if they experience problems, they could return to the orbiting station for rehabilitation. Rotating stations with AG represent a challenge to build. However, they are likely the best choice for the future of space travel and colonization.

Chapter 3: The Human Biology of Anti-Aging Research

We as humans have more control over our health and aging than is commonly believed. An important take away from recent research is that approximately seventy percent of human health and aging is influenced by lifestyle (Dawson, Human Aging-The Latest Researh 2020, 2). That is significant. The biological mechanisms of how this happens are both complex and fascinating. We have the ability and opportunity to fundamentally change our physiology and rate of aging. Epigenetics, which is a relatively new area of study, provides a way to better understand the biology of aging and how it can be mitigated. The mechanisms of epigenetics control gene expression. Chemical functional groups attach to DNA, or to the proteins it is wrapped in, which then affects how particular genes are expressed. This mechanism is influenced by how an individual lives, in other words, lifestyle choices. Contrary to common belief, our DNA is not our final destiny (Sinclair and LaPlante 2019). This provides a unique opportunity to influence our genetic expression and thus our health and longevity. There is a great need for this information to be communicated, in layperson's terms, to the general public.

Epigenetics was studied in some detail during previous semesters in recent coursework. The following excerpt is from the first paper,

> Sources cited in previous sections of this paper have stated that the environment influences epigenetics. A good question that follows is: What can be considered the environment? An overly simplistic answer could be: Whatever is outside of our bodies. It is that, but much more. The environment is also what is inside of our bodies and what is put into our bodies. In eukaryotic cells most of the DNA is in the cell nucleus with some found in the mitochondria (Brooker, Genetics Analysis & Principles 2nd Edition 2005). It is reasonable, then, to say that epigenetics occurs inside the cell. If that is true then any signal arriving from outside the cell could possibly alter genetic expression. That makes for an expansive environment which presents numerous possibilities and opportunities for

us! In his book, The Biology of Belief, Bruce Lipton, Ph.D. has an entire chapter titled, “It’s the Environment Stupid” (Bruce H. Lipton 2008)!

Many of our lifestyle choices have the potential to produce those signals. They can come from such choices as where we live, how we live, what we eat, and how we exercise. The University of Des Moines Medical School acknowledged this in a 2019 report, “When you eat a healthy diet and exercise regularly, your body can change how much specific genes are expressed in two primary ways: 1) by altering how the genome is packaged inside the cell and 2) by placing chemical tags onto specific genes in the genome” (Weber 2019).

A common theme in sources cited thus far is that acetylation generally increases transcription and methylation inhibits transcription. (Dawson, Epi-Genetics: Nutrition and Exercise 2019, 15)

The biological mechanisms of how all of this works is the focus of ongoing research. Why it works is also a good question. To put it rather unscientifically, the human body just seems to naturally know what to do. Understanding it better will have implications for lifestyle changes as well as future medical treatments. Figures 3.1, below, illustrates some molecular epigenetic modifications,

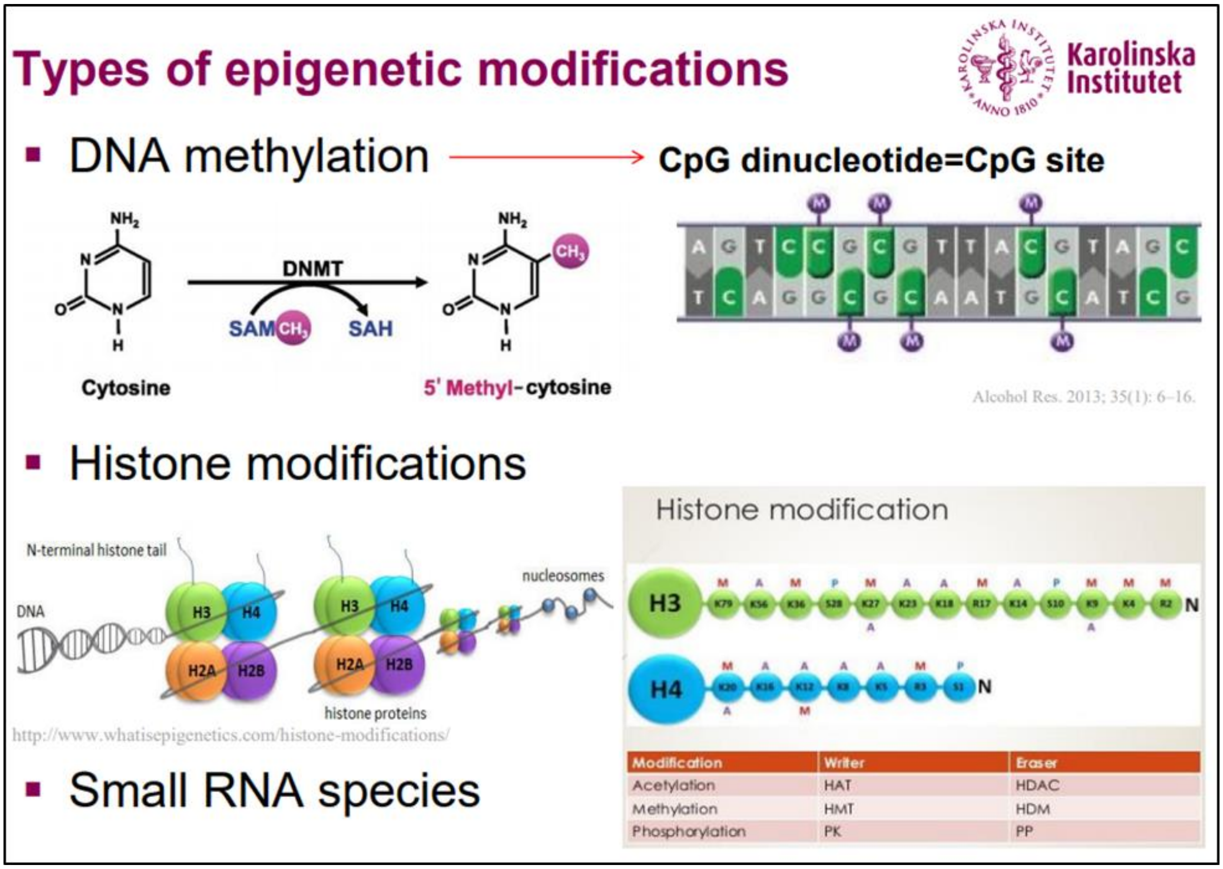

Figure 3.1. *Types of epigenetic modifications* (Karolinska 2022).

Some basic knowledge of epigenetics can offer an entirely new motivation for individuals wishing to improve their health. The benefits of positive lifestyle choices such as diet and exercise have been promoted to the general public in recent decades. Many people understand some of the common knowledge and common sense benefits. But less known is that these choices create effects that go all the way to the molecular and epigenetic level within our cells and change the way our DNA is expressed. It is very profound that we can affect our genetic expression. The relevance of this and the need for change in attitudes on aging was addressed in previous work,

> Human health and aging are often stereotyped in our world. Whether it's anticipating mental or physical decline, or when people are expected to retire, or generalities made by the medical profession, there are many things that are commonly expected at certain ages. It's a one age fits all mentality and it is a societal problem. In the world of medicine it is not uncommon to hear things like: "We won't treat or screen for that disease because it progresses slowly and they will probably die of something else first." Or "We expect that problem because they are 90, or because they are 70, or 50" etc. Unfortunately, if individuals in our society continually hear those generalities, their attitude towards their own aging will likely be negatively affected. (Dawson, Human Aging-The Latest Researh 2020, 2).

The concept of epigenetics originally came to my attention around 2009 while reading a self-improvement book by Deepak Chopra M.D. (Chopra 2009). I had recently graduated with a bachelors in biology so it caught my interest. I was excited, but skeptical, because I did not recall hearing the term epigenetics in my recent courses. That's understandable because increased awareness was just beginning at that time. Since then interest and research on epigenetics has greatly accelerated. It is now accepted as a branch of biology. What Chopra was describing seemed to make sense. However, I was eager to verify it independently so I referred to some of my recent biology and genetics textbooks. Although epigenetics was not a common term then, from what I found, the mechanism was possible. My reaction was excitement because it meant that we could have some control over our genes.

The search for additional information led me to the work of Bruce Lipton, Ph.D. His book *The Biology of Belief*, was originally published in 2005. It has since been updated in 2008 and 2015 (Lipton 2015). His focus on the cell's environment is particularly relevant to the discussion in my previous research. Dr. Lipton's credentials and work in this area are significant,

> Dr. Lipton began his scientific career as a cell biologist. He received his Ph.D. Degree from the University of Virginia at Charlottesville before joining the Department of

> Anatomy at the University of Wisconsin's School of Medicine in 1973. Dr. Lipton's research on muscular dystrophy, studies employing cloned human stem cells, focused upon the molecular mechanisms controlling cell behavior. An experimental tissue transplantation technique developed by Dr. Lipton and colleague Dr. Ed Schultz and published in the journal Science was subsequently employed as a novel form of human genetic engineering.
>
> In 1982, Dr. Lipton began examining the principles of quantum physics and how they might be integrated into his understanding of the cell's information processing systems. He produced breakthrough studies on the cell membrane, which revealed that this outer layer of the cell was an organic homologue of a computer chip, the cell's equivalent of a brain. His research at Stanford University's School of Medicine, between 1987 and 1992, revealed that the environment, operating though the membrane, controlled the behavior and physiology of the cell, turning genes on and off. His discoveries, which ran counter to the established scientific view that life is controlled by the genes, presaged one of today's most important fields of study, the science of epigenetics. Two major scientific publications derived from these studies defined the molecular pathways connecting the mind and body. Many subsequent papers by other researchers have since validated his concepts and ideas. (Lipton 2015, 277)

His discoveries were controversial at the time because they challenged biology's central dogma of: DNA>RNA>Protein. He explains, "The new, more sophisticated flow of information in biology starts with an environmental signal, then goes to a regulatory protein and only then goes to DNA, RNA, and the end result, a protein (Lipton 2015, 45)." He continues,

> In the chromosome, The DNA forms the core, and the proteins cover the DNA like a sleeve. When the genes are covered, their information cannot be "read". Imagine your bare arm as a piece of DNA representing the gene that codes for blue eyes. In the nucleus, this stretch of DNA is covered by bound regulatory proteins, which cover your blue-eye gene like a shirtsleeve, making it impossible to be read.
>
> How do you get that sleeve off? You need an environmental signal to spur the "sleeve" protein to change shape, i.e., detach from the DNA's double helix, allowing the gene to be read. Once the DNA is uncovered, the cell makes a copy of the exposed gene. As a result, the activity of the gene is "controlled" by the presence or absence of the ensleeving proteins, which are in turn controlled by environmental signals. (Lipton 2015)

It is mind boggling to attempt to imagine all of the environmental events which could create those signals. It is certainly more than just diet and exercise although they are very important. It is the air we breathe, the climate, where we live, and even what goes on in our mind with our beliefs and emotions. When it comes to the mind-body connection there can be skepticism and a lot of hocus-pocus associated with it. However, it is hard to deny the possibilities even if we do not yet understand all of the molecular pathways. As referenced above, Dr. Lipton has focused on the epigenetics of the mind body connection. Each possible environmental signal, including from the mind, could be a course study in itself. Suffice to say, we have many opportunities to influence the expression of our genes.

The study of epigenetics has now made its way into current day anti-aging research, From recent coursework,

> My interest and passion for this topic got a major boost when I discovered Dr. David A. Sinclair's 2019 book. It includes some of the latest research. Sinclair is a well-known and respected professor of genetics at Harvard Medical School with twenty-five years' experience in his field. In addition, he is co-director of the Paul F. Glenn Center for the Biological Mechanisms of Aging and runs a sister lab at New South Wales in Sidney, Australia (Sinclair 2019). In his book he analyzes aging and what can be done about it at more specific molecular and genetic levels than I had previously encountered. Other resources will be included in this paper but developing a good understanding of Sinclair's work will be a top priority. He presents new and encouraging findings which could significantly change our view of human aging in the future. (Dawson, Human Aging-The Latest Researh 2020, 2)

Anti-aging research is ongoing around the world. In an effort to understand aging, several "hallmarks of aging" have been established. They are: telomere attrition, epigenetic alterations, loss of proteostasis, deregulated nutrient sensing, mitochondrial dysfunction, cellular senescence, stem cell exhaustion, altered intercellular communication, and genomic instability (Lopez-Otin 2013). Treatments in some areas are already in clinical trials. Sinclair, however, offers a more comprehensive approach which he refers to as *The Information Theory of Aging*,

> Yet, I believe that such an answer exists—a cause of aging that exists upstream of all the hallmarks. Yes, a *singular* reason why we age. Aging, quite simply, is loss of information (Sinclair and LaPlante 2019, 20).” Dr. Nir Barzilai MD, who is founder of the Insitute for Aging Research at Albert Einstein College of Medicine, lauds Sinclair’s work as one of the latest theories of aging, “One of the latest theories of aging—and my favorite—is presented by my friend and colleague David Sinclair…The information theory of aging proposes that we age and become more susceptible to diseases because our cells lose information (Barzilai 2020, 57; Dawson, Human Aging-The Latest Researh 2020, 15)

> The loss of information referred to is epigenetic information. He explains,

> Sinclair compares digital vs. analog information in his explanation, “But there are two types of information in biology, the first type of information—the type my esteemed predecessors understood—is digital. Digital information, as you likely know, is based on a finite set of possible values—in this instance, not in base 2 or binary, coded as 0s and 1s, but the sort that is quaternary or base 4, coded as adenine, thymine, cytosine, and guanine, the nucleotides A, T, C, G of DNA (Sinclair 2019, 20).” Information stored this way is analogous to storing it in a computer or DVD. It is precise and can be copied over and over. It’s also durable. DNA can last thousands of years withstanding environmental extremes. We can think of our genes as containing information in a digital type of form.

> “The other type of information in the body is analog. We don’t hear as much about analog information in the body. That’s in part because it’s newer to science even though that’s how it was first described when geneticists noticed strange effects in plants they were breeding. Today, analog information is more commonly referred to as the epigenome, meaning traits that are heritable that aren’t transmitted by genetic means (Sinclair 2019, 21).” (Dawson, Human Aging-The Latest Researh 2020, 15)

> So how can aging be corrected at this level?

> Digital storage is best for keeping long-term genetic data but, when life needs to respond to variable environmental conditions, analog is preferred because it is flexible and can be changed back and forth. The analog information stored in our epigenome, however, is vulnerable, “…analog information degrades over time—falling victim to the conspiring

> forces of magnetic fields, gravity, cosmic rays, and oxygen. Worse still, is information is lost as its copied (Sinclair 2019, 22)."
>
> If a DVD is scratched the information can often be restored by polishing off the scratches. Sinclair's intent is to find a way to polish off the "scratches" from our DNA, "As cloning beautifully proves, our cells retain their youthful digital information even when we are old. To become young again, we just need to find some polish to remove the scratches. This, I believe, is possible (Sinclair 2019, 23)." (Dawson, Human Aging-The Latest Researh 2020, 16)

Sinclair's research has established a couple of very important understandings. First is that humans are not programed to age. We do not have aging genes (Sinclair and LaPlante 2019, 28). Aging happens but it is from the wear and tear of life, and lifestyle choices. This results in the loss of proper information and order within the epigenome. In other words, genes are no longer being turned on and off in an optimal manner. The encouraging news is that there are specific molecular mechanisms which can help restore that information,

> On the other hand, longevity genes have been found. "Scientists have found more than two dozen of them within our genome. Most of my colleagues call these "longevity genes" because they have demonstrated the ability to extend both average and maximum lifespans in many organisms. But these genes don't just make life longer, they make it healthier, which is why they can also be thought of as "vitality genes" (Sinclair and LaPlante 2019, 23)." This is important and encouraging. We have longevity genes within us!
>
> Sinclair has done a lot of work with sirtuins, "The longevity genes I work on are called "sirtuins" named after the yeast SIR2 gene, the first one to be discovered. There are seven sirtuins in mammals, SIRT1 to SIRT7, and they are made by almost every cell in the body (Sinclair and LaPlante 2019, 24)." Surtuins have come to the forefront of medical research. "Descended from gene B in *M. Superstes*, sirtuins are enzymes that remove acetyl tags from histones and other proteins and, by doing so, change the packaging of DNA, turning genes off and on when needed. These critical epigenetic regulators sit at the very top of cellular control systems… (Sinclair and LaPlante 2019, 24)" They control our health, and fitness, responding to what we eat, the time of day, and how much we exercise. They literally protect us from the common diseases of aging by preventing cell death, boosting mitochondria, and countless other processes. "In studies on mice, activating the sirtuins can improve DNA repair, boost memory, increase exercise, endurance, and help the mice stay thin regardless of what they eat (Sinclair and LaPlante

> 2019, 25)." All that they do, says Sinclair, is well established and has been published in journals such as *Nature, Cell,* and *Science*. They also evolved to require nicotinamide adenine dinucleotide (NAD) (Sinclair and LaPlante 2019, 24). This is one key to aging because NAD levels decline as we age which results in reduced sirtuin activity.
>
> Two other longevity genes have also been well studied: Target of rapamycin (TOR), and AMP-activated protein kinase (AMPK). (Dawson, Human Aging-The Latest Researh 2020, 16,17)

It has been found that longevity genes are activated as a response to biological stress so long as it is not so much stress as to cause permanent damage. Future clinical interventions will likely involve newly created molecules which will mimic that stress. Some are already being studied. However, it may be awhile before it is certain that they are safe and in what dosage. The good news is that our bodies will activate these genes in response to activities that we have the ability to do now. From previous research, "The key to activating longevity genes is to induce stress without causing lasting damage. This is called hormesis. It can be induced with stressors such as, "…certain types of exercise, intermittent fasting, low-protein diets, and exposure to hot and cold temperatures (Sinclair 2019, 26)." (Dawson, Human Aging-The Latest Researh 2020, 18)."

Exercise is number one and is an ideal example of stressing the body, but not too much. As antiaging researcher, Nir Barzilai, says, "Regular exercise appears to have a positive effect on all the hallmarks of aging, and that may be due in part to a process called hormesis, by which a certain amount of stress can be helpful and protective because it activates many of our natural defenses (Barzilai 2020, 195)." "The benefits of exercise for both the young and the old are greater than the benefits we have seen from any particular diet (Barzilai 2020, 194)." Sinclair describes it, "Exercise, by definition, is the application of stress to our bodies. It raises NAD levels, which in turn activates the survival network, which turns up energy production and forces muscles to grow extra oxygen-carrying capillaries. The longevity regulators AMPK, mTOR, and the sirtuins are all modulated in the right direction by exercise (Sinclair and LaPlante 2019, 103)." In the not too distant past, who would have dreamed that we could influence our genetic expression by simply exercising!

Molecules matter. The human body has trillions of cells which are involved in countless chemical reactions each second and food is the chemistry that we put into our bodies. The potential positive effects of certain foods on epigenetics was discussed in my very first graduate research project (Dawson, Epi-Genetics: Nutrition and Exercise 2019, 15). The mechanisms can be rather complex. However, making it happen can be as simple as consuming many of the foods that we already know are good for us. Figure 3.3 below shows a partial list of common foods and their associated epigenetic chemical modifiers.

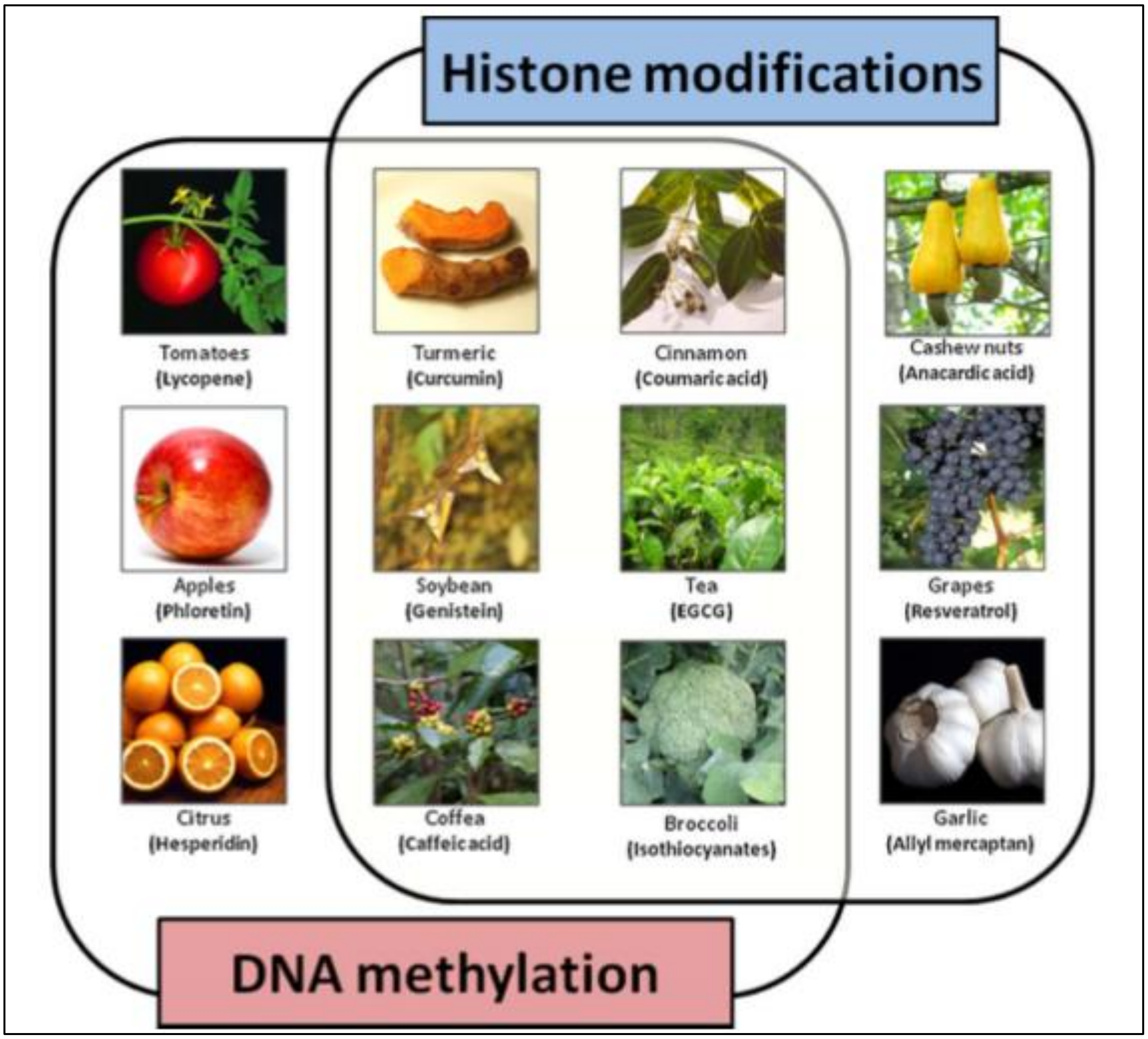

Figure 3.2. *Epigenetic foods*. (Link, Balaguer and Goel 2010)

"It is encouraging to note that the above plants are common, plentiful, and available in grocery stores. If an individual wants to begin eating with epigenetic intent, all they have to do is to start incorporating these plants into their diet on a frequent basis." (Dawson, Epi-Genetics: Nutrition and Exercise 2019, 18).

Living Closer to Human Potential

Recall, as stated earlier, approximately seventy percent of health and aging is controlled by lifestyle choices. That leaves the remaining thirty percent that is not so much in our control and is where screening and medical intervention is crucial. In those cases where medical treatment is needed, the healthier an individual is, the stronger they will be to endure whatever treatment is needed. If we can do the things needed, we can live closer to our human potential,

> We can do ourselves a benefit in a couple of ways. First, we can influence our health to be closer to what is naturally possible. The Blue Zones populations demonstrate what is possible without clinical intervention. 100 or more healthy years is a reasonable expectation, “Our maximum potential life span as a species is thought to be about 115 years, but many people die before 80 after suffering from an average of three diseases. So we have an extra 35 years that we can realize, like some of our centenarians have, and we are beginning to understand how to scientifically capture those years and make them healthy (Barzilai 2020, 187).” “We know that humans, both male and female, are capable of living past the age of 115. It has been done, and it can be done again. Even for those who reach only their 100th year, their 80’s and 90’s could be among their best (Sinclair 2019, 180).” (Dawson, Human Aging-The Latest Researh 2020, 32). (Buetner 2008)

The Blue Zones, mentioned in the above quote, is a very reliable source of information on living to our potential. The study distilled commonalities from all the Zones and then made recommendations. From previous research,

> It’s been well established that, even without new discoveries, new drugs, or clinical intervention, positive lifestyle choices can extend health span into the 90’s and even over 100. One of the most comprehensive and well documented sources I have found was published by National Geographic in 2008. The study is in the *Blue Zones* book written by Dan Buettner. It was cited in the introduction above (Buetner 2008). Buettner and his colleagues discovered and studied populations around the world where people have been living extraordinarily healthy and long lives. When they circled those areas on their world map they happened to use a blue marking pen and thus the term *Blue Zone(s).* They describe their research,

To identify the secrets of longevity, our team of demographers, medical scientists, and journalists went straight to the best sources. We traveled to the Blue Zones — four of the healthiest corners of the globe — where a remarkably high rate of the longest-living people manage to avoid many of the diseases that kill Americans. These are the places where people enjoy up to a 3 times better chance of reaching 100 than we do.

In each of the Blue Zones, we used a survey developed in collaboration with the National Institute on Aging to identify the lifestyle components that help explain the area's longevity — what the inhabitants choose to eat, how much physical activity they get, how they socialize, what traditional medicines they use, and so forth. We looked for the common denominators — the practices found in all four populations — and came up with what I consider to be a cross-cultural distillation of the best practices of health, a de facto formula for longevity.

The areas are: The Barbagia region of Sardinia in Italy, Okinawa in Japan, Loma Linda in California, and the Nicoya Peninsula in Cosa Rica. It may be surprising that a place in America, (Loma Linda) is a Blue Zone. This area is predominately Seventh Day Adventists and they put a high priority on taking care of their health.

Since the original study a fifth area was discovered: Ikaria, Greece. Sinclair referred to the Blue Zones when describing Ikaria Greece as “the island where people forget to die”. One-third of their population lives past age 90!

The Blue Zones study was an ambitious seven year effort. Buettner explains how they did it, “Over the course of seven years my team circled the globe, making several trips to each of the four Blue Zones and meeting with the remarkable people who lived there. In each place we confirmed that people were as old as they said they were, interviewed dozens of centenarians, worked with local medical experts, and methodically studied each of the local lifestyles, habits, and practices (Buetner 2008).” Buettner describes many of the people he interviewed in each region.

Hearing what these long-lived people had to say and how they lived was touching, inspiring, and informative! It was found that they all got physical exercise of some sort, they ate mostly unprocessed plant-based foods. Meat was consumed occasionally but not daily. They also ate in moderation and knew how to de-stress and enjoy friends and family. (Dawson, Human Aging-The Latest Researh 2020, 5). (Buetner 2008)

Creating a Personal Health Zone

The problem with most health advice is that it is too general and lacks biological explanation. We need to get away from the overused and over generalized phrase, “exercise and a healthy diet is good for you.” Few people would argue with that, but most are not truly motivated by it either. On the other hand, imagine if people received a layperson explanation of epigenetics highlighting some of the epigenetic opportunities discussed earlier in this paper. The biology community has become aware of epigenetics but it is not common public knowledge yet. I work at a hospital and, even there, I find that most staff and professionals are not aware of it. If we are having a conversation and I mention epigenetics, people usually respond by talking about genetics instead of epigenetics. The, epi, part of the term is missed and not understood. Education is clearly needed. People should know that, contrary to common belief, their fate is not entirely set by their DNA because of the mechanisms of epigenetics (Sinclair and LaPlante 2019). A layperson understanding of this could give people a feeling of empowerment over their health.

This section will be somewhat anecdotal. While doing this research I came to the realization that, over the past fifteen plus years, I have been creating my own “personal health zone”. The path has been simple: Educate myself and then gradually integrate changes into my life. My commitment to regular exercise began forty-three years ago but a deeper understanding of other choices, such as food, has grown during the recent fifteen years. I am still learning and integrating. It is always a work in progress.

Creating a personal health zone can be anyone's work in progress. The concept is simple for anyone wanting to positively affect their health and aging. The key is to gradually integrate positive changes a little at a time. Attempting to make drastic changes rarely lasts over time. Gradual changes, perhaps just one or two changes each week, or even in a month, increase the chances of retaining them for a lifetime.

My research concludes that high priority anti-aging points are, one's beliefs and attitudes about aging, exercise, and diet. Why is it that what we believe about aging is important? Firstly, is that it can lead to actual practical decisions which are self-limiting because of what society has conditioned us to expect at certain ages. Secondly, is that there is evidence, such as cited earlier in Bruce Lipton's work, which indicates signals from our thoughts and emotions affect our epigenome (Lipton 2015). One thing which I have done in this regard is to stop telling "old jokes" or making "old" comments about myself. They are easy to do, some can be funny, and since it is directed towards oneself, no one is offended. But still, it is best to just stop. Even if it is done for humor, why add to the age conditioning that our society already gives us? Recall, from earlier, that anti-aging research shows human potential to be much greater than what society believes. Sometimes when I am visiting with someone in my age range I can't help but notice how often they make "old" comments about themselves. Again, why add to the negative conditioning which our society already gives in abundance?

The concept of creating a personal health zone is a primary suggestion of this chapter. It is not a diet plan or an exercise regimen. The idea is to encourage interested individuals to consider their entire health status and gradually integrate positive changes over time. The first thing an individual would do is to make an honest evaluation of where they are currently in regard to the important areas of health, including positive and negative choices. No self-judgment, just the facts to establish a baseline. This is not to be compared to anyone else or any form of analytics. Call that baseline the zero line. For any individual positive choice above that line, ten points can be tallied. The points are arbitrary but will provide a guide and awareness. Again, the points will not be compared to anyone else nor any analytics. They should, however, be helpful in creating an overall awareness. Weekly tallying is suggested. If one positive food choice was added above the baseline award ten points. Also, if a poor choice is avoided, award ten points. Go an entire week without making an "old" comment about oneself, add another ten points. That might suffice for one week. Perhaps the next week some additional exercise was added so an additional ten points can be added. Just keep that method going. Additionally, setting an appointment for an annual physical or other screening should be worth ten points. Recall the thirty percent of health which is not in our control and is important to detect. Screening and detection are very important in that regard. A feature of the personal health zone point system is that a person can choose among a number of activities to make an improvement and thus award points. It doesn't have to be an all or nothing diet plan or exercise commitment. For example, on a given week, it might be easier to make one positive food choice rather than adding exercise. As long as there is awareness, an individual's personal health zone can improve. Gradual changes, integrated, can become lifetime habits.

There are numerous sources which can provide a guide for what consists of positive health choices. Learning from the Blue Zones study is suggested here because it grew from a seven-year National Geographic study of the world's longest-lived people (Buetner 2008). The study, mentioned earlier, in this paper is well documented and the recommendations are not complicated. Since the original study, the Blue Zones organization has continued to reach out to provide ways for everyone to learn to live like the people in the Blue Zones. They can be found on social media as well as their main website (Buettner 2021). Additional books have been written including cook books. The Blue Zones Project reached out and found entire communities in the United States and Canada who were willing to convert their cities to be like an original Blue Zone (Buettner 2021).

Distilling everything learned, nine commonalities of Blue Zones populations were determined. They are: move naturally, have a purpose (many Blue Zones people never retire), downshift-they have routines to reduce stress, 80 per cent rule-stop eating when 80 per cent full, plant slant-eat more plant based food and meat in moderation, Wine at 5-meaning a glass or two with dinner and friends can be good, right tribe-have a social network that supports healthy choices, community-most had a faith-based community but the denomination did not seem to matter, loved ones first-family was important and older members lived close (Buettner 2015). Their book, *The Blue Zones Solution*, has an entire section titled, *Building Your Own Blue Zone*, which gives specific and practical suggestions on how to eat and live like the Blue Zones people (Buettner 2015). That concept pairs well with the point system suggested in this section for creating a personal health zone.

Chapter 4: Theoretical Physics

Theoretical Physics could appropriately be called Theoretical Natural Sciences because all branches of the sciences can be involved when considering the greatest mysteries of our world, both local and distant. Theoretical Physics explores some of the most intriguing and elusive questions of science. It is encouraging that seemingly unanswerable questions often get answers, eventually. Note figure 4.1 below.

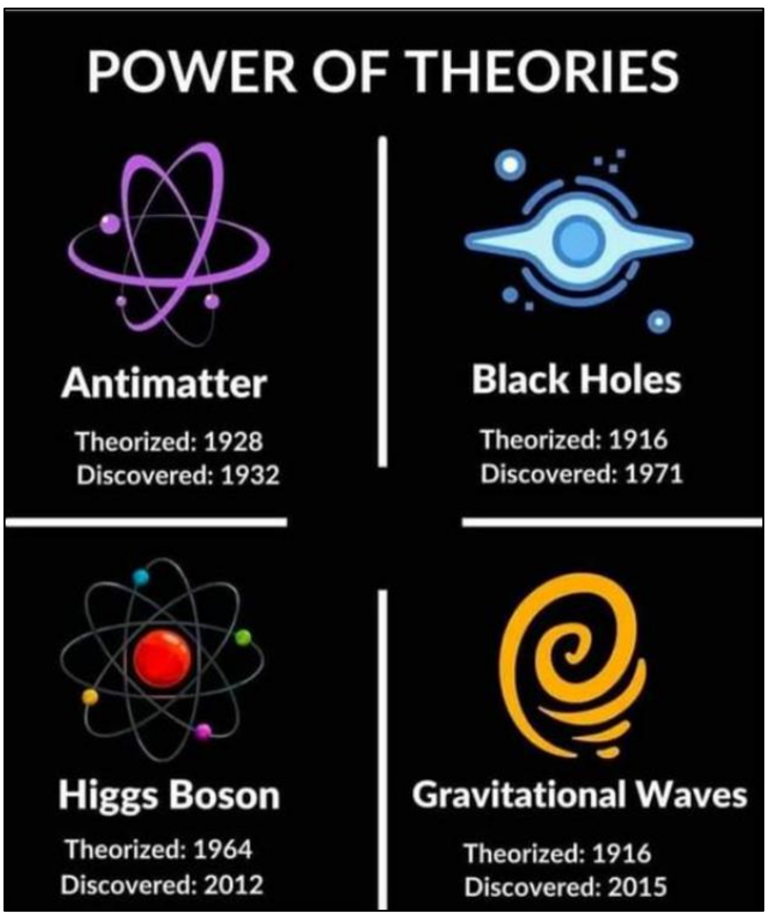

Figure 4.1 *Power of Theories* (Physics- Astronomy Lovers 2022).

And Einstein gave us the answers depicted in figure 4.2 below.

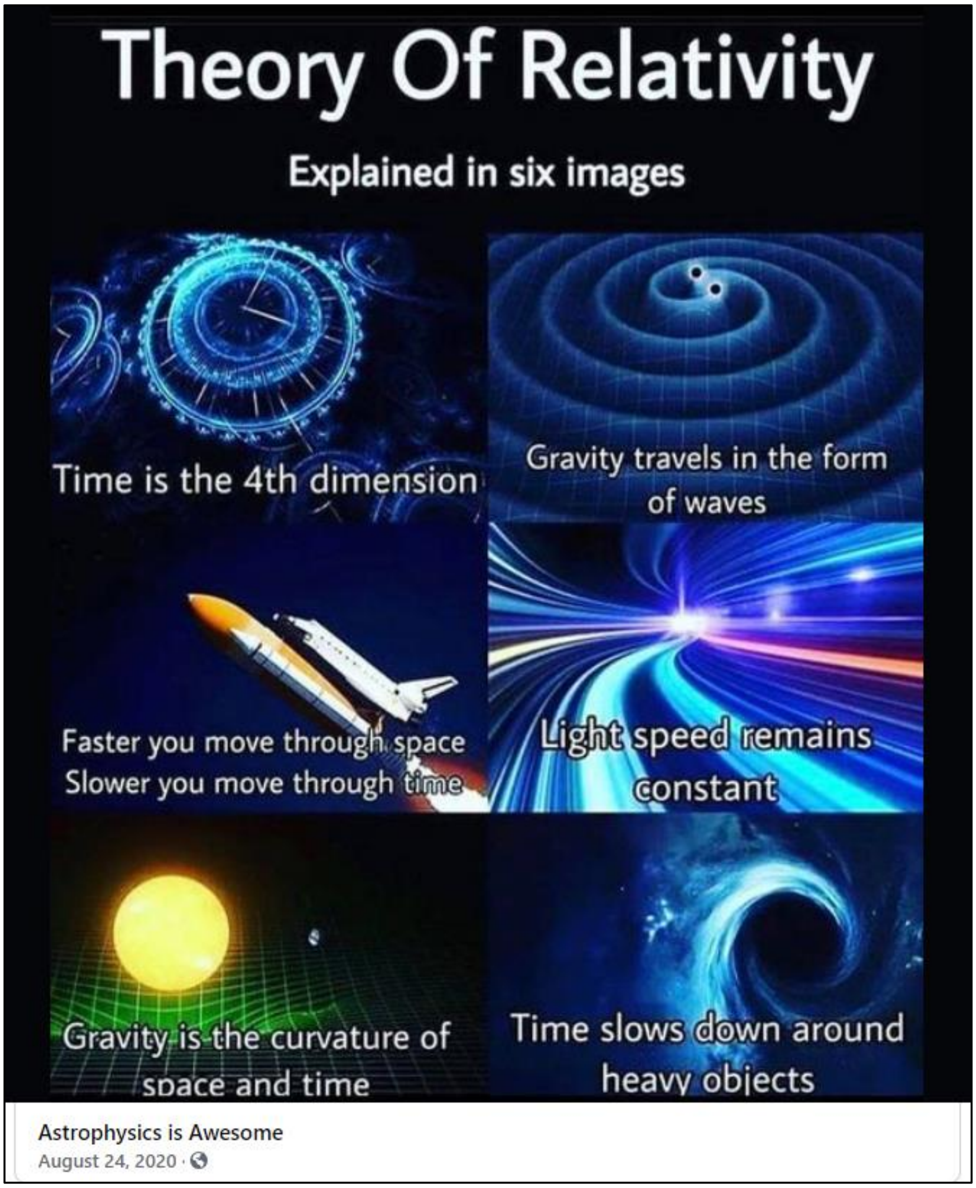

Figure 4.2. *Theory of Relativity in six images* (Astrophysics is Awesome 2020).

Great scientists and thinkers of the past have contributed much. However, there are also creative and inspiring current day scientists such as Brian Greene, Michio Kaku, Robert Lanza, Carlo Rovelli, and Neil DeGrass Tyson, just to name a few. Their thinking is not only scientific but they are great communicators, each in their own way. Deep questions and concepts come alive in their words. The Theory of Relativity and Quantum Theory raise questions about our very existence and origin. The incompatibilities between the two theories continue to perplex scientists. There is a desire by many to explain everything in one all-encompassing theory. In other words, a "Theory of Everything". Current scientists are working toward that goal.

My own intrigue about "unknowns" led to the course research paper, Time, Space, and Gravity-Searching for answers (Dawson, Time, Space and Gravity-Searching for Answers 2020). Two primary sources were studied. First was Carlo Rovellis' book, *The Order of Time*, (Rovelli 2018). Rovelli is an Italian theoretical physicist who works mainly in the field of quantum gravity and is a founder of loop quantum gravity theory. The other was Brian Greenes' book, *Until the End of Time* (Greene 2020). Greene is a professor of physics and mathematics at Columbia University and is world-renowned for his discoveries in the field of superstring theory (Greene 2020).

My studies naturally led me to Relativity and Quantum theory, although that was not a specific intention. The goal was just to have a better understanding of Time, Space, and Gravity, all of which can be difficult to comprehend. Take gravity for example. We might feel that we are familiar with it because we know that it keeps us solidly on the ground. A lot is known about how it works, and there is an equation for it: $F = G\frac{m_1 m_2}{r^2},\ G = 6.67 \times 10^{-11}$. G is the gravitational constant, m_1 and m_2 are the masses of two objects experiencing the force of gravity (F) between them and r is the distance between the centers of those masses. Paths of projectiles through Earth's atmosphere or spacecraft traveling into outer space can be predicted with great accuracy. However, understanding how it works is different than understanding what it is. We cannot see it, and so far do not completely understand why it works as it does. Consider electricity for comparison. We know a lot about how it works and we have learned how to create and manipulate it for practical uses. We cannot see it either but at least we have some knowledge of what it is, such as the movement of electrons or transfer of positive and negative charges. It would be pertinent here to mention that, for gravity, the idea of a point particle has been tried. Scientists labeled it a graviton but without success, "Quantum corrections created by gravitons were infinite and could not be absorbed somewhere else. Here physicists hit a brick wall (Kaku 2021)."

The other two concepts, time and space, can feel deceptively familiar to us because we use them routinely in our everyday lives. We often calculate space when measuring the volume of a container or a room, or how many miles to the next town. Time, as we use it daily, can give us the impression that it flows continuously and is the same everywhere. But if we get away from our daily lives, things change because space is said to have curvature and time can speed up or slow down. Einstein gave us that (Einstein 2015). Rovelli, in his book, dispels many common beliefs about time,

> The study of time reveals that a lot of what is commonly presumed about time is not true. It may actually be more appropriate to ask what time isn't it rather than what time is it. Rovelli, in part 1 of his book, describes dispelling common beliefs as the crumbling of time (Rovelli 2018, 7). "One after another, the characteristic features of time have proven to be approximations, mistakes determined by our perspective, just like the flatness of earth or the revolving of the sun (Rovelli 2018, 4)."
>
> Einstein understood that time doesn't pass uniformly everywhere a good century before there were clocks precise enough to measure it (Einstein 2015). Very sensitive clocks

> exist now, “Observers in relative motion or at different gravitational potentials measure disparate clock rates. These predictions of relativity have previously been observed with atomic clocks at high velocities and with large changes in elevation. We observed time dilation from relative speeds of less than 10 meters per second by comparing two optical atomic clocks connected by a 75-meter length of optical fiber. We can now also detect time dilation due to a change in height near Earth’s surface of less than 1 meter (Matson 2020).” Time passing at different rates, as astonishing as it may sound, can now be easily observed in labs with the right equipment. (Dawson, Time, Space and Gravity-Searching for Answers 2020, 4)
>
> From previous research a conclusion about time,
>
> Thinking further, and drawing from what was just discussed, one must conclude that there are many different times or time points. If the rate of time passage varies with change in gravitational potential due to a large mass, then there would literally be an infinite number of times surrounding masses such as earth. Gravitational force/potential is dependent (inverse square relationship) on the distance between the centers of two masses. Change that distance by even a tiny bit and there will be a different gravitational potential and thus a different time point. In addition, since the rate of time is affected by differences in relative speeds, even more time points are created. (Dawson, Time, Space and Gravity-Searching for Answers 2020, 5)

That is fascinating if not disturbing. Even more fascinating is that there is no law of physics that says time cannot go backwards, “To make matters worse, physicist Brian Greene, states that there is no law of physics which says that time cannot go backwards,“Given the state of the world right now, the mathematical equations treat unfolding toward the future or past in exactly the same way (Greene 2020, 23).” Theoretical physicist, Carlo Rovelli, when discussing the direction of time concurs, “It is not directional: the difference between past and future does not exist in the elementary equations of the world (Rovelli 2018, 91).” (Dawson, Time, Space and Gravity-Searching for Answers 2020, 6)

If there are a multitude of time points then we must also conclude that there is no universal “NOW”. Local time maybe, but no absolute time. “More than a hundred years have passed since we learned that the “present of the universe” does not exist (Rovelli 2018).” Rovelli goes on to present more interesting concepts such as: there may be a quanta, or minimum time. Also, that events are needed for time to pass. Studying his entire book is indeed a thought-provoking experience.

A Thought Experiment

In previous research I created a thought experiment. The example herein is different but the concept is the same. Consider the experience of returning to a place where you have visited in the past. Revisiting a particular geographical location can evoke feelings of familiarity, but also strangeness, especially if it creates feelings of nostalgia. It is the same location but feels different because time has passed. That is the mystery of time. Perhaps there is a way that we could understand time in a way that makes it less mysterious. What if time could be represented by distance?

Imagine being in a classroom and drawing an X, Y, and Z axis as a cartesian coordinate system on the whiteboard. We name as our reference point to be the intersection of those axes, which is zero for all three. We will begin recording time on a designated clock when we start. The coordinates for our point are (0,0,0) the values of X, Y, and Z. We can revisit that whiteboard numerous times, regardless of how much time has passed, and those coordinates will still be (0,0,0) for the reference point in relation to the whiteboard in our classroom. It looks the same but we know that time has passed. Each time we revisit, our experience is the same, yet different. So now let's add a fourth coordinate for time (T). The coordinates at T=0 are (0,0,0,0). If we return in 24 hours the coordinates will be (0,0,0,T=24 hours). That may be true but it just states an obvious point.

We now expand our observation and realize that our reference point is part of that room, which is in a building, which is located on our planet, which is moving through space. Perhaps we could come up with a distance measurement if we knew how Earth is moving through space. Before proceeding, we need to ask if the Earth moving through space counts as time happening. There is growing consensus that events are needed before time can pass. It is not just independently flowing. Time is dependent upon events. Rovelli says, "Thinking of the world as a collection of events, of processes, is the way that allows us to better grasp, comprehend, and describe it (Rovelli 2018, 98)." "It is the realization of the ubiquity of impermanence, not of stasis in a motionless time (Rovelli 2018, 97)."

The point was made that things persist in time but events have a limited duration. Life itself is a combination of countless processes. Even if we sit still our body is performing millions of biochemical reactions per second. Imagine watching a river flow or ocean waves crashing on a beach. They are the epitome of flowing processes. Maybe that is why many of us are mesmerized by those experiences. We tend to take notice of change and flowing movement. Even for objects which are very "thing-like", such as a hard stone, they will eventually turn to dust. It is just a very, very, slow event (Rovelli 2018, 98; Dawson, Time, Space and Gravity-Searching for Answers 2020, 16).

From what has been discussed one could conclude a few things about events. First is that they are widespread throughout nature. They also have a limited duration even if it is a hard stone gradually turning to dust. They happen in relation to something else which can make their location temporary or indeterminate. Quantum properties are also present. Some values exist while others do not. It could be an electron jumping from one energy level to another, or time notching by in minimum increments of Planck time, and they happen in their own local time (Dawson, Time, Space and Gravity-Searching for Answers 2020, 14; Rovelli 2018, 83).

So, does Earth traveling through the vacuum of space create or experience events? A quick answer might be “no” because there is nothing present in that vacuum. Upon further thought, though, the answer could be yes. Some phenomena permeate vacuums such as gravitation, radiation, and the whole spacetime-gravity matrix. It turns out that space is not so empty. And then there is all of the dark matter and dark energy in the cosmos whose presence has been detected but not actually seen (Tyson and Trefil 2021). For our purpose here, it seems reasonable to say that Earth moving through space qualifies as events happening and thus time passing.

Many things affect the path of Earth through space. Its net movement was described in detail by Astrophysicist and Science educator Ethan Siegel Ph.D. in the following article,

> ***How Does Earth Move Through Space? Now We Know, On Every Scale.*** Ask a scientist for our cosmic address, and you'll get quite a mouthful. Here we are, on planet Earth, which spins on its axis and revolves around the Sun, which orbits in an ellipse around the center of the Milky Way, which is being pulled towards Andromeda within our local group, which is being pushed around inside our cosmic supercluster, Laniakea, by galactic groups, clusters, and cosmic voids, which itself lies in the KBC void amidst the large-scale structure of the Universe. After decades of research, science has finally put together the complete picture, and can quantify exactly how fast we're moving through space, on every scale. Most likely, as you’re reading this right now, you’re sitting down, perceiving yourself as stationary. Yet we know — at a cosmic level — we’re not so stationary after all. For one, the Earth rotates on its axis, hurtling us through space at nearly 1700 km/hr for someone on the equator. That might sound like a big number, but relative to the other contributions to our motion through the Universe, it's barely a blip on the cosmic radar. That’s not really all that fast, if we switch to thinking about it in terms of kilometers per second instead. The Earth spinning on its axis gives us a speed of just 0.5 km/s, or less than 0.001% the speed of light. But there are other motions that matter more. Much like all the planets in our Solar System, Earth orbits the Sun at a much speedier clip than its rotational speed. In order to keep us in our stable orbit where we are, we need to move at right around 30 km/s. The inner planets — Mercury and Venus — move faster, while the outer worlds like Mars (and beyond) move slower than this. As the planets orbit in the plane of the solar system, they change their direction-of-motion continuously, with Earth returning to its starting point after 365 days. Well, almost to its

same exact starting point. Because even the Sun itself isn’t stationary. Our Milky Way galaxy is huge, massive, and most importantly, is in motion. All the stars, planets, gas clouds, dust grains, black holes, dark matter and more move around inside of it, contributing to and affected by its net gravity. From our vantage point, some 25,000 light years from the galactic center, the Sun speeds around in an ellipse, making a complete revolution once every 220–250 million years or so. It’s estimated that our Sun’s speed is around 200–220 km/s along this journey, which is quite a large number compared both Earth's rotation speed and its speed-of-revolution around the Sun, which are both inclined at an angle to the Sun's plane-of-motion around the galaxy. But the galaxy itself isn't stationary, but rather moves due to the gravitational attraction of all the over dense matter clumps and, equally, due to the lack of gravitational attraction from all of the under dense regions. Within our local group, we can measure our speed towards the largest, massive galaxy in our cosmic backyard: Andromeda. It appears to be moving towards our Sun at a speed of 301 km/s, which means —when we factor in the motion of the Sun through the Milky Way — that the local group's two most massive galaxies, Andromeda and the Milky Way, are headed towards each other at a speed of around 109 km/s. The Local Group, as massive as it is, isn't completely isolated. The other galaxies and clusters of galaxies in our vicinity all pull on us, and even the more distant clumps of matter exert a gravitational force. Based on what we can see, measure, and calculate, these structures appear to cause an additional motion of approximately 300 km/s, but in a somewhat different direction than all the other motions, put together. And that explains part, but not all, of the large-scale motion through the Universe. There's also one more important effect at play, one that was quantified only recently: the gravitational repulsion of cosmic voids. For every atom or particle of matter in the Universe that clusters together in an over dense region, there's a region of once-average density that's lost the equivalent amount of mass. Just as a region that's more dense than average will preferentially attract you, a region that's less dense than average will attract you with a below-average amount of force. If you get a large region of space with less matter than average in it, that lack-of-attraction effectively behaves as a repellent force, just as extra attraction behaves as an attractive one. In our Universe, opposite to the location of our greatest nearby over densities, is a great under dense void. Since we're in between these two regions, the attractive and repulsive forces add up, with each one contributing approximately 300 km/s and the total approaching 600 km/s. When you add all of these motions together: the Earth spinning, the Earth revolving around the Sun, the Sun moving around the galaxy, the Milky Way headed towards Andromeda, and the local group being attracted to the over dense regions and repulsed by the under dense ones, we can get a number for how fast we're actually moving through the Universe at any given instant. We find that the total motion comes out to 368 km/s in a particular direction, plus or minus about 30 km/s, depending on what time of year it is and which direction the Earth is moving. This is confirmed by measurements of the cosmic microwave background, which appears preferentially hotter in the direction we're moving, and preferentially colder in the direction opposite to our motion. (Siegel 2017)

Let’s just use the 368 km/s for our purpose but knowing it can be, give or take, 30 km/s. Going back to our coordinate system starting at T=0 coordinates are: (0,0,0,0). The fourth coordinate will now be calculated as the distance Earth travels on its path through space in the duration we choose. If we take a reading after just one second, using 368 km/s times one second = 368 km or about 228 miles. That’s a long way in just one second! Our coordinates now read (0,0,0,368 km). If we let our clock run for 24 hours the distance will be 31,795,200 km or about 19,713,024miles! The coordinates now read: (0,0,0,31,795,200 km). Our reference point is nowhere near where it was when we first observed it. By expanding our perspective, we can understand that when we return to that place it is not in the same original place. Perhaps this can remove some of the mystery from time.

Does Consciousness Determine the Structure of the Universe?

A very recent and intriguing source addressing the mysteries of the Universe was written by a biologist, a physicist, and an astronomer. The *Grand Biocentric Design* written by Robert Lanza M.D. who is head of Astellas global regenerative medicine is one of the most prominent scientists in the field of stem cell biology, and Matej Pavsic who is a physicist in foundations of theoretical physics, and Bob Berman who is an American astronomer, author, and science popularizer (Lanza, Pavsic and Berman 2020). Exploring this work could fill several course studies. A brief overview will be included here before closing.

Lanza makes a point about quantum theory by quoting Neils Bohr and Richard Feynman, “First, QT often defies logic. So much so that Neils Bohr, one of its founders, said “Those who are not shocked when they first come across quantum theory cannot possibly have understood it." A half century later, the famous theoretician, Richard Feynman went further: "It is safe to say that *nobody* understands quantum mechanics." (Lanza, Pavsic and Berman 2020, 36)." So, it is okay to study some things without completely understanding them. That is a comforting thought when studying Relativity and quantum theory.

The incompatibility of Relativity and quantum mechanics has puzzled scientists for years. "Quantum mechanics works exquisitely well in describing nature at the scale of molecules and subatomic particles, while general relativity is peerless in revealing cosmic behavior on the huge scales between the stars (Lanza, Pavsic and Berman 2020, 238)." "Yet after almost a century, we lack an understanding how the two are compatible" (Lanza, Pavsic and Berman 2020, 238).

One of the most puzzling aspects of quantum mechanics is the behavior of certain particles. Their behavior changes depending on if they were observed or not. This has led some current scientists to believe that the observer is the basis of reality. As Lanza puts it in one of his principles of biocentrism, "Observers ultimately define the structure of physical reality—of states of matter and spacetime—even if there is a "real world out there" beyond us, whether one of fields, quantum foam, or some other entity (Lanza, Pavsic and Berman 2020, 177)." Appendix 3 of the book is titled, *Observers define the structure of the Universe*. The non-technical portion is three pages. The technical portion is twenty-seven pages of fine print filled with explanations, equations, and references (Lanza, Pavsic and Berman 2020, 221 -267)! Substantial thought was put into this theory. It deserves serious consideration.

Another very recent source on the latest thinking in quantum theory is Carlo Rovellis' book, *Helgoland* (Rovelli 2020). It is worth a course study in itself and is beyond the scope of this paper. He explains the evolution of quantum theory from the beginning to current times. His newest concepts summarized, “Rovelli argues that its most unsettling contradictions can be explained by seeing the world as fundamentally made of relations rather that substances. We and everything around us exist only in our interactions with one another. This bold idea suggests new directions for thinking about the structure of reality and even the nature of consciousness (Rovelli 2020, cover).” A section of technical notes and references are also included in his book (Rovelli 2020, 207-221). Note that he, like Robert Lanza, ends up pondering the nature of consciousness!

Chapter 5: Closing Statement

The mysteries of the natural world around us provide limitless opportunities of study for those who are intrigued by them. Several areas have been covered in this paper but they represent only the beginning of what remains to be understood in each.

References

Agency, European Space. 2022. *ESA Bedrest Studies.* Accessed January 26, 2022. https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Bedrest_studies/New_bedrest_adventure_adds_artificial_gravity.

Astrophysics is Awesome. 2020. *Theory of Relativity*. Facebook Photo. August 24, 2020. Accessed January 27, 2022. https://www.facebook.com/search/top?q=astrophysics%20is%20awesome.

Barzilai, Nir. 2020. *Age Later*. New York: St. Martin' Press.

Beuttner, Dan. 2021. *The Blue Zones.* Accessed December 7, 2021. https://www.bluezones.com/.

Bonestell, Chelsey. 1952. *von Brauns Space Station.* NASA/Marshall Space Flight Center, Huntsville, Alabama.

Buetner, Dan. 2008. *The Blue Zones.* Washington D.C.: National Geographic.

Buettner, Dan. 2021. *Blue Zones Project.* Accessed December 7, 2021. https://www.bluezones.com/services/blue-zones-project/.

—. 2015. *The Blue Zones Solution.* Washington D.C.: National Geographic.

Chopra, Deepak. 2009. *Reinventing the Body, Resurrecting the Soul.* New York: Harmony Books.

Dawson, Clinton. 2019. *Epi-Genetics: Nutrition and Exercise.* Biology 601 Research Paper, Saint Cloud State University: Self.

Dawson, Clinton. 2020. *Human Aging-The Latest Research.* Biology 690 Research Paper, Saint Cloud State University: Self.

Dawson, Clinton. 2019. *Investigations into Space Habitats.* Astronomy 600 Research Paper, Saint Cloud State University: Self.

Dawson, Clinton. 2020. *Reduced Gravity Experiment.* Physics 600 Research Paper, Saint Cloud State University: Self.

Dawson, Clinton. 2020. *Reduced Gravity Experiment for the ISS.* Biology 601 Research Paper, Saint Cloud State University: Self.

Dawson, Clinton. 2020. *Time, Space and Gravity-Searching for Answers.* Physics 694 Research Paper, Saint Cloud State University: Self.

Einstein. 2015. *Relativity, The Special and General Theory 100th Aniversary Edition.* Princeton: Princeton University Press.

Globus, Al, and Tom Marotta. 2017. *Space Settlement: An Easier Way.* San Jose: San Jose State University.

Globus, Al, Stephen Covey, and Daniel Faber. 2017. "Space Settlement: An Easier Way." *National Space Society Journal.* July. Accessed September 26, 2021. https://space.nss.org/wp-content/uploads/NSS-JOURNAL-Space-Settlement-An-Easier-Way.pdf.

Greene, Brian. 2020. *Until the End of Time.* New York: Brozoi Books tradmarks of Penguin Random House.

Hall, Theodore W., and Al Globus. 2015. "Space Settlement Population Rotation Tolerance." Universty of Michigan and San Jose State University.

Kaku, Michio. 2021. *The God Equation.* New York: Doubleday.

Karolinska. 2022. *Karolinska Institute a Medical University.* Accessed January 27, 2022. https://ki.se/en.

Lanza, Robert, Matej Pavsic, and Bob Berman. 2020. *The Grand Biocentric Design-How Life Creates Reality*. Dallas: BenBella Books, Inc.

Link, Balaguer, and Goel. 2010. "Cancer Chemoprevention by Diatary Polyphenols: Promising Role for Epigenetics." *Biochemical Pharmacology* 1771-1792.

Lipton, Bruce H. 2015. *The Biology of Belief Tenth Aniversary Edition.* United States, Australia, United Kingdom, India: Hay House, Inc.

Lopez-Otin. 2013. *The Hallmarks of Aging.* Accessed September 11, 2020. http://longevityfacts.com/9-hallmarks-aging-age-explains-hallmark-aging.

Physics-Astronomy Lovers. 2022. *Power of Theories*. Facebook photo. Accessed January 27, 2022. https://www.facebook.com/physicsastronomylovers.

NASA. 2022. Accessed January 26, 2022. https://i.dailymail.co.uk/i/pix/2015/04/08/10/275DE32200000578-3030087-Artificial_gravity_has_been_considered_many_times_before_most_fa-a-42_1428485974890.jpg.

Rovelli, Carlo. 2020. *Helgoland.* New York: Riverhead Books.

—. 2018. *The Order of Time.* Italy: Riverhead Books.

Siegel, Ethan. 2017. *Forbes Science.* June 16. Accessed December 9, 2020. https://www.forbes.com/sites/startswithabang/2017/06/16/how-does-earth-move-through-space-now-we-know-on-every-scale/?sh=215395c4861f.

Sinclair, David A., and Matthew D. LaPlante. 2019. *Livespan Why We Age-And Why We Don't Have To.* New York: Atria Books.

Tyson , Neil DeGrass, and James Trefil. 2021. *Cosmic Inquiries.* Washington D.C.: National Geographic.