The American Institute of Stress

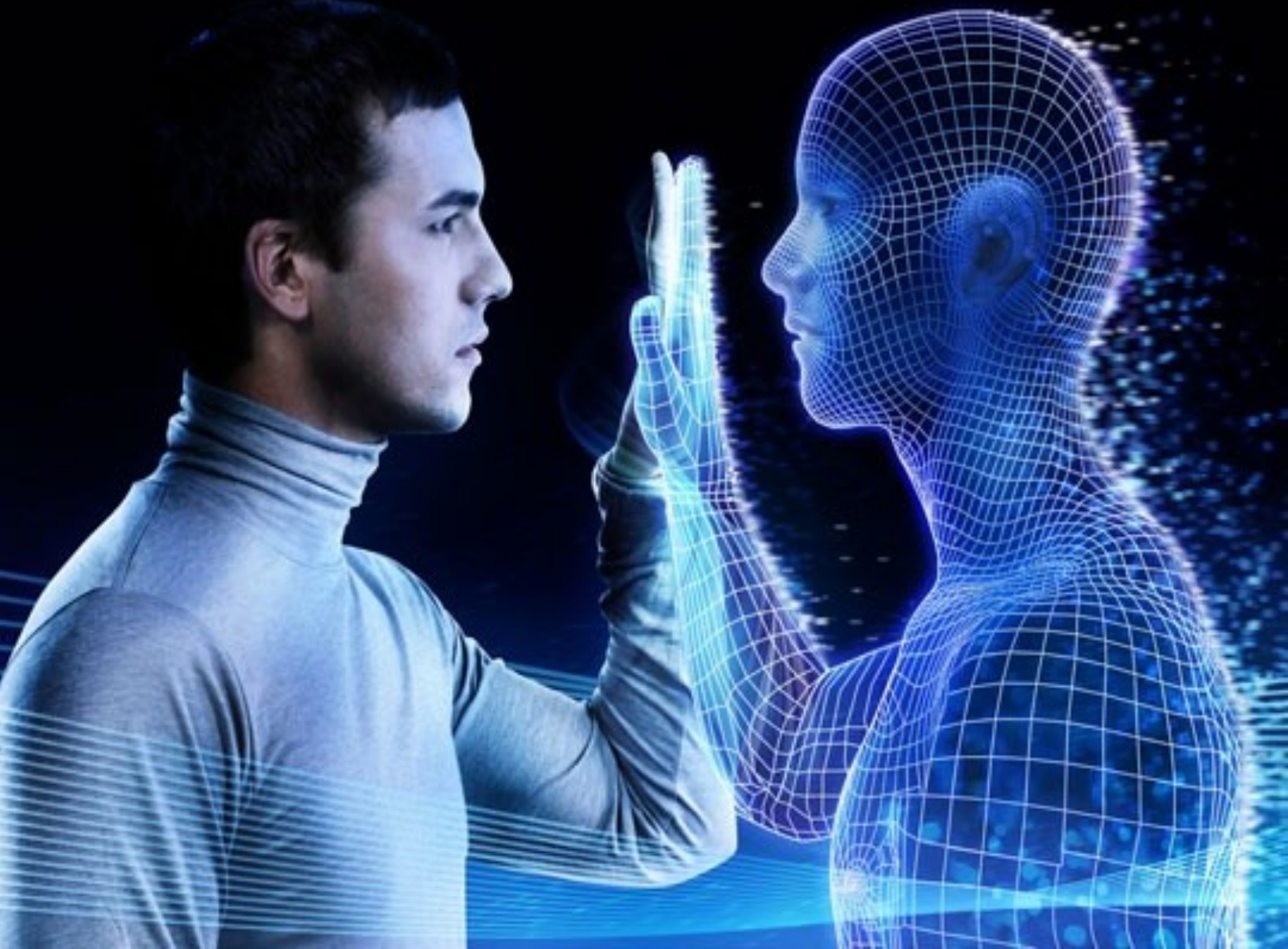
HEALTH AND STRESS

Your source for science-based stress management information

Volume 28 Issue 1 January 2016

Live Long and Prosper...

HOW NEW TECHNOLOGY WILL TRANSFORM OUR LIVES IN 2050



The mission of AIS is to improve the health of the community and the world by setting the standard of excellence of stress management in education, research, clinical care and the workplace. Diverse and inclusive, The American Institute of Stress educates medical practitioners, scientists, health care professionals and the public; conducts research; and provides information, training and techniques to prevent human illness related to stress.

AIS provides a diverse and inclusive environment that fosters intellectual discovery, creates and transmits innovative knowledge, improves human health, and provides leadership to the world on stress related topics.

Your source for science-based stress management information

HEALTH AND STRESS

We value opinions of our readers.

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Health and Stress is a quarterly magazine published in January, April, July and October, designed exclusively for AIS Members. However, it appeals to all those interested in the myriad and complex interrelationships between health and stress because technical jargon is avoided and it is easy to understand. Health and Stress is archived online at stress.org. Past issues can be purchased in the AIS Marketplace. Information in this publication is carefully compiled to ensure accuracy.

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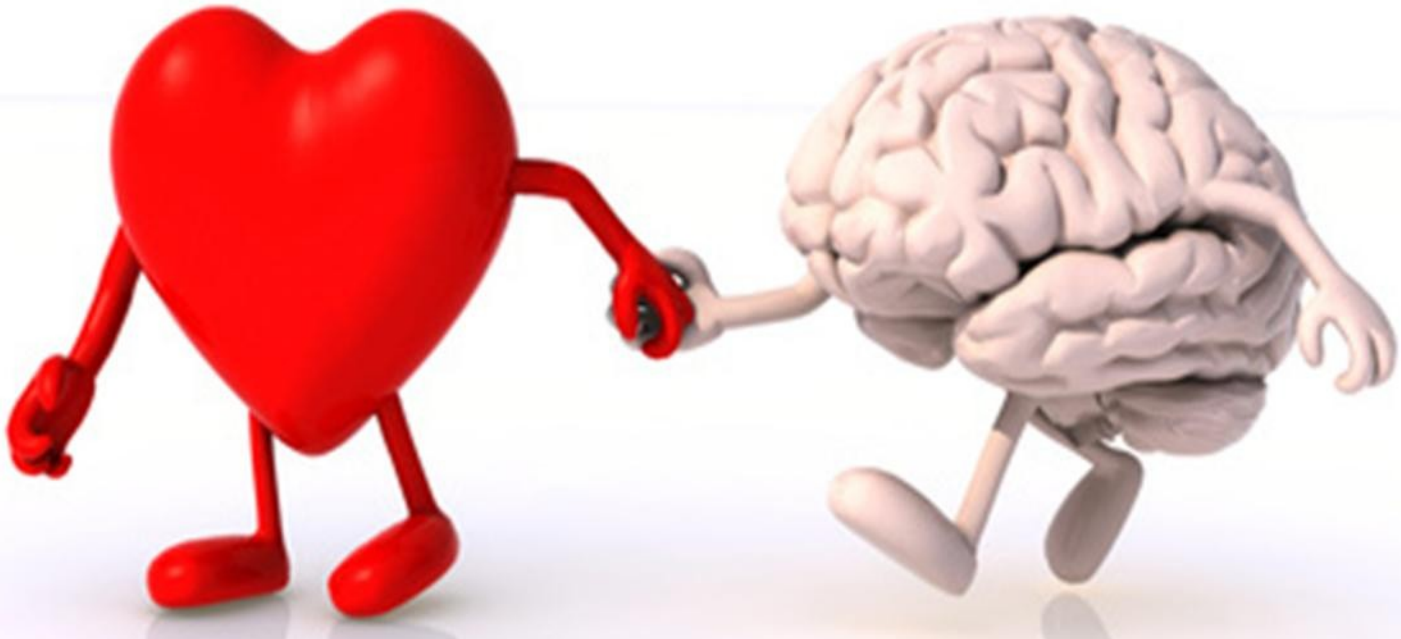

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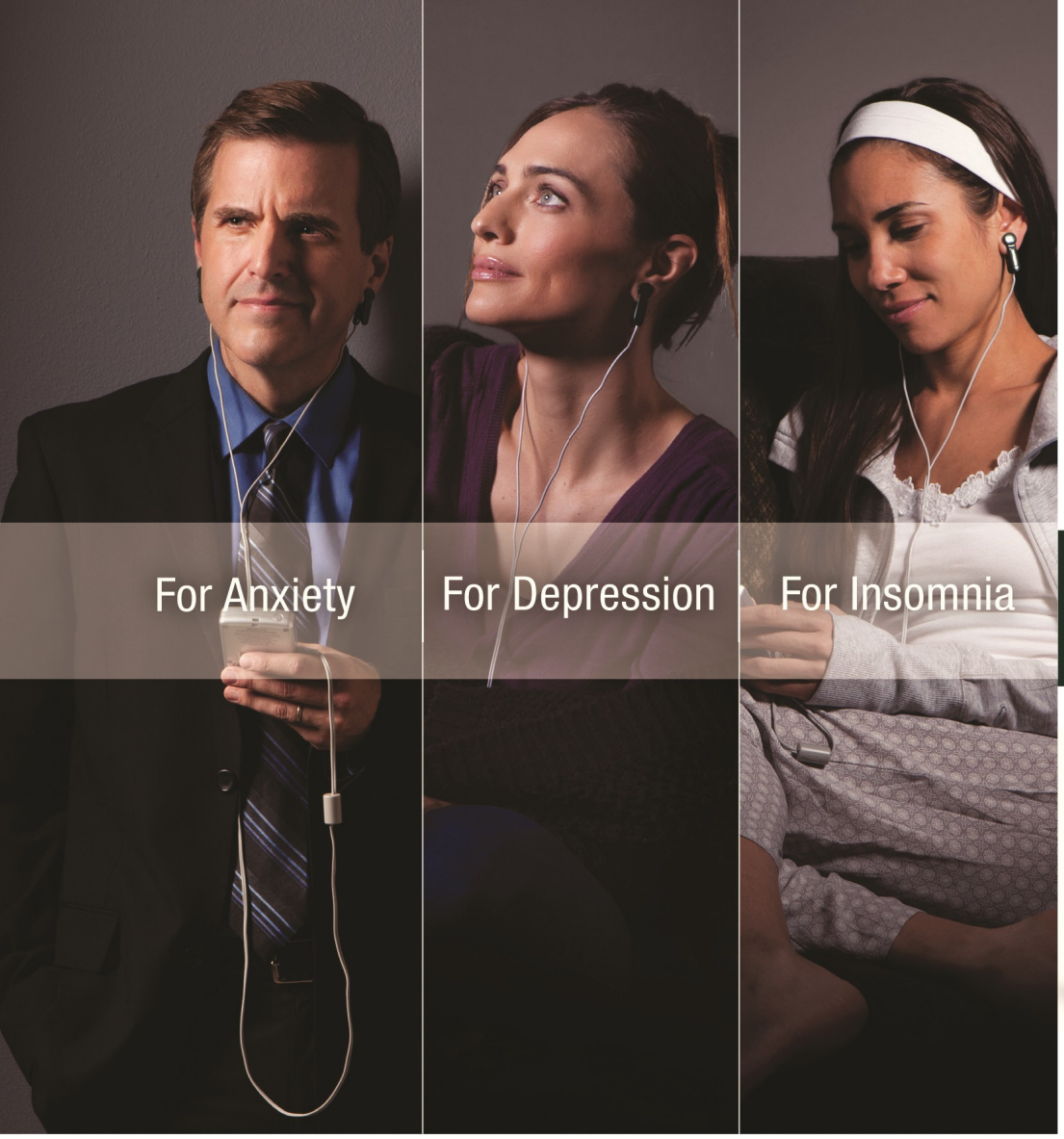

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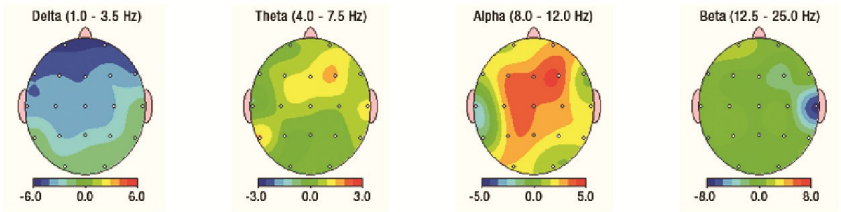

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*Kennerly R. Changes in quantitative EEG and low resolution tomography following cranial electrotherapy stimulation. PhD Dissertation, the University of North Texas. 2006; 529 pp., 81 tables, 233 figures, 171 references.

By Paul J. Rosch, MD, FACP

As illustrated in the last Newsletter, various governmental and other research groups here and abroad have designated 2050 as the year to select when attempting to forecast the future. One UN official explained, "It's a nice round number that's not too near or distant", and since numerous organizations also shifted their predictions to 2050, there is a flood of speculations about what life might be like at the midcentury. Some of these, such as greater longevity, are more accurate than others, since life expectancy has progressively increased over the past 100 years due to improved medical care and a dramatic drop in childhood mortality rates. As previously noted, this has led to an escalating eldercare crisis in the U.S. with serious health, financial and societal ramifications.

The world's population is currently about 7.2 million, and the U.N. predicts there will be closer to 9.6 billion by 2050. Most of this population growth will occur in Africa and poorly developed countries where life expectancy is now less than 50 years but is projected to reach 66 by 2050. India will have the largest population (1.6 billion) and although it will retain a Hindu majority, it will have the largest Muslim population of any country. Muslims will constitute 10% of the population of Europe and Nigeria, which is now 50% Muslim, will have a higher percentage, as well as more people than the United States. The reason for this is that the world's population is expected to grow by 35% in 2050, but Muslims are projected to increase 73% because of higher birth rates and a lower average

age. The number of U.S. Muslims is expected to triple by 2050 from 2.77 million to 8.1 million, replacing Judaism as the second largest religious group.

The U.S. population is expected to increase from 319 million to 401 million in 2050, and super seniors (80 and over) will continue to be the fastest growing age group. The number of centenarians increased 65% from 1980 to 2010 and is projected to rise even more rapidly over the next few decades. The vast majority are Caucasian women and some have speculated that up to half of girls born today could live to 100.

Everyone Wants To Live Longer, But No One Wants To Grow Old

As also previously emphasized, the current focus is on increasing longevity while avoiding or delaying the stigmata of biological aging. Most Americans doubt this is feasible, and according to a Pew Research Center survey, the majority don't seek to live much longer than their current life expectancy, which averages about 79 years. These negative views may be due to greater exposure to the very elderly with chronic age related disabilities that seriously impair their quality of life and concerns that advances in medicine will merely prolong these rather than halt or even slow the inevitable decline in health. The survey of some 2,000 American adults also revealed that others had surprisingly optimistic opinions that were not justified. One in four thought it was likely that by 2050, just 35 years from now, "the average person in the U.S. will live to be at least 120", 69 % looked forward to "a cure for most forms of cancer" and 71 % to "artificial arms and legs that perform better than natural ones." This is due to advertising hype by pharmaceutical and medical device manufacturers and repeated media reports of sensational medical breakthroughs.

Some enthusiasts like Ted Williams, the legendary baseball star, have opted to undergo cryonic preservation by immersion of their brain and/or body in liquid nitrogen at minus 196° C. as soon as they are declared dead. They believe that technologic advances will allow them to be resuscitated when a cure for their illness is discovered, similar to Woody Allen in The Sleeper. The Cryonics Institute in Michigan has over 100 people in "cryonic suspension" at its facility. Its minimum fee for cryopreservation is $28,000 but there are additional costs for

Baseball hall of fame Ted William's remains are stored at ALCOR in Scottsdale, Arizona.

preparing and transferring the corpse. Alcor in Arizona charges $80,000 for "neurocryopreservation" (the head only) and $200,000 for the whole body but this includes all costs and perpetual maintenance. KrioRus, a Russian company, offers a service starting at $12,000 although since it is based in Moscow its services to foreign clients are "more complicated and expensive". Cryopreservation can be covered by special insurance policies that cost $40 to $60/ month depending on health and age but premiums can increase each year in line with inflation.

However, the majority of people surveyed said that "even if new medical treatments slow the aging process and allow the average person to live decades longer, to at least 120 years old", it would "strain our resources and be a bad thing for society." Sixty-eight percent think that "most people would want these medical treatments," but when asked whether they would personally want such treatments, 56% said they wouldn't. Many who were wealthy and could afford any therapy or had faith in an afterlife had no desire to postpone their death. The percentage was even higher in people who don't have faith in heaven, hell, purgatory, limbo or reincarnation. As one commentator wrote, "The prevailing view seems to be that everybody else wants to live forever, but not me." An interesting finding was that the older the respondent, the less likely they were to favor life extension. Those aged 18 to 29 were closely divided since 48 % said that living to 120 would be good for society. This dropped to 46 % for ages 30 to 49, 37 % for the 50 to 64 age group and only 31 % for those 65 and older. When asked how long they would like to live, fewer than 10% chose 100 or older and only 20% wanted to live into their 90s. Only 32% wanted to live into their 80s but almost as many didn't want to make it past 80.

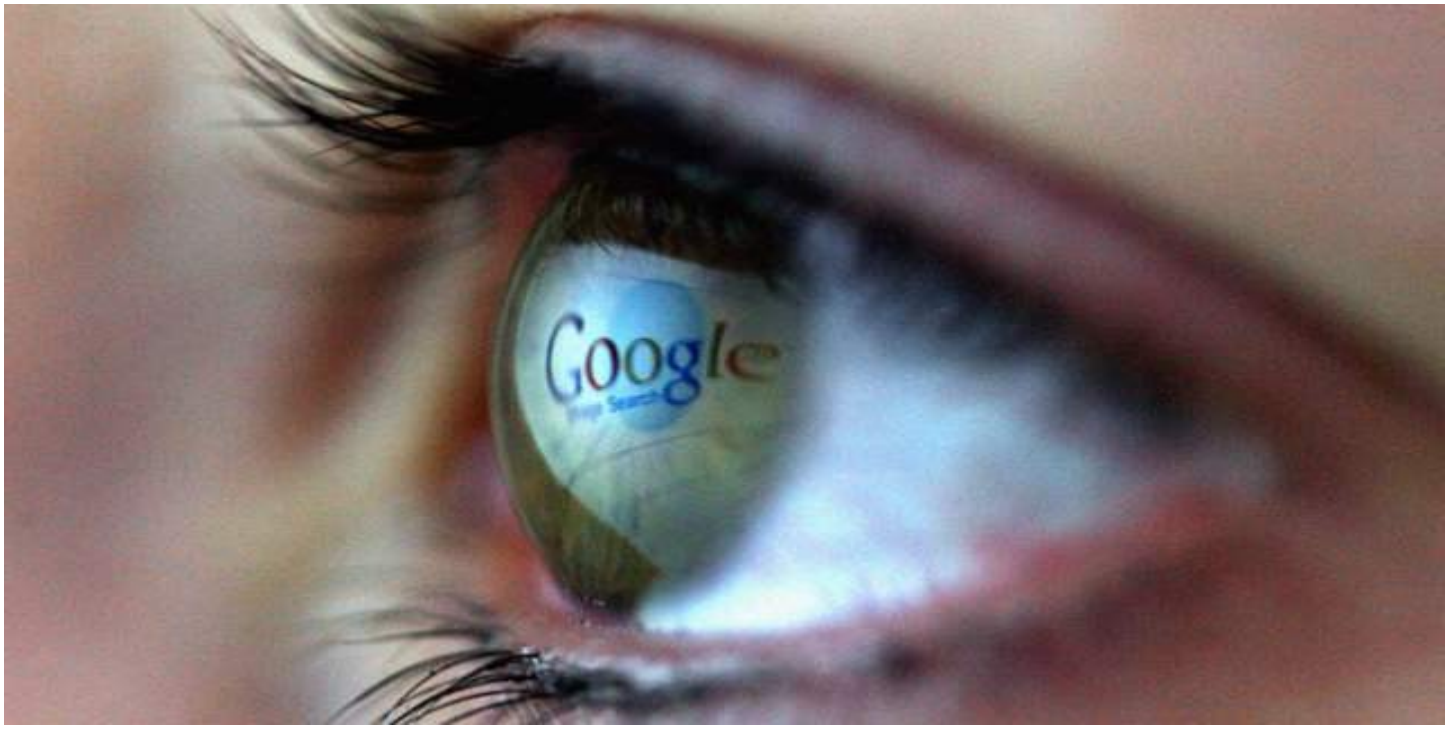
Will Calico And Human Longevity Inc. Change These Negative Opinions?

If rejection of life extension is based on the assumption that these extra years will be frail and uncomfortable, this may change in the near future. Billions are now being spent to prove that advances in medicine will slow the aging process so that the average 90-year-old will feel as good as today's 70-year-old and those who preferred to die at 80 might well want to live to 100. Google's Calico is in the forefront of these efforts, and the 410 billion Internet-search giant is sparing no expense to insure it succeeds. Other companies have focused on specific diseases,

but Calico is targeting the cellular degradation involved in aging that plays a role in most deadly diseases. When Google's CEO, Larry Page, announced the formation of its new subsidiary to combat aging by focusing on "health, wellbeing and longevity", Time magazine summarized its purpose as an attempt to "cure death". That was two years ago, and over the next twelve months, Calico acquired, funded or entered into agreements with over a half dozen leading research groups and companies with expertise in how genetics, molecular biology and drugs affect the aging process. It has also hired eminent authorities who have made significant contributions to these and related or pertinent disciplines.

Calico, which stands for California Life Company, is headed by the legendary Arthur Levinson, who succeeded Steve Jobs as chairman of the board of Apple Inc. He is also the former CEO of Genentech, which creates and develops new medicines for malignancies and other disorders not responsive to current therapies and has received numerous awards for his biotech achievements. As indicated in our last Newsletter, others are also exploring ways to determine the causes of aging. Six months after Calico was inaugurated, Craig Venter announced the formation of Human Longevity Inc. to develop genomic and stem cell therapies that will not only extend lifespans, but insure that these added years are worth living.

Its leadership is equally impressive. Dr. Venter is also a Founder and CEO of the J. Craig Venter Institute, a not-for-profit research organization with approximately 250 scientists and staff dedicated to human, microbial, plant, synthetic and environmental genomic research, and the exploration of social and ethical issues in genomics. Venter spent $100 million to map the human genome in 2000 and later created the first artificial life form.



He accomplished this by utilizing synthetic DNA to generate functional and reproducing microorganisms that manufacture alternative fuels. He believes it will soon be possible to build and activate a synthetic functioning chromosome and two co-founders are assisting him in achieving this and other goals.

One is Dr. Peter H. Diamandis, who serves as Vice Chairman. He is Chairman and CEO of the X PRIZE Foundation, best known for its $10 million Ansari X PRIZE for private spaceflight. Diamandis is a pioneer in innovation and space travel and Co-Founder/Co-Chairman of Planetary Resources, a company designing spacecraft to enable the detection and prospecting of asteroids for precious materials. He is also the Co-Founder of Space Adventures and Zero-Gravity Corporation. In 2014, Fortune Magazine named him one of "The World's 50 Greatest Leaders". He earned an undergraduate degree in Molecular Genetics and a graduate degree in Aerospace Engineering from MIT, and received his M.D. from Harvard Medical School. While in medical school, he co-founded the International Space University and served as its CEO for 2 years. It has now grown into a $30 million university campus headquartered in Strasbourg that offers a Space Studies program and two accredited Master of Space Studies degrees. His 2012 book, Abundance: The Future Is Better Than You Think, explores the potential for exponential technology and other emerging market forces that will significantly raise standards of living within the next 25 years. It was #2 on the New York Times Best Seller List and #1 on the non-fiction best seller lists of Amazon and Barnes and Noble. His 2015 book, Bold: How to Go Big, Create Wealth, and Impact the World also made the New York Times and other best seller lists.

Robert Hariri, MD. Ph.D., the third co-founder, is a neurosurgeon who pioneered the use of stem cells to treat a variety of life threatening diseases and is President of Human Longevity Cellular Therapeutics. Hariri founded and is CEO of Celgene Cellular Therapeutics, one of the world's largest human cellular therapeutics companies. He also founded and is Chairman of Myos Corporation, which develops products that improve muscle health and function. He has received numerous awards for his discovery of pluripotent stem cells from the placenta and delineating the function of tumor necrosis factor (TNF), and authored over 100 papers and 90 patents. Human Longevity has assembled a team of machine–learning experts in Silicon Valley led by the creator of Google Translate, to build models that can predict health risks and traits from a person's genes. The company already has the world's largest DNA -sequencing lab and plans to collect one million genomes in the next few years to create a gigantic database of DNA and medical records.

Preliminary studies suggest it can even predict what people will look like in the future based on facial recognition data and genomic analysis. Last October, it opened its first Health Nucleus program at its La Jolla headquarters, that will offer a full genome analysis, measurements of over a thousand body chemicals, quantitative MRI brain volume and advanced

body imaging analysis, monitoring of sleep, cardiovascular function and body composition, ProKinetic gait assessment and other sophisticated tests that could provide insights into the aging process. The results will be analyzed and coordinated by a team of experts who will decide on what recommendations should be made and what follow-up is advisable. Priced at around $25,000, it is targeted to self-insured athletes, executives and celebrities who would also become part of the database and receive constant updates as discoveries are made.

More Health Nucleus facilities are slated to open in 2016 in other US and foreign cities but the company is also bringing genome analysis to the general public. It has arranged with one health insurance company that has 4 million subscribers to make its genome service available as part of an optional wellness program for $250, but the client will only have to pay $125. Gene data would be returned to doctors or genetic counselors, not directly to individuals, who will receive a comprehensive report detailing their risks for specific diseases and potential strategies to reduce those risks. The data collected, called an "exome," is about 2% of the genome, but includes nearly all the genes that increase risk for cardiovascular disease, and malignancies such as the BRCAs for breast cancer as well as APC and other genes for colorectal cancer. The cost for a BRCA test ranges from $400 to $4,000 but colorectal cancer genetic screening can be more expensive.

Some companies are also offering employees free or subsidized tests for genetic markers associated with metabolism, weight gain and overeating, while others like Visa, Slack Technologies and Instacart recently began offering workers subsidized tests for genetic mutations linked to breast and ovarian cancer. A study monitoring over 200,000 women for 14 years just reported that genetic testing reduced ovarian cancer death rates by 20 %. Screening for genetic markers linked to obesity is also increasing because of the potential to prevent or reduce Type 2 diabetes, heart attack and stroke. These and other obesity associated disorders are responsible for a large share of healthcare costs now estimated to be $12,000/worker annually.

Ray Kurzweil And Could New Technology Allow Us To Live Forever?

Calico has already hired Ray Kurzweil, a celebrated futurist, computer scientist and inventor as a consultant. Kurzweil, who is 67, decided decades ago that he didn't have to die, and has been working feverishly since then to achieve this goal. As Google's Director of Engineering, he heads a team of artificial intelligence experts in a project called "Google Brain" that includes teaching machines to understand language and somewhat dovetails with his plans to cheat death. His father was a noted conductor and musician, his mother was a visual artist and Kurzweil decided he wanted to be an inventor at the age of five. Two years later he built a robotic puppet theater and robotic game and was constructing computerized devices by the time he was twelve. He wrote a paper detailing his theory of how the neocortex operated at the age of fourteen and in 1963, one year later, finished his first complete

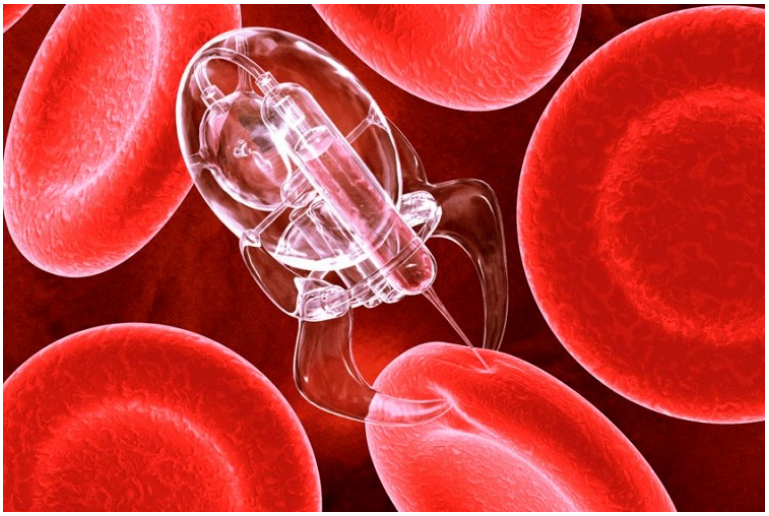
computer program. Since then, his numerous inventions include the first flatbed scanner, the first omni-font optical character recognition program, the first print-to-speech reading machine for the blind, the first commercial text-to-speech synthesizer, the Kurzweil K250 music synthesizer capable of simulating the sound of the grand piano and other orchestral instruments, and the first commercially marketed large-vocabulary speech recognition.

The Wall Street Journal described him as "the restless genius" and "the ultimate thinking machine", Forbes magazine ranked him #8 among entrepreneurs in the United States, and called him the "rightful heir to Thomas Edison." PBS also selected Kurzweil as one of 16 "revolutionaries who made America," along with other inventors of the past two centuries. He is the recipient of 20 honorary doctorates and numerous awards including honors from 3 U.S. Presidents. More importantly, he has a 30-year track record of accurate predictions, even though many seemed outlandish at the time, such as his late 1980 prophecy that a computer would win the world chess championship by 2000. In 1999 he predicted self-driving cars as well as continuous speech recognition, and we now have Google's driverless car and Apple's Siri, which stands for Speech Interpretation and Recognition Interface. (In Norwegian, "siri" also means beautiful woman who leads you to victory", which may explain why Siri's voice is usually female.)

Kurzweil believes in what has been called the "singularity", a point at which machines will become as intelligent humans, and subsequently much more intelligent. He predicts that by 2045, computing will be somewhere in the neighborhood of one billion times as powerful as all the human brains on earth. However, this is not threatening, because by then, computers will probably be part of us. Smartphones are already becoming extensions of our minds and he believes that we will soon be implanting computers and nanobots in our bodies and brains to enhance their natural function. A nanobot is a minuscule robot made from DNA strands that has a specific task and lasts forever since it is self-replicating. In addition, the resulting mechanical and electrical changes occur much more rapidly than larger

counterparts because nanobots function at a molecular level. We have gone from computers the size of houses to devices that fit onto the frame of a pair of glasses and Kurzweil points out that one scientist has already cured Type I diabetes in rats with a nanobot the size of a red blood cell. He predicts that by the 2030s we'll be putting nanobots inside our bodies to augment our immune system's ability to eradicate different diseases.

Others have implanted brain-computer interfaces in completely paralyzed and uncommunicative patients that allow them to turn a switch on and off or move a cursor on a computer screen up and down merely by their thoughts. One learned to speak simple words and sentences using electrodes implanted at specific speech motor cortex sites that transmit wireless signals to a speech synthesizer. Plans are underway to see if implanting electrodes in other locations might restore motion to paralyzed extremities. Facebook recently reported it had developed an algorithm to allow computers describe images to blind people, Microsoft showed off a new Skype system that can automatically translate from one language to another and IBM singled out artificial intelligence as one of its greatest potential growth areas.



Kurzweil predicts that by 2045, machines will be so sophisticated that we will be able to back up our minds to the cloud, where constantly updated contents will be permanently preserved and available to anyone. And this stored material will be much more than facts, figures, pictures and memories, as it will also include our intelligence, creativity, ability to love and spiritual components. He believes that as humans evolve, they become more intelligent, creative and loving in an effort to achieve godlike qualities. When asked if he believed in God, his response was "Not Yet". Although born to secular Jewish parents who had emigrated from Austria just before the onset of World War II, Kurzweil was exposed to and studied several religious faiths during his upbringing, and is now an agnostic with neither faith nor disbelief in God. He pointed out that all religions seem to agree that God represents an infinite amount of memory, intelligence, creativity, love, and the highest achievements the neocortex is capable of. He believes in the potential of humans to achieve more of these godlike attributes due to technological evolution, which is now 1 million times faster than biological evolution. However, unlike God, we will never become infinite.

With respect to his own attempts to achieve immortality, Kurzweil stated he had no health concerns until he was 35, when it was discovered he had an

early form of type 2 diabetes, a risk factor for heart disease. He combed the literature to identify anything associated with diabetes and longevity and developed an extreme regimen that included hundreds of pills, red wine, intravenous chemicals and other therapies. He found a doctor who supported his unconventional views, and was ingesting "250 supplements, 8 to 10 glasses of alkaline water and 10 cups of green tea" daily, and drinking several glasses of red wine a week" in an attempt to "reprogram" his biochemistry. More recently, the number of supplements has been reduced to 150 daily and his attitude appears to be if it can't hurt and might help, why not try it. He has also signed up to be cryopreserved by Alcor. Even if these measures are ineffective, he believes technology will allow our minds to be preserved, thus making part of us immortal.

Artificial Intelligence, Epigenetics, Pharmacogenomics, CRISPR And Cas9

Kurzweil agrees that there are numerous questions about the pros and cons of artificial intelligence and he enumerated some of these a few weeks ago at the Nobel Prize Awards. Every year, the Nobel Prize Committee selects a theme of interest to the world on the state of science in different arenas. This year's theme was the future of intelligence, with a focus on different technologies that are changing our ability to see and comprehend large sets of information and create computer systems that might reach or exceed human levels of thinking. Kurzweil, who believes this process is accelerating, was chosen to give the keynote address. Some of the questions he asked and topics that were discussed in various related panels included:

- When will artificial intelligence exceed human intelligence
- Are fears of super-intelligent systems justified
- Does our developing relationship with technology change our brains
- How well do we understand the basis of human intelligence
- What are the economic consequences of increasingly intelligent systems
- What role will creativity have in the future
- Who will benefit and who will lose out
- What is the link between technology, education and inequality
- What will humans do when robots take over even more of our roles
- How can society best prepare for the changes ahead
- What should we learn in the future
- How will learning change in the decades ahead

For those who fear that artificial intelligence could eventually control everything, Kurzweil believes we have a moral imperative to keep developing this technology while minimizing any potential dangers, stating:

As I wrote starting 20 years ago, technology is a double-edged sword. Fire kept us warm and cooked our food but also burnt down our houses. Every technology has had its promise and peril. It's not us versus them. We've created these tools to overcome our limitations, and we've integrated with them already. Artificial intelligence today is not in three or four dark federal intelligence agencies; it's in billions of mobile devices around the world.

Incredible advances in our understanding

of how genetic diseases are inherited and how these can be prevented or treated are also attracting increased controversy. Humans have 46 chromosomes studded with hundreds or thousands of genes that are DNA segments carrying the code used to synthesize a particular protein. These 46 chromosomes contain all the instructions needed to recreate and maintain the organism, and since they are present in the nucleus of every cell in the body, represent a genome. Our genome is actually 23 pairs of chromosomes, 22 of which carry genes for the same traits, with one coming from the mother and the other from the father. The 23rd chromosome is different, since it determines our gender. Males have an X and a Y chromosome whereas females have 2 X chromosomes. Every female gets one X chromosome from her mother and one X from her father. Every male gets an X chromosome from his mother but a Y from his father. Genetic diseases as well as certain physical characteristics occur when there is a mutated gene that is passed down to the offspring, but the likelihood of this depends on whether the gene is "dominant" or "recessive." These terms were coined by the 19th century Austrian monk Gregor Mendel, who cross-fertilized pea plants that had opposite characteristics—tall with short, smooth with wrinkled, those containing green seeds with those containing yellow seeds, etc. Mendel discovered that inherited characteristics could be predicted depending on which gene was dominant or stronger. With seed color, he showed that when a yellow pea and a green pea were bred together their offspring plant was always yellow. However, in the next generation of plants, the green peas reappeared at a ratio of 1:3. In this example, yellow peas were dominant and green peas were recessive. He published his work in 1866, demonstrating the actions of invisible "factors" now called genes in providing visible traits in predictable ways. At the time, it was generally accepted that the hereditary traits of the offspring of any species were merely the diluted blending of whatever traits were present in the "parents", and that over generations, a hybrid would revert to its original form, implying that that a hybrid could not create new forms. Mendel, who cultivated and tested some 30,000 pea plants and followed successive generations for 8 years, disproved these beliefs.

He also proposed that all living things had similar traits. In humans, blue eyes are usually recessive and brown eyes tend to be dominant but it took three decades for his contributions to be fully recognized. Scientists now use the term autosomal dominant pattern to indicate that the genetic mutation is on an autosome, a chromosome that is not an X or a Y, and that the condition can occur if only one of the two paired autosomes carries the mutation. In autosomal dominant disorders, the chance of having an affected child is 50% with each conception. Autosomal recessive conditions require two mutations, one from each parent, to produce a disease, and the likelihood of this is 25% for each pregnancy. If there is only one mutated gene for a disease that requires two, it may remain silent for generations until there is a child with someone who has a mutation in the same autosomal gene. Such individuals are said to be carriers of the disorder and are usually protected from developing it by a normal

corresponding gene on the other chromosome it is paired with.

Genetic diseases due to mutations in genes on the X chromosome are usually inherited in a recessive pattern that affects males more severely than females. That's because females have two X chromosomes, and if there is a mutation in an X-chromosome gene, there is a second, “backup” X chromosome with a normal version of the gene that compensates for this. In contrast, a male only has a Y chromosome paired with his sole X. Females with very mild or no disease symptoms who have one mutated gene on an X chromosome and a normal version of the gene on the other X chromosome are referred to as X-linked carriers. When the mother is a carrier, the chance of having an affected offspring is 50% for each male child and her daughters will be carriers. If the father has the mutation, his sons won’t be affected because they receive only a Y chromosome from him, but girls receive his X chromosome and will also be carriers. Genetic disorders occur when DNA changes and alters genetic instructions. They can also result when errors are made in copying genes, copying is incomplete, or the number of chromosomes is higher or lower than normal.

But it's far more complicated because of environmental influences. Identical twins result when a single egg fertilized by the same sperm splits into two embryos. They will both have the same DNA and blood type, but characteristics such as height, susceptibility to cancer and other diseases can vary due to non-genetic factors such as diet, smoking, exercise, vitamins, other supplements and stress.

Epigenetics (above the gene) the study of the effect of such influences on gene expression, has helped to identify disorders that are more likely due to nurture than nature. Epigenetic actions don't change the actual genetic code but alter its accessibility by attaching chemical groups to or removing them from the DNA. German researchers recently reported that psychological stress accelerates the aging process because of epigenetic changes at binding sites for stress hormone receptors in highly traumatized African Americans. This type of premature "biological" aging has also been shown to increase risk for age related diseases like Alzheimer's, macular degeneration and Type 2 diabetes.

Pharmacogenomics (often called pharmacogenetics) is devoted to understanding how genes affect individual responses to drugs with respect to therapeutic as well as adverse effects. There have been recent dramatic breakthroughs, especially in a gene editing system called CRISPR that makes it possible to edit genomes with unprecedented precision, efficiency, and flexibility. CRISPR is an ancient defense mechanism that was first identified three decades ago when it was noted that some bacterial genomes had a strange pattern in which a DNA sequence would be repeated over and over with unique sequences in between each repeat. They called this odd configuration "clustered regularly interspaced short palindromic repeats," or CRISPR. The significance of this was not appreciated until it was discovered that the unique sequences in between the repeats matched the DNA of specific viruses that prey on bacteria. CRISPR retains snippets of these viruses so it can recognize and pro-

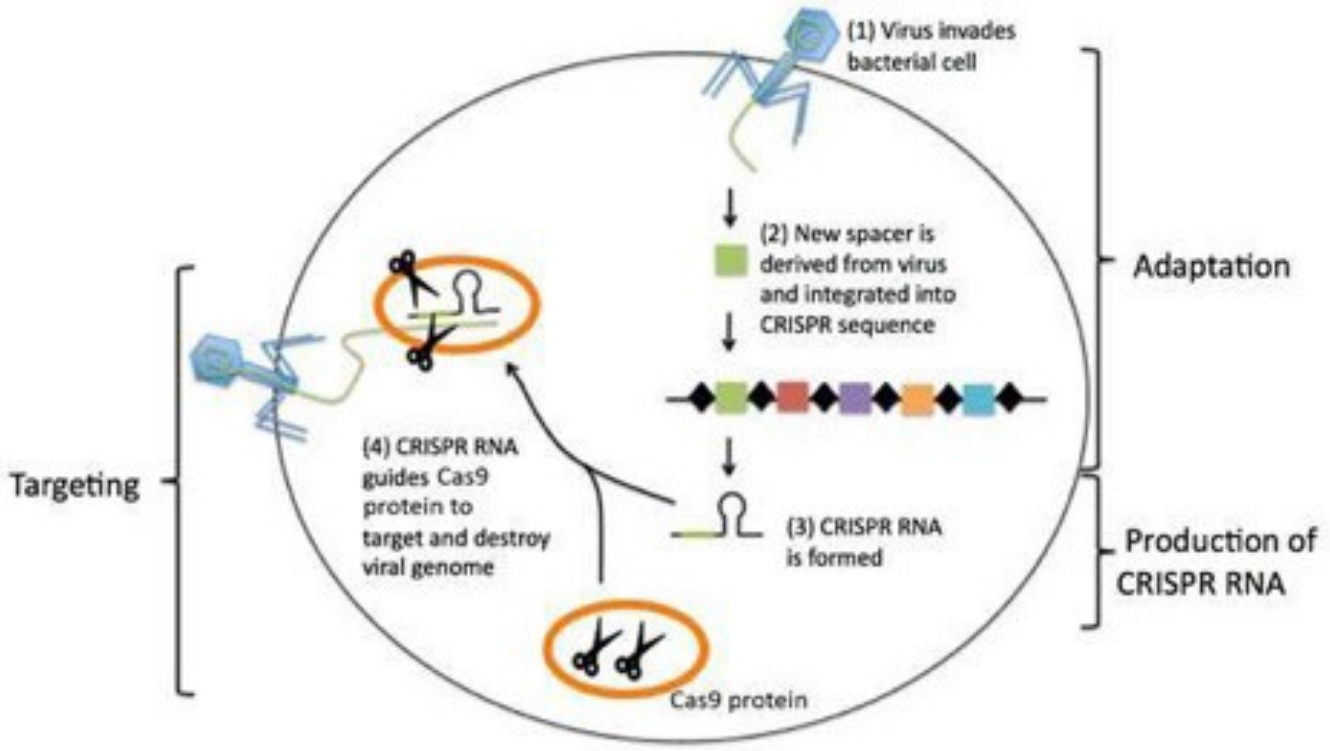
tect itself the next time it is attacked. This battle is waged by a set of enzymes called Cas (CRISPR-associated proteins) that can precisely snip DNA out of invading viruses and inactivate or destroy them. As New York Times science columnist Carl Zimmerman explained,

As the CRISPR region fills with virus DNA, it becomes a molecular mostwanted gallery, representing all the enemies the microbe has encountered. The microbe can then use this viral DNA to turn Cas enzymes into precision-guided weapons. The microbe copies the genetic material in each space into an RNA molecule. Cas enzymes then take up one of the RNA molecules and cradle it. Together, the viral RNA and the Cas enzymes drift through the cell. If they encounter genetic material from a virus that matches the CRISPR RNA, the RNA latches on tightly. The Cas enzymes then chop the DNA in two, preventing the virus from replicating as illustrated below.

CRISPR and Cas9 Mediated Immunity

In the diagram below, CRISPR regions are composed of short DNA repeats (black diamonds) and spacers (color boxes). When a new virus infects the bacterium, a new spacer derived from the virus is incorporated among the existing spacers. The CRISPR sequence is transcribed and processed to generate short CRISPR RNA molecules. The CRISPR RNA associates with and guides bacterial DNA cutting protein (Cas9 protein) to a matching target sequence in the invading virus. The Cas9 protein cuts up and destroys the invading viral genome. (Reproduced with permission from Dr. Mae-Wan Ho from I-SIS website at http://www.i-sis.org.uk/CRISPR_too_fast_for_comfort.php)

Scientists quickly realized that they could also turn these molecules into the genetic equivalent of a global positioning system and learned how to create synthetic versions of the RNA guides and program them to deliver their cargo to virtually any cell. Once the enzyme locks onto the matching DNA sequence, it can cut and paste nucleotides with the precision of a search-



and-replace function of a word processor. The potential for CRISPR technology has precipitated a cascade of experiments that have now transformed genetic research in laboratories all over the world. Oncologists are having a field day, since they already have identified genetic defects that could be corrected for cancer of the breast, ovary, uterus, pancreas, bowel, kidney, thyroid, melanoma and retinoblastoma, as well as a gene believed to be responsible for metastases in breast and certain malignancies.

Other applications being intensively investigated include deleting the HIV virus from patients' cells, eradicating malaria by developing a more powerful strain of mosquitoes that does not carry the Plasmodium parasite, creating a limitless supply of organs for transplants, producing more and superior crops and treating cystic fibrosis and sickle cell anemia. Chinese scientists have already developed gene edited dogs, goats, rabbits and rats, and are working on humans. Some of these studies show that it is possible to delete or disable genes in an embryo, which is more effective and simpler than changing the DNA sequence in only certain cells.

However, like artificial intelligence, some fear that this Pandora's box could also have disastrous effects. The precise effects of genetic modification of an embryo may not be known until long after birth and successive generations have been evaluated. Insuring patient safety is the primary problem and some 40 countries have banned embryo studies. Fifteen of 22 nations in Europe prohibit any modification of the germ line and the NIH’s Recombinant DNA Advisory Committee explicitly states that it "will not at present entertain proposals for germ line alterations." Non-therapeutic genetic enhancement such as creating "designer babies" is also a concern.

To avoid this, some scientists believe it will soon be possible to turn a stem cell into a sperm or egg using CRISPR technology. Such new sperm and egg cells could be joined to create an embryo with the corrected or enhanced genes. Once this has been done with animals, especially primates, it should be achievable in humans. However, as one authority warned, *But at that point you'd want to think long and hard before doing such a thing with humans. 'Can you do it?' is one thing, but then you ask "'Would you do it? Why would you want to do it? What is the purpose?' As scientists we want to know if it's feasible, but then we get into the bigger questions, and it's not a science question, it's a society question.*

We are currently at a crucial point in trying to determine how our genetic editing achievements in the laboratory can best be utilized to prevent and treat a host of diseases without incurring any future adverse consequences.

Although this would lead to longer and healthier lives in the over 85 age group, it would put an additional strain on housing, medical care and other overburdened resources that we must plan for now.

As Winston Churchill noted, "It is always wise to look ahead, but difficult to look further than you can see." Nevertheless, I believe that by 2050, a progressive deterioration in the family as a cohesive unit and other societal stresses will have transformed our lives more than any advances in artificial intelligence and genetics so stay tuned for the next Newsletter!!

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