Quandary - Are Molecularly Manufactured Burgers Imbued with the Life Force?

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Introduction – Humanity's Guiding Spirit

It may be apt to commence with a quote from our book *Nanomedical Device and Systems Design: Challenges, Possibilities, Visions*:

> It would seem that the unfathomable wellsprings of cumulative human imagination, ingenuity, passion, and effort are not subject to any tether or constraint that cannot, over time, be unbound or circumvented.

Since its inception, humanity has been driven by an insatiable curiosity and quest for knowledge, while constantly striving to attain cherished ideals, which encompass innovation, advancement, adventure, freedom, honor, love, and hope. We invariably have a deep desire to challenge ourselves to be the best that we can possibly be, know no bounds and to devise elaborate tools if necessary, to assist us in the attainment of our goals.

Current State of Humanity and Potential Trajectories

We currently find ourselves in the midst of a complex multifaceted convergence of momentous challenges (e.g., a rapidly growing population, the increasingly profound climactic effects such as anthropologically initiated global warming, coupled with strained water, food, and energy resources). These culminate to an overarching question; how will humanity continue to survive and flourish in the face of the many seemingly intractable forces that threaten to severely hobble, or perhaps even extinguish us as a species?

To any objective observer with a historical overview of Earth and its inhabitants, it would seem blatantly evident that at this juncture, humanity is hurtling rapidly along an unsustainable path. One that will inevitably see the depletion of our (once thought) inexhaustible non-renewable fossil fuel resources, combined with ever higher loadings of CO_2 (and other greenhouse gases) resident in the ambient atmosphere, with the consequence of further exacerbating global warming and its cascading negative environmental effects, and associated human tolls. This situation, and its seemingly unavoidable dire consequences, has been poignantly highlighted in a recent report from the U.N. Intergovernmental Panel on Climate Change (IPCC), which states that, for us to stave off some of the more serious global warming threats that "…greenhouse-gas emissions will have to be cut by 40% to 70% compared with 2010 by midcentury, and to near zero by the end of this century." The report also points out that; "Only major institutional and technological change will give a better than even chance that global warming will not exceed this threshold". This "threshold" referred to is a median global temperature increase of "between 2 and 3.2 degrees above preindustrial levels by midcentury." Beyond this threshold we can expect extensive and abrupt "high-impact changes—such as melting of the Greenland ice sheet…" [1, 2].

The authors propose that one of the critical initial prerequisites toward the establishment of a sustainable, clean and flourishing future for humanity relates to our ability to flex beyond our fossil-fuel drenched energy mindset/paradigm toward the robustly expedited development of advanced solar technologies and other environmentally compatible renewable energy sources, via intense collaborative efforts, dedicated focus and allocation of resources. The Institution of Mechanical Engineers, UK, shares its thoughts on the fate of fossil fuels: "There are an estimated 1.3 trillion barrels of proven oil reserve left in the world's major fields, which at present rates of consumption will be sufficient to last 40 years. By 2040, production levels may be down to 15 million barrels per day – around 20% of what we currently consume. It is likely by then that the world's population will be twice as large, and more of it industrialized (and therefore oil dependent)."

When we contrast this (relatively) short lived energy source with its diminishing returns (over time, despite technological advances, it will be less and less cost effective to extract oil from deeper and deeper recesses within the Earth) against the virtually limitless source of solar energy, the correct path appears abundantly obvious and clear. An *EcoWorld Magazine* article offers: "In full sun, you can safely assume about 100 watts of solar energy per square foot. If you assume 12 hours of sun per day, this equates to 438,000 watt-hours per square foot per year. Based on 27,878,400 square feet per square mile, sunlight bestows a whopping 12.2 trillion watt-hours per square mile per year." In terms of the current power draw for individual homes, the US Department of Energy estimates that the average American dwelling consumes 10,837 kWh annually, or 29.7 kWh per day. The highest commercially available (and most expensive) solar cell efficiency presently is ~44.7% (concentrator quadruple junction cell by the Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany). Current nanomaterials based solar cells (silicon nanowires - Bandgap Engineering, Inc., Woburn, MA) that are produced using standard processing technologies, have attained efficiencies of 19%. Researchers at Lund University, Sweden are developing an InP nanowire based solar cell that has strong potential for the attainment of 100% efficiency.

Nanotechnology is defined as the capacity for the controllable manipulation of matter at scales of from 1-100 nm, where materials may exhibit unique and enhanced properties as compared to their bulk counterparts. With the advent of mature nanotechnology we are likely to see the development of molecular manufacturing (MM), through which virtually any consumer item, including foods, smart phones, high efficiency photovoltaic cells, advanced energy storage devices, etc. may be produced from atomic and/or molecular feedstocks on site, in microwave sized MM units (the personal nanofactory as envisaged by Drexler) [3]. Specialized MM systems will also make possible the fabrication of sophisticated autonomous nanomedical devices that have the capacity to address practically every human disease state, including the *disease* of aging. Hence, the authors propose that once these disruptive technologies are manifest, they might serve as catalysts for dramatic positive paradigm shifts that touch practically every facet of human society, at least in terms of physical needs, and that nanotechnology may itself serve as a significant beneficial trajectory for humanity.

Superseding the Doom and Gloom

There is, of course, much more to consider than simply physical needs. Life demands motivated purpose. How will humanity extricate itself from being inundated by, and mired within the negative sensationalist muck that permeates the daily news and myriad hypnotic doomsday scenarios? Has humanity always been so fixated on its own demise? Molly Downs, in an article for *The Skyline View*, explores the roots of this dilemma by initially quoting Dr. Michael Moynihan, Professor of Sociology at Skyline College, who offers his view as to how humanity has contemplated the Apocalypse for millennia: "It often represents a desperate attempt to reestablish order in people's lives and to cling to something that has meaning," Ms. Downs then reflects and concludes: "Why is America obsessed with the Apocalypse? Ironically, we may all have a deep desire to start over, to begin each day as if it were our first, not our last. Don't we always want that second chance and that opportunity to try again? Perhaps the obsession with the Apocalypse is not about endings at all. Perhaps it is, in fact, about beginnings."

Yes!… new beginnings, an unwavering optimistic attitude, imagination and creativity, unceasingly seeking opportunities for advancement, enlightenment, harmony, health, synergy, adventure, fulfillment (happiness), liberating freedom… always love… and that eternally rising brilliantly incandescent core spark of life itself…. "hope". Are not these cherished ideals what all humans within their deepest selves aspire to, and hope for in the lives of others? Can we, as a common species, ever dare "hope" to recreate/reshape our collective world view, global environment, our connection with amazing mother Earth, and our own interrelations so as to manifest them toward an envisaged glorious, peaceful and harmonious reality?

In fact, well acknowledged scientists recommend that it would behoove humanity to strive to dwell in a state that encompasses an unwavering optimistic attitude, positive constructive imagination, and creativity. The emotional environment generated by these positive attitudes has well documented beneficial effects on the biochemical processes of the human body [4]. When the body's own self-healing forces are engaged by positive expectations (e.g., placebo effect) they have strong potential to be as beneficial, or indeed, even more effective than conventional medical treatments [5]. We can anticipate that the biochemistries of belief and hope will be understood more deeply in the future, as ancient spiritual knowledge merges with western science in broadening the focal point of awareness. Continually enhanced highly sensitive measurement techniques are developed to enlarge our view into the molecular, nanometric and quantum domains as they unite to provide a clearer understanding of our biology. In the future, it is likely that we will be better equipped to elucidate the underlying quantum fabric of our consciousness as well as the interconnectedness between the human mind/spirit/essence and the material world [6]. We surmise that the immense power of cumulative optimistic, positive and creative attributes will have the effect of not only creating an increasingly healthy population, but will also spread and be amplified due to the connective nature of consciousness [7].

Nanotechnology and Molecular Manufacturing - Emergence of the Grand Equalizer?

The still nascent discipline of nanotechnology comprises a rapidly evolving and fundamentally disruptive and enabling set of capabilities that have extremely strong prospects for imparting extensive and primarily positive impacts on virtually every sector and aspect of human societal life on a global scale. It involves capacities for the ultrafine controllable manipulation of matter at the atomic and molecular levels toward the fabrication of unique materials, components, devices and systems with novel attributes with dramatically improved performance. As espoused by Eric Drexler in his 1986 book, *Engines of Creation*, and in his latest book, *Radical Abundance*, myriad and significant facets of human society are likely to undergo dramatic paradigm shifts. The prerequisite and prime driver of these possibly dramatic changes will be ushered in with the advent of mature Molecular Manufacturing (MM), which is integrated with advanced Artificial Intelligence (AI).

The rapidly increasing sophistication and popularity of 3D printing that we are currently witnessing might be viewed as an early precursor of envisaged, exponentially more powerful and dynamic MM capabilities. These MM units might initially be manifest as microwave oven-sized "factory-at-home" systems, which would utilize atomic and molecular feedstocks, rather than the primarily polymeric feedstocks that are employed in 3D printers today. The ultrafine positioning of specific molecular and atomic species might enable the cumulative assembly of practically anything we can imagine (e.g., healthy gourmet foods, running shoes, toothbrushes, physician prescribed nanomedical diagnostic or therapeutic devices, photovoltaic cells, smart phones, computers, as well as components for building additional MM units) with atomic/molecular layer by layer precision. The parameters of what might be produced would be limited only by the human imagination, design inputs, and the dimensional constrains of a given MM unit. This will translate to enabling the capacity for the average person to produce practically any type of consumer product.

Issues to be considered here may pertain to who will control the production, supply, distribution and cost of MM “inks” (atomic/molecular feedstock cartridges). It is conceivable that these supplies might also be produced at home/on site by the user via an addition appliance (e.g., dedicated atomic/molecular disassemblers and highly sophisticated recycling and atomic/molecular sortation units, for the sole purpose of generating MM feedstock cartridges). An additional consideration will relate to who will administer and regulate the data that is required to direct what is produced by the MM units (perhaps for the most part, MM software data will be open source, save for highly encrypted files for nanomedical devices that are custom prescribed to align with individual patient requirements, and other items related to national and global security).

When MM evolves to the stage where it becomes available to any practically any individual on the planet, it will undoubtedly translate to dramatic paradigm shifts as relates to conventional manufacturing facilities that generate commercial goods and foods, which will impact retail sectors, transportation infrastructures, energy production and distribution grids, banking and monetary systems, and underlying social constructs. The arrival of MM will likely enable the domestic on-site fabrication of ultrahigh efficiency solar cells, which will translate to a new paradigm of decentralized energy self-sufficiency. When coupled with considerable anticipated

improvements in other renewable energies, such as wind, wave, geothermal, energy storage, ubiquitous piezo energy harvesting (e.g., via integrated zinc oxide nanowire arrays), and factors such as enhancements in the electronic efficiencies of domestic, commercial and industrial heating, cooling, appliances, etc., humanity's reliance on fossil fuels is likely to undergo a dramatic reduction. Hence, for the most part, every dwelling, which in the future might conceivably themselves be fabricated on site via multiple specialized MM systems, worldwide would be off grid. This considerable paradigm shift, though somewhat unthinkable at present, could invariably lead to progressively diminished requirements for centralized energy grids, thus they might come to be considered as icons of an earlier era, and relegated to obsolescence.

A critical question to explore in regard to MM will relate to how we can failsafe MM units to prevent their malicious use. This possibility might be addressed via inbuilt programming that would intuitively establish parameters on exactly what can be made; with a default dwell mode status being engaged should these parameters be exceeded. That said, if humanity is empowered with the ability to fabricate and possess practically any material object that they desire, would this translate to the absence of discontent on a global scale, when humans eventually; ideally, arrive at a place where there are no longer any marginalized victims? If all of humanity could be endowed with optimally healthy bodies and selectively lengthy lifespans, would we finally be fulfilled and truly happy? These are important questions. In essence, for the human species and all of its current constructs, nanotechnology may indeed be raised to attain the status of the "grand equalizer".

How will we relate these tenets to the impoverished, marginalized and suffering in the world, where currently, at least 80% of humanity lives on less than $10 a day? If we posit that nanotech might serve as the grand equalizer for humanity as far as the provision of all manner of consumer goods, and that nanomedicine may have the capacity for making each of us robustly healthy, the logical first step will be to assist the majority of humanity, to significantly raise their standards of living, with the aim of attaining a human equilibrium; an even playing field. This will also serve to exponentially augment humanity's collective intellectual resources, which may be applied to the resolution of serious challenges beyond those associated with climate change (e.g., development of human undersea habitats to facilitate housing for increasing populations, advance space travel and the colonization of other planets, address multiple issues brought on by the capacity for dramatically increased longevity).

Nanomedicine and Energy Fields - Radical Paradigm Shifts in Global Healthcare

There is a potent and rapidly increasing drive toward the development of smaller (less invasive), smarter, more efficacious and cost effective medical diagnostics and therapeutics. These trends are evolving in conjunction with the emergence of what may currently be considered as alternative diagnostics and therapeutics, such as the manipulation of energy fields that are associated with the human body, and indeed permeate and intimately connect us with the universe. The nascent discipline of nanomedicine holds great potential for the development of advanced medical procedures that may, in the not too distant future, negate the requirement of invasive surgeries, eradicate practically every disease state and condition brought on by pathogens, toxins or microorganisms, and finally conquer the *disease* of aging.

Aubrey de Grey (Chairman and Chief Science Officer of the Methuselah Foundation and Editor-in-Chief of the high-impact journal Rejuvenation Research) proposes that within 25 years it may be possible, through various rejuvenative strategies, for humans to live to 1,000 years of age.….should they wish to. These approaches might include the eradication of lipofuscin from the lysosomes ("garbage disposal" organelles) of human cells. Lipofuscin accumulates over time within cells to the point that it can begin to negatively impact the proper functionality of non-dividing cells (e.g., brain, liver, kidney, heart muscle, adrenals, eyes, nerve cells), and is associated with a range of age related conditions. Thus, if lipofuscin can be efficaciously extricated from these cells it may (hypothetically) have the effect of revitalizing them, with potentially significant beneficial health effects [8].

Though it may sound somewhat naïve or utopianist, the authors envisage that advanced nanomedicine might serve as a beneficial and benevolent facilitator toward the eventual attainment of health care homeostasis/equilibrium globally; enabling access to beneficial advanced medical technologies for those in remote regions and the developing world, while significantly reducing medical expenditures in the developed world. These considerable savings might be reallocated, for instance, to further advancing and expediting clean and renewable energy harvesting/generation technologies and water purification/seawater desalination technologies for the large scale provision of clean potable water, which will be increasingly precious and in high demand.

A prudent developmental strategy for nanomedicine might involve the establishment of stringent standardized protocols to ensure the safe development of nanomedical components, devices, and systems, validation of their robust efficacy, and the assurance of appropriate post-use trajectories (e.g., capacity for complete recyclability or biodegradability, benign environmental fates). This would require that nanomedical components and devices be comprised of non-toxic nanometric elements from their inception. A critical element in all of this would be the establishment of genuine transparencies and interactivity, initiated and conveyed by those who are engaged in the development of these nanotechnologies and nanomedicines, as relates to the general public. After all, we will all be in this together.

On another front, we can expect the development of ever faster and more sensitive measurement techniques to assist us in deciphering the kinetics and connectivities that are inherent to nanoscale and quantum domains, and how they relate to the macroworld. Indeed, various aspects of diverse research fields have already been understood in minute detail. Examples may be found in particle physics: Higgs Boson [9], which will help us to elucidate and understand, among other of our deep queries; the origin of mass, and the nature of dark matter and dark energy [10]. In terms of structural biology, a milestone has been recently achieved toward deciphering the extremely complex protein units of the yeast mitochondrial large ribosomal subunit, at the atomic level, utilizing electron microscope detectors with unprecedented speed and sensitivity [11]. In the realm of biophysics, we are learning to decode energetic forces and pervasive, albeit subtle energy fields at subatomic levels. At this juncture, interdisciplinary cross-pollination has not yet been optimized, given the complexity of each area in conjunction with the different personalities involved who may set a certain breath of focus as relates to their particular area of research. However, as cross communication between these

fields' continues to increase, a cumulative effect can be expected that may abruptly and exponentially enhance integrative knowledge between these disciplines.

Concomitant with our increased knowledge of how to create at the nanoscale will arise an exponentially deeper understanding of our own highly complex physiological processes. Hence, more symbiotic and holistic approaches to medicine will also accelerate toward continually less invasive procedures. An excellent illustration of a symbiotic approach that harnesses the body's own functions utilized nanotechnology fused with cell biology in the visionary work of Spatz who employed gold nanoparticles to "train" human immune cells outside the body to boost the immune system when the now specifically trained immune cells were introduced back into the human host [12].

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The potential plethora of MM foods may hold great promise in the provision of optimal sustenance for immense human populations who are yet to come (the UN estimates that by 2075 the global population will peak at 9.25 billion, and will level off at ~8.97 billion by 2300) [13], as the precise control of food constituents will be possible. With our growing molecular scale understanding of food ingredients and food related biochemistries, specific beneficial biological molecular level food compounding will be standardized. Thus MM is likely to replace high volumes of low quality processed food items, which may contain large amounts of unhealthy "unidentified edible objects" which are under increasingly intense scrutiny by a rapidly expanding health conscious population. MM may also offer an alternative to meat products that are derived from animals that are kept under unacceptable conditions, and/or have been fed or treated with ingredients that might compromise human health. The analytical aspect of MM foods may also spur the development of accompanying technologies that would enable the consumer to custom-generate unique food items via health optimizing or enhanced molecular "recipes" to align precisely with an individual's body requirements.

The prospect, however, of replacing a "natural" grass-fed free range bison burger with a MM "artificial" meat item may elicit, for many people (not only gourmets) a wincing feeling that… "*something* is just not right." Might this reaction be a reminiscence of the life force that is innate to all living things? Would we be missing a most critical aspect of food? We have proven to get by without the traditional honoring of the spirit of the buffalo (integration or transference of their strength and wisdom), which was celebrated by early Native Americans, in our model bison burger. Even if molecular food fabrication succeeds in replicating the identical compositions and chemistries of essential food ingredients; amino acids, proteins, fats, etc., atom by atom, and succeeds in fusing them into a digestible food item, is the energetic imprint of the life force something that is essential for our health and quantifiable; playing a vital role in sustaining our own life force; an aspect which is yet to be understood? May this aspect be considered as being transferable via constituent "live" atomic/molecular feedstocks, by virtue of integrated "living" electrons and underlying quantum energies? Measurements of the energy fields in plants and humans is of growing interest as we begin to understand the subtle yet ubiquitous interconnectedness between these energetic fields within and between organisms, and acknowledge their importance in sustaining health. Advances in this field likely will enhance

our knowledge as relates to the importance of the energetic profiles of food and biochemistry, which may lead to not only physically and chemically, but also energetically precise biomimetic MM.

Integration of the 10 Billion Synapse World Mind

Humans have an innately deep seated need for communication, which is the prime driver of the increasing globalization that we are witnessing today, facilitated in no small measure by mobile phones and the internet. There are currently more than one billion smart phones in use [14], while the number of mobile phones is set to outpace the human population, to 7.3 billion by 2014 [15]. These technologies have enabled us to communicate with others in the most far flung regions on Earth. We propose that nanotechnology will take this massive human dialogue to unprecedented levels. Nanotechnology enabled MM, in conjunction with advanced AI, will likely enable the transition from our use of extraneous devices to those that are integrated directly with our brains via imperceptible nanomedical implants. In essence, these embedded "nanonetworks" may serve as wireless interfacial conduits to an omnipresent Internet [16], which may also have (optional) direct links to our optic nerves and other senses. This would give us the capacity, if we so desire, to experience fully immersive stories, movies, or indeed, if consent and access is granted by other parties, segments of the lives of any individual on the planet, via non-intrusive "transparent shadowing", where one would "plug in" to another person's experiences. This would take human collaboration and empathy to unprecedented levels, as one might literally walk in someone else's shoes and directly "sample" their experiences. The proviso here would be that the thoughts/emotions of the "host" would remain completely private and inaccessible.

Conclusion - Humanity's Guiding Spirit

It seems appropriate to conclude with a final quote from our book as well:

> In the larger frame, we live day-to-day on our miraculous and beautiful blue world (at times oblivious to the overwhelming odds for us not existing at all) in the midst of the deep and inconceivably vast expanse of darkness speckled with trillions of stars. Where do our boundaries lie? It may be suggested that any constraint imposed upon the human imagination and the extent to which we may explore and advance within ourselves and into the without, are entirely self-imposed.

The title of our essay pertains to a central and critical question, with the proviso that nanotechnology and AI driven MM will indeed come to fruition, of whether humanity will ultimately reject or embrace these advanced technologies in the interests of cumulative survival and the creation of a vibrant, healthy, creative, and fulfilled humanity. When we consider that an extensive variety of conventional food items, including non-animal derived "meats" (the "blueprints" of which would be meticulously derived from "real" foods and optimized for nutritional value and discerning tastes) might be readily available to virtually every individual on the planet via MM, this in itself is likely to convey dramatic positive impacts toward a sustainable and flourishing human future. However, will they be accepted by humanity? One

need not look further than the controversies spun around genetically modified (GM) [17] foods to see the understandable and natural cautiousness with which we approach any new technology, of which we do not, or do not yet fully understand its implications. A timely report released by the Pew Research Centre, which was based on a national phone survey of 1,001 adults in the US, revealed that only 20% of respondents "…would be willing to eat meat that was grown in a lab." [18]. This is indeed indicative of the substantial gap that will have to be traversed toward the acceptance of MM foods, which may coalesce as a pivotal in defining our collective fate.

In short, despite all of our shortcomings, the authors firmly believe that humanity possesses the capacities to efficaciously identify, rationally assess and resolve the most recalcitrant of challenges, and subsequently, to implement prudent and positive modifications toward the continuation and expansion of our prosperity; perhaps in the future, to the edges of our galaxy, or indeed the periphery of the universe.

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