This article was submitted for publication within Terasem Movement's Journal of Geoethical Nanotechnology by David Hegstad of Olney, MD.

David, after taking an externship in internal medicine and working in 3rd World Health Care, identifies an increasingly prevalent need for a mutual participation of nonscientists and the private and public/non-profit sectors for the betterment of science toward improving public interest and support for research.

IN 2007, I VISITED A LABORATORY AT one of the world's leading biological research universities, where scientists had recently discovered that ganglions (an eye cell, commonly occurring at a 1:10,000 ratio of photoreceptors in most mammals, including humans) are physiologically linked to the hypothalamus. Before this discovery, experiments related to Circadian Rhythm [1] were conducted by introducing stimulus to loosely controlled environments. In recent years, biologists at this particular university had genetically removed ganglions from test subject genomes, thereby producing mature organisms that operated on biological clocks regardless of light stimulus. In the context of physiological psychology, the results of this study were profound; and the participating members regarded their work with appropriate tenacity, objectivity, professionalism, and patience, until the weeks following my visit, in which a neighboring university submitted a similar study for peer review, not knowing that ganglions were also central to my host's research.

I thereafter had a rare opportunity to witness my host university's response, and mayhem only begins to describe it. This literally became a blind race to publication, wherein the contesting teams did not meet the criteria required for participation. In an attempt to add validity to the project, sophomore PhD students were listed as senior researchers; median lines were shamelessly drawn through bar graphs that contained

clusters of activity outside standard deviations; and the cited team of researchers had not previously found an opportunity to gather in one room, much less become acquainted with one another on a joint project.

Provided the corporate sector's market potential for applied research, particularly in the context of medicine (where patents for the ten most commonly-used technological devices, exclusive of production rights, are expected to exceed $14 billion USD by 2014), I understood confidentiality is a recognized necessity. *But this was academic research with little or no recognizable market potential.* From an objective standpoint, the exact relationship of ganglions to the hypothalamus should be considered a celebration of scientific development, as opposed to a competition amongst universities resulting in highly unscientific practices.

In following months, I learned that this is a common occurrence among universities, precipitated by a term familiar to research-based scientific institutions: the H Index. In a community composed of individuals who commonly exceed the 95th percentile in standardized tests, there is little foundation to independently judge the affluence of an individual and his or her affiliated university based on academic merit, even though competition for grants necessitate such judgment (the differentials in grant approvals, when considered relative to university rankings, provides an exponential disparity based on the aforementioned <5% deviation).

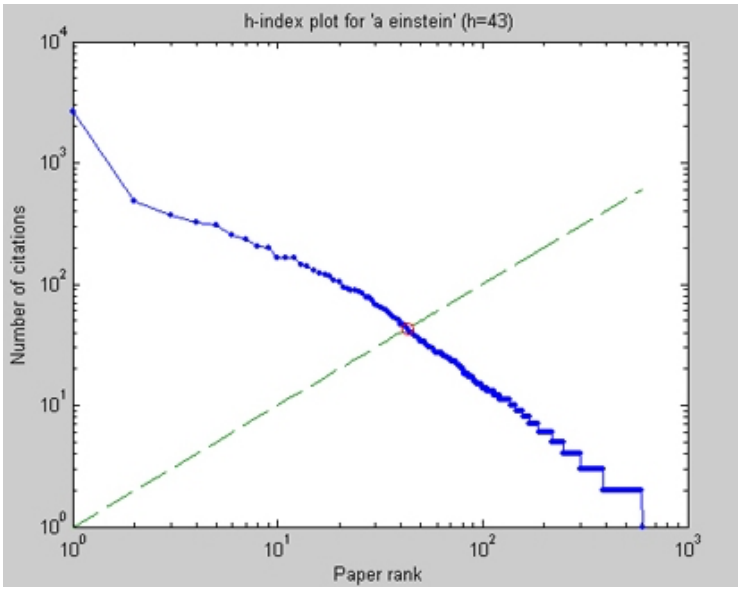


Image 1 – Factoring the "H" Index

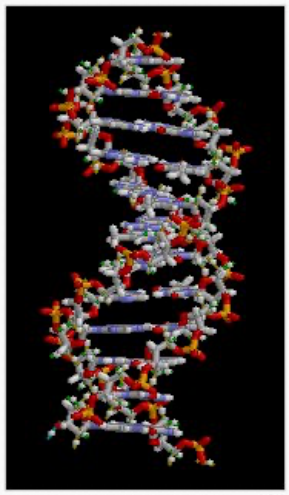
http://www.fast.u-psud.fr/~moisy/ml/misc/hindex.jpg

The H Index measures the productivity and value of a scientist based on his or her number of publications and subsequent citations, therein 1) determining university rankings based on professors' average index; 2) assessing probability of receiving grants (restricted and unrestricted); 3) providing directly proportional access to scientific contributors based on similar indexes; and 4) leveraging academic journals for publication.

Aasdasdad The H Index undoubtedly attributes a researcher's future success with prior success; but it does not take into account many aspects of scientific character. Albert Einstein, for instance, would have received a low index for his initial publication on general relativity, should subsequent publications not followed, even though it is recognized as one of the most important publications of the 20th century. There are also significant deficiencies in index regulation, which include, but are not limited to, self-reference, context of citations (particularly among colleagues), and number of authors cited per publication. If these criticisms were to posthumously apply to Renaissance Art,

Michelangelo's reputation for unfinished work would have destroyed his career vis-à-vis *The Last Judgment*, whereas the lesser-known Albrecht Dürer [2] may have become the history's most famous and circulated artist due to his application of Gutenberg's press to artistic prints.

There is a much greater consideration than humanist criticism at hand however, and that is benevolent communication and recognition of mutual objectives among scientific universities. My host's university, in attempt to over-characterize the scope of its research (which far exceeded the research submitted for publication by at least three competing universities in following months) for purposes of increasing H Indexes of participating members, failed to identify an appropriate journal. As a nonscientist, I developed an analogy for this model, wherein participating universities were mere players in the Milton Bradley game "Battleship," save that the objective was to slag a metaphorical tip of an iceberg in a proverbial arctic rather than observe its environment and formation. The winner of this particular game would achieve the academic equivalent of a patent, thereby depriving other participants the opportunity to contribute their unique findings—in whole or in part—thus committing many years of scientific character and small fortunes to nonexistence.



The structure of part of a DNA double helix

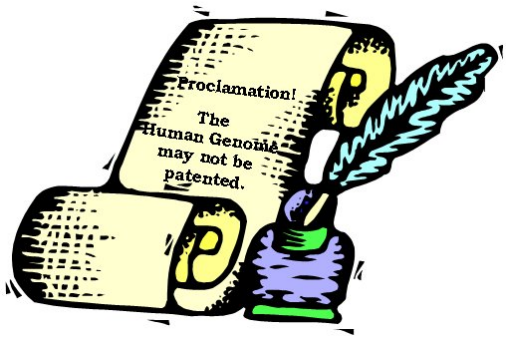
http://en.wikipedia.org/wiki/DNA November 2, 2009 1:40PM EST

THE RECENT HISTORY OF DNA'S STRUCTURE and its discovery is an anomaly of scientific character: Oswald Avery [3] ("the most deserving scientist to not receive the Nobel Prize" per Arne Tiselius) [4] was unreserved in communicating his discovery that DNA is the genetic material of the T2 phage, [5] even though reservation would have provided him an opportunity to exercise nigh exclusive rights to consequent research; Linus Pauling [6] and Robert Corey [7] maintained little academic discretion for their earliest proposals of a triple-helix model, [8] which uncharacteristically precipitated open lines of communication among universities and research institutes; Maurice Wilkins [9] and Rosalind Franklin [10] were arguably more eager to promote high quality X-ray diffraction photography than to promote their unique findings (which favored a double-helix model); and James Watson [11] and Francis Crick, [12] perhaps the most nonsensical pair of scientists to endure formal society, stumbled through a high profile waltz of unintentional, cross-continental collaboration. A singularity occurred in this familiar lesson because of mutual (sometimes friendly, sometimes forceful) momentum, as a result of open dialog, in a wide spectrum of analytical research. This lesson does not

propose that competition was not a motivating factor among participating members; it does however, consider that all events occurred: 1) in less than eighteen months; 2) at the outbreak of the Cold War [13] and McCarthyism, [14] wherein a) international travel (even between the U.S. and U.K.) was made difficult; b) scientific research was fast becoming nationalized and confidential; and 3) with the cooperation of three continents. There exists a far more intricate and singular history to DNA research however, and that was the mapping of the human genome.

In 1993, Francis Crick assumed the position of director at the National Human Genome Research Project (NHGRP), [15] replacing James Watson, who resigned when confronted with the board's decision not to patent its findings. The projected fifteen-year public project was nearly three years in process at that time; and Watson's departure set a precedent for non-affiliated private corporations to withhold new sequencing techniques in an attempt to patent selections of the human genome before the NHGRP. Celera Genomics, [16] the most well known private contender, made use of "shotgun sequencing" (a practice that is nearly as visceral as the "Battleship" analogy used earlier in this essay) in attempt to attain not only patents but intellectual property protection on fully characterized important structures as well. From a scientific perspective, private sector activities were largely confidential, but from an economic perspective, the overnight infusion of approximately $100 billion USD in NASDAQ was universally conspicuous. The NHGRP's continued commitment to publicize the human genome as free and public information was hailed by a continuum of scholars as an ethical contribution to human sciences; and the realization that this objective could be

compromised by the private sector's market interest created concern for the public sector's ability to compete.



Celera Genomics and an entire host of private corporations were preparing for patent application and publication on select sequences in early 2000 when President Clinton declared that the human genome sequence could not be patented; in the following two days, participating private biotechnology firms lost $50 billion USD in corporate stock. A unique relationship shared between Information Technology (IT) firms (an industry whose market potential was otherwise defunct following the Y2K hype) and private biotechnology firms dissolved. Scores of the world's leading geneticists operating in the private industry, including several who were central to discovering the structure of DNA, found their employers nonexistent in following weeks, as well as their cumulative research.

And therein, a singularity occurred: the NHGRP proceeded to publish the human genome shortly thereafter, three years ahead of schedule, amidst the resignation of the field's leading geneticist and external turmoil. In contrast to the insular research universities I have visited in recent years, the NHGRP prided itself on open lines of communication among its international consortium, which spanned public institutions

throughout the United States, Canada, China, France, Germany, India, New Zealand, United Kingdom, and Japan. In contrast to the private sector, the NHGRP operated on a $3 billion USD fifteen-year budget, approximately 3% of the NASDAQ's two-year interest in competing private corporations. In contrast to visceral methods used by the private sector in an attempt to delineate the basic operations of particular sequences (thereby acquiring a critical mass for patenting), the NHGRP successfully published its own findings of complete sequences first, on numerous occasions, prior to President Clinton's declaration.

THE PURPOSE OF THIS COMPARISONS IS not to propose that scientific research conducted by the public sector is superior in method or finding to the private sector; it is instead to recognize that a consistent scientific character, from observation to publication, promotes scientific results; and although open communication reduces the attributed success of an individual or affiliated body by association, results are potentially more timely and precise. It is with these thoughts in mind that we consider Karl Popper. [17] Popper published "Conjectures and Refutations: The Growth of Scientific Knowledge" [18] in 1963, which fast became a keystone to a 20th Century criticism: the philosophy of science. Central to Popper's thesis was the term "falsification," wherein he inadvertently applied many of Sigmund Freud's [19] hypotheses on psychic apparatus to his own observations, thus identifying a natural tendency for scientists to accept an ad hoc hypothesis more readily than not. Although "Conjectures and Refutations" utilizes a vocabulary and categorical analysis that is familiar to my education, I prefer a narration used in an earlier lecture when considering Popper's address:

1. It is easy to obtain confirmations, or verifications, for nearly every theory – if we look for confirmations.
2. Every "good" scientific theory is a prohibition: it forbids certain things to happen. The more a theory forbids, the better it is.
3. A theory, which is not refutable by any conceivable event, is non-scientific. Irrefutability is not a virtue of a theory (as people often think) but a vice.
4. Every genuine test of a theory is an attempt to falsify it, or to refute it. Testability is falsifiability; but there are degrees of testability: some theories are more testable, more exposed to refutation, than others [are]; they take greater risks.
5. Confirming evidence should not count except when it is the result of a genuine test of a theory; and this means that it can be presented as a serious but unsuccessful attempt to falsify the theory.
6. Some genuinely testable theories, when found to be false, are still upheld by their admirers. Such a procedure is always possible, but it rescues the theory from refutation only at the price of destroying, or at least lowering, its scientific status.

These observations undoubtedly appear obvious in the context of this essay; one must consider at great length, however, their scope and implications. Popper is herein proposing that: 1) because scientists have a natural tendency to confirm their own theories instead of opposing them, it is unwise to conduct science in environments where external factors (such as publication deadlines and budgets) influence internal factors; 2-5) two minds work better than one, and two people with different experiences and educational backgrounds are more likely to conduct well-rounded experiments than two

people with similar backgrounds; and 6) conducting scientific research within a consistently diverse community promotes individuals' integrity.

If we are to apply Popper's observations not to my personal experiences but the H Index itself, we identify three natural conflicts: the H Index is bolstered by a hybridization of external and internal conflicts; relies on confidentiality through independence in research; and encourages participation among partisan communities in favor of self-reference. We also find that, although the H Index has increased performance of qualified researchers (particularly in recent years); it has potentially reduced the well-roundedness of publications in which the index is considered. In the near future, as global initiatives dominate public interests via the public sector, it is possible and perhaps likely that revisions will be made to the H Index. In the event of such revisions, I believe foremost among them will be a chronological database that catalogs the findings of research institutions regardless of their publications. In the spirit of Popper's famous analogy, the discovery of a white swan [20] should not formulate the statement that all swans are white; it should instead encourage observations contrary to this finding (many species of swans south of the equator are in fact black). As the costs of communication (and globalization, for that matter) lessen, participation of an international community is a scientific necessity, particularly in the context of diverse and well-communicated observation.

If we are to apply Popper's observations to the NHGRP's success, we recognize that the environment provided for scientific research was nigh unparalleled: a committed board of directors with no stated personal objectives utilized a national public sector and non-profit organizations, while relying on an international consortium to maintain a

balanced perspective through diversity. Private sectors will inevitably recognize this level of participation in the future and may seek not to compete to achieve results, but instead may look to facilitate methods to assist in the observation and collection of data; therein, we may yet find a vast and untapped market, private firms that rely on equal contributions from an array of professional fields to develop such methods.

As we continue to experience globalization and exponential technological development, Popper's lessons are increasingly inherent to our societies. Among scientific communities, there is an increasing awareness of strengths and weaknesses inherent to public and private sectors, as well as not-for-profit organizations, which provide an opportunity for high budget operations to make use of each. Proliferation of personal computers encourages benevolent cooperation between engineers, linguists, artists, and mathematicians (at the most fundamental levels), while simultaneously establishing a market for products used in scientific research. The internet and public databases therein have also provided an unprecedented wealth of accessible information, which provides professionals an opportunity to interact with one another, as well as communicate new ideas to hosts of amateurs. It is only natural for us to begin to recognize the fundamental themes of our success and to reconfigure our institutions—scientific first and foremost—accordingly.

The developing sense of human sciences—not merely the term used to describe social sciences in recent history, but a practicum of sciences relevant to human preservation—is also infusing our cultures; it is for this reason that an executive proclamation stating the human genome may not be patented is viewed as an ethical achievement. As geopolitics

continues to expand and take responsibility for global issues, we may expect to see an increase in such proclamations in the near future, as well as amendments to patents that may already be in use. This is not an accusation that the private sector does not participate in global issues; it is instead an acknowledgment that increases to technology as it relates to human life—particularly medicine—bestow great obligations upon an international community. In recent months, the application of such practices has produced our greatest step in finding a vaccine for HIV—in what may be considered an ethical dilemma (let us not forget that technology is inevitably one step ahead of morality)—wherein an international consortium involving participation of public and private sectors shared this vision. Imagine what we may accomplish tomorrow.

Footnotes & Citations

1. **Circadian Rhythm** – *n*. A daily rhythmic activity cycle, based on 24-hour intervals, that is exhibited by many organisms.

The American Heritage Stedman's Medical Dictionary. Boston, New York: Houghton Mifflin Company, 2004: 282, 158.

2. **Dürer, Albrecht** - (b. May 21, 1471, Imperial Free City of Nürnberg [Germany]--d. April 6, 1528, Nürnberg), German painter, printmaker, draughtsman and art theorist, generally regarded as the greatest German Renaissance artist. His vast body of work includes altarpieces and religious works, numerous portraits and

self-portraits, and copper engravings. His woodcuts, such as the *Apocalypse* series (1498), retain a more Gothic flavour than the rest of his work.

http://www.ibiblio.org/wm/paint/auth/durer/ October 26, 2009 2:12PM EST

3. **Oswald Theodore Avery** (1877-1955) was a physician, medical researcher and early molecular biologist. Avery was one of the first molecular biologists and was a pioneer in immunochemistry, but he is best known for his discovery in 1944 with his co-worker Maclyn McCarty that DNA is the material of which genes and chromosomes are made.

http://www.bio-medicine.org/biology-definition/Oswald_Avery/ October 26, 2009 2:18PM EST

4. **Tiselius, Arne** - 1902–71, a Swedish biochemist who received the 1948 Nobel Prize in Chemistry for developing new methods of separating and detecting colloids. One system (electro-phoresis) employs an electrical apparatus (Tiselius apparatus) for the separation of heavy molecules in solution; the other is a method of adsorption analysis that permits the differentiation and separation of substances, e.g., proteins, sugars, salts, and acids. Tiselius isolated the virus of mouse paralysis and developed synthetic blood plasma.

http://encyclopedia2.thefreedictionary.com/Arne+Tiselius October 26, 2009 2:24PM EST

5. **T2 phage -** Virulent bacteriophage and type species of the genus T4-Like Phages, in the family MYOVIRIDAE. It infects E. coli and is the best known of the T-even phages. Its virion contains linear double-stranded DNA, terminally redundant and circularly permuted.

http://www.online-medical-dictionary.org/T2+Phage.asp?q=T2+Phage October 26, 2009 2:27PM EST

6. **Linus Pauling** – (b. 1901, d. 1994), the only person to win two unshared Nobel Prizes, revolutionized the study of chemistry, helped found the field of molecular biology, and made important advances in medical research.

http://profiles.nlm.nih.gov/MM/Views/Exhibit/narrative/biographical.html October 26, 2009 2:38PM EST

7. **Robert Corey** – (b. 1897, d. 1971), an American biochemist, mostly known for his role in discovery of the α-helix and the β-sheet with Linus Pauling. Also working with Pauling was Herman Branson. Their discoveries were remarkably correct, with even the bond lengths being accurate until about 40 years later. The α-helix and β-sheet are two structures that are now known to form the backbones of many proteins.

http://en.wikipedia.org/wiki/Robert_Corey October 26, 2009 2:44PM EST

8. **Triple Helix Model -** a partnership between the industrial, academia and governmental groups which recognize the differing goals and stakeholder communities of these three groups but emphasizes on the common interest of those groups in order to provide value to the societies in which they reside.

http://blog.iphandbook.org/?p=442 October 26, 2009 2:53PM EST

9. **Maurice Wilkins** – (b. 1916, d. 2004), was a British biophysicist best known for his contributions to the discovery of the structure of DNA. X-ray diffraction pictures done by Wilkins and his assistant/co-worker Rosalind Franklin on the aligned fibers within DNA were seen by James Watson and Francis Crick who, incorporating what it revealed, were then able to build an accurate, detailed model of the DNA molecule. Wilkins, Watson, and Crick were jointly awarded the Nobel Prize in Physiology and Medicine in 1962.

http://www.nndb.com/people/979/000030889/ October 26, 2009 3:06PM EST

10. **Rosalind Franklin** – (b. 1920, d. 1958), an English biophysicist, physicist, chemist, biologist and X-ray crystallographer who made contributions to the understanding of the fine molecular structures of DNA, RNA, viruses, coal and graphite. Franklin is best known for her work on the X-ray diffraction images of DNA. Her data, according to Francis Crick, was a part of the data used to formulate Crick and Watson's 1953 hypothesis regarding the structure of DNA.

http://en.wikipedia.org/wiki/Rosalind_Franklin October 26, 2009 3:15PM EST

11. **James Dewey Watson** - born April 6, 1928, is an American molecular biologist, best known as one of the two co-discoverers of the structure of DNA, with Francis Crick in 1953. Watson, Francis Crick, and Maurice Wilkins were awarded the 1962 Nobel Prize in Physiology or Medicine "for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material".

http://en.wikipedia.org/wiki/James_D._Watson October 26, 2009 3:17PM EST

12. **Francis Harry Compton Crick** – (b. 1916, d. 2004), was a British molecular biologist, physicist, and neuroscientist, and most noted for being one of two co-discoverers of the structure of the DNA molecule in 1953, together with James D. Watson. He, James D. Watson and Maurice Wilkins were jointly awarded the 1962 Nobel Prize for Physiology or Medicine "for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material"

http://en.wikipedia.org/wiki/Francis_Crick October 26, 2009 3:21PM EST

13. **Cold War** - the name given to the relationship that developed primarily between the USA and the USSR after World War Two. The Cold War was to dominate international affairs for decades and many major crises occurred - the Cuban Missile Crisis, Vietnam, Hungary and the Berlin Wall being just some. For many the growth in weapons of mass destruction was the most worrying issue.

http://www.historylearningsite.co.uk/what%20was%20the%20cold%20war.htm October 26, 2009 3:24PM EST

14. **McCarthyism** - the politically motivated practice of making accusations of disloyalty, subversion, or treason without proper regard for evidence. The term specifically describes activities associated with the period in the United States known as the Second Red Scare, lasting roughly from the late 1940s to the late 1950s and characterized by heightened fears of communist influence on American institutions and espionage by Soviet agents.

http://en.wikipedia.org/wiki/McCarthyism October 26, 2009 3:32PM EST

15. **National Human Genome Research Project (NHGRP)** - Begun formally in 1990, the U.S. Human Genome Project was a 13-year effort coordinated by the U.S. Department of Energy and the National Institutes of Health. The project originally was planned to last 15 years, but rapid technological advances accelerated the completion date to 2003. Project goals were to:

- *identify* all the approximately 20,000-25,000 genes in human DNA,
- *determine* the sequences of the 3 billion chemical base pairs that make up human DNA,

- *store* this information in databases,
- *improve* tools for data analysis,
- *transfer* related technologies to the private sector, and
- *address* the ethical, legal, and social issues (ELSI) that may arise from the project.

http://www.ornl.gov/sci/techresources/Human_Genome/project/about.shtml October 26, 2009 3:37PM EST

16. **Celera Genomics** - a healthcare business that uses knowledge of human variability to provide new tests and services to personalize disease management.

https://www.celera.com/celera/about October 26, 2009 3:51PM EST

17. **Karl Raimund Popper** – (b. 1902, d. 2004), is generally regarded as one of the greatest philosophers of science of the 20th century. He was also a social and political philosopher of considerable stature, a self-professed 'critical-rationalist', a dedicated opponent of all forms of skepticism, conventionalism, and relativism in science and in human affairs generally, a committed advocate and staunch defender of the 'Open Society', and an implacable critic of totalitarianism in all of its forms.

http://plato.stanford.edu/entries/popper/ October 27, 2009 12:18PM EST

18. **Conjectures and Refutations: The Growth of Scientific Knowledge** - written by philosopher Karl Popper and published in 1963 by Routledge, this book is a collection of his lectures and papers that summarized his thoughts on the philosophy of science.

http://en.wikipedia.org/wiki/Conjectures_and_Refutations October 27, 2009 3:27PM EST

19. **Sigmund Freud** – (b. 1856, d. 1939), physiologist, medical doctor, psychologist and father of psychoanalysis, was an influential thinker of the twentieth century.

> Working initially in close collaboration with Joseph Breuer, Freud elaborated the theory that the mind is a complex energy-system, the structural investigation of which is proper province of psychology.

http://www.iep.utm.edu/freud/ October 27, 2009 3:30PM EST

20. **White swan** – a term made popular by Karl Popper. Popper asserted that a hypothesis, proposition, or theory is scientific only if it is falsifiable. [T]he statement *all swans are white* is testable by being falsifiable. For, if in testing many swans, the researcher finds a single black swan, then the statement *all swans are white* would be falsified by the counterexample of the single black swan.

http://en.wikipedia.org/wiki/Falsifiability October 29, 2009 4:27PM EST

Bio

No photo provided by the author – none publicly available

David R. Hegstad is a perpetual college student (since a week before his sixteenth birthday), studying in California, Washington, Maryland and Washington, D.C. At seventeen, after taking an externship program in internal medicine, David became involved in 3rd World Healthcare. Currently an accountant with Handel & Associates in Maryland, he hopes his volunteer efforts will compel him to pursue a Masters in Public Health. Upon retirement, David plans to retire to the Horn of Africa, proud to return to the cradle of civilization.