

Connecting Evolution, Medicine, and Public Health

Many evolutionary anthropologists are actively involved in the emerging field of evolutionary medicine, which is a global, interdisciplinary effort to use evolutionary perspectives to understand and improve human health.^{1–4} Indeed, in today's world, ecological and evolutionary perspectives are proving increasingly essential for understanding and addressing a wide array of infectious and non-infectious diseases. In evaluating options for cancer therapy, for example, measures of the ecological diversity of precancerous lesions have been used to predict later recurrence of cancer in patients⁵ because a higher diversity of cells enables tumors to escape chemotherapy. Along similar ecological lines, many of today's most pressing infectious disease challenges, including Ebola, influenza, and Middle Eastern respiratory syndrome, reflect spillover from other animals, as was the case with HIV and two species of malaria.^{6–8} Evolutionarily, the rise of resistant microbes presents a worldwide crisis that threatens many of humanity's most remarkable advances against infectious disease. More rigorous evolutionary modeling is needed to devise better treatments that reduce selective pressures for resistant parasites and pathogens.⁹ Simultaneously, public health successes against infectious disease are demonstrating how important many of those organisms are for training effective immune responses; their loss is associated with increases in autoimmune diseases and cancers.¹⁰

With these many health challenges in mind, new collaborations between medical specialists and evolutionary biologists are sorely needed. Multiple new centers and programs on evolutionary medicine are helping to set the stage for such collaborations at places such as ASU; Durham (UK); the Research Triangle of North Carolina (involving Duke, North Carolina,

North Carolina State, and North Carolina Central); UCLA; Temple; and the University of Zurich. Two new journals are also available for publishing results in evolutionary medicine: *Evolution, Medicine and Public Health*, edited by Stephen Stearns, and the *Journal of Evolutionary Medicine*, edited by Paul Ewald. Moreover, a longstanding web site continues dynamic sharing of information, teaching resources, and the latest research (*Evolution and Medicine Review*, <http://evmedreview.com>).

Many evolutionary anthropologists are actively involved in building and contributing to these efforts in evolutionary medicine, and in forging new research directions. We witnessed many of these emerging collaborations at the Inaugural Meeting of the International Society for Evolution, Medicine and Public Health (ISEMPH), held on March 19 to 21, 2015, in Tempe, Arizona. The conference brought together more than 300 faculty, students, clinicians, and teachers, and was supported by the Foundation for Evolution, Medicine, and Public Health and by ASU's Center for Evolution and Medicine.

The conference highlighted keynote speakers who are leaders in this field. Importantly, Harvey Fineberg, the former head of the National Academy of Sciences' Institute of Medicine, was among the keynote speakers, reflecting the growing realization in the medical community that ecology and evolution are central to efforts to improve human health. Other participants gave 15-minute talks or posters, largely in a single-session format that enabled participants to see the majority of presentations. In what follows, we highlight some of the major concepts and talks that are most relevant to evolutionary anthropologists. These and other talks are available via the web site for ASU's Center for Evolution and Medicine (<http://evmed.asu.edu/cem-videos-0>).

"Evolutionary mismatch" is one theme in evolutionary medicine that is highly relevant to research in evolutionary anthropology. Mismatch disorders arise as a consequence of our bodies being inadequately adapted to the environments in which most of us now live. Well-known life-style risks such as sedentism and poor nutrition are at the root of a variety of mismatch diseases; even our sleep presents vastly different patterns from those in our evolutionary past. Notable among these mismatch diseases are the growing prevalence of obesity and type 2 diabetes in developed countries; this was nicely highlighted in a presentation by Stephen Corbett (University of Sydney). However, mismatches can also stem from seemingly benign sources. For example, Daniel Lieberman (Harvard) argued that the shoes we wear ultimately weaken our feet and encourage us to walk and run in ways that predispose us to injury. Mismatches may even be triggered by certain modern medical practices. As discussed by Wenda Trevathan (New Mexico State), caesarean delivery, when not medically required, might unnecessarily increase a child's risk of obesity and chronic immune disorders. In another provocative and stimulating talk, Pascal Gagneux (San Diego) raised the question of whether assisted reproduction technologies such as *in-vitro* fertilization jeopardize health by bypassing the evolutionary norm of postcopulatory cryptic female choice such as choosing among particular sperm.

Identifying which disorders are evolutionary mismatches can be a challenging task. Good candidates include those that are common in industrial populations but are rare among hunter-gatherers. Thus, health data from subsistence-level societies are providing important new insights into these issues and are areas where evolutionary anthropology is making

significant contributions to evolutionary medicine research. Many presentations on aspects of health status in forager populations were presented at the conference, including studies of the Congo Basin Aka helminth load (Casey Roulette, Washington State), Bolivian Tsimane mucosal immunity (Carolyn Hodges-Simeon, Boston), and the prevalence of musculoskeletal disorders among extinct hominins (Martin Häusler, Zurich). In a study that was especially relevant for men in the audience, Benjamin Trumble (Santa Barbara) showed that age-related prostate enlargement, one of the most common diseases affecting men in Western populations, is much less pronounced among Tsimane men, probably because of their generally low levels of obesity, testosterone, and metabolic syndrome. This study suggests that the modern pattern of high rates of prostate enlargement may not have been an inevitable part of aging in our evolutionary past.

All of the forager studies, however, reminded us that diseases common in developed countries are not entirely absent among traditional-living peoples. What is unique about the health status of industrial populations is the high prevalence of certain diseases, not their presence *per se*. Similarly, Marlene Zuk (Minnesota) stressed that caution is necessary to avoid oversimplification, and that reversion to so-called “paleo” life styles is not always a practical or appropriate approach to reducing the burden of mismatch diseases.

Many of the participants were excited to have a sneak peak at a forthcoming textbook on evolutionary medicine, *A Primer of Evolutionary Medicine* by Stephen Stearns and Ruslan Medzhitov (both at Yale). With each author taking a different set of chapters, they considered fundamental questions that force us to reconsider some seemingly simple questions, such as “What is a patient?” (Stearns) and “What is a disease?” (Medzhitov). Stearns explained the numerous ways in which, “patients are not machines designed by engineers with replaceable parts. They are bundles of tradeoffs because adaptive advances in one trait are often bought at a



Figure 1. The Omenn Prize and its winners in 2013 and 2014. From left to right, Gilbert Omenn, winners Matt Barber and Anna Demongines, and meeting host Randolph Nesse. (Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.)

cost of another.” Medzhitov provided a new framework for thinking about evolution and disease that goes beyond proximate and ultimate causation. He suggested that qualities such as robustness, resilience, and vulnerability give a new perspective on the breakdown of health and the recovery from disease. Medzhitov promoted the concept of disease arising from lack of maintenance as an understudied cause of intrinsic mortality.

Barbara Natterson-Horowitz (UCLA) focused on the importance of comparative medicine to make the point that common human conditions are not unique to us. She promoted the concept of a “phylogeny of disease” to connect the history of pathologies such as heart failure and preterm birth across a great array of species. She also considered the natural history of specific pathologies relevant to their presentation, treatment, and outcomes today. With a similar focus on comparative medicine, Athena Aktipis (ASU) spoke on the growing field of comparative oncology,¹¹ with an amazing database on cancers across the tree of multicellular life.

Infectious disease was also a prominent feature in many talks. Of relevance to evolutionary anthropologists, Anne Stone (ASU) reviewed the latest advances in understanding the complex origins and history of tuberculosis as revealed by genetic analyses. She and her colleagues suggested that *Mycobacterium tuberculo-*

sis is a zoonotic organism that was transmitted from nonhuman animals to humans approximately 6,000 years ago. Intriguingly, for ancient Peruvian samples, the strains of *Mycobacterium* appear to be from marine mammals. Along similar lines, Elizabeth Uhl (Georgia) used genetic data and analyses to consider the origin of the canine distemper virus, specifically as a reverse zoonosis from the human measles virus.

Two talks covered fascinating questions about the microbiome of primates. Julie Horvath (North Carolina Museum of Natural Sciences) presented a talk on the skin microbiome of several species of nonhuman primates. More specifically, she dealt with the ticklish area scientifically known as the axillary vault or, more colloquially, as the armpit. She presented evidence that the composition and abundance of microorganisms in human armpits differ from those found in the armpits of other primates, with consequences for health and disease. Activities such as, for example, the use of antiperspirants and deodorants, further influence the composition of microorganisms in human armpits. Along other lines, Katie Hinde (Harvard) considered how the composition of human milk might influence microorganisms living in the guts of primates. Specifically, she investigated how milk oligosaccharides influence microbial colonization of infant guts, with consequences for competitive exclusion of pathogenic



Figure 2. Baba Brinkman performing his new "Rap Guide to Evolutionary Medicine." (Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.)

organisms and support of beneficial ones. Across human populations, she showed that characteristics of milk oligosaccharide composition cluster according to subsistence patterns.

We also heard from the two recent winners of the Omenn Prize (Fig. 1), a highly competitive \$5,000 award given in recognition of the most exciting publications in evolutionary medicine. The winning papers in 2013 and 2014 dealt with vulnerability to and defenses against infectious disease, with an evolutionary perspective on transferrin and the transferrin receptor genes. Ann Demogines (BioRad) won the inaugural Omenn Prize for the Best Paper Published in Evolutionary Medicine in 2013.¹² She and her colleagues discovered how genetic variation in the transferrin receptors of South American rodent hosts influence susceptibility to arenaviruses such as Junin and Machupo. Matthew Barber (Utah) won the Omenn Prize in 2014 for a paper¹³ in which he and Nels Elde investigated the transferrin system as the battleground where host and pathogen compete for iron. Professor Gilbert Omenn, Chair of Computational Medicine at the University of Michigan and past president of the American Association for the Advancement of Science, presented the prize that he established.

For many of us, an unforgettable highlight of the conference was a

performance by hip-hop artist Baba Brinkman (Fig. 2). As many readers know, Baba produces peer-reviewed rap music on a wide range of topics, including an album entitled "The Rap Guide for Evolution." For the conference (and through support from ASU's Center for Evolution and Medicine), Baba produced a new "Rap Guide to Evolutionary Medicine," which is available for free download from the ISEMPH website (www.evolutionarymedicine.org). We highly recommend that you check it out, especially if you are one of the growing number of evolutionary anthropologists who teach courses in evolutionary medicine — it is a promising resource for connecting students to fundamental concepts and examples.

Overall, the conference was a real inspiration for the future of this field and for interdisciplinary collaboration in general. We witnessed how many people in our field and, more generally, in biology are engaged in applying rigorous evolutionary thinking to many of our most pressing global health challenges. We also networked with many scientists and students who do not typically attend the physical anthropology meetings or, for that matter, other organismal biology meetings. The general consensus was that future meetings should be held on a yearly basis. Join the ISEMPH and stay tuned to the Evolution and Medicine Review to find out when and where the next meeting will

be held, and to keep posted on how to nominate an evolutionary anthropologist for the next 2015 Omenn prize!

Charles L. Nunn
Department of Evolutionary
Anthropology
Duke Global Health Institute
Triangle Center for Evolutionary Medicine
Duke University, Durham NC

Ian Wallace
Department of Anthropology
Stony Brook University, Stony Brook NY

Cynthia M. Beall
Department of Anthropology
Case Western Reserve University
Cleveland, OH

REFERENCES

- 1 Nesse RM, Williams GC. 1996. Why we get sick. New York: Vintage Books.
- 2 Perlman R. 2013. Evolution and medicine. New York: Oxford University Press.
- 3 Stearns SC, Koella JC. 2007. Evolution in health and disease. New York: Oxford University Press.
- 4 Trevathan WR, Smith EO, McKenna JJ. 1999. Evolutionary medicine. New York: Oxford University Press.
- 5 Maley CC, Galpeau PC, Finley JC, et al. 2006. Genetic clonal diversity predicts progression to esophageal adenocarcinoma. *Nat Genet* 38:468–473.
- 6 Hahn BH, Shaw GM, De Cock KM, et al. 2000. AIDS as a zoonosis: scientific and public health implications. *Science* 287:607–614.
- 7 Liu W, Shaw KS. 2014. African origin of the malaria parasite *plasmodium vivax*. *Nat Comm* 5:1–10.
- 8 Liu W, Li Y, Learn GH, et al. 2010. Origin of the human malaria parasite *Plasmodium falciparum* in gorillas. *Nature* 467:420–425.
- 9 Read AF, Day T, Huijben S. 2011. The evolution of drug resistance and the curious orthodoxy of aggressive chemotherapy. *Proc Natl Acad Sci USA* 108:10871–10877.
- 10 Rook GA. 2012. Hygiene hypothesis and autoimmune diseases. *Clin Rev Allergy Immunol* 42:5–15.
- 11 Maley CC. 2015. Cancer across life: Peto's paradox and the promise of comparative oncology. *Philos Trans R Soc B*
- 12 Demogines A, Abraham J, Choe H, et al. 2013. Dual host-virus arms races shape an essential housekeeping protein. *PLoS Biol* 11:e1001571.
- 13 Barber MF, Elde NC. 2014. Escape from bacterial iron piracy through rapid evolution of transferrin. *Science* 346:1362–1366.