Evolutionary Medicine

2014 UNM Evolutionary Medicine
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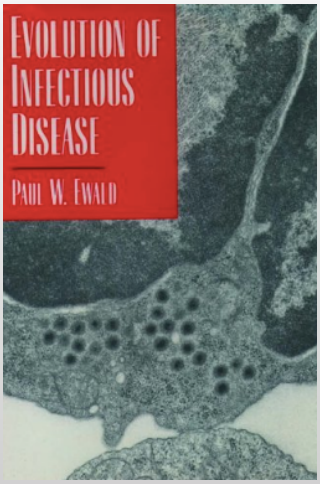
Department of Emergency Medicine
Adjunct, Dept. Biology

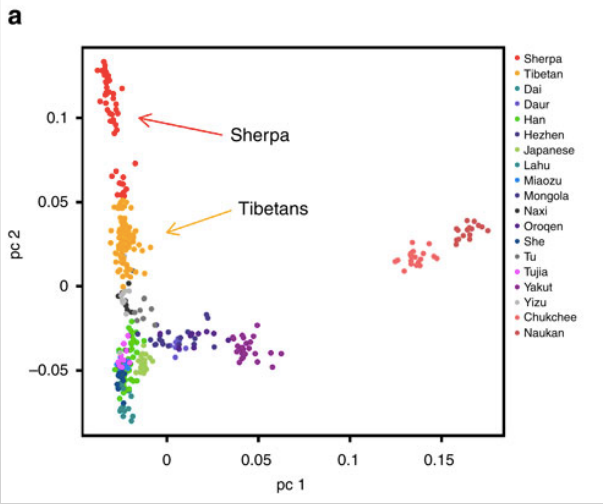


What is Evolution?

- Population change
- Genetic change
- Natural selection: non-random change
- Drift: random change
- Occurs all the time

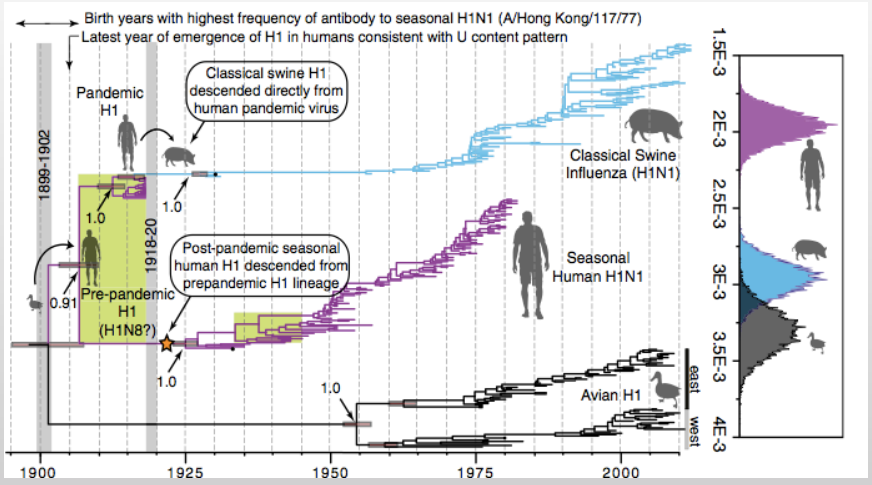
Population Change

Genetic Change

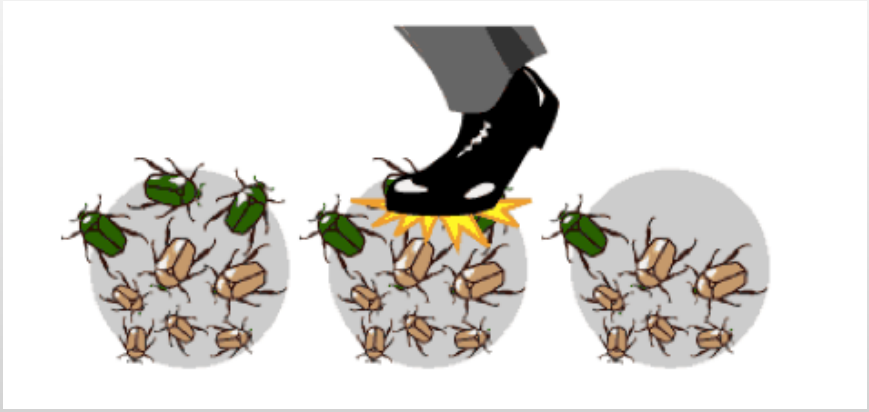


Jeong et al. 2013 Nature Communications 5;3281

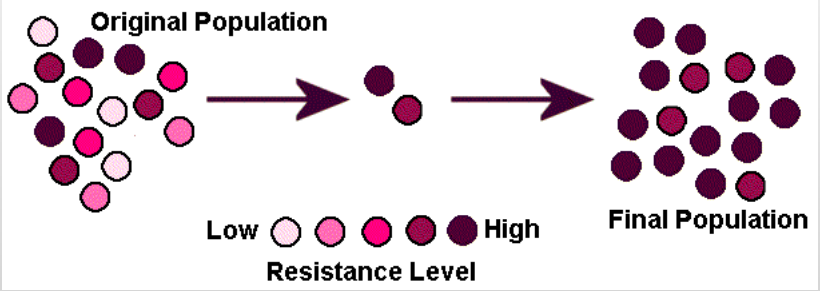
Genetic Change



Random Change
Genetic Drift



Non-random Change
Natural Selection



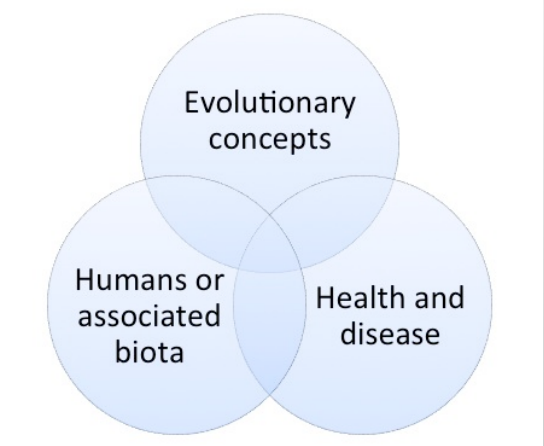
VIST

- Variation
- Inheritance
- Selection
- Time

Evolution by natural selection happens all the time

- Changes in gene frequencies – changes in survival and reproduction
- All you need is genetic variation and differences in reproduction

Evolutionary Medicine



Adaptation

" *Adaptation* is the evolutionary process whereby an organism becomes better able to live in its habitat"

Theodosius Dobzhansky

Increase fitness

Origin of function and complexity in biology and medicine.

Fitness

- Relative ability to survive and reproduce and pass genes on to the next generation
- Can be inferred from medical and epidemiological studies of mortality

Inclusive fitness

- Gene centric view – ability of an allele to promote its replication in the next generation.
- Is a feature of an individuals ability to reproduce along with relatives who share genes.
- Kin selection

Group selection

- Unit of selection is the group, not the individual

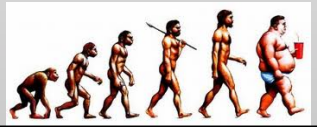
AAMC-HHMI

Scientific foundations for future physicians

"Describe the functional elements in the human genome, their evolutionary origins, their interactions, and the consequences of genetic and epigenetic changes on adaptation and health"

Proximate and Evolutionary Causes

- from proximate "*what*" questions
  - What mechanisms lead to disease in individuals?
    - About pathophysiology and epidemiology
- to evolutionary "*why*" questions
  - How and why are populations vulnerable to disease?
    - About selection forces and phylogenetics



New MCAT 2015

MCAT 2015
A Better Test for Tomorrow's Doctors

- Addition of the social and behavioral sciences section
- Critical analysis and reasoning skills
- Natural sciences sections reflect recent changes in medical education
  - Evolutionary biology highlighted

The Preview Guide for MCAT[2015]

Biological and Biochemical Foundations of Living Systems

Foundational Concept 1

Biomolecules have unique properties that determine how they contribute to the structure and function of cells, and how they participate in the processes necessary to maintain life.

Evolution (BIO)

- Natural selection
  - Fitness concept
  - Selection by differential reproduction
  - Concepts of natural and group selection
  - Evolutionary success as increase in percent representation in the gene pool of the next generation
- Speciation
  - Polymorphism
  - Adaptation and specialization
  - Inbreeding
  - Outbreeding
  - Bottlenecks
- Evolutionary time as measured by gradual random changes in genome

PNAS

Making evolutionary biology a basic science for medicine

Randolph M. Nesse[a,1], Carl T. Bergstrom[b], Peter T. Ellison[c], Jeffrey S. Flier[d], Peter Gluckman[e], Diddahally R. Govindaraju[f], Dietrich Niethammer[g], Gilbert S. Omenn[h], Robert L. Perlman[i], Mark D. Schwartz[j], Mark G. Thomas[k], Stephen C. Stearns[l], and David Valle[m]

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Edited by Daniel L. Hartl, Harvard University, Cambridge, MA, and approved September 29, 2009 (received for review August 2, 2009)

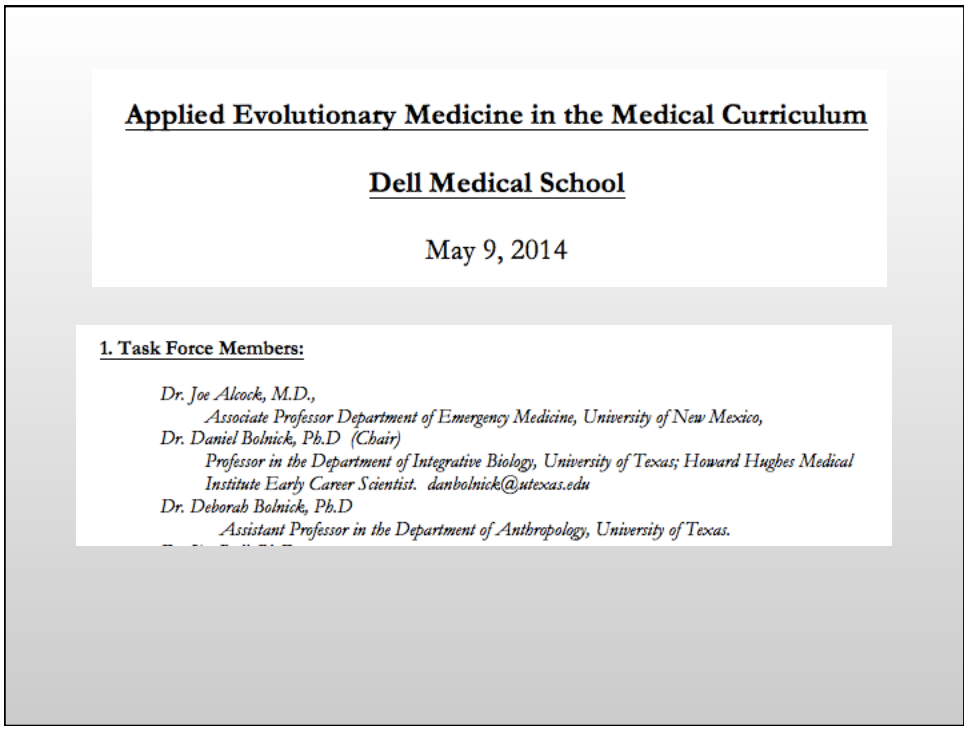
New applications of evolutionary biology in medicine are being ... ing on the stable foundation of Darwin and Wallace's theory of

Evo Edu Outreach (2011) 4:574–579
DOI 10.1007/s12052-011-0362-1

CURRICULUM AND EDUCATION ARTICLE

A Clinical Perspective in Evolutionary Medicine: What We Wish We Had Learned in Medical School

Joe Alcock · Mark D. Schwartz



Applied Evolutionary Medicine in the Medical Curriculum

Dell Medical School

May 9, 2014

1. Task Force Members:

Dr. Joe Alcock, M.D.,
Associate Professor Department of Emergency Medicine, University of New Mexico,
Dr. Daniel Bolnick, Ph.D (Chair)
Professor in the Department of Integrative Biology, University of Texas; Howard Hughes Medical Institute Early Career Scientist. danbolnick@utexas.edu
Dr. Deborah Bolnick, Ph.D
Assistant Professor in the Department of Anthropology, University of Texas.

Medical Curriculum

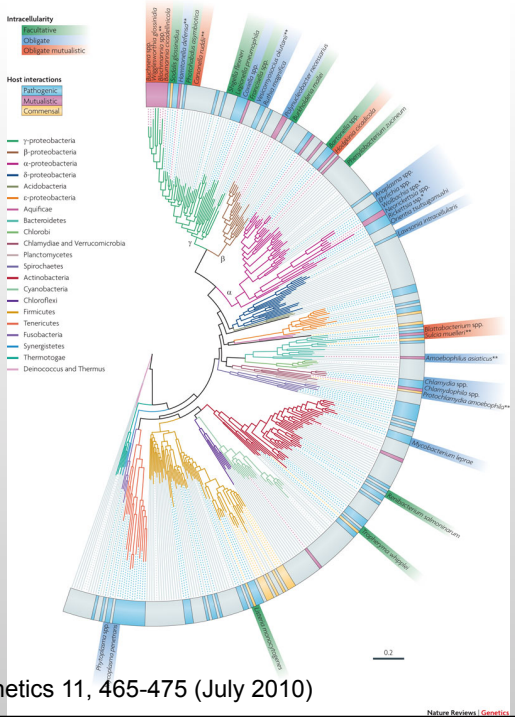
- Genetic diversity in human populations
- Pathogens and tumors are genetically variable & consequently evolve.
- Evolution provides analytical tools: phylogenetics and population genetics .

Practical Benefits

- *A. Understanding evolution can improve diagnosis*.
- *B. Understanding evolution can improve preventative or treatment plans.*
- *C. Evolution provides a framework for understanding physiology and pathology*

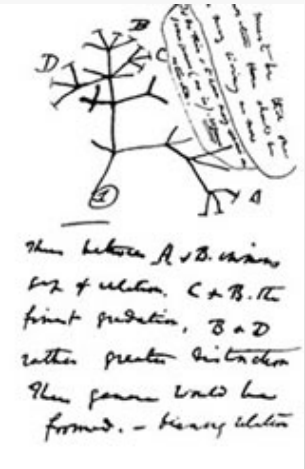
WHO report: Antibiotic resistance happening right now all over the world

CHARLIE COOPER | HEALTH REPORTER | Wednesday 30 April 2014



Nature Reviews Genetics 11, 465-475 (July 2010)

- Medicine is based on biology, and biology is based on evolution



Page from Darwin's notebooks (1837) showing his first sketch of an evolutionary tree.

Evolutionary medicine research

- Big data – testing for patterns of selection using medical databases
- Understanding the role of human-microbiota coevolution in health and disease
- Understanding selection in cancer evolution and antibiotic resistance evolution.

The evolution of drug resistance and the curious orthodoxy of aggressive chemotherapy

Andrew F. Read[a,b,1], Troy Day[c], and Silvie Huijben[a]

Key Question 1

- Natural selection allows the healthiest and most disease-free individuals to survive and pass their genes. Wouldn't humans evolve towards health?

Answer: no

- Case in point: Breast Cancer genes BRCA
- Selection apparently maintains genetic "achilles heels" in generation after generation.

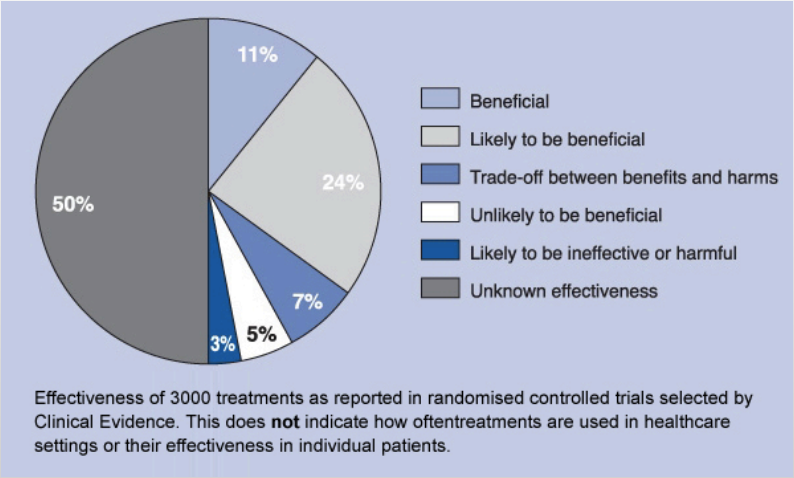
Key Question 2

- Do we evolve towards longevity? Does natural selection favor long life?

Answer 2

- Not necessarily
- You are product of innumerable ancestors who survived until reproduction
- Natural selection should promote survival during childhood and early adulthood
- Selection rewards reproductive success not longevity

Room for improvement



Effectiveness of 3000 treatments as reported in randomised controlled trials selected by Clinical Evidence. This does **not** indicate how oftentreatments are used in healthcare settings or their effectiveness in individual patients.

Selection in trauma

Medical Decision Making

Baso %	0.2 %
Gran #	**8.0 thous/mm3 HI**
Lymph #	3.2 thous/mm3
Mono #	0.7 thous/mm3
Eos #	0.6 thous/mm3
Baso #	0.0 thous/mm3
Sodium Level	**147 mmol/L HI**
Potassium Level	4.5 mmol/L
Chloride	**110 mmol/L HI**
CO2	25 mmol/L
Anion Gap	12 mmol/L
Glucose Level	**116 mg/dL HI**
BUN	19 mg/dL
Creatinine	1.03 mg/dL
eGFR	>60 mL/min
eGFR Afri-Amer	>60 mL/min
Calcium Level	10.3 mg/dL
Total Protein	8.0 g/dL
Albumin Level	4.7 g/dL
Bili Total	0.3 mg/dL
ALT	36 IntUnit/L
AST	33 IntUnit/L
Alk Phos	76 IntUnit/L
LDH	489 IntUnit/L
Lipase Level	**3,063 IntUnit/L HI**
Cholesterol	**232 mg/dL HI**
Triglyceride	**199 mg/dL HI**
HDL	67 mg/dL
LDL Chol Calc	**125 mg/dL HI**
Ethanol Level	<10 mg/dL

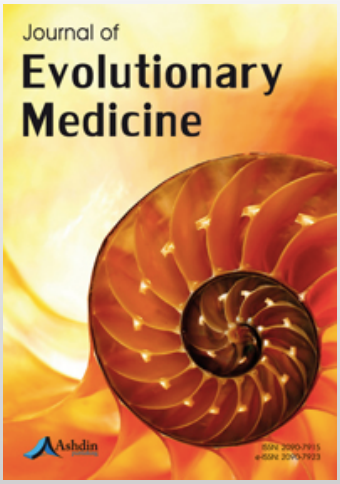
Evolution and Cancer Care

- Adaptation at the cellular level

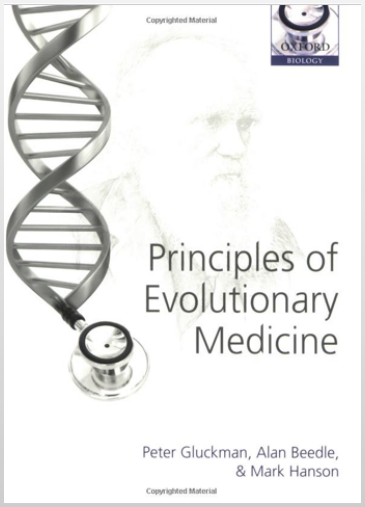
Improving Medicine with Evolution

Importance of Phylogenetics	Implications of Adaptation	Acting as an Agent of Selection	Competition between Genomes

New Journals



New Textbooks



New Training Opportunities

Success in this class

- Show up, participate
- Writing projects on time and in person
- Do not plagiarize
- Points off for late assignments
- Let us know in advance if you can't make a class for some reason.
- Written and oral communications skills
- Critical thinking skills
- Be creative