EVOLUTIONARY BIOLOGY
FALL 2017

WHEN: MWF 11:30 – 12:20
WHERE: 283 Galvin Life Science Center

INSTRUCTOR: Mike Pfrender

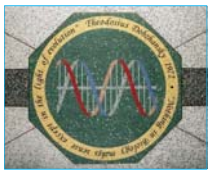
Course webpage:

http://www3.nd.edu/~mpfrende/Evolutionary_Biology/Homepage.htm

"Nothing in biology makes sense except in light of evolution"

Theodosius Dobzhansky 1973

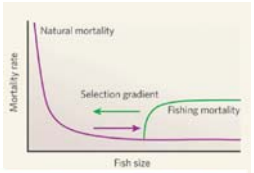
"Seen in the light of evolution, biology is, perhaps, intellectually the most satisfying and inspiring science."

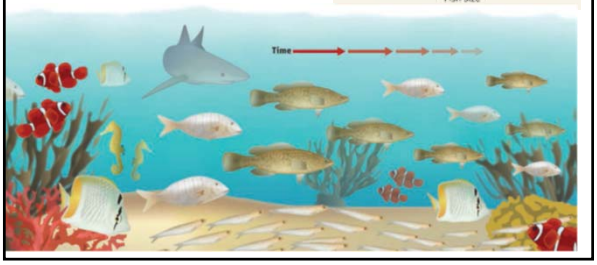


Managing Evolving Fish Stocks

- Evolutionary impact assessment is a framework for quantifying the effects of harvest-induced evolution on the utility generated by fish stocks.

Conover, *Nature* 2007 450:179-180
Jorgensen et al. *Science* 318:1247- 8





How do complex organisms evolve?

What explains these exaggerated phenotypes???

What happened to these organisms?

How does social behavior evolve?

Is there an evolutionary theory to explain aging and senescence?

LIFE HISTORY

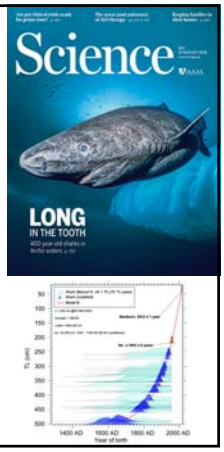
Eye lens radiocarbon reveals centuries of longevity in the Greenland shark (*Somniosus microcephalus*)

Julius Nielsen,[1,2,3,4]* Rasmus B. Hedeholm,[2] Jan Heinemeier,[5] Peter G. Bushnell,[6] Jørgen S. Christiansen,[4] Jesper Olsen,[5] Christopher Bronk Ramsey,[7] Richard W. Brill,[8,9] Malene Simon,[10] Kirstine F. Steffensen,[1] John F. Steffensen[1]

A Greenland shark (*Somniosus microcephalus*). These creatures are among the worlds largest carnivorous sharks and are distributed throughout Arctic waters. For decades, the longevity of this slow-growing species has remained a mystery. Using well-established radiocarbon dating techniques applied on Greenland shark eye lens tissue, Nielsen *et al.* estimate that these animals are the longest-living vertebrates known to date. This species is large yet slow-growing. **The oldest of the animals that they sampled had lived for nearly 400 years, and they conclude that the species reaches maturity at about 150 years of age.**

Science AAAS

12 AUGUST 2016 • VOL 353 ISSUE 6300



What are the evolutionary consequences of small population size?

MAJOR GOALS IN THIS COURSE:

- Describe major evolutionary events and patterns in the history of biological diversity on Earth
- Develop analytical frameworks to describe the process of evolutionary change in natural populations
- Apply these frameworks to understand evolutionary dynamics – especially with regard to human populations

COURSE REQUIREMENTS:

1) **Problem Sets, Writing Assignments, etc.**

Total	**~100 pts.**

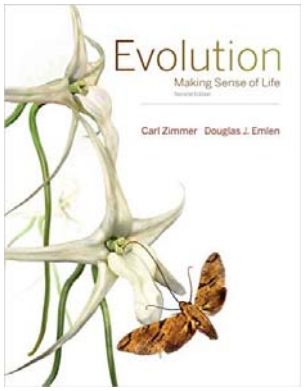
2) **Exams**

1st Midterm	100 pts.
2nd Midterm	100 pts.
Final	100 pts.
Total	**300 pts.**

ACHIEVING HIGH FITNESS IN EVOLUTIONARY BIOLOGY:

- Attend lectures regularly.
- Take detailed notes.
- Read over material before lecture.
- Ask lots of questions and discuss the material with instructor and classmates.
- Take advantage of review sessions & office hours!!!!

- Text for Evolutionary Biology
- On reserve at the Library (soon!)



#1 Question in Evolutionary Biology

What material is going to be on the exams?

Answer:

Any **material in Assigned Readings, PowerPoints or discussed in lecture is fair game.**

Some Practical Applications of Evolutionary Biology:

Pharmaceutical Industry:

- Drug design by *in vitro* or *in vivo* evolution.
- Targeted searches for natural products; bio-prospecting.

Agriculture:

- Crop & Livestock improvement by selective breeding.
- Evolution of pesticide resistance.
- Transgenic organisms – evaluating the advantages and risks.

Some Practical Applications of Evolutionary Biology:

Fisheries Biology:

- Genetic consequences of selective harvesting.
  - How does selective harvesting affect the future of fisheries?
- Genetic consequences of hatcheries.
  - How do hatchery raised fish affect wild stocks?

Some Practical Applications of Evolutionary Biology:

Conservation Biology:

- Identification of evolutionary significant units (ESUs).
- Avoidance of inbreeding depression in captivity.
- Avoiding the loss of adaptive variation.
- Identification of minimal population size for viability.
- Predicting the response to global change.

Evolutionary Ecological Genomics

Pfrender Lab

ENVIRONMENTAL CHANGE INITIATIVE

ECK INSTITUTE FOR GLOBAL HEALTH

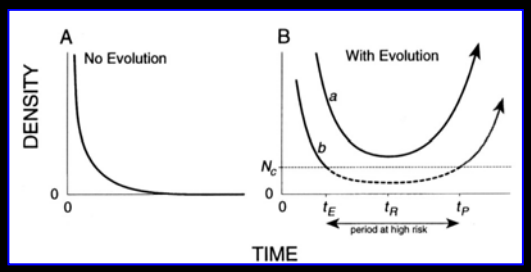
How do natural populations and communities cope with environmental change?

Response to Environmental Challenges

NATURAL POPULATIONS FACED WITH A CHANGING ENVIRONMENT CAN:

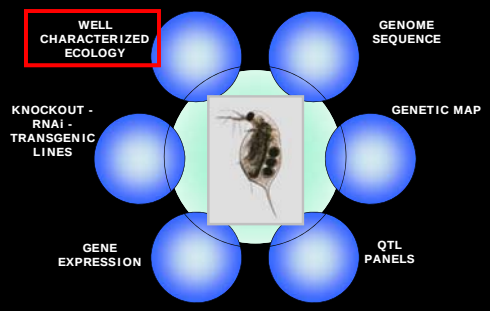
- Physically move to track a beneficial habitat
- Accommodate the altered environment with phenotypic plasticity (direct response to the environment)
- Adapt to the altered environment through genetic changes
- **Go extinct!**

- Even populations capable of rapid evolution may face a high risk of extinction due to reductions in population size during the initial period of adaptation.



FROM: Gomulkiewicz & Holt. 1995. When does evolution by natural selection prevent extinction. *Evolution* 49:201–207

Model Systems For Evolutionary & Ecological Genomics?



Rapid Ecosystem Changes

- In the Sierra Nevada ecosystem, the recent introduction of salmonids is a dramatic and rapid change in the environment.

Undisturbed *Daphnia* Populations in the Sierra Nevada

4 mm

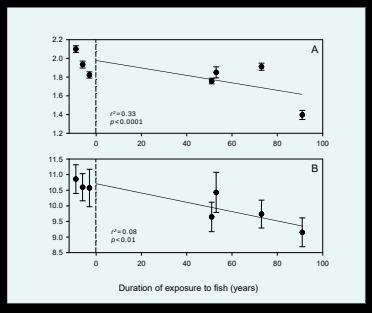
- High elevation populations of *Daphnia melanica* are typically highly pigmented and have large body size.

Lower Skelton Lake
Elevation ~3,000 meters.
Yosemite Natl. Park

- Dark pigmentation is due to the elevated levels of incident UV-B radiation at these extreme elevations
- No vertebrate predators leads to large body size

Rates of Adaptation

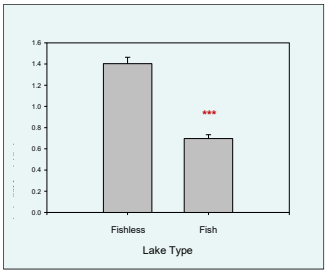
- From these data we can estimate the rate of adaptation
- Do Sierra Nevada *Daphnia* show high rates of evolutionary change in response to introduced predators?



Fisk et al. 2007

Changes in Pigmentation

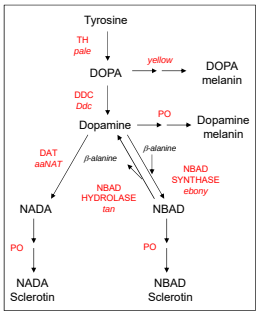
- Daphnia exposed to predation from introduced fish have reduced pigmentation



Scoville & Pfrender 2009

Genetic Basis of Changes in Pigmentation

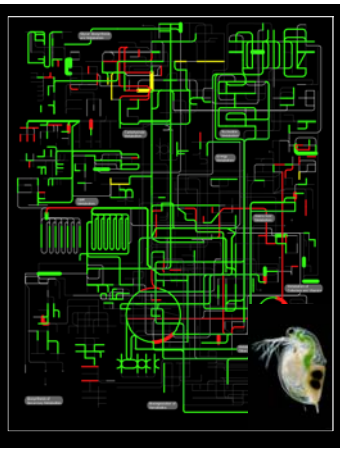
- Data from other arthropod systems provides a set of candidate genes involved in pigmentation
- We are examining these gene for structural and functional changes as well as examining the patterns of gene expression



Insect Melanin Biosynthesis Pathways

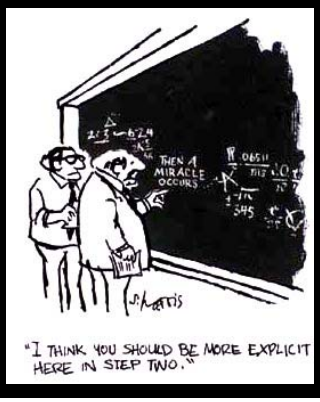
(Melanin pathway modified from True 2003)

The complexity of organismal responses to their environment requires an understanding of regulatory networks.



- Transcriptional response of *Daphnia* to thermal stress
  - Up-regulated (28° C)
  - Down-regulated (28° C)

Our Current Understanding of the Genetic Basis of Adaptation



Primary Goals of Evolutionary Biology:

1. **To document evolutionary history.**
2. **To understand the mechanisms that drive biological change through time.**
3. **To apply this knowledge to understand the genetic underpinnings of biological diversity, and to solve practical problems in the life sciences.**

WHAT IS EVOLUTION?

Darwin: descent with modification

Futuyma: changes in the properties of populations that transcend the lifetime of a single individual.

F & H: changes in allele frequencies over time.

Key Ingredients:

1. Change that is heritable across generations.
2. A property of populations, not individuals.
3. Includes the possibility of cultural evolution (*not* in our genes).

All evolving systems have the following properties:

- **POPULATIONS: Groups of entities.**
- **VARIATION: Members of the population differ from one another with respect to some characteristic.**
- **HEREDITARY SIMILARITY: Offspring resemble parents.**