General goal: To make sense of life’s complexity and diversity

ECOL 330 will explore the evolutionary link between the two...

Evolution requires continuity at some level

Invention of novel functions

General theme 1: Deep conservation of mechanisms on a cellular level and stunning diversity on anatomical & physiological levels

This cone and squirrels share (very) many genes...

ECOL 330 will discuss how to reconcile such conservation with diversity...
Intolerance of random changes vs. Dependence on random changes

Genes
ancient, some "immortal"

"Age of life"

Genomes
gene order and architecture
10^3-10^6 yrs

Gene expression
state
10^9-1 ms

BRIEF ASSOCIATION OF GENE AND TRAIT

Hidden in contemporary diversity is an image of the past diversifications

How much of past diversity can we still see?
considering that nearly all species that ever existed are extinct

Sequence space of a specific function

General theme 2: Importance of developmental context

General theme 3: heritable vs non-heritable changes

Neck stretching in giraffe and Pa Daung woman
— same cellular & physiological mechanisms
— neither is transmitted to next generation directly

ECOL 330 will explore how various components (e.g., DNA sequence) get involved in development...

ECOL 330 will discuss the difference between the two...
Central focus: Link between Evolution and Development

What actually evolves here?
- Individuals? No!
- Genes? No!

Parents
Survived Wal-Mart finches (strong)

Kids
Regular Wal-Mart finches? Or Strong Wal-Mart finches?

It depends on where in development changes reside...

1) Traits are not transmitted to offspring. Instead traits are reconstructed in development.
2) Individuals look differently because they had different growth, i.e. different inherited material, different growth environments, etc.
3) Evolution, proximally speaking, is a change in development.

Thus - development evolves!

Hence the link between evolution and development!
Basic definitions:

1) Natural selection - the differential reproduction & survival due to improvement in functioning
2) Adaptation - the product of natural selection
3) Evolution - change over time in the composition of developmental programs (ontogenies) in a population or lineage

Two super questions in evolution and development:

I. How does fertilized egg give rise to adult body?

II. How does that adult body produce yet another body?

"The Greatest of all Wonders in the Universe: …So stunning that we may fairly ask what hope there is to ever discover its solution, its hidden laws and causes."

William Keith Brooks, 1883

Seven general questions in evolution and development:

1) The question of differentiation
   A single cell – the fertilized egg – gives rise to hundreds of different cell types.
   Each cell contains the same set of genes
   — How can a single cell with "same set of genetic instructions" produce different types of cells?

https://youtu.be/3mCgHK-X6lE

7) The question of morphogenesis
   Differentiated cells are not randomly distributed: the organs and tissues formed and arranged in a particular way.
   The production of ordered form is called morphogenesis. Coordination of cell growth, cell migration, cell death
   — How can the cells form such ordered structures?

https://vimeo.com/293618382

Seven general questions in evolution and development:

3) The question of growth
   Just one more cell division on each side of a body will produce horrible malformations
   — How is cell division so tightly regulated?

https://vimeo.com/293618382
Seven general questions in evolution and development:

4) The question of reproduction
The sperm and egg are very specialized cells.
They transmit the instructions for making the organism to the next generation.
— How are these cells set apart? Why apart?
Why so early?
— How is age reset during fertilization?

The sperm and egg are very specialized cells.
They transmit the instructions for making the organism to the next generation.

This is what you looked like when your germ cells
(future eggs and sperm) segregated from the rest
of your body's cells to never see them again.

Seven general questions in evolution and development:

5) The question of regeneration
Some organisms can regenerate their entire bodies, some – parts. Stem cells...

— How do stem cells retain their
capacity to form new structures?

“New you”:
By ECOL 330 finals (early May) you will have completely replaced your:
1) Skin: 8 times
2) Blood (RBC): once
3) Intestine surface: 30 times
4) Liver: 1/2
5) All sperm cells: 40 times (2 full cell
lineages, ~27 billion)
6) Skeleton: ~5% completely
7) Only 2-3 of your tissues will have ALL
cells that witnessed today’s lecture.
— How do stem cells retain their
capacity to form new structures?

Seven general questions in evolution and development:

6) The question of evolution
Evolution involves inherited changes in development.

The Red Jungle Fowl
(Gallus gallus)

Polish White Crested Frizzle
Black Sicilian Buttercup

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7 October 2012 Nobel Prize follows 11 September 2012 ECOL330 lecture

The Nobel Prize in Physiology or Medicine 2012
Sir John B. Gurdon, Shinya Yamanaka

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Sir John B. Gurdon
Shinya Yamanaka

The Nobel Prize in Physiology or Medicine 2012 was awarded jointly to Sir John B. Gurdon and Shinya Yamanaka "for the discovery that mature cells can be reprogrammed to become yu..."
Seven general questions in evolution and development:

6) The question of evolution

Evolution involves inherited changes in development.

---What evolutionary changes are allowed by development?

---How do changes in development create new body forms?
Seven general questions in evolution and development:

7) The question of environmental integration

The development of all organisms is influenced by the environment.

How are environmental cues integrated into development?
Seven general questions in evolution and development:
7) The question of environmental integration