

Ecology: Jeff Podos

General Biology: Duncan Irschick

Statistics: Paul Sievert

Evolution: Craig Albertson

Moderator: Ben Letcher

Ecology (Podos)

1. I am teaching a large non-majors class in Ecology. What are the main pressing issues in Ecology that you think would be important to teach to this class?
2. Which type of population growth model fits what happened when rabbits were introduced to Australia in the 1800s (draw a graph)? What is the equation that best fits their population growth? What is the simple form of the equation?
3. Draw a food web (your system or hypothetical).
4. What was the famous debate regarding how food webs are regulated (top-down vs. bottom-up)? Where does your food web fit in?
5. What is a species? Give examples of systems that fit each of the species concepts you mentioned. What properties of organisms lead to each concept?
6. What is a hybrid? Does acknowledging hybrids negate the biological species concept?

General Biology (Irschick)

1. Name and describe different types of mating systems. Give examples.
2. How does testosterone come into play in these different systems?
3. How do testosterone levels fluctuate through the year in Anolis? In birds? Mammals?
4. What does testosterone do? How does it affect mating behavior?
5. Are there down sides to having too much testosterone?
6. What determines whether an embryo becomes male or female (mammals)?
7. How is sexual behavior regulated in humans versus gerbils?
8. How and why is the timing of reproduction different in humans and gerbils?
9. What about birds? How do they know when to begin reproductive behaviors?
10. What are the two classifications of hormones?
11. Which classification is testosterone in birds and why?

Statistics (Sievert)

1. What is the function of statistics in biological research?
2. What is the role of probability in statistics?
3. What are p-values? How would a frequentist describe a p-value of .05?
4. What is a Type I error?
5. What is the standard error of the mean?
6. What is pseudoreplication?

7. What does robust mean?
8. What are the assumptions of parametric statistics?
9. Which of these assumptions are parametric stats most robust to violations of?
10. What can you do if your response variable is not normally distributed?
11. What is power?
12. What is model selection? How do you determine which model fits the data best?
13. What is the difference between randomized complete block and repeated measures analyses?
14. What distributions are used for generalized linear models? What are the three components?
15. What is the error distribution for logistic regression?
16. What is PCA?
17. What is a contingency table?

Evolution (Albertson)

1. Heuristically speaking, what is the G-P mapping function? How is it a metaphor for the history of evolutionary biology?
2. What is epigenetics? Where did this term come from? Examples?
3. What is plasticity? Examples?
4. How heritable is a complex trait?
5. What is a constraint?
6. What is evolvability? Draw a figure that illustrates your examples.
7. Does genetic variability determine evolvability?
8. Is constraint always negative?
9. What does 'genes as followers' mean?
10. What is selection acting on?

Examinee: Evan Palmer-Young Date: 23 April 2013

Examiners:

General Biology—Ben Normark

Statistics—Paul Sievert

Ecology—Joe Elkinton

Evolution—Adam Porter

Entomology—Ben Normark

General Bio (Normark):

What are xylem & phloem? What are structure & roles of each?

Describe the structure & ultrastructure of DNA. What are the effects of changes to DNA (such as methylation, acetylation...)?

How do animal cells communicate? Draw me an action potential. Describe the mechanisms underlying an action potential.

Draw me a flower. Which tissues are diploid & which haploid? What are the four products of meiosis in female gametes?

Can sexual selection occur in plants?

Statistics (Sievert):

Why would a football coach say that "stats are for losers"?

What are Type I error, Type II error and power? What is the relationship between them?

What would be the effects of a design flaw (eg pseudoreplication) on the risk of the different types of error?

What are the assumptions of general linear models? What do you do if the assumptions are not met? Are there any error distributions besides normal?

Consider the decision to launch the Challenger space shuttle in 1986. What were some statistical errors made?

Evolution (Porter):

What are the consequences of habitat fragmentation for the evolution of metapopulations?

How would migration affect evolution of otherwise isolated populations?

What is an adaptation? How could you test whether something is an adaptation?

Is there such thing as a non-heritable adaptation?

What is meant by plasticity? What is a "norm of reaction"?

What makes a community vulnerable to invasion? What makes for a good invader? Speculate about the evolutionary forces acting on the invader and what (genetic) changes you might expect to occur in the invader.

Creationists have made a "chicken & egg" argument for the universe being intelligently designed: DNA cannot be replicated without proteins. Therefore DNA and protein had to be created at the same time (presumably by some intelligent designer). How would you respond to this argument? (I wasn't sure how to answer this. I said something about RNA have both catalytic & self-replicating capabilities. Adam indicated that perhaps I had not understood the question... but then we ran out of time)

Ecology (Elkinton)

What is exponential population growth? Can growth ever be faster than exponential? How does human population growth look since 1700?

What happens when a population reaches or exceeds carrying capacity?

Give an example of a trophic cascade.

Tell me about the classic paper by Hairston, Smith & Slobodkin ("Green World" hypothesis). Have their arguments been supported empirically?

We discussed a paper in Ecology class by Paine—a classic paper that everybody should know about. (I asked for clarification & got some hints that it was about a trophic cascade in a stream with trout, minnow, fly larvae & algae). What were the effects of removing the top predator?

How does one measure diversity? What are the components of diversity and how are they calculated? What are alpha, beta & gamma diversity? (I tried to thoroughly address alpha and beta to cover up my lack of understanding about gamma, but Joe didn't let me get away with it)

Are diverse communities more or less stable (than less diverse communities)?

Entomology (Normark):

What are some examples of sexual selection in insects? Are there any insects with flexible mating strategies (ie not always sexual)?

Why do insects have such diverse genitalia?

What are the most diverse orders of insects? What are the predominant "lifestyles" of the insects in each of these orders?

Do plant-feeding insects feed on xylem or phloem? Are there any that feed on both? What are some adaptations to feeding on plants?

PLUS the obligatory name-the-family component...

Notes:

For general bio & ent I agreed upon a set of readings (... half the textbook...) that would be fair game. Some of the questions came from outside those readings, though—I'd recommend clarifying with your committee members (very) shortly before the exam to remind them about the agreed-upon boundaries.

For stats, ecology, and evolution, I was told that any material covered in the biostats course or the core courses might be tested.

Committee:

Paul Sievert – Statistics
Bruce Byers – Evolution
Jeff Podos – Ecology
Craig Albertson – General Biology
Ben Letcher - Moderator

Statistics

Describe the three major statistical inference frameworks? What are the advantages/disadvantages of each? Which one do you prefer and why?
What are the components of a Generalized Linear Model?
What's the difference between a General Linear Model and a Generalized Linear Model?
What are some methods of model selection?
Why is having a lot of parameters in a model bad?
What are the disadvantages of Forwards/Backwards selection?
How is fitness determined in a genetic algorithm model selection approach? (from Bruce)
How do you calculate AIC?
What's a randomized complete block design?
What's the blocking factor in a repeated measures design?
When would you use a randomized complete block design vs a factorial design?
What's an F ratio? What does a high F ratio mean?
What's a PCA?
How do you calculate PC axes?
Given 10 variables, how many PC axes will you have?

Evolution

Describe non-adaptive evolutionary processes
How does drift affect genetic diversity both within and between populations?
Does drift always lead to the loss or fixation of alleles?
How does gene flow affect genetic diversity both within and between populations?
How does inbreeding affect genetic diversity?
How would you build a phylogeny?
What are the advantages/disadvantages of using morphological vs genetic data?
How do you know which genetic data to use?
How do you determine the timing of divergence between lineages?
Why are cichlids so colorful?

Ecology

Jeff and I both read the book Evolution's Wedge in preparation for the exam. Half of my questions came from topics in that book.
He described different species interactions and had me identify them (competition, commensalism, amensalism, predation/parasitism, mutualism).
Give an example of commensalism in the wild.
What is the thesis of the book?
What is character displacement?

Describe the pattern of trait evolution you expect to see if character displacement has occurred. Give an example of this in the wild.

Are there other processes that could also result in this pattern?

Describe species sorting. Give an example of this in the wild.

What's the difference between inter- and intra-specific character displacement?

What are the outcomes of each?

What are invasive species?

Do invasive species always have detrimental effects on local species?

Jeff referenced a recent paper which I had read about domestic cats as invasive species.

How many birds and small mammals are killed each year by cats?

How would you recommend we manage these invasive species?

What can cat owners do to prevent their cats killing local animals?

Next Jeff took a massive egg out of his bag and asked me to pretend my committee members were retired sanitation engineers and I was a scientist there to answer questions they had about the egg.

What kind of egg is this?

What's inside of it?

Why does the ostrich let its babies develop in the egg? Why don't the babies develop inside the ostrich?

Why is the egg so big?

Why does the ostrich only have 1 baby? When my dog had puppies there were 8.

How does the baby breathe while it's inside the egg?

The egg looks really thick - how does the baby eventually get out of the egg?

Why is the egg white? Why isn't it pretty and blue like a robin's egg?

Why is a robin's egg blue?

General Biology

Are hybrids always at a disadvantage?

How would transgressive segregation occur genetically?

Is speciation through hybridization a general phenomenon in adaptive radiations? Give an example of a radiation where it has played a role.

What is QTL mapping?

Can you identify the causative gene using QTL mapping?

What are some methods to identify causative genes?

How do you measure selection in the genome?

What does a high F_{st} vs low F_{st} indicate?

What's a gene? This led to a discussion of cis and trans regulatory elements

Define genetic modularity.

Can both regulatory elements and genes be modular? How so?

Craig showed me a picture of a cat with extra digits. What is this disorder called? How does it arise developmentally? Imagine two human populations- one with lots of people with an extra pinky and the other with lots of people with an extra thumb. What's the potential genetic/developmental basis of this difference?

Prelim questions Andrew Smith

Committee.

Evolution Craig Albertson

Ecology Bethany Bradley

Statistics Paul Sievert

General Biology Jeff Podos

Evolution

Discuss the modern synthesis and how it informed the extended evolutionary synthesis.

Discuss a few of the prominent figures that were part of the modern synthesis.

What is required for evolution to occur?

List some of the conditions for natural selection to occur.

What kind of constraints can limit the scope of evolution?

Mechanical, developmental etc, this led into a discussion about integration.

Can you explain the ways that morphological integration could both constrain and facilitate evolution?

What is modularity and how is it related to integration?

Ecology

How many species are there currently living on the planet?

What percentage of these species are endangered? Why are many of them at risk?

How has habitat destruction led to the loss of so many species?

What is habitat fragmentation and why is it a concern?

Why is island ecology important to study in light of habitat fragmentation?

How has climate change led to the loss of species?

In what ways have species responded to climate change?

How has nutrient addition led to the loss of species?

Which ecosystems are most at risk from nutrient addition?

How do we have evidence of climate change events in the past?

Have these also led to extinctions?

Discuss the temperature increase during the Palaeocene-Eocene thermal maximum with respect to current climate change figures.

How do we know this event occurred?

What are we measuring when looking at core data?

(Oxygen isotope data).

How do we get this from ice cores and marine sediment cores?

(Oxygen bubbles in the ice, oxygen from organic matter in sediments).

What are invasive species?

Discuss more about the enemy release hypothesis, what is the evidence for it?

General Biology

On the day I was wearing a sweater with four cartoon dogs on it.

What is biodiversity?

Are the dogs on your sweater a biodiverse population?

Why would Darwin be interested in those dogs if he were here now?

Are there differences between natural and artificial selection?

What did Mendel teach us about evolution?

How were his ideas incorporated into early evolutionary thought and the modern synthesis?

There's a spider sitting in front of a television and it sees a dot on the screen getting larger and larger. Why would it run away?

Name the three main nerve types.

What's involved in an action potential?

What does it mean to go above 0mv (I drew an action potential diagram)?

What are the charges in and out of the cell and along the neuron?

What are the ions involved?

Statistics

Discuss the three major frameworks of statistical inference.

What are the advantages and disadvantages of each of these frameworks?

What are the assumptions of the randomization framework?

What's the difference between ANOVA and a multiple regression with dummy variables?

Explain the difference between a factorial and nested ANOVA.

What's a repeated measures ANOVA, and how does it differ from a randomized block ANOVA?

What are some of the components of a multiple regression?

What is the link function used for?

Which is older, the Bayesian or frequentist framework?

Who was Mr. Bayes?

Yi-Fen Lin (May 2, 2013)

Statistics (Paul Sievert)

- Three frameworks of statistics
- The methods for model selection. Which one will you choose?
- How does non-parametric analysis work? What is the difference between parametric and non-parametric statistics? What kind of non-parametric analysis you will use? Why?
- The assumptions of multiple linear regression. How to test whether you violate these assumptions or not? If yes, what will you do?
- What is Generalized Linear Regression (GLM)?
- Describe your experiment design.
- The difference between randomized block ANOVA and nest ANOVA.
- When do you use MANOVA?
- What is central limited theorem? Is it important?

General Biology (Adam Porter)

First round: physiology

- What is Physiology? Why it is important?
- How will you teach "physiology" if you have a chance to give a lecture to people who don't study biology and don't understand physiology at all? What is the most important thing you think they should know? What does syllabus/outline look like?

Second round: Genetics

- What is genome?
- How do you identify the genes that underlie a specific phenotype?
- Detail of QTL, including "what the x and y axis means", "what the width of peak means" and "the statistic principle of QTL".
- What is your opinion of Genetically Modified Foods? If they might cause allergy, what is the potential mechanism?

Ecology (Jeff Podos)

- How does action potential pass from cell to cell?
- What cause climate change? Give me an example of "positive feedback" in climate change.
- How camel physiologically adapt to climate change? How they reserve water? What will happen to them if the weather becomes warmer?
- Give me an example about how animal adapt to cold environment.
- How the ecology of Yellow Stone National Park change due to the repeal of wolf hunting ban? Right now they are considering re-introducing the wolf to the park, what will happen?
- Are domestic cats invasive species? How will they change ecology?
- Why tropic areas have more biodiversity than temperate areas? Three hypotheses.

Evolution (Bruce Byers)

- How many species of moles in the world?
- How to define a "species"? Which one you prefer?
- What is phylogenetic tree? How to build one?
- How do you know a character is ancestral or derived?
- The definition of adaptation.
- The definition of fitness. How to measure?
- Why evolution is not perfect?
- Any trade-off or constrain in the species you study?

Evolution – Laura Katz

- What did Darwin accomplish, and what was his major effect on biology today?
- When was Origin of Species written? What other books did Darwin write?
- What was Mendel wrong about?
- How many genes are there in the human genome? E. coli genome? What is a gene anyway?
- Why is the human genome so much bigger than the E. coli genome? Selective and non-selective hypotheses?
- What is a ribosome and what is a ribozyme? How do ribosomes and ribozymes fit into the tree of life?
- Draw the tree of life (in 30 seconds).
- What is genetic drift? What is effective population size?

Ecology – Joe Elkinton

- What are the different ways in which animals can be distributed? How to test these statistically?
- What is exponential growth? What is geometric growth? Draw them. Write the equations.
- How do you describe growth that approaches a carrying capacity?
- How can the human population grow faster than exponentially? What is affecting birth and death rates?
- What is competition? How can the Lotka-Volterra equations be modified to model competition?
- What was the famous study done by Robert Paine about competition?
- Is competition important in your study system?
- What is the competitive exclusion principle?
- What is the “green world” hypothesis?

Statistics – Adam Porter

- Draw a fake datatable for a t-test. Modify that for a paired-sample t-test.
- What does a p-value mean?
- What are degrees of freedom? Are they good or bad?
- When would you use an anova? What's the difference between a two-way anova and a t-test?
- What are dependent and independent variables?
- What is likelihood? What is Bayesian stats? What's a prior, posterior? How do you set a prior?
- How do you assess whether your sample was big enough?
- When would you use a correlation vs a regression?
- What is the difference between covariance and correlation?
- What do you do if your treatments don't have equal variance? What is that called?
- How do you deal with truncated data? Zero-inflated?
- What is model choice and how do you do it?

Entomology – Adam Porter

- How can you kill this bug (cucumber beetle)?
- What is biocontrol? Can you think of examples where biocontrol went wrong?
- How can you kill invasive coccinellids?
- Insect ID from specimens and photos.

General Biology – Michael Hood

- Define sex. Do you need two organisms for sex?

P. Peterson Jan 22, 201

(2)

What are the two types of recombination?

Where does recombination not occur?

How is DNA packaged at meiosis?

How do homologous chromosomes match up (mechanistically)?

How could selection drive the reduction of recombination in a certain segment of the genome?

What is a host? What is host range?

What is a host shift? How can you know when one has occurred?

What are the underlying themes in your research? Where do those themes come up in other systems?

Melissa Ha
February 7, 2014

Joe Elkinton (Ecology)

- What is chaos?
- Who first discovered chaos?
- Are all populations that fluctuate erratically chaotic?
- How do you detect chaos?
- What is the Hairston et al. 1960 paper about?
- What are elaborations on "The World is Green" Hypothesis? (plant defenses, trophic cascades)
- What is an example of a trophic cascade?
- How do you sample dispersion in the field?
- What distribution would abundance data from plots of randomly dispersed organisms follow? What about aggregated dispersal?
- What is competitive exclusion?
- How is competition incorporated into the Lotka-Volterra model? What conditions would lead to coexistence?
- How do you detect whether a predator is regulating the prey population? (led to a discussion of density dependence, functional response, and numerical response)
- What is the Allee effect? Why is it important to consider for rare species?
- How do you measure population size?
- What factors determine when a population outbreak occurs?
- What principle underlies mark-recapture methods? (Lincoln index)

Bruce Byers (Evolution)

- How does speciation occur?
- What is reinforcement?
- How do you detect coevolution?
- Why are there so many species of angiosperms?
- If pollination by animals is such a good strategy, why has wind pollination re-evolved? Why aren't all angiosperms animal-pollinated?
- Define sexual selection.
- Does one sex typically experience sexual selection more than the other sex? Why? (led to a discussion of unequal parental investment and different levels of promiscuity between sexes)
- Is it ever advantageous for the resource-limited sex to seek out additional mates? (If you can only have raise one offspring per year, is it advantageous to mate more than once per year?)

Martha Hoopes (Statistics)

- What is the difference between a p-value and alpha?
- What is the difference between generalized linear models and general linear models? If your data were suited for both analyses, is it ever better to use general linear models?
- Why did you choose to use Mahalanobis distance to calculate a floral dissimilarity among species? Why not Euclidean distance?
- Can you use AIC to compare any models?
- How do you select explanatory variables in multiple regression? What is the problem with using variables that are not included in the final model to help you select the final model?
- What determines statistical power?
- What data are suited for logistic regression?
- What are the types of variables? (continuous, categorical)

- If you have a binary response variable and a categorical independent variable, would you use logistic regression? What is an alternative approach?

Craig Albertson (General Biology)

- What is a gene?
- In my yard, I have a patch of red flowers, a patch of white flowers, and a patch of purple flowers in between them. If I could only make one cross, what would be the best way to determine the inheritance pattern of flower color in this species?
- Describe transcription. Where does transcription occur?
- What are the defining characteristics of an organism?
- How do mutations arise?
- What are Mendel's two laws?
- Is it ever advantageous to be a heterozygote?
- How does speciation via polyploidy occur? Why is this more common in plants than in animals?
- Describe the different patterns of inheritance (dominance, codominance, incomplete dominance, epistasis, etc.)
- What is development? What is necessary for development to occur?
- How is cell fate determined? (led to a discussion of signal transduction)
- Are signals from other cells the only factor determining cell fate?
- How do ion channels work?

Hannah Broadley
OEB Preliminary Exam Questions
Date of exam: 3 March 2015

Committee:

Statistics: Paul Sievert
General Biology: Lynn Adler
Evolution: Adam Porter
Ecology: Joe Elkinton (my advisor)

Statistics:

You're teaching a one-hour "Introduction to Statistics" course. How would you structure your lecture? Wanted me to touch upon the following:

What is statistics used for?

Why is it an important tool for biologists?

What is a simple random sample?

What types of statistics are there? Frequentist and Bayesian

What is the Central Limit Theorem?

What is a P-value?

What is a random sample?

What is an F-statistic? What is a mean squared?

What is a linear model?

How is hypothesis testing used in statistics? Why do we use null models?

Kevin McGarigal hardly ever uses analysis of variance while Wes Autio primarily uses ANOVA. Why might this be?

General Biology:

How is mitosis different from meiosis? What is crossing over? Can a haploid organism undergo meiosis?

Describe life to an alien. Is fire alive? Is a virus alive?

We're sitting around eating some delicious snacks. What happens to this food? Tell me the steps of cellular respiration?

How is a C3 plant different from a C4 plant?

How are primers used in DNA replication?

What is the Central Dogma?

Evolution:

What is a parasitoid, a pathogen, and a parasite? How are they different? Is a giraffe a parasite of acacia?

Suddenly all parasitoids, pathogens, and parasites have been removed from the world. What happens? Would host species keep resistance alleles? Would anything take the place of these organisms? What would be most likely to become pathogens or parasites?

What is coevolution?

How does coevolution work for invasives?

What is the Red Queen Hypothesis?

When does escape and radiate evolution happened?

How is virulence defined? Do pathogens evolve towards increased virulence or avirulence?

What role do cheaters play in coevolution?

Ecology:

Tell me about population growth?

What is a survivorship curve? Draw one. What axis did you use? Can you present it with different axes?

What does Lotka-Volterra's predatory prey model tell us? How is it described mathematically? What does it look like when plotted over time? And when plotted as prey against predators? What if one disrupts this cycle?

Tell me about trophic cascades. Do you have an example of one? How are meso-predators involved in this process?

What is a Moran effect?

What is an Allee effect?

What is a metapopulation? How is this applicable to biocontrol research?

Tell me about the HSS paper? What were some of the papers following up on this topic? Tell me about Ehrlich and Raven's addition and the additions from Fretwell et al.

Emily Fusco
OEB Preliminary Exam Questions

Bethany Bradley- Biogeography

Round 1:

- What are some barriers to dispersal?
- How are oceans formed?
- Are rifts only in the ocean?
- What is an example of a rift that is not in the ocean?
- Will Africa look the same in another one hundred million years?
- How are deserts formed?
- Why isn't there rain in the deserts?
- How are mountains formed?
- How were the Andes formed?
- What are the lines of evidence for continental drift?
- What has driven the glaciation cycles over the past 1 million years?
- What about before the last million years?

Round 2:

- Draw the species area relationship.
- Draw the species distance relationship.
- What is a niche?
- How do biogeographers define islands?
- Why are islands more susceptible to invasive species?
- What factors go into modeling species distribution at a global, regional, landscape, and local level?
- How do biogeographers justify excluding competition from distribution models at the global scale?
- Graph how the abundance of a species might change across an environmental gradient for increasing NPP. How would this line change for a temperate frog?

Jack Finn- Statistics

Round 1:

- What is a model?
- How do you fit a model?
- How do you know if a model is good on its own?
- How do you know if a model is good compared to other possible models?
- What does AIC stand for?
- Is a low or high AIC better?
- What is the difference between Bayesian and Frequentist statistics?
- How do Bayesians determine their models?
- What is a generalized linear model?

How is a generalized additive model different from a generalized linear model?
How old are GAMs? GLMs?

Round 2:

What is a pvalue?

What is the other type of error?

What is the Bayesian definition of a pvalue?

Why haven't we always used Bayesian statistical methods?

Courtney Babbitt- Evolution

Round 1:

What is natural selection?

What is an example of an adaptation?

How can you test to see if trait is adaptive?

How can you test to see if a gene is adaptive?

How can you tell if DNA is experiencing positive selection?

What is a preadaptation?

On what levels can natural selection work?

Can these levels of selection work against each other?

What are some patterns of coevolution? Draw them.

Round 2:

How are phylogenies used to show coevolutionary relationships? Draw it.

How does coevolution impact invasive species?

Can you consider predator release a preadaptation?

Paige Warren- Ecology

Round 1:

What is ecology?

What are some major themes in ecological study?

What are some commonalities among those themes?

At what levels is ecology studied?

How do you define a population?

What is a metapopulation?

What are some types of metapopulations?

Are source populations always source populations?

Give an example of a species that exists in a metapopulation.

What factors affect population growth?

Draw a graph showing population increase over time.

Will it increase forever? What does the graph look like when it stops increasing? Name those graphs.

What are the equations for population growth?

What is island biogeography?
How does this apply to non oceanic islands?

Round 2:

What is a famous study in trophic dynamics?

What happened to the mussels when Paine took away the seastars? Why?

What are keystone species?

What is a trophic cascade?

Do trophic cascades act in the same direction on all levels?

What is an example of a trophic cascade?

How does fire fit into the food web?

Moderator: Craig Alberston
General Biology: Lynn Adler
Statistics: Paul Sievert
Evolution: Jeff Podos
Ecology: Bethany Bradley

General Bio 1:

A group of Martians comes down to Earth. You are their tour guide. They're curious about this thing called life that they've heard so much about. What can you tell them makes life?

What are the elements that make up most of life? *I named 4.* Can you name two more?

Tell me more about this life. How is it organized? *Getting at domains and kingdoms.* What distinguishes these groups?

You brought some delicious food here today. How can we use it for energy?

Talk me through the stages of cellular respiration. How many carbons does glucose have? Pyruvate? Do you ever lose carbons during cellular respiration?

What if you're a plant? What is photosynthesis? What are the parts? What is the carbon fixation part? What is the enzyme that helps with this? What is its claim to fame?

It is the summer and I have this particular new kind of grass growing in my yard rather than the type that I like. Why might that be? What does it mean to be C4? Why is it useful? How is it different? What enzyme is used? How does this enzyme differ from the C3 enzyme?

What is mitosis? Talk me through the stages.

General Bio 2:

Back to mitosis. How is it different from meiosis? Go to the board and draw where in the cycle you could detect the differences. Can a haploid organism go through meiosis?

Why is recombination important? *I mentioned linkage disequilibrium.* What is LD?

Before genetic sequencing, how could we tell if something was in LD?

Bonus: Draw an angiosperm seed for me. Label the ploidy of the tissue layers.

Where does the ploidy of the embryo come from? The endoderm? The seed coat?

Where would we see maternal effects for seed germination?

Statistics 1:

Why do we use statistics? Why are they important? Can you see the future of science without statistics? What would we do? *I said that's tough so he prompted:* What did we do before the development of statistics? Did science just not exist?

There's been a lot of debate about null hypotheses. What are null hypotheses? How are they used? *Jeff interjected to ask more about the Neyman Pearson decision-making framework.* Why aren't nulls often useful? How do we test them? Some people completely disagree with using null hypotheses. What do they do instead?

I've been thinking about how to teach simple statistical concepts to undergraduate classes. From that perspective: what is an F value? When do you use it? What can it tell you? What is the difference between an F value for a regression or an ANOVA? Then he went through and asked about some different kinds of ANOVA F values. What is a mean squares? What is it a measure of? How do you calculate it? If you have a large F value would you reject the null?

You mentioned using an ANOVA in regression. What is the difference between regression and ANOVA? The other day I ran a linear regression with categorical predictors. Did I do that wrong?

What is the difference between a nested hierarchical ANOVA and a crossed factorial ANOVA? Define the sampling design differences. What about the F statistic?

In multiple regression you don't have the same study design as a crossed factorial ANOVA, and yet you can still test for interactions. How do you do this?

Statistics 2:

What is a randomization test? How do you do it? Why would you use it? What does it mean to be nonparametric? Do you just have no parameters?

Why would you use parametric vs. nonparametric? *I mentioned stronger inference.*

Why does parametric allow you to make stronger inferences?

What are the classic assumptions for regression? When looking at homogeneity of variance, what are the variances you are comparing? How can you look for those?

How can you look for homogeneity of variance in multiple regression?

How can you measure collinearity?

What analysis do you perform if you have cross-classified count data? How do you make a contingency table? What is the statistic associated with it? How is it calculated? How do you calculate expected values? If you get a significant result, what does that tell you i.e. what is the table testing? You can get some really really complex big tables. How do you test those interactions?

Evolution 1:

To start, Jeff gave a container with a seed from the Galapagos. Can you tell me what that is? To start, is it animal or vegetable? It's a seed. It was a Tribulus seed. Can you tell me the role it plays in the most classic example of natural selection? What happened in the Galapagos during the 1970s? Tell me that story.

What is character displacement? How can natural selection and character displacement lead to speciation?

I needed a lot of help through this question because I wasn't sure what Jeff was trying to get at. So we worked on it step by step.

What is natural selection? What are the three necessary components? What are the different types?

During the 1970s there was a drought. How does natural selection come into play in this story?

He sent me to the board to draw the general pattern of character displacement. We talk about allopatry vs. sympatry.

How is species sorting different from character displacement?

Evolution 2:

What is cladogenesis vs. anagenesis?

Coming back to these ideas, you've mentioned competition as a driving force. What are the different options for competition? What does competitive exclusion mean? You've mentioned the pattern of the shift in phenotypes in sympatry – what causes that shift? Which is faster, evolution of *in situ* novel traits or standing genetic variation, and why?

So the Pfennigs wrote this book. Do you remember what they worked on? What is the story in that example? How does this relate to phenotypic plasticity? Is phenotypic plasticity truly character displacement? Tell me more about the plasticity first hypothesis that you mentioned earlier.

What are the two main categories of character displacement? Can you give me an example of each? How does reinforcement relate to reproductive character displacement?

**I think the most difficult part of this whole line of questioning was mixing up what factors work on populations vs. species vs. individuals. It made some of the concepts a bit muddy but Jeff helped me through it.*

Ecology 1:

I was recently reading a paper that said we are currently going through the sixth great mass extinction. Do you agree with that and why? What is some of the evidence for this mass extinction? What makes this extinction different? How many species have gone extinct?

What are some of the largest changes occurring globally to influence species diversity? I'm particularly thinking about plants. How can these changes influence diversity and ecosystems?

You mentioned one of the largest changes is habitat loss. How can habitat loss affect diversity? What are some ways that we measure diversity?

How can habitat fragmentation influence diversity? Tell me more about the theory of island biogeography. How does it apply here?

Describe some of the global changes in more detail. Tell me about the two big ones. How are they going to influence plants?

If we were to fast forward 10 million years, would there be greater or less diversity? Why? Think about two big changes and plants.

Ecology 2:

Do you think the woolly mammoth should be on the extinction list? Is there evidence that influences other than man caused its extinction?

When it comes to invasive species, what are some of the better known hypotheses and factors that contribute to them?

What is the PAB framework? How do hypotheses fall into this framework?

What is the invasion meltdown hypothesis? What would be an example of an invasive trait contributing to this phenomenon?

What leads to the increase of available resources in a community?

What is the open niche hypothesis?

What is the release from natural enemies hypothesis? What evidence is there for it? Is it good evidence? Do you buy it? What would be a better way to test this? What is the relationship between species diversity and community stability? Can you think of a classic experiment of this hypothesis?

**Bethany then listed two additional invasion species hypotheses that I am less familiar with. One included functional redundancy. They were both intuitive hypotheses I just can't remember the names exactly. She then asked for evidence for the second one. When I said I couldn't think of an example, she said there isn't one that she knows of – it is just conceptual at this stage.*

This is what I remember to the best of my ability. There were a lot of smaller questions to help me understand where the questioner was going. The most difficult task during the test was trying to communicate effectively, especially about concepts.

To study:

Books: Campbell et al. :Biology, Futuyma :Evolution, Cain et al. :Ecology, Quinn and Keough :Experimental Design and Data Analysis for Biologists, Gotelli and Ellison :A Primer of Ecological Statistics, Pfennig and Pfennig :Evolution's Wedge: Competition and the Origins of Diversity

Papers: Global Change Ecology and Invasion Ecology papers from Bethany

Notes: Notes from Analysis of Environmental Data and Applied Biostatistics courses

Groups: Mock Qualls study group and individual study groups with students who had the same examiner/topic combination

***If you are looking at this to study, Jeff and Bethany assigned me specific material, so if the questions seem limited to particular topics in Evolution and Ecology, that is why.

***Start early, don't panic, and focus on the bigger picture. I spent a lot of time on details that matter in general, but don't matter in this context.

OEB Preliminary Exam 2015

Here's what I can remember...

Student: Amy Strauss

Advisor: Jeff Podos

Exam Date: 03.23.15

Research Area: acoustic communication in birds/neurobiology of behavior/behavioral ecology

Committee:

- General Biology – Jeff Podos (my advisor)
 - What he told me to study:
 - *Behavioral Neurobiology: The Cellular Organization of Natural Behavior*, Thomas J. Carew
 - Anything in general biology
- Evolution – Bruce Byers
 - What he told me to study:
 - *Evolution*, 3rd Edition; Douglas J. Futuyma
 - Foundational/key papers in evolutionary biology (none specified)
 - Anything from the OEB Evolution Core Course
- Ecology – Paige Warren
 - What she told me to study:
 - *Ecology*, 2nd Edition; Cain, Bowman, & Hacker
 - *Foundations in Ecology: Classic Papers with Commentaries*, Real & Brown
- Statistics – Ben Letcher
 - I was supposed to have Paul Sievert for statistics, but Paul got stuck in Belize before my exam and Ben stepped in as substitute, so we had not discussed anything ahead of time.

Questions:

1. General Biology (Jeff Podos, advisor)
 - *Congratulations – you have just been given a job to teach a biology class to a group of students who have zero background in biology, zero interest in science, and zero interest in being in school. They want to graduate ASAP and make money. How would you structure the course? How would you get them excited about biology?*
 - *Name and explain the levels of ecological organization. Now explain why each level is relevant to the lives of the above-mentioned people.*
 - *In this discussion, I mentioned how forests take up CO₂. This led to a discussion of both photosynthesis and cellular respiration – the equations, the processes, molecule and nutrient cycling, etc.*
 - *I also mentioned health/medicine in discussing the relevance of cells. Jeff followed up -- what does cancer have to do with cells? How does smoking cause cancer, mechanistically? This led to a discussion of cell replication/mitosis.*
 - *If I have a cold, what does that mean, biologically?*
 - *What is the evidence that birds came from dinosaurs? Tell me about bird/dinosaur evolution.*

- *What is sound?*
- *How does sound travel?*
- *How does sound (vibration/movement of particles) translate into a neurological signal that an animal understands as a sound?*
- *What is an action potential? How do neurons communicate with each other and with sensory and motor systems?*
- *When a mouse moves across the ground, how does an owl localize that mouse and accurately catch it? He wanted a very detailed, mechanistic explanation at the molecular/cellular level.*

2. Evolution (Bruce Byers)

- *What is an adaptation?*
- *How can you test whether or not something is adaptive?*
- *How do you measure fitness?*
- *Are adaptations always derived?*
- *What does it mean for a trait to be derived?*
- *Why is it useful to know whether a trait of interest is derived or ancestral?*
- *What traits are useful for constructing phylogenies, and how do you use those traits to build your tree?*
- *What is homology? What is analogy?*
- *If selection is acting on a trait, why do we see variation in that trait? What mechanisms maintain variation?*
- *What is a signal?*
- *How do signals evolve? How can we test competing hypotheses of how signals have evolved?*
- *What maintains signal honesty?*
- *What is the acoustic adaptation hypothesis? Explain the theory behind this idea.*
- *Is there evidence to support the acoustic adaptation hypothesis? How would you test it?*
- *What is the role of behavioral plasticity in song evolution and how would you test it?*
- *What is the role of genetics in song evolution and how would you test it?*
- *What is the role of learning in song evolution and how would you test it? This led to a discussion of cultural evolution.*

3. Ecology (Paige Warren)

- *What are some examples of how humans are affecting the natural world? Explain.*
- *This led to a discussion of invasion ecology. What determines whether a non-native that is introduced will become an invasive? What defines an invasive?*
- *What factors influence community composition? How so?*
- *Why in one region do we have a certain species composition, and in another region we have a different species composition? This led to a discussion of niche partitioning, competitive exclusion, resource availability, population regulation (top-down and bottom-up), abiotic influences, disturbance, ecological drift...*
- *Identify and describe a classic paper that looked into one of these factors. What did they find? This led to a discussion of the intermediate disturbance hypothesis.*

- *What is a niche? How have different people defined niches in the ecological literature?*
- *Why are the tropics so diverse?*
- *What is Island Biogeography Theory? Explain the predictions, draw the graph, etc. Who proposed this theory? What evidence is there to support/reject it?*
- *Let's talk about population growth. A population colonizes a new area – what does the population growth look like? Why? What factors affect population growth? This led to a discussion of exponential vs. logistic growth, density-dependence and delayed density-dependence, and the concept of carrying capacity (and oscillations around carrying capacity).*
- *What are density-dependent factors that affect population growth?*
- *What are density-independent factors that affect population growth?*
- *How do you measure population growth rate? Here we discussed the intrinsic rate of increase and how you calculate 'r'.*
- *What does the human population growth curve look like? Where are we on that curve today? How would you calculate human population growth rate?*
- *Explain the hypothesis, "the world is green". Who said this? How do ecologists today feel about this idea?*
- *Do you consider yourself an ecologist? How does ecology fit into your work?*
- *Is there such thing as acoustic niche partitioning? Explain.*

4. Statistics (Ben Letcher)

- *What are statistics and when are they useful?*
- *How do you design an experiment? How do you pick a model? How do you know what stats to use?*
- *This led into a discussion about hypothesis testing, alternative and null hypotheses, setting significance levels, etc.*
- *What is power analysis and what factors go into it? Why is it useful? When is it useful?*
- *What is pseudoreplication and why is it problematic? Give an example.*
- *What is a design matrix and how do you use it?*
- *What is a link function and when do you use it? Give an example.*
- *Explain model selection – how does it work? Why is it useful?*
- *What is an AIC and what can it tell us?*

Dina Navon – Qualifying Exams

4/1/2015

Committee Members:

Ecology – Jeff Podos
General Biology – Craig Albertson
(advisor)

Evolution – Bruce Byers
Statistics – Adam Porter
Moderator – Laura Katz

Ecology

Round One: Jeff and I read Ecology of Adaptive Radiations by Dolph Schluter together (I highly recommend it). He began by commenting on how dense the book is, and expressed hope that I got something out of it. I did, and mentioned briefly (and broadly) what I enjoyed about the book. He then asked the following questions about it:

- What is an adaptive radiation?
- Is there such a thing as a nonadaptive radiation? What is it? Can you give me an example of one?
- What are the four criteria to classify something as an adaptive radiation?
- Walk me through the steps of an adaptive radiation. How do you go from one ancestral species to the variety of forms you see in an adaptive radiation? (This question definitely took the longest, and we spent most of the remaining time talking about it using the Galapagos finch story as a discrete example). Subquestions included:
 - What is competition?
 - How does competition lead to divergence?
 - What is the role of natural selection at the earliest stages of evolution?
 - How does speciation occur within adaptive radiations? (What is a species, what is speciation, etc.)

Round Two: Jeff opened his ecology book to a picture of an invasive cactus in Australia, and told me briefly about its history. He then asked me to talk about the process of invading a new environment.

- Draw a graph of cactus population size over time.
- What kind of growth do you see towards the beginning? (exponential)
- What factors may be contributing to that growth?
- You (correctly) drew that the shape of the curve changes over time. Why did you draw it like that? What kind of growth are you describing here? (logistic) What factors may be contributing to it?
- Have you heard of the Lotka-Volterra model? Draw a graph of the outcome of a predator-prey interaction. Is this the only outcome possible? What is another one?

General biology

Round One:

- What kinds of cells are there? What are some of the differences between plant and animal cells?
- Are there other kinds of cells? What do those look like?
- What makes a cell happy? Why does a cell need food? (We talked about the steps of cellular respiration very generally)

-How does a cell sense and respond to its environment (We discussed signal transduction pathways in very broad terms, ending with transcription factors entering the nucleus and turning on or off genes)

-So, how does a transcription factor work? (I diagrammed a gene, including the promoter and a cis-regulatory region upstream of the exons, and showed where the TF binds.) Ok, so which part of your picture is a gene? Circle it. (Again, got into trouble here because I said that a gene is the part that gets made into a protein, but not all genes become proteins, so I had to revise my definition.) You provide your students with this diagram and ask them to circle the gene. Which answers would you provide full credit for? Half credit? Are there any wrong answers?

-What's a gene? What's an allele? How many alleles are in a diploid individual? How many alleles are in a population?

Round Two:

-How does development happen? Starting at fertilization, and moving all the way to a fully developed organism, what happens at each stage? Stages I discussed in detail:

-Fertilization (talked a bit about maternal effects)

-Cleavage (how maternal effects act here, animal/vegetal poles of the embryo)

-Gastrulation (sweeping migration of cells)

-You mentioned the three germ layers – what are they? When did the mesoderm evolve? (I got into loads of trouble with this question, and had all of them chiming in at one point or another.)

-What is evolvability? What is the most evolvable part of the embryo?

-When talking to Jeff, you mentioned skepticism about species and speciation. Why are you skeptical? Do you think species actually exist in nature? Why?

Evolution

Round One: Bruce mentioned that, in the last section, I had talked about how the mitochondria have a double membrane. He asked why this might be, which led to a discussion about endosymbiotic theory:

-What is the endosymbiotic theory?

-What observations, other than the double membrane of mitochondria, could this explain?

-So mitochondria have genomes? If used those genomes to put mitochondria on the tree of life, which domain would they be in? (I wasn't sure between Archaea and Bacteria – it's Bacteria)

-Is there a way, based on sequence information, to tell how long ago two species diverged? What assumptions are made by the molecular clock? How does the neutral theory fit into the molecular clock idea? What kinds of sequences would you want to use to do this kind of dating?

Round Two:

-Say I wanted to determine which genes underlie a particular phenotype, and I come to you for advice. What would you tell me to do? How does QTL analysis work? (I walked him through an example, loosely based on an analysis I ran earlier this year).

-Is there another way to go about this? Is it possible to do QTL experiments in every organism? What could you do instead?

Statistics

Round One:

- What kinds of data are there?
- How would you analyze these different kinds of data?
- What's a t-test? Draw a fake data table for a t-test. How do you analyze this data?
- What's a p-value?
- Draw a fake contingency table.
- What's the difference between parametric and nonparametric statistics?
- What is maximum likelihood? How is it different from the frequentist method? (I said I didn't see them as different, just that ML is used in a frequentist framework sometimes)
- What's the difference between a frequentist and a Bayesian? How does the Bayesian method work?
- Ok, I'm bored (yes, he actually said that. Yes, I started laughing). Tell me about morphometrics. How do I know if one shape is different from another shape? (This was where I really started to struggle, partly because I was exhausted and partly because it's a complex method)

Round Two:

- Ok, let's draw this out on the board. Show me two different shapes that you want to compare – pick your favorite shape. Now, using a different color, superimpose one on the other. What are the Procrustes distances? Outline them in a third color. How do you tell if these two shapes are different from each other?
- What if your favorite shape shows allometry? What is allometry? How do you deal with it? (I was flailing through a complicated statistical procedure when Craig interrupted: You know a better way to do this. What do you do when you have a relationship between two variables? [You run a regression.] Ok so then what do you have? [Residuals] So how do you deal with allometry? [Use the residuals from the regression between body size and shape for your morphometric analysis – I have done this with my own data, but was not thinking clearly enough to reach for the familiar.]

General Advice:

Breathe! You wouldn't be in OEB if they didn't think you could do this. Stay calm and confident – they're looking to see that you handle yourself well under pressure (and you can, as long as you trust in the undeniable fact that you are a smart person that belongs in this program. And it is undeniable – see above re: you wouldn't be here if they didn't think you belonged).

I started off with Jeff/Ecology because it was the subject I felt I had studied the most/was the most confident in, but I made a mistake putting my less familiar subjects/questioners last – I was tired by the time I got to Bruce and Adam. So, in the second round, I bounced back in the opposite direction so that I was as fresh as I could be for the difficult stuff.

It's ok to not know things – but if you don't know something, it's best to hazard an informed guess (and explain your reasoning). Craig asked me when mesoderm evolved, and all I came up with was "sometime after multi-cellularity". And I passed. You don't – and shouldn't! – know everything they're going to ask you. That's the whole point, after all. I know that's a scary concept, but let go of your inherent I'm-a-scientist-and-thus-a-perfectionist hat and do the best you can.

Time goes by way faster than you think – you never have to talk for the full 3 hours, because usually they spend quite a bit of time articulating their questions.