



2014 Undergraduate

Summer Internships

The 2014 REU summer internship begins on **Monday, June 9, 2014**, and **Monday June 16, 2014**.
The Annual Undergraduate Research Symposium is scheduled for **Friday, August 15, 2014**

2014 REU Participants

Luis Allende, lmallend@neiu.edu, Northeastern Illinois University, sophomore.

Project: *What's in a name? That's what we call a species - addressing species delimitation in lichenized fungi* with Dr. Thorsten Lumbsch (Curator, Botany and Associate Director, Integrative Research Center)

Anne Gibbons, aegibbons17@gmail.com, University of Michigan - Ann Arbor, junior.

Project: *Hairy legs in the Nursery* with Drs. Petra Sierwald (Curator, Arachnida and Myriapoda) and Estevam da Silva (Postdoctoral Researcher, Arachnida and Myriapoda)

Wilson Guillory, wxguillo@email.uark.edu, University of Arkansas, freshman.

Project: *One leg at a time: The morphology of millipedes* with Dr. Petra Sierwald (Curator, Arachnida and Myriapoda)

Chris Kyriazis, CKyriazis33@gmail.com, University of Chicago, junior.

Project: *Speciation and Diversification of Mammals on Islands* with Drs. John Bates (Curator, Birds) and Lawrence Heaney (Curator, Mammals)

Armita Manafzadeh, armita.manafzadeh@berkeley.edu, University of California – Berkeley, sophomore.

Project: *Morphological Integration in the Mandibles of Living Reptiles and Fossil Synapsids* with Dr. Kenneth D. Angielczyk (Curator, Geology)

Ian Medeiros, imedeiros@coa.edu, College of the Atlantic, sophomore.

Project: *ATM meets MET - Assembling a Taxonomic Monograph using Modern Electronic Tools* with Drs. Robert Lücking (Adjunct Curator and Collections Manager, Botany) and Thorsten Lumbsch (Curator, Botany and Associate Director, Integrative Research Center)

Dana Reuter, reute22d@mtholyoke.edu, Mount Holyoke College, junior.

Project: *Morphological evolution of carnivoran milk teeth* with Drs. Kenneth Angielczyk (Curator, Geology) and Susumu Tomiya (Postdoctoral Researcher, Geology)

Max Witynski, birdmax922@gmail.com, Cornell University, freshman.

Project: *What can we learn from 30+ years of bird migration data?* with Drs. David Willard (Adjunct Curator, Birds), Ben Marks (Collection Manager, Birds) and Douglas Stotz (Research Ecologist, Action Center)

2014 Affiliated Interns

Undergraduate intern: **Ethan Gyllenhall**, ethanofthegulls@gmail.com, University of Rochester, sophomore.

Project: *Phylogeography of the Pteroglossus azara (Ramphastidae) complex: Implications for prioritizing conservation and defining areas of endemism in the Amazon* with Dr. Jason Weckstein

Undergraduate intern: **Stephanie Pedersen**, stephaniepedersen11@augustana.edu, Augustana College, senior.

Project: *Osteohistology of an Antarctic sauropodomorph dinosaur* with Dr. Peter Makovicky

Undergraduate intern: **Aaron Goodman**, amgoodman@ucdavis.edu, University of California - Davis, junior.

Project: *Utilizing the isolated theropod tooth record to answer paleoecological questions* with Dr. Peter Makovicky

Fulbright African Visiting Research Scholar: **Tshifhiwa Nangammbi**,

tshifhiwanangammbi@yahoo.com, Tshwane University of Technology, South Africa.

Project: *Genetic characterization of Oreochromis niloticus and indigenous riverine fishes through the use of Microsatellites for a better conservation of the indigenous fishes in Limpopo, South Africa* with Kevin Feldheim.



2014 REU Program: Dates and Locations

Note: at all events at 4:30pm cookies and crackers will be available.

Monday, June 9 at 8:30am: Orientation in Human Resources

Wednesday, June 11 from 12:00 - 1:30pm: Lecture 1, *Introduction to internship program and scientific collections, organismal classification* with instructors Drs. Petra Sierwald and Ken Angielczyk. Meet in the zoology classroom on the 3rd floor. Participation is mandatory for REU interns.



Thursday, June 12 from 9:30 - 10:00am: Library orientation in the Library Reading Room on the 3rd floor.

(Attending one library orientation session is mandatory for use of the library. Three are offered, June 12, 17 and 19.)

Monday, June 16 at 8:30am: Orientation in Human Resources

Tuesday, June 17 from 9:30 - 10:00am: Library orientation in the Library Reading Room on the 3rd floor.

Wednesday, June 18 from 10:00 - 11:00am: Tour of Anthropology Collections with Collection Manager Chris Phillips. Interns meet in front of the elephants in Stanley Field Hall at 10:00am. This tour is limited to 20 participants. Contact Melissa Anderson, manderson@fieldmuseum.org to reserve your spot.

Wednesday, June 18 from 12:00 - 1:30pm: Lecture 2, *Introduction to phylogenetic reconstruction* with instructor Dr. Ken Angielczyk. Meet in the zoology classroom on the 3rd floor. Participation is mandatory for REU interns.

Thursday, June 19 from 9:30 - 10:00am: Library orientation in the Library Reading Room on the 3rd floor.

Thursday, June 19 from 10:00 - 11:00am: Tour of Mammals Collections with Assistant Collection Manager Anna Goldman. Interns meet in front of the elephants in Stanley Field Hall at 10:00am. This tour is limited to 20 participants. Contact Melissa Anderson, manderson@fieldmuseum.org to reserve your spot.

Wednesday, June 19 from 12:00 - 1:30pm: Ethics seminar with instructor Dr. Petra Sierwald. Meet in the zoology classroom on the 3rd floor. Participation is mandatory for REU interns.

Tuesday, June 24 from 10:00 - 11:00am: Tour of Insect Collections with Collection Assistant Jim Louderman. Interns meet in front of the elephants in Stanley Field Hall at 10:00am. This tour is limited to 20 participants. Contact Melissa Anderson, manderson@fieldmuseum.org to reserve your spot.



Friday, June 27 from 9:45am - 3:15pm: Tour of the Field Museum hosted by the Field Museum REU interns with guests from the Chicago Botanic Garden REU program and Morton Arboretum undergraduate research internship program (details on page 8). Participation is mandatory for REU interns.

Friday, June 27 at 10:00am: Seminar, *How to apply for graduate school in the Sciences* with Dr. Corrie Moreau. Meet in the zoology classroom on the 3rd floor. Participation is mandatory for REU interns.

Wednesday, July 2 from 4:30 - 6:30pm: *Phylogenetic workshop I* with instructors Drs. Timothy Swain and Estevam da Silva. Meet in the zoology classroom on the 3rd floor to be escorted to the computer lab in the Underground Adventure exhibit. Participation is mandatory for REU interns.

Wednesday, July 9 from 4:30 - 6:30pm: *Phylogenetic workshop II* with instructors Drs. Timothy Swain and Estevam da Silva. Meet in the computer lab in the Underground Adventure exhibit. Participation is mandatory for REU interns.

Thursday, July 10 from 10:00am - 11:00am: Tour of Mammals Collections with Assistant Collection Manager Anna Goldman. Interns meet in front of the elephants in Stanley Field Hall at 10:00am. This tour is limited to 20 participants. Contact Melissa Anderson, manderson@fieldmuseum.org to reserve your spot.

Thursday, July 10 at 5:00pm: Enter a preliminary title of your symposium presentation into the Google spread sheet (details on page 15). This is mandatory for symposium participants.

Wednesday, July 16 from 4:30 - 6:30pm: *Phylogenetic workshop III* with instructors Drs. Timothy Swain and Estevam da Silva. Meet in the computer lab in the Underground Adventure exhibit. Participation is mandatory for REU interns.

Thursday, July 17 from 10:00 - 11:00am: Tour of Anthropology Collections with Collection Manager Chris Phillips. Interns meet in front of the elephants in Stanley Field Hall at 10:00am. This tour is limited to 20 participants. Contact Melissa Anderson, manderson@fieldmuseum.org to reserve your spot.

Friday, July 18 from 8:00am – 6:00pm: Field trip to the Chicago Botanic Garden hosted by the Chicago Botanic Garden REU interns with guests from the Field Museum REU program and the Morton Arboretum undergraduate research internship program (details on page 10). Participation is mandatory for REU interns.



Tuesday, July 22 from 10:00 - 11:00am: Tour of Insect Collections with Collection Assistant Jim Louderman. Interns meet in front of the elephants in Stanley Field Hall at 10:00am. This tour is limited to 20 participants. Contact Melissa Anderson, manderson@fieldmuseum.org to reserve your spot.

Wednesday, July 23 from 4:30 - 6:30pm: *Phylogenetic workshop IV* with instructors Drs. Timothy Swain and Estevam da Silva. Meet in the computer lab in the Underground Adventure exhibit. Participation is mandatory for REU interns.



Friday, July 25 from 10:00am – 12:00pm: REU interns present their research to the public as part of the outreach program - *Meet a Scientist: the Next Generation*. This will take place in Stanley Field Hall. REU intern advisers will guide and assist interns with how to effectively explain scientific research to a general audience. This event will be organized by REU instructor Dr. Estevam da Silva. Participation is mandatory for REU interns.

Wednesday, July 30 from 4:30 - 6:30pm: *Phylogenetic workshop V* with instructors Drs. Timothy Swain and Estevam da Silva. Meet in the computer lab in the Underground Adventure exhibit. Participation is mandatory for REU interns.

Friday, August 1 from 8:00am - 5:45pm: Field trip to the Morton Arboretum hosted by Morton Arboretum undergraduate research internship program with guests from the Field Museum REU program and the Chicago Botanic Garden REU interns (details on page 12). Participation is mandatory for REU interns.



Wednesday, August 6 from 4:30 - 6:30pm: *Phylogenetic workshop VI* with instructors Drs. Timothy Swain and Estevam da Silva. Meet in the computer lab in the Underground Adventure exhibit. Participation is mandatory for REU interns.

Monday, August 11 at 5:00pm: Undergraduate Research Symposium abstracts due to Dr. Kenneth Angielczyk. Send as attachment to kangielczyk@fieldmuseum.org (see instructions on page 16). This is mandatory for REU interns.

Thursday, August 14 at 12:00pm (noon): Undergraduate Research Symposium presentations due electronically to Ken Angielczyk. Send as attachment to kangielczyk@fieldmuseum.org. See instructions on page 15. Participation is mandatory for REU interns.

Thursday, August 14: Exit Interviews in Human Resources. Please contact Stephanie Ware, sware@fieldmuseum.org, to schedule your exit interview.

Friday, August 15 from 9:00am - 5:00pm: Undergraduate Research Symposium in the Montgomery Ward Theater. Lunch and refreshments will be served. Participation is mandatory for REU interns.

Friday, August 22: Exit Interviews in Human Resources. Please contact Stephanie Ware, sware@fieldmuseum.org, to schedule your exit interview.



Tour of the Field Museum

Hosted by the FMNH REU interns



Friday June 27: Chicago Botanic Garden REU interns and Morton Arboretum undergraduate research interns will tour the Field Museum's REU laboratories and work-stations. The FMNH REU's will give a short, 5-minute explanation of their respective research.

9:45 am: CBG and Morton Arboretum interns arrive at Field Museum. They will be issued visitor stickers and then will be escorted to zoology class room for Dr. Moreau's seminar

10:00 am: Seminar - *How to apply for graduate school in the Sciences*, given by Dr. Corrie Moreau in the zoology class room on the 3rd floor

11:00 am: CBG, Morton and FMNH REU interns tour the bird collections. Project presentation by FMNH REU intern Max Witynsk: *What can we learn from 30+ years of bird migration data?* Advisers: Dr. David Willard (Adjunct Curator, Birds), Dr. Ben Marks (Collection Manager, Birds) and Dr. Douglas Stotz (Research Ecologist, Action Center)

11:30 am: CBG, Morton, and FMNH REU interns tour the mammal collections. Project presentation by FMNH REU intern Chris Kyriazis: *Speciation and Diversification of Mammals on Islands*. Advisers: Dr. John Bates (Curator, Birds) and Dr. Lawrence Heaney (Curator, Mammals)

12:00 pm (noon): Pizza lunch in the zoology classroom for FMNH, Morton and CBG interns

1:00 pm: CBG, Morton, and FMNH REU interns tour the Botany collections. Project presentation by FMNH REU intern Luis Allende: *What's in a name? That's what we call a species - addressing species delimitation in lichenized fungi*. Adviser: Dr. Thorsten Lumbsch (Curator, Botany and Director, Integrative Research Center)

REU research project presentation by FMNH REU intern Ian Medeiros: *ATM meets MET - Assembling a Taxonomic Monograph using Modern Electronic Tools*. Advisers: Dr. Robert Lücking (Adjunct Curator and Collections Manager, Botany) and Dr. Thorsten Lumbsch (Curator, Botany and Director, Integrative Research Center)

1:45 pm: CBG, Morton, and FMNH REU interns tour Geology collections. Project presentation by FMNH REU intern Armita Manafzadeh: *Morphological Integration in the Mandibles of Living Reptiles and Fossil Synapsids*. Adviser: Dr. Kenneth D. Angielczyk (Curator, Geology)

REU research project presentation by FMNH REU intern Dana Reuter: *Morphological evolution of carnivoran milk teeth*. Advisers: Dr. Kenneth Angielczyk (Curator, Geology) and Dr. Susumu Tomiya (Postdoctoral Researcher, Geology)

2:30 pm: CBG, Morton, and FMNH REU interns tour the pinned Insect collections, east mezzanine, led by assistant collection manager Jim Louderman. REU research project presentation by FMNH REU intern Anne Gibbons: *Hairy legs in the Nursery*. Advisers: Dr.

Petra Sierwald (Curator, Insects) and Dr. Estevam da Silva (Postdoctoral Researcher, Insects)

REU research project presentation by FMNH REU intern Wilson Guillory: *One leg at a time: The morphology of millipedes*. Adviser: Dr. Robert Lücking (Adjunct Curator and Collections Manager, Botany) and Dr. Thorsten Lumbsch (Curator, Botany and Director, Integrative Research Center)

3:15 pm: CBG and Morton interns free to explore FMNH public exhibits (FMNH REU interns can join them)

5:00 pm: CBG and Morton interns to meet with advisers at 5pm at West door for departure.



Tour of the Chicago Botanic Garden

Hosted by the CBG REU interns



Friday, July 18: The Chicago Botanic Garden REU interns will give short presentations about their summer research projects. The Morton Arboretum undergraduate research interns will join the group. Field Museum and Morton Arboretum interns will get a guided tour through the garden and green houses and see the research facilities. All interns will have time to explore parts of the garden on their own in the afternoon. Lunch for all interns will be provided.

*Please note that it may be very hot in the summer in the garden. You will spend a considerable time outside. Please bring hats and sun screen, and a large water bottle.

Stephanie Ware will provide tickets for the Metra ride to Glencoe for each FMNH REU participant. You will take the Union Pacific North Line to and from the Braeside Metra train station near Glencoe. Stephanie Ware will accompany you both ways.

If you prefer to travel by private car to the CBG, please let us know well in advance. Arrive at the entrance of the CBG by 9:30am: 1000 Lake Cook Road, Glencoe, IL 60022 - (847) 835-5440. Admission to the Garden is free. If you arrive in a private car, parking fees will apply.

8:00 am: FMNH REU interns meet Stephanie Ware at the Ogilvie Transportation Center, 500 West Madison

8:35 am: Train departs Ogilvie Transportation Center

9:20 am: Train arrives at Braeside Metra station where interns will be shuttled to the Chicago Botanic Garden

9:40 am: Tour of the McDonald Woods (<http://www.chicagobotanic.org/explore/mcdonaldwoods.php>)

10:40 am: Garden Tour including Bonsai collection, Greenhouses, Sensory Garden and Evening Island

12:00 pm (noon): Lunch (CHIPOTLE) in Atrium

1:00 pm: Tour of the Herbarium, Population Biology Lab, Ecology Lab and Soil Labs

- The **ITW Plant Systematics Laboratory and Nancy Poole Riche Herbarium:** for project presentations by Jaileen Merced on Assessing Ravine Flora & Jeremy Sutherland on Historic changes in genetic diversity of *Castilleja levisecta*
- The **Population Biology Lab:** for project presentations by Giselle Varrientos on When seed sourcing matters for restoration on the Colorado Plateau
- The **Abbott Ecology lab :** for project presentations by Allison Brackley on Interactions between a Suite of Biocontrol Weevils and the Ecosystem of *Cirsium pitcheri* & Pairsa

Belamaric on Estimating Impacts of Bison Grazing on Rare Plants at the Nachusa Grasslands

- The **Soil lab**: for project presentations by Benjamin Sanchez-Sedillo on Soil Fungal Biomass: Its Degradation and Contribution to Soil Organic Matter, Ramsey Millison on Impacts of tallgrass prairie restoration on decomposition and microbial communities & Rosalba Herrera on Genetic and stable isotope analyses of fungi from Mexico's Yucatan Peninsula

1:45 pm: Tour of the Herbarium, Population Biology Lab, Ecology Lab and Soil Labs

- The **Microscopy Lab**: for project presentations by Carolyn Thornton & Linsey Nowack on Fossil Plants from Mongolia
- The **Reproductive Lab** and Seed Bank: for project presentations by Lisa Hintz on Using native winners to improve restoration outcomes on the Colorado Plateau & Courtney Devoid on Impacts of Climate Change on Germination of Native Species.
- The **Astellas Economic Botany Laboratory Lab**: for project presentations by Matthew Murphy on Analysis of breadfruit domestication (*Artocarpus altilis*, Moraceae)
- The **Harris Family Foundation Genetics Lab**: for project presentations by Deisi Williamson on Genetics for good: helping to conserve a rare plant in the Pacific Northwest & Mike Daichendt on Genetic comparison of the Calylophus clade of Oenothera

2:20 pm: Tour of the Green Roof of the Science Center with Monica Cesinger who will talk about her project on Green Roof Ecology

3:00 pm: Free time to explore the gardens

4:45 pm: FMNH interns meet at the entrance to garden for ride/shuttle to Braeside Metra train station.

5:26 pm: Train departs Braeside Metra station.

6:09 pm: Train arrives at Ogilvie Transportation Center

Contact phone numbers at Chicago Botanic Garden

- Dr. Jeremie Fant, cell phone: 773-474-4540, jfant@chicagobotanic.org
- Dr. Dan Larkin, dlarkin@chicagobotanic.org
- Adrienne Basey, info@cbgreu.org: REU coordinator at CBG
- Petra Sierwald's cell phone: 708-751-4798
- Stephanie Ware's cell phone: 312-576-9111
- For details about the Chicago Botanic Garden see: <http://www.chicagobotanic.org/>

Tour of the Morton Arboretum

Hosted by the MA Undergraduate Research Interns



Friday, August 1: Field trip to The Morton Arboretum for Undergraduate Student Research Interns from The Morton Arboretum, The Field Museum of Natural History and Chicago Botanic Garden. A seminar on Interpreting Science to the Public will be given by Kate Sackman of EcoMyths Alliance. The Morton Arboretum undergraduate research fellows will give short field presentations about their research. The Field Museum and Chicago Botanic Garden interns will get a guided tour through the Arboretum Research, Collections and Natural Areas. All interns will have time to explore the Arboretum. Lunch for all interns and advisors will be provided.

* Please note that it may be very hot in the summer in the Arboretum and we will be spending a considerable amount of time outside. Please bring hats and sun screen, and a large water bottle.

A shuttle between The Morton Arboretum and the Lisle Metra Station will pick up and drop off students. Please contact Christine Carrier to ensure you are included on the list.

If you prefer to travel by private car to the Morton Arboretum, please let us know well in advance. Arrive at the entrance of the Arboretum by 9:30am: 4100 ILLINOIS ROUTE 53, LISLE, IL 60532, Phone: 630-968-0074. Admission to the Morton Arboretum is free. Students traveling to the Arboretum in personal vehicles should let Christine Carrier know to ensure that admission and parking fees are waived.

8:00 am: FMNH REU interns meet Stephanie Ware in the Great Hall of Union Station, 225 South Canal Street

8:50 am: Train departs Union Station

9:42 am: Train arrives at Lisle Metra station.

9:45 am: Two vans will be at the station by 9:45am to transport interns to the Morton Arboretum.

10:00 am: Arrive at The Morton Arboretum, meet in Cudahy Auditorium in Research Center. Welcome and Orientation (Drs. Gerard Donnelly and Nicole Cavender).

10:15 am: Seminar: *Interpreting science to the public* (Kate Sackman, Ecomyths Alliance)

11:15 am: Research project presentation in the main parking lot by Brian Maule – Northern Illinois University: *Effects of urban trees and green infrastructure on water quality and runoff* (Advisor: Dr. Bryant Scharenbroch)

11:30 am: Research project presentation in the Sedge Garden by Breane Budaitis – Ohio Wesleyan University: *Inferring the history of morphological diversification in sedges* (Advisor: Dr. Andrew Hipp)

11:45 am: Research project presentation near the Visitor Center by Elizabeth Carter – DePaul University: *Do oak species that are genetically associated with warmer climates have greater isoprene emission rates?* (Advisor: Dr. Mark Potosnak)

12:00 pm (noon): Research project presentation near the Visitor Center by Erick Desotelle – University of Wisconsin-Stevens Point: *Assessing performance of volunteers to monitor the urban forest* (Advisor: Dr. Bryant Scharenbroch)

12:15 pm: Lunch. Box lunches provided in the atrium of Cudahy Auditorium.

1:15 pm: Tram tour of The Morton Arboretum: Research, Collections and Natural Areas. Note: additional research intern presentations will be made during the tour.

1:30 pm: Research project presentation in the Research & Interpretation area by Felipe Santich – University of California-Davis: *Assessing the use of morphological characteristics to predict branch attachment strength* (Advisor: Dr. Jason Miesbauer)

1:45 pm: Research project presentation in the Research & Interpretation area by Katherine Klaus-University of Illinois: *Towards a sustainable designer urban soil for trees* (Advisor: Dr. Bryant Scharenbroch)

2:00 pm: Research project presentation in the Research & Interpretation area by Christina Fites- Indiana University-South Bend: *Carbon storage and distribution across The Morton Arboretum* (Advisor: Margaret Bialecki)

2:15 pm: Research project presentation in the East Woods by Stuart Hupp-Virginia Tech: *Oak seedling survival and growth in relation to canopy structure and understory competition* (Advisor: Dr. Robert Fahey)

2:45 pm: Free time to explore the Arboretum.

4:30 pm: All interns meet at Visitor Center for departure. An Arboretum van will be available to shuttle students and advisors to the Lisle train station. Please contact Christine Carrier if you will need a ride to the train station.

5:08 pm: Train departs Lisle Metra station.

5:42 pm: Train arrives at Union Station

CONTACTS

- Dr. Bryant Scharenbroch [E: bscharenbroch@mortonarb.org, T: 608-213-7233]
- Dr. Andrew Hipp [E: ahipp@mortonarb.org]
- Dr. Robert Fahey [E: rfahey@mortonarb.org]
- Christine Carrier [E: ccarrier@mortonarb.org, T: 815-751-7684]
- Petra Sierwald's cell phone: 708-751-4798
- Stephanie Ware's cell phone: 312-576-9111
- The Morton Arboretum: <http://www.mortonarb.org/>
- The Morton Arboretum-Center for Tree Science-Undergraduate Research Fellowship: <http://www.mortonarboretumctsurf.com/>

2014 REU Program: Phylogenetic Systematics Course: *Analyzing Biodiversity*

Which came first, the chicken or the egg? This conundrum can be solved. The workshop series will show how we reconstruct phylogenetic trees, which depict the evolutionary relationships that exist among all organisms. We'll also discuss how to use phylogenetic trees as a framework for answering diverse evolutionary questions, ranging from trace the spread the infectious diseases and antibody-resistance to the timing of the evolution of the amniotic egg over 215 million years ago. The workshop will consist of lectures and hands-on practice using modern analytical methods and software.

Location: Computer Lab, Underground Adventure exhibit

Dates: Wednesdays, July 2 July 9; July 16; July 23, July 30, August 6

Time: 4:30 – 6:30pm

Instructors: Drs. Timothy Swain and Estevam da Silva

Phylogenetics Reference Library

Invertebrate curator Dr. Rüdiger Bieler and REU Program Director and Insect curator Dr. Petra Sierwald have assembled a reference library of books on systematics and phylogenetics. These are books from their personal libraries. They are located in the Insect Library/office on the 3rd floor, room 3307, starting June 14. The books are for **reading in the room only**; no book can leave the room. The books are protected by a ferocious (knitted, pink) tarantula.

Syllabus

July 2

Instructor: Dr. Estevam L. Cruz da Silva

1. Historical background of systematics
 - a. Systematics – the scientific study of the kinds and diversity of organisms and the relationships among them
 - b. Aristotle→Linnaeus→Darwin (different ways of organizing biodiversity)
 - c. Phylogeny – the evolutionary history/geneology of a group of organisms
2. Why phylogenetic knowledge is important
 - a. Information about the evolutionary history of Earth's biodiversity
 - b. Predictive power of phylogenies
 - c. Why are natural history museums important?
 - d. Uses of phylogenies in evolutionary biology
3. Concepts: groups of organisms, relationships of taxa, terms for classification, etc.
4. Phylogeny and classification
 - a) What is a phylogeny, what is a classification?
 - Definitions and examples of these terms

- b) Systematics – taxonomy and classification
 - Linnean binomial nomenclature
 - Species and higher taxa
 - Classification and the problem of paraphyly
 - Phylogenetic classification and nomenclature
- c) Phylogenetics (cladistics) vs. phenetics
- d) Phylogeny vs. tokogeny
 - The hierarchy of life

July 9

Instructor: Dr. Estevam L. Cruz da Silva

- 5. Phylogenetic tree basics
 - a. Hierarchy in evolutionary history
 - b. Monophyletic vs. paraphyletic vs. polyphyletic groups
- 6. Basic phylogenetic techniques
 - a. Basic rules of analysis
 - b. Sample analyses
- 7. Homology
 - a. Non-evolutionary (Owen) vs. Evolutionary (Darwin) definitions
 - b. Homologies as a way to recognize monophyletic groups
 - c. Homology at the molecular level
- 8. Phylogenetic characters
 - a. Characters (and states) as hypotheses of homology
 - 1) Character – observable part of organism
 - 2) Character state – alternate forms a character can take
 - 3) Each character implies division/grouping of organisms
 - b. Character congruence
 - 1) Descent with modification should produce nested groups, therefore multiple characters should imply nested groups, and multiple characters should imply the same groups
 - c. Practical matters
 - 1) Qualitative vs. quantitative characters
 - 2) Binary vs. multistate characters
 - 3) Unordered vs. ordered characters

July 16 – How to Infer a Tree from Characters

Instructor: Dr. Estevam L. Cruz da Silva

- 9. Creating and editing phylogenetic data matrices
 - a. Taxon by character matrices
 - b. Sources of data
 - 1) Novel (e.g., create new data)
 - 2) Morphobank, Treebase, Genbank
 - c. Multiple sequence alignments
 - d. Software

1) MacClade & Mesquite basics

10. Optimality criteria

- a. Parsimony
- b. Maximum likelihood
- c. Bayesian inference

11. Evolutionary models

- a. Models of nucleotide substitution
- b. Models of evolutionary rate
- c. Distance models

12. Tree Search

- a. Tree space
 - 1) Local (tree islands) vs. global optima
- b. Exact searches
 - 1) Enumeration of possible trees
 - 2) Exhaustive search, branch & bound search
- c. Heuristic searches
 - 1) TBR, SPR branch swapping
 - 2) Parsimony ratchet, tree fusing
- d. Long branch attraction

July 23 – Generating & Interpreting Cladograms**Instructor:** Dr. Timothy D. Swain**13. Performing analyses**

- a. Methods & software
 - 1) Methods: Parsimony, Maximum Likelihood, & Bayesian
 - 2) Software: Modeltest, PAUP, MrBayes, & RAxML
 - 3) Access: CIPRES portal: Cyberinfrastructure for phylogenetic research
- b. Worked examples: loading dataset, changing settings, running analyses, exporting results

14. Character optimization

- a. Fitch optimization (parsimony)
- b. Down pass vs. up pass
- c. Worked examples

15. Cladogram terminology

- a. Outgroups vs. Ingroups
- b. Monophyletic vs. paraphyletic vs. polyphyletic groups
- c. Sister-group relationships
- d. Terminals (OTUs), roots, nodes vs. internodes (branches)

July 30 – Consensus Methods, Species trees & Support**Instructor:** Dr. Timothy D. Swain**16. Consensus trees**

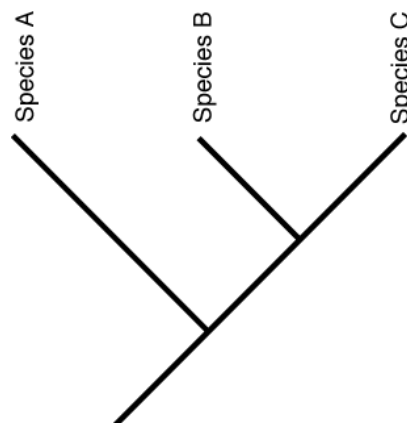
- a. Strict consensus, semi-strict consensus
- b. Adams consensus

- c. Majority rule consensus
 - d. Supertree methods
- 17.** Multilocus species trees versus concatenated gene trees
- 18.** Support measures & tree comparison
- a. Bootstrap & Jackknife
 - b. Bremer support
 - c. Posterior probabilities
 - d. Constraint trees & Kishino–Hasegawa
 - e. Tree to tree distances
 - f. Assessing suboptimal topologies

August 6 – Applications of Phylogenies

Instructor: Dr. Timothy D. Swain

- 19.** Character evolution and correlation
- a. Inferring ancestral states
 - 1) Parsimony vs. likelihood
 - 2) Brownian rate parameter
 - b. Assessing character correlation
 - 1) Concentrated changes test
 - 2) Phylogenetic independent contrasts
- 20.** Diversification rates
- 21.** Divergence time analyses
- a. Fossil calibrations (minimum vs. maximum ages)
 - b. Molecular clocks
 - c. Relaxed clocks
- 22.** Biogeography & host-parasite evolution
- a. Pattern vs. character-based methods
 - b. Areas of endemism
 - c. Method case studies
- 23.** Community ecology
- a. Phylogenetic diversity & dispersion/clustering
 - b. Phylogenetic evenness



Undergraduate Research Symposium Presentation and Poster Guidelines

The Undergraduate Research Symposium will be held Friday August 15, from 8:30am to 4:00pm. The symposium will be a joint venture of three Chicago REU programs: Field Museum (FMNH), Chicago Botanic Garden (CBG) and Morton Arboretum (MA). All FMNH REU interns and several of the CBG and MA REU interns will give oral presentations (using powerpoint) at the symposium. Other interns in FMNH Science & Education department are encouraged to prepare a poster describing their intern activity. Below, you will find the guidelines and information about oral presentations and abstracts, as well as the deadlines for the submission of your abstract and talk.

1. The Symposium (Friday, August 15): We will hold our 6th annual Undergraduate Research Symposium here at the museum in Montgomery Ward Hall in the West lobby. Our symposium audience is friendly and highly supportive. If you have never given a talk, this is the right place to start. We will also have two forty-five minute poster sessions, one in the morning and one in the afternoon. This was very well attended last year and received high marks from attendees and poster presenters alike.
2. For those giving an Oral Presentation: We have created a Google doc for all presenters (link below). Please go to the Google doc and fill out all of the information. We will need the tentative title for your talk **no later than July 10**. The completed PowerPoint presentation needs to be sent to Ken Angielczyk (kangielczyk@fieldmuseum.org) by **Wednesday, August 13, noon, not a minute later**.
3. For those wishing to participate in the Poster Session: We have created a Google doc for all poster presenters (link below). Please go to the Google doc and fill out all of the information. We will need the tentative title for your poster **no later than July 10**. We do not have an unlimited supply of poster easels, so please sign up early if you would like to present a poster. Space will be reserved on a first come, first serve basis. Please observe the size restrictions for posters.

Here is the address to the Google doc (if you have any trouble opening it, contact Stephanie Ware, sware@fieldmuseum.org):

<https://docs.google.com/spreadsheets/d/1CSGaSnV6ACUyvWKQU3996ONE2pgh0ekYSyipsEOe4-w/edit?usp=sharing>

4. The day-long symposium is organized as any other research conference in our field: the symposium is organized into four thematic sessions guided by a moderator, each session consists of 4-5 presentations, and each presentation lasts about 12 minutes, leaving 3 minutes for questions from the audience. Each speaker is properly introduced by the session moderator.

5. The posters will be set up in the West Lobby of the West Lobby of the museum at 8am on August 15. We will have mounting board and limited mounting supplies available. During the symposium day, there will be two poster sessions, where poster authors will be standing next to their poster to answer questions from the audience. These two poster sessions are scheduled for 10:15am to 11:00a and from 2:00pm to 2:45pm. Coffee will be available during the poster sessions.
6. Logistics: The coffee breaks are open to all, speakers and the audience. Lunch for speakers and mentors will be provided. Please feel free to invite family and friends to attend the Symposium. Sadly, we cannot provide lunch for friends and family, but they are welcome to join us for the coffee breaks.
7. For your talk (or poster), you will have to prepare a written abstract (your mentor will help you). E-mail the abstract to Dr. Ken Angielczyk, kangielczyk@fieldmuseum.org, and to Stephanie Ware, sware@fieldmuseum.org, **no later than Monday, August 11.**
8. The abstract should be about 300 words. An abstract is a short summary of your completed research. If done well, it makes the reader want to learn more about your research. These are the basic components of an abstract in any discipline: a) Motivation/problem statement: Why do we care about the problem? What practical, scientific, or theoretical gap is your research filling? [= the big picture] b) Methods/procedure/approach: What did you actually do to get your results? (e.g. analyzed DNA of several species of primates, targeting the following genes..., examined the morphology of the gills of ten bivalve species, etc.) c) Results/findings/product: As a result of completing the above procedure, what are your results? Did you discover a new species? Illustrated new morphological details of bivalve gills or beetle mandibles? Contributed novel DNA sequences for a particular gene or group of species? d) Conclusion/implications: What are the larger implications of your findings, especially for the problem/gap identified in step 1?

See examples of abstracts of symposium talks on Field Museum's web site at:

http://fieldmuseum.org/sites/default/files/reu_symposium_2009.pdf

http://fieldmuseum.org/sites/default/files/REUSymp2010_0.pdf

http://fieldmuseum.org/sites/default/files/REUSympProg2011_13Aug.pdf

9. Oral presentation will most likely have the following components:
 - a. Title Slide: Your name and name of your university. Put an image of your organism on the title slide. If you use the Latin name of your organism in the title, give the phylum and class in parentheses. Example: Charlotte's web: the writings of *Araneus cavaticus* (Arthropoda: Arachnida: Araneida: Araneidae)
 - b. Introduction slide(s): Background knowledge the audience needs to understand the main question posed .
 - c. Question slide(s): What are the main questions?
 - d. Method slide(s): Explain your methods and techniques.

- e. Results: Explain the data you generated.
 - f. Discussion: What worked, what did not work, was your hypothesis confirmed, refuted or modified?
 - g. Conclusion: What does your data mean, how do they fit into the larger context, what is the next step in the research program?
 - h. Acknowledgments: Discuss your presentation with your mentor frequently and seek advice. End your presentation with an acknowledgment slide, listing persons who helped, taught and funding agencies.
10. Posters can be prepared in PowerPoint. For printing, the poster must be saved as a .pdf file. The normal poster size is 26 inches by 34 inches. **The maximum size of the poster is 32 by 40 inches.** Posters can be printed by the Field Museum print shop on the ground floor at no extra charge. The poster **must** not have any image with a solid black background. In order to have the poster printed in Field Museum's print shop, the print ready .pdf file must be delivered on flash drive on **Monday, August 11** to the Ed Czerwin (x7960) in the mail room/print shop downstairs. Please arrange with Ed when you will pick up the printed poster. On Friday morning, August 15, the printed poster must be brought to the West Lobby in the Museum at 8:30am and mounted on foam board. Foam board, tape, pins, and easels will be provided.
11. Poster Components: A poster should address pretty much the same points as an oral presentation, but using as little text as possible. On a poster you may decide to feature only one of the main questions asked in the study. Use as little text as possible and instead try to convey the content in bulleted lists. Methods and results should be presented by images and graphs. Each image and graph should have a figure legend containing the basic explanation. The discussion and/or conclusion sections may be reduced to a few points, possibly presented as bulleted lists. The acknowledgements may a short list, possibly containing the logos of institutions, your college and funding agencies.

Contact Information

Email addresses of REU and affiliated summer interns:

Luis Allende, lmallend@neiu.edu
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Field Museum Faculty, Instructors, and Program Coordinators

Dr. Petra Sierwald, REU Program director, curator (Zoology – Insects, x7744, room 3315, psierwald@fieldmuseum.org)
Dr. Kenneth Angielczyk, REU Co-Director, curator (Geology, kangielczyk@fieldmuseum.org)
Stephanie Ware, REU program administrative assistant, (Zoology – Insects, x7765, room: 3315, sware@fieldmuseum.org)
Dr. John Bates, curator (Zoology, Birds, x7730, jbates@fieldmuseum.org)
Dr. Deborah Bekken, Ethics compliance officer and sponsored program officer (room: 3300C x7807, dbekken@fieldmuseum.org)
Dr. Lawrence Heaney (Curator, Mammals)
Dr. Robert Lücking (Adjunct Curator and Collections Manager, Botany)
Dr. Thorsten Lumbsch, curator (Curator, Botany and Associate Director, Integrative Research Center; x7881, tlumbsch@fieldmuseum.org)
Dr. Ben Marks (Collection Manager, Birds), bmarks@fieldmuseum.org
Dr. Estevam da Silva (Postdoctoral Researcher, Arachnida and Myriapoda), mentor and Instructor: Phylogenetic Workshop
Dr. Douglas Stotz (Research Ecologist, Action Center)
Dr. Timothy D. Swain, Department of Civil and Environmental Engineering, McCormick School of Engineering and Applied Sciences, Northwestern University; and Field Museum
Dr. Susumu Tomiya (Postdoctoral Researcher, Geology); stomiya@fieldmuseum.org
Dr. Jason Weckstein, Staff scientist field Museum (and soon Professor at Drexel University and curator at the Philadelphia Academy of Natural Sciences)
Dr. David Willard (Adjunct Curator, Birds), dwillard@fieldmuseum.org

2014 REU Projects

Luis Allende, lmallend@neiu.edu, Northeastern Illinois University, sophomore.

Project: **What's in a name? That's what we call a species - addressing species delimitation in lichenized fungi** with Dr. Thorsten Lumbsch (Curator, Botany and Associate Director, Integrative Research Center)

One of the most successful group of fungi forms stable symbiotic associations with algae and/or cyanobacteria, so-called lichens. These fungi are called lichenized fungi and the traditional delimitation of species within this group of organisms was based mainly on morphology and secondary chemistry. Species were believed to have very wide distributions, often including different continents. However, DNA sequence data suggest that these concepts vastly underestimated the true diversity of lichenized fungi. Recent studies suggest that many distinct lineages are hidden under common species names. In a project focusing on species delimitation in Parmeliaceae and related clades, this study will address species delimitation in lichens in a phylogenetic context. DNA sequence data of different genes will be used to address the delimitation of species. The lichenized fungi selected for this study belong to the genus *Oropogon* in the family Parmeliaceae (Lecanorales) and will mainly include specimens from East Asia. Previous studies of this genus in the Neotropics revealed cryptic diversity and in this extension, the question will be addressed whether cryptic species can be discovered in East Asia as well.

Research methods and techniques: REU participants in this project will receive training in molecular and organismal research methods. They will learn how important a combination of both methods is for an understanding of the evolution of the diversity of life. The training will include introduction to the literature, handling of herbarium specimens. Chemical examination will include chromatographic methods, such as HPTLC and HPLC. Molecular methods will include DNA isolation, PCR and subsequent direct sequencing of certain gene regions. Subsequently, the analysis of DNA sequence data will be performed.

Anne Gibbons, aegibbons17@gmail.com, University of Michigan - Ann Arbor, junior.

Project: **Hairy legs in the Nursery** with Drs. Petra Sierwald (Curator, Arachnida and Myriapoda) and Estevam da Silva (Postdoctoral Researcher, Arachnida and Myriapoda)

With over 300 species, the nursery web spiders (family Pisauridae) have conquered the world; they can be found on every continent. The family members hunt on the water, in the vegetation, in trees, on the forest floor, and in webs. Females of the family carry their silken egg sacs in their fangs, and build a nursery web for the spiderlings, when these are hatching. As in other spiders, the Pisauridae have complex male and female copulatory organs, and hairy legs, often with an intricate spine pattern. Analyzing the evolutionary relationships among the over 40 genera of the family using morphological and molecular characters in conjunction with their geographic distribution will enable us to explain speciation events, and trace geologic events, such as glaciations, climate and vegetation changes of the past.

Research methods and techniques: The intern will be trained in spider morphology, identification, and dissections. S/He will acquire skills to operate light and scanning electron microscopes, to produce and to manipulate images using sophisticated software. The newly generated morphological data will be added to the existing data pool, allowing comparative analyses and phylogenetic inference using these data.

Wilson Guillory, wxguillo@email.uark.edu, University of Arkansas, freshman.

Project: **One leg at a time: The morphology of millipedes** with Dr. Petra Sierwald (Curator, Arachnida and Myriapoda)

Millipedes are the main nutrient recycler in forest ecosystems; they chew down the leaf litter for further decomposition. Despite their ecological importance for soil health, their biodiversity, morphology and general biology are severely underexplored. The millipede research program at the Field Museum of Natural History will produce a morphological atlas of various millipede groups to develop a comprehensive identification key to millipede families. Such tools promote further research into the group, such as local species richness, biogeography, and phylogeny. The 2014 REU project will investigate the morphology of the millipede orders Polydesmida, Julida and Stemmiulida in detail, using the scanning electron microscope and various light microscopes. High quality images will be generated for the comparative analysis of complex structures in various millipede groups, such as sense organs, mouth parts, eyes and copulatory organs.

Research methods and techniques: The intern will be trained in millipede morphology, identification, and dissections. S/He will acquire skills to operate light and scanning electron microscopes, to produce and to manipulate images using sophisticated software. The newly generated morphological data will be added to the existing data pool, allowing comparative analyses and phylogenetic inference using these data.

Chris Kyriazis, CKyriazis33@gmail.com, University of Chicago, junior.

Project: **Speciation and Diversification of Mammals on Islands** with Drs. John Bates (Curator, Birds) and Lawrence Heaney (Curator, Mammals)

Oceanic islands have been recognized as centers of unique biodiversity since before the time of Charles Darwin, and studies on islands have been key to developing our understanding of evolutionary and biogeographic processes. The mammals of the Philippines are becoming a classic example of diversification, with over 90% of the species on some islands being the product of local speciation, based on extensive recent field and museum studies. This project aims to investigate genetic divergence within the previously unstudied *Bullimus luzonicus*, a widespread endemic small mammal on Luzon, the largest of the Philippine islands, in the context of the dynamic geological history of the island.

Research methods and techniques: REU participants will be introduced to conceptual issues in the evolutionary dynamics of island biogeography. The participants will produce data in the museum's molecular genetics lab, and will learn primary techniques for analyzing these data to produce estimates of evolutionary relationships. The results will be compared to patterns shown by other small mammals, in an effort to detect general biogeographic patterns among species with differing ecologies and histories.

Armita Manafzadeh, armita.manafzadeh@berkeley.edu, University of California – Berkeley, sophomore.

Project: **Morphological Integration in the Mandibles of Living Reptiles and Fossil Synapsids** with Dr. Kenneth D. Angielczyk (Curator, Geology)

Living mammals have a unique mandible (lower jaw) morphology compared to other tetrapods. In mammals, each side of the mandible is formed by a single bone, the dentary, whereas all other tetrapods possess a series of postdentary bones in addition to the dentary. The reason for this difference is the fact that the postdentary bones of the ancestors of mammals have been reduced in size, detached from the jaw, and incorporated in to the hearing system of mammals. However, mammals are a subgroup of a larger group called Synapsida, and many nonmammalian synapsids possess large postdentary bones that resemble those of other tetrapods.

Research Methods and Techniques: The REU participant will collect geometric morphometric data on the jaws of a wide range of living reptiles, all of which have post dentary bones, and will examine whether all of the bones of the mandible form a single integrated unit or if subgroups of bones form distinct modules. We will then apply similar methods to the jaws of nonmammalian synapsids with postdentary bones to determine whether they show similar patterns of modularity/integration or if there are differences that may help to explain why the ancestors of synapsids were able to co-opt their postdentary bones for hearing.

Ian Medeiros, imedeiros@coa.edu, College of the Atlantic, sophomore.

Project: **ATM meets MET - Assembling a Taxonomic Monograph using Modern Electronic Tools** with Drs. Robert Lücking (Adjunct Curator and Collections Manager, Botany) and Thorsten Lumbsch (Curator, Botany and Associate Director, Integrative Research Center)

Taxonomic monographs provide baseline information for many questions related to environmental and human health issues, such as biodiversity assessment and conservation, as well as ecosystem services and bioprospecting to discover new drugs. Monographs are considered a "dusty" and outdated field of biological sciences, but with the advent of new tools such as DNA sequencing, electronic data dissemination, and social media, have entered a new era which allows for a much broader impact of such revisionary work. Monographs are now more important than ever, considering that a large number of species on earth remain to be discovered and are at the same time at the brink of extinction due to the continuous loss of natural habitats.

Research methods and techniques: REU participants will be working on a specific, small group of the lichen family Graphidaceae (about 10–20 species) to produce a monographic treatment for that group. By doing so, they will be trained and work with a broad array of basic and modern techniques required to assemble a monograph, including nomenclature and revision of type specimens, specimen curation, light microscopy and thin-layer chromatography for chemical analysis, producing and analyzing DNA sequence data, assemble phenotype datasets for automated generation of taxonomic keys and descriptions using DELTA and similar programs, imaging and image editing, and using web tools and social media (KE EMu, Symbiota, EOL, LifeDesks, DiscoverLife, Tree of Life, Zooniverse Microplants, FaceBook) to disseminate their data.

The monograph will be published in an international journal with the REU student as lead author.

Dana Reuter, reute22d@mtholyoke.edu, Mount Holyoke College, junior.

Project: **Morphological evolution of carnivoran milk teeth** with Drs. Kenneth Angielczyk (Curator, Geology) and Susumu Tomiya (Postdoctoral Researcher, Geology)

Carnivorans (dogs, cats, and their relatives) show remarkable diversity of forms and habits. The variations in the shapes of their cheek teeth are prime examples of dietary adaptations that enabled different lineages to exploit such disparate food items as fruits, insects, mollusks, and vertebrate meat. However, most of what we know about the relationship between diet and tooth shapes in carnivorans is based on studies of adult teeth. Do the milk teeth of carnivorans show a range of dental morphology comparable to that of adult teeth? The goal of this project is to investigate whether similar selective pressures drive the morphological evolution of milk teeth and adult teeth.

Research methods and techniques: We will examine carnivoran skulls in the Mammals Collections of the Field Museum to gather information on the shapes of milk teeth, taking detailed notes and photographs. Measurements of the milk teeth will be taken that, when taken from their adult counterparts, are known to be indicative of adult diet. Variation in the shapes of milk teeth among species will be described. Using phylogenetic comparative methods, we will test how closely milk-tooth shapes are: (1) correlated with adult-tooth shapes; and (2) tied to juvenile/adult diet.

Max Witynski, birdmax922@gmail.com, Cornell University, freshman.

Project: **What can we learn from 30+ years of bird migration data?** with Drs. David Willard (Adjunct Curator, Birds), Ben Marks (Collection Manager, Birds) and Douglas Stotz (Research Ecologist, Action Center)

Every spring and fall, large numbers of birds migrating through the Chicago region are killed as they collide with buildings. For the last 35 years, the Bird Division of The Field Museum has been monitoring bird migration through these collisions at McCormick Place, and over the last 8 years also in the loop region of Chicago. Over 60,000 specimens have been recovered. These birds provide a unique data set for analyzing trends in migration and this will be the focus of this internship. Among the questions to be addressed are 1) whether there have been changes in morphology over the span of the study and 2) what are the effects on bird collisions of lights on versus lights off at McCormick Place. Development of independent uses of the dataset will also be encouraged.

Research methods and techniques: REU participant will be trained in museum collection management, morphological data collection, specimen preparation, and data analysis. Participant will be taught to analyze his/her data with modern statistical methods. Also included will be literature review and working toward preparing a manuscript for publication.

Field Museum Policies for Responsible Conduct in Research

The responsible and ethical conduct of research (RCR) is critical for excellence, as well as public trust, in science and engineering. Consequently, education in RCR is considered essential in the preparation of future scientists and engineers [Section 7009 of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Act (42 U.S.C. 1862o–1)].

Field Museum developed a comprehensive plan to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduate students, graduate students, and postdoctoral researchers participating in research projects.

Field Museum Ethics Compliance Officer: Dr. Deborah Bekken, Director of Government Affairs and Sponsored Programs, room 3300C, extension 7807
Please do not hesitate to contact Dr. Bekken, if there are any questions or concerns.

All REU interns are required to complete the CITI program RCR ethics course before the begin of the internship. REU interns are provided with a tutorial regarding the completion of the course. Documentation regarding the successful completion of the selected course are filed with Field Museum's Ethics Compliance officer Dr. Bekken.

All REU interns are required to attend the RCR lecture and discussion on June 27, 2013, 12 noon – 1pm in the zoology class room

A copy of the *ORI Introduction to the Responsible Conduct of Research*, developed by the U.S. Public Health Service's Office of Research Integrity (ORI), is available in the REU Phylogenetic Reference Library in the Zoology-Insects Library (and at: <http://ori.hhs.gov/documents/rcrintro>). The *ORI Introduction to the Responsible Conduct of Research* draws together, in a single, easy-to-read book, the fundamentals of responsible research. Readers are guided through the complex world of regulations and best practices, from initial design through to publication. Each chapter is devoted to one of ORI's nine core areas, including:

- Research misconduct,
- Human and animal research
- Data management
- Conflict of interest
- Collaboration
- Mentoring
- Authorship
- Peer review