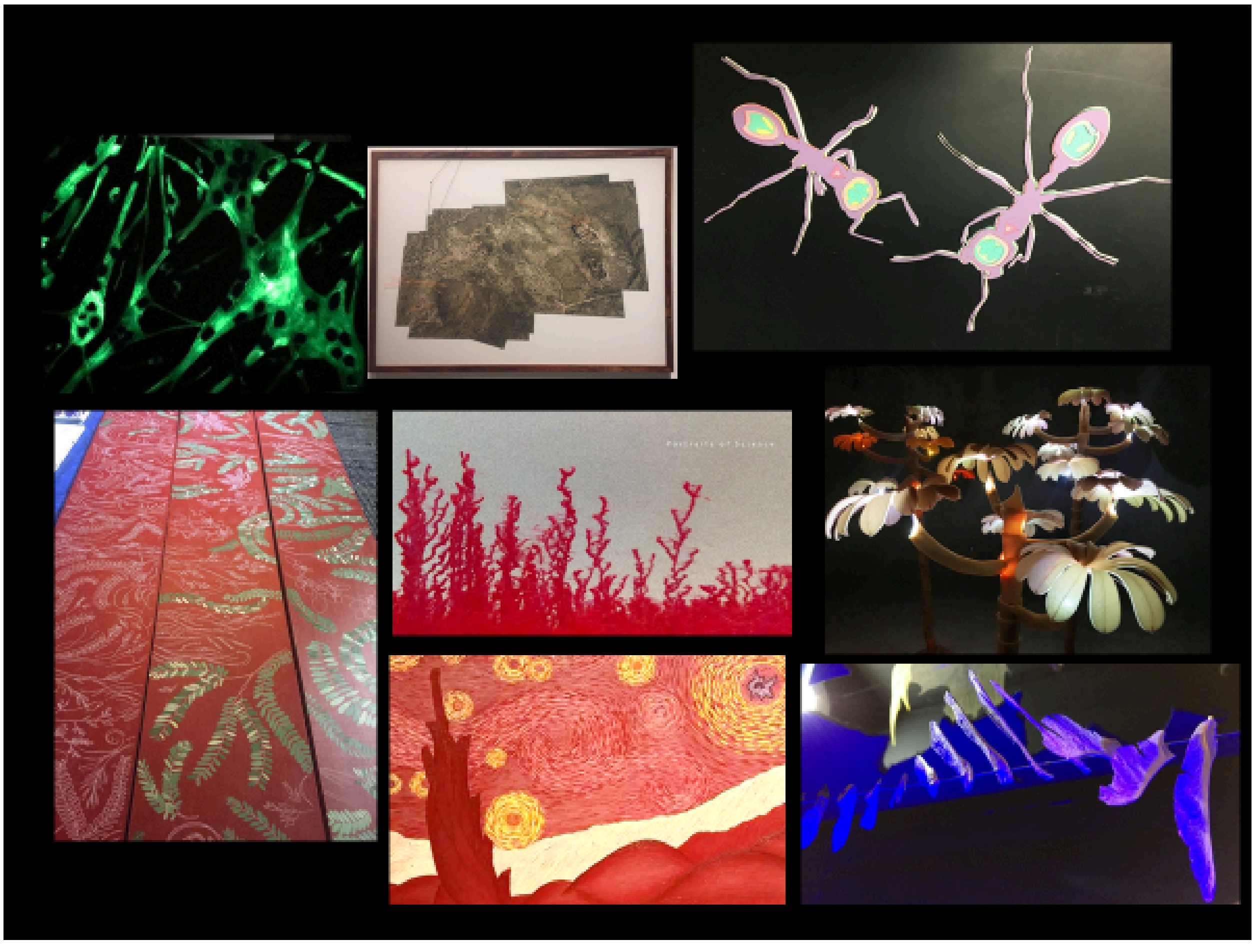
Artistic Expression of Original Research

Course Curriculum

By Peter R. Marting



Grade level: graduate students, advanced undergrads, persons with analyzed research results

Course length: 1 semester, 4-6 months

Objective: This course empowers scientists to engage with their own data, each other, and the public through art. Through collective brainstorming, prototyping, and feedback from professional artists, students will create a project that expresses their own research through any artistic medium of their choice. The course culminates in a public art exhibition where students interact with a general audience to discuss their research, art, and what it means to be a scientist.

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Syllabus

Artistic Expression of Original Research

As basic scientists, we are often asked why. Why would you spend your life studying that specific thing? How does it benefit society? Personal motivation for conducting original research is different for everyone, but some find motives aligned with art and literature. Where these disciplines seek to understand truth, beauty, and construct a narrative, we do this with the natural world. We discover small, beautiful truths hidden among us and use rigorous, quantitative tools to understand how they fit into our world. Regardless of our motives or inspiration, sharing these beautiful truths with the world is an incredibly important and rewarding part of being a scientist. The inventiveness and creativity we use to design and conduct experiments should be celebrated and harnessed in the dissemination of our findings – pushing forward with different ways to represent and experience the beauty of our data.

In this course, we will hold weekly gatherings to work toward individual projects that artistically express your research through any medium (examples listed below). The stipulation is that the project must express original research that you've conducted or helped with. You are the scientist, you are the artist. We will have a number of guest artists and designers to help with technique and inspiration. The goal will be to display our finished projects in an art exhibit at a gallery on a First Friday City Art Walk.

Possible Outlets:

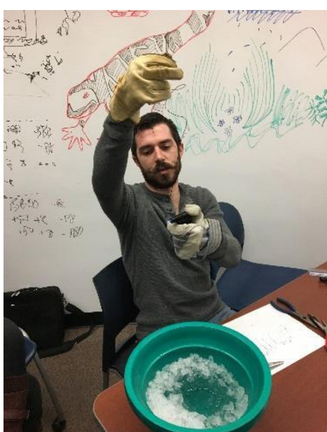
Painting
Sculpture
Electronics
Music or sonification
Video
Photography
Performance
Creative writing
Storytelling
Mixed media

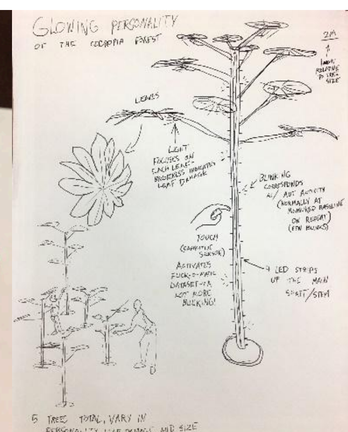
Class Schedule:

Week 1 – Introduce class scope and structure, give examples and inspiration
Week 2 – Brief individual presentations on the research they want to express artistically and group brainstorming about potential representations, "walk in someone else's shoes" activity
Week 3 – Rough drafts of art projects, feedback
Week 4 – Joel Smalley, 3D printing tutorial
Week 5 – Michelle Fehler, the art of storytelling

Week 6 – Danielle Foushee, Ink, alcohol, and mixed media
Week 7 – Mkrspace Staff, vinyl cutting tutorial
Week 8 – Spring Break
Week 9 – Susan Biener, detailed ceramics
Week 10 – Progress presentations
Week 11 – Solo project time
Week 12 – Andy Quitmeyer, art, technology, and making
Week 13 – Michelle Fehler, effective poster design
Week 14 – Mark Klett, art photography
Week 15 – Class presentations of final projects
Week 16 – Gallery preparations
Week 17 – First Friday art exhibit opening

Photos from the Spring 2017 Course:





Getting the course listed

Getting the course listed will be different at every institution but will likely follow these basic steps: 1) convincing your programs director that the course is necessary, 2) identifying the primary instructor, and 3) listing the course for registration.

1. Convincing your programs director

   To convince your programs director to have a new course listed is relatively simple. You need to demonstrate that a) the topic is important for students' education, b) there is a general interest in the topic, and c) that there is a lack of such topic currently offered. In my case, I stopped by and spoke to the School of Life Sciences Graduate Programs Director in person.

   a) Justifying the course's importance will depend on the outlook of your programs director. It was very easy for me because my programs director already deeply valued aesthetics and had supported similar initiatives in the past. Here are a few talking points to get you started:
      - Students can gain new insight about hidden patterns in their data by engaging with it using different, non-traditional sensory modalities.
      - Students will create impactful ways to disseminate their research to a broader audience.
      - Honing these skills will make students more competitive for grants from publicly funded institutions like NSF.
      - By providing an engaging, aesthetic narrative of our research, we can allow our audience to make a longer-lasting emotional connection that will not only lead to a more science-literate society, but one that values and actively supports basic research and evidence-based policy.

   b) Before meeting with the programs director, I surveyed general interest among my fellow graduate students by discussing it with a few potential students I thought would be enthusiastic about it to help spread the word. I then made a brief announcement at a weekly graduate student seminar and asked for a show of hands for who might be interested in enrolling in a course of this kind.

   c) Showing that there is no current course like "Artistic expression of original research" should be very easy for most science programs.

2. Identifying the primary instructor

   Typically, you can be the primary instructor of a course only if you hold a degree higher than your students. If you have a PhD, this step is easy – you will likely be the primary instructor. However, if you are a don't have one yet, and you plan on grad students enrolling, you will need to find a faculty surrogate to act as the primary instructor. I was lucky enough to find a microbiology faculty member who had a history of collaborations with artists – he was more than happy to act as primary instructor (without having to contribute much). Here's the email I sent to him:

Hi Dr. Roberson,

My name is Peter Marting and I am a PhD student in Animal Behavior here at ASU. Susanne Neuer recommended that I contact you for your expertise and interest in art and science and leading the Sculpting Science exhibit. I am developing an art class for scientists (primarily other BIO grad students) entitled "Artistic Expression of Original Research" (syllabus draft attached) for this semester. Students will translate their data into works of art through any media (painting, sculpture, music, performance, electronics, creative writing, etc.) and display them in a gallery at the end of the semester. We have a space and a time set, but to make it an official course (BIO 591 class), we need a faculty to act as the official instructor on paper. Since you have been actively involved in bringing these fields together in the past, I thought you would be a good person to ask. If this sounds intriguing to you, I would like to meet briefly to discuss some details and ask some advice. Your involvement could be what you wish it to be - at the very least we would need you to assign pass or fail to the students (12 students max). Let me know what you think!

Thanks for your time!

Peter

3. Listing the course

The easiest way to get the course off the ground and listed for student to enroll is to give it your program's generic, catch-all seminar designation. In my case, BIO 591 is the designation for grad seminars, reading groups, and special topics, and worked perfectly for AEOR. I had the class meet for 3 hours in the evening once a week, and the course was worth 2 credits because it does require a bit of work, but most of it can be achieved in class. I had the class capped at 12 students. To get the course up for registration, I contacted the School of Life Sciences Graduate Programs Coordinator with the Programs Director's blessing and the primary instructor faculty surrogate signed on, and it was listed within the hour: BIO 591 – Artistic Expression of Original Research.

Course	Title		Class#	Instructor
BIO 591 (SEM)	Topic: Artistic Expression of Original Research	Add	93736	Marting

Booking the right room

The best room is one that promotes a comfortable, productive, and collaborative ambience. To achieve this, ideally the room will allow students to bring in materials, work on their projects in class, and leave their materials there between classes. Ideally the room will also have a projector set-up for the students and professional guest that present. You may be thinking about contacting the art school to see what's available – in my experience, those rooms are highly sought-after, book up very fast, and give priority to courses listed in the school of art. Instead, I found a perfect lab room with large communal tables in the basement of a life sciences building that is rarely used.

To book it, I contacted the building coordinator of the building the room was in. We were the only ones using it for the semester, so students could leave their materials there between classes, making it much more likely for everyone to use the class time to work on their projects. The room had a key code that all students in the course were given, so students could work on their projects between class too if they wanted. The room did not have a projector set up, so we either rented one from the library or I brought my own from home, which worked well.

Inviting professional guests

Before the course started, I met with a few art and design faculty to ask some questions about how to run an art course. Their advice really helped shape what the course ultimately became – I recommend doing the same. Here's an email I sent to an art/design professor:

Dear Dr. Foushee,

My name is Peter Marting and I am a PhD student in Animal Behavior here at ASU. Michelle Fehler recommended that I contact you for your expertise in design, art, and community. I am developing an art class for scientists (primarily other BIO grad students) entitled "Artistic Expression of Original Research" (syllabus draft attached) for this semester. Students will translate their data into works of art through any media (painting, sculpture, music, performance, electronics, creative writing, etc.) and display them in a gallery at the end of the semester. I don't have any experience developing an art course, and I had a few questions for you. I am also hoping to invite a few professionals from the design school and the art department to give advice to the students. If this sounds intriguing to you, I would like to meet briefly to discuss some details and ask some advice.

Thanks for your time!
Peter

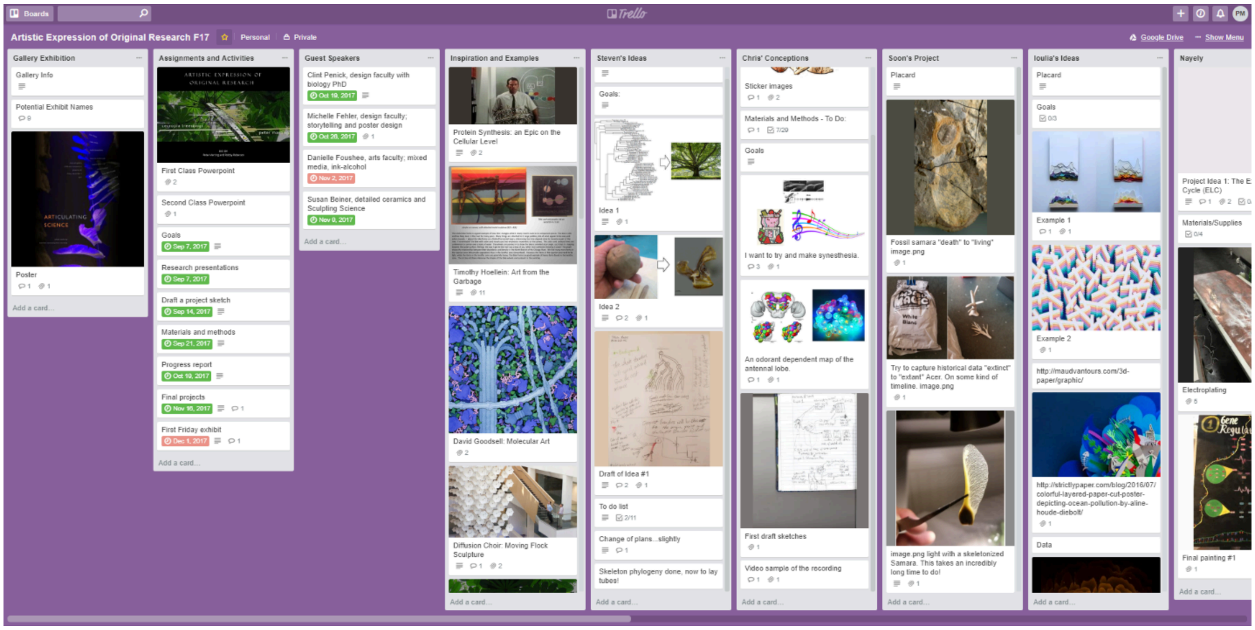
A major portion of the course is learning from professional artists and designers about their work, techniques, and getting their feedback. Typically, I dedicated the first hour of class to the guest – they would give a 30-40 min presentation, we would do an activity, and students would ask for feedback on their projects. For simplicity, nearly all the guest who spoke to my class were faculty at my university. Not knowing what student would end up specializing in, I tried to get a diverse representation of sculptors, painters, makers, graphic designers, musicians, photographers, storytellers, and poets. I also had a few spots dedicated to touring useful facilities at our university like 3D printers, laser-cutters, and vinyl cutters. Here's an email I sent to a Professor of Photography inviting him to be a guest for the course:

Hi Mark,

We met at Julie Anand's seminar on Art and Ecology. It was great to hear about your photography course! I lead a course for science graduate students to express their own research through art (syllabus attached). We have a 3-hour class every Monday where we typically hear from an artist or designer about their work and techniques, time for questions and activities, and then break out to work on individual projects. It was checking out your excellent course website - beautiful projects! I think my student would be curious to hear about what's possible through photography. Would you be interested in talking to my class (about 8 students) next Monday, April 3?

Cheers,
Peter

Course website

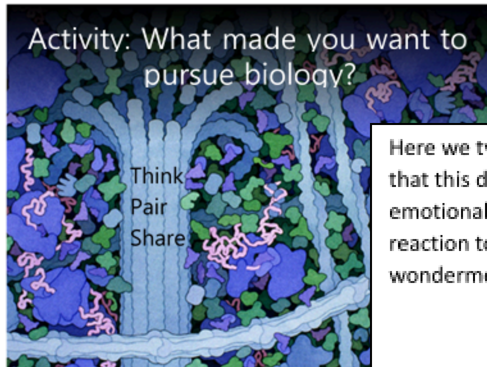


To organize the class and keep progress flowing, I used Trello – a free project organizing website. This was especially useful for students who worked from home or off campus, so they could share their progress and get feedback. I had students create an account to access our private class "Board." Each student created a "List" for their project, which contained "Cards" that detailed their ideas and progress throughout the semester. Students can comment on each other's posts, upload pictures, and make to-do lists. In addition to student project "lists," I had separate lists dedicated to assignments, guest speaker schedules, and art-science inspirational examples.

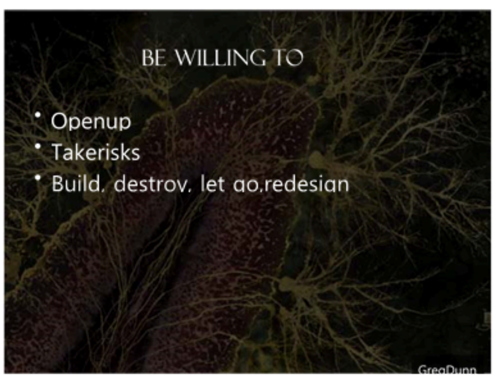
Sample presentation

I only presented for the first two weeks of class. Students and guest speakers gave all other presentations.

Week 1: I had the students introduce themselves. I introduced myself, the reasons why I started this course, and what to expect for the semester, and ended with an example from my own work. The homework was to create an account on Trello (see previous section) and generate and post their own goals for the course.



Here we typically find that this decision is an emotionally charged reaction to the wonderment of nature

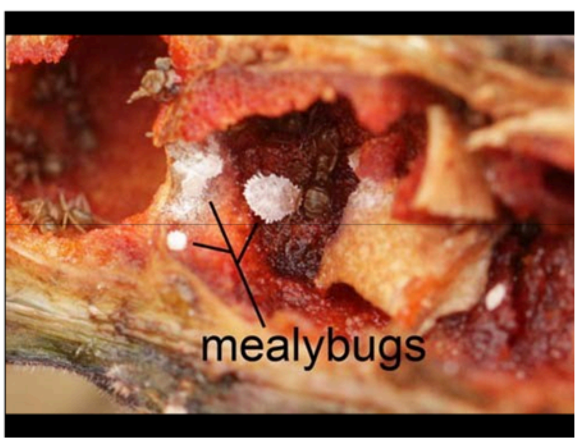



L IST OF POTENTIAL SPEAKERS
• Roby Roberson, SOLS: Microscopy imaging
• Kim Shaffer, Art-Bio-Pilot-MBA: Bio-inspired art, selling art, project management
• Michelle Fehler, Design: Storytelling, poster/placard design
• Danielle Foushee, Design: Mixed Media
• Susan Beiner, Art: Ceramics
• Garth Pain, Arts-Media-Engineering: Musical composition
• Design school: Exhibition design
• Many more TBA
David Goodsell

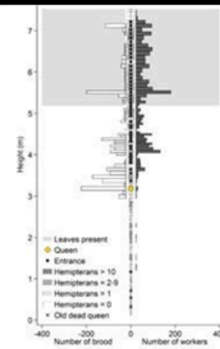

Final projects


Portraits of Science
Gallery exhibit -MonOrchid
First Friday May 5, 2017

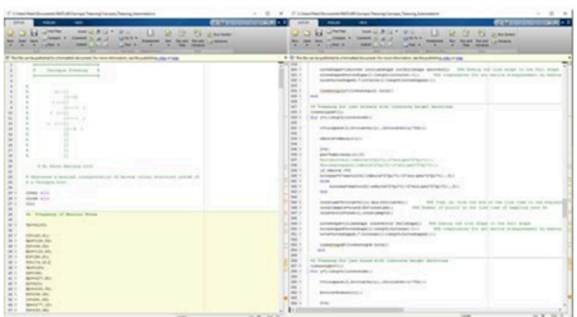

CECROPIA TREESONGS
cecropia treesongs
peter marting
the music of an ant-plant mutualism
Peter Marting


mealybugs

COLONY STRUCTURE



MATLAB PROGRAM



MAPPED VARIABLES

$$n = \sin(2\pi f) + I * sin(2\pi p)$$

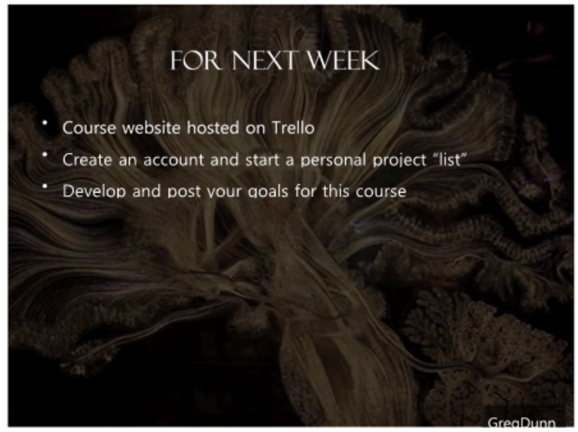
- **clicks:** 1 per internode, spacing = height of internode
- **chords:** root note triad changes to the 4th triad when internodes have leaves
- **lower melody:** workers, number in internode = note frequency
- **higher pure-tone melody:** brood, number in internode = note frequency
- **vibrato on melodies:** scale insects, number in internode = vibrato period
- **high-pitched buzzy pulses:** queen's internode
- **low-pitched thumps:** entrances
- **layered reverb:** lament for destroying that which I love

Colony 33

Colony 21

Colony 26

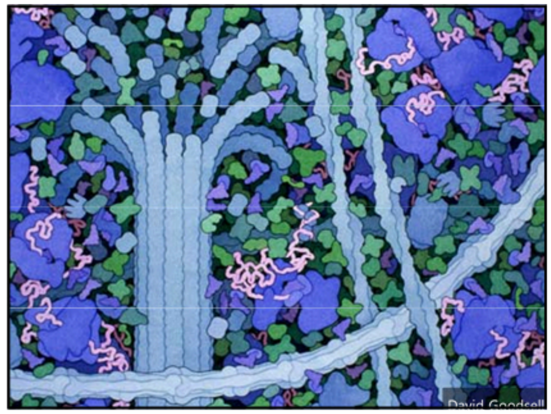

cecropia treesongs
peter marting
Free album at petermarting.bandcamp.com

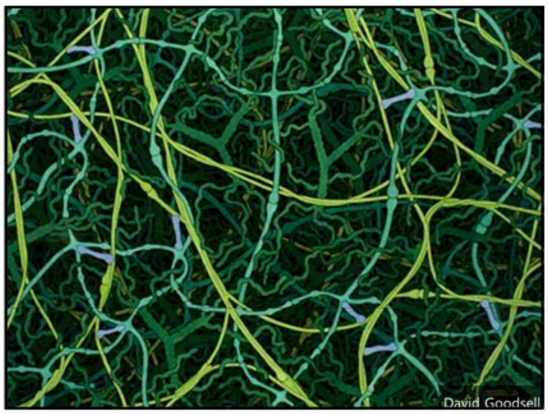

FOR NEXT WEEK
• Course website hosted on Trello
• Create an account and start a personal project "list"
• Develop and post your goals for this course
GregDunn

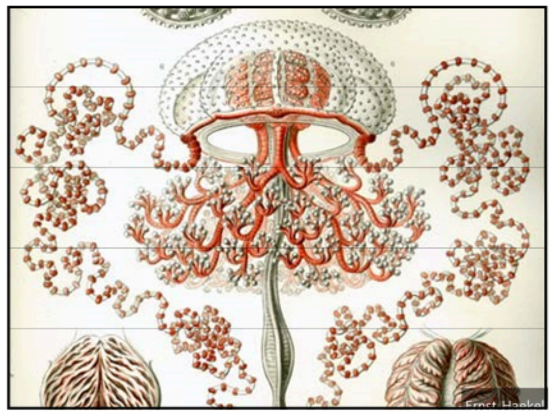
Week 2

I discussed a few sci-artists that were featured as the slide backgrounds from the previous week's presentation – David Goodsell, Ernst Haekel, and Greg Dunn. Students then gave brief 10-min presentations about the research they are aiming to express artistically. Presentations were focused on the science – but students that did include project ideas led the class into productive brainstorming.


ARTISTICEXPRESSIONOF
ORIGINALRESEARCH
cecropia treesongs
peter marting
BIO 591
Peter Marting and Robby Roberson




David Goodsell



PROTEIN SYNTHESIS

Students gave 10 min presentations about the research they aim to express artistically

PRESENTATIONS

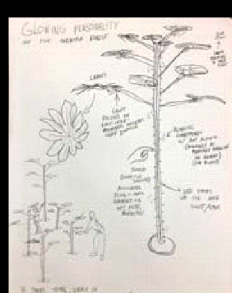
WALK IN SOMEONE ELSE'S SHOES

1. Pair up and imagine how your partner felt about conducting some aspect about their research. Write a paragraph and share it with each other.
2. Draw their study organism/system
3. Compare

The imagination part is critical here. Make sure they don't directly ask their partners how they felt before writing.

FOR NEXT WEEK

- First draft
  - Sketch and label your initial idea
  - Be prepared to talk about how your idea meets your goals



Class activities and assignments

1. Goals

   Assigned Week 1, Due Week 2

   On the Trello website, create a "List" for your personal project and add a new card that outlines your personal goals for this class. They can be simple and broad, or elaborate and specific.

2. Research presentations

   Assigned Week 1, Due Week 2

   Prepare a very brief, 10 min presentation about your research you aim to express artistically during the course. You don’t need to include any project ideas, but they are certainly welcome.

3. Walk in someone else's shoes

   Completed in class, Week 2

   Having just heard about the research conducted by all your classmates, pair up and write a paragraph about how you imagine your partner might *feel* about conducting some aspect of their science – not just a description about what they do, but the emotion(s) they may have about it. This can be written in first or third person perspective. Below the paragraph, draw their study organism/system. Share your work with your partner and discuss.

4. Draft a project sketch

   Assigned Week 2, Due Week 3

   Draft a sketch of your initial idea - actually draw it out on paper. Include details like materials, dimensions, and labels. Be prepared to explain how the idea will meet your stated goals. We will share these ideas in class and discuss ways to create, feasibility, and potential improvements.

5. Materials and methods

   Assigned Week 3, Due Week 4

   Create a to-do list card on your project list that includes the materials you'll need, and the steps you foresee to make your idea a reality.

6. Speed brainstorming

Typical activity after any given guest speaker

Imagine yourself using the same techniques our guest speaker just presented on. You have 5 minutes to generate 10 different project ideas that express your own data using this technique. Share your favorite idea with the class.

7. Progress report

Assigned Week 4, Due Week 8-10

I'd like everyone to prepare a brief presentation of your progress:
1. What have you done so far?
2. What's working?
3. What's not working?
4. What's your vision for the next step?

We will be giving feedback and brainstorming troubleshooting issues as a class. If you've been working from home, or your piece is too big to bring in, just bring some pictures.

8. Final projects

Assigned Week 1, Due Week 15

Present your art project in its final form and explain it in detail to the class. Write a 200-500-word placard description to accompany your piece, aimed toward the public. Include a brief description of the research expressed, how it is depicted, materials used, and any personal connections it may bare.

9. Gallery requirements

Assigned Week 4, Due Week 15

Write a short physical description of your piece with the art gallery exhibit in mind. What kind of space will you need – what are the dimensions, how many pieces, how can it be mounted, what kind of floor space, wall space, table, or lighting do you need?

Sample project workflow

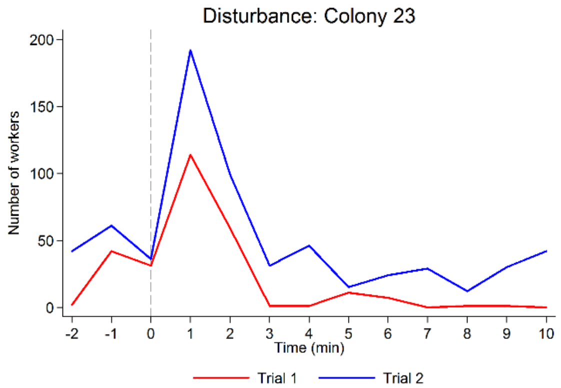
This example project is what I created during the first iteration of the course. Each item below was added as a “card” to my personal project “list” on the Trello class website. Other students had similar workflows.

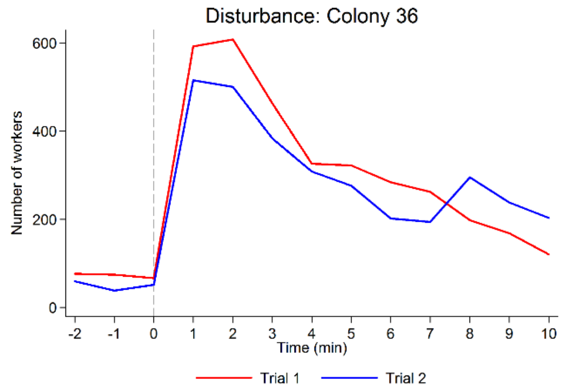
Goals:

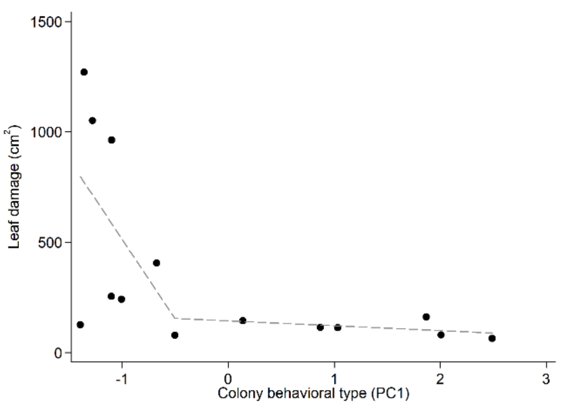
1. Create something beautiful
2. Embodied with emotion
3. Uses my data
4. Expresses my scientific narrative

Research Data:

Azteca ants live inside and protect Cecropia trees in return for food and shelter. Colony response to many traits (shown here is the vibrational disturbance) is substantially different between colonies, but very consistent within colonies. Their overall response level in these traits correlates with their host plant health such that more active, aggressive colonies have less leaf-damaged trees.

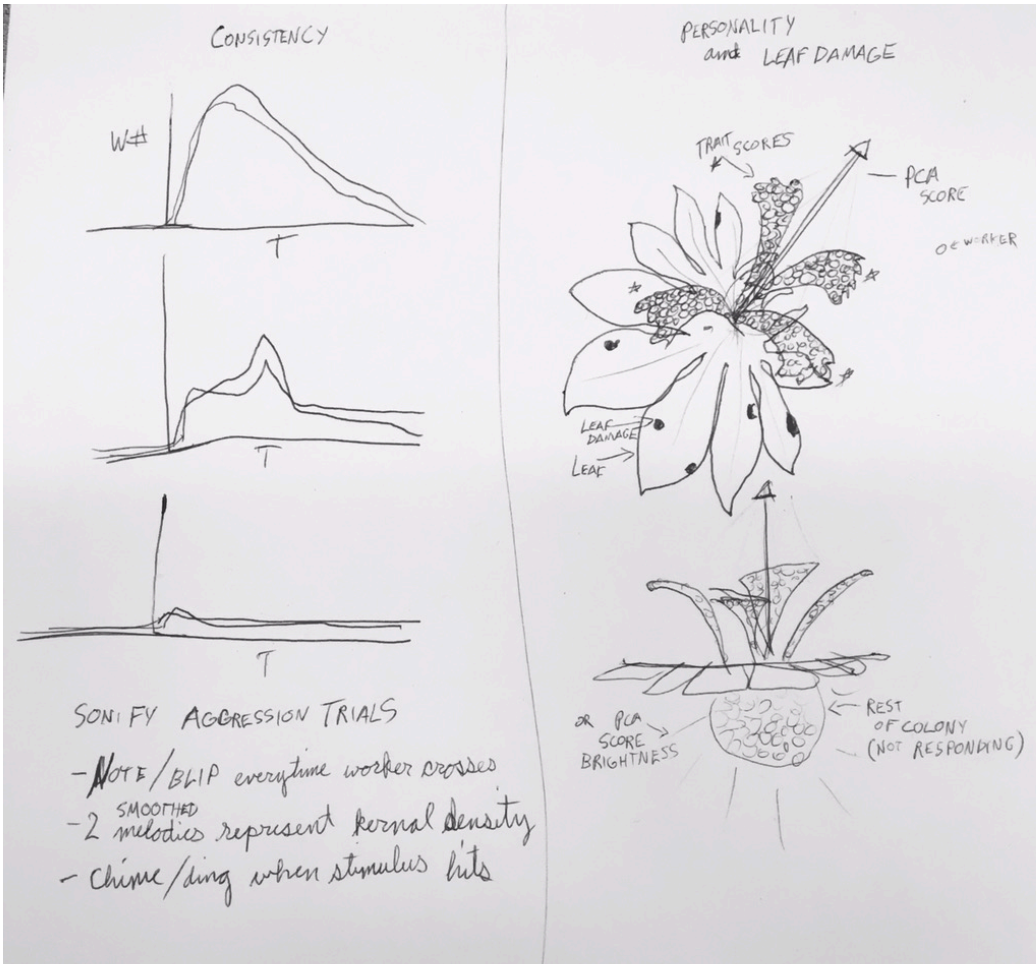




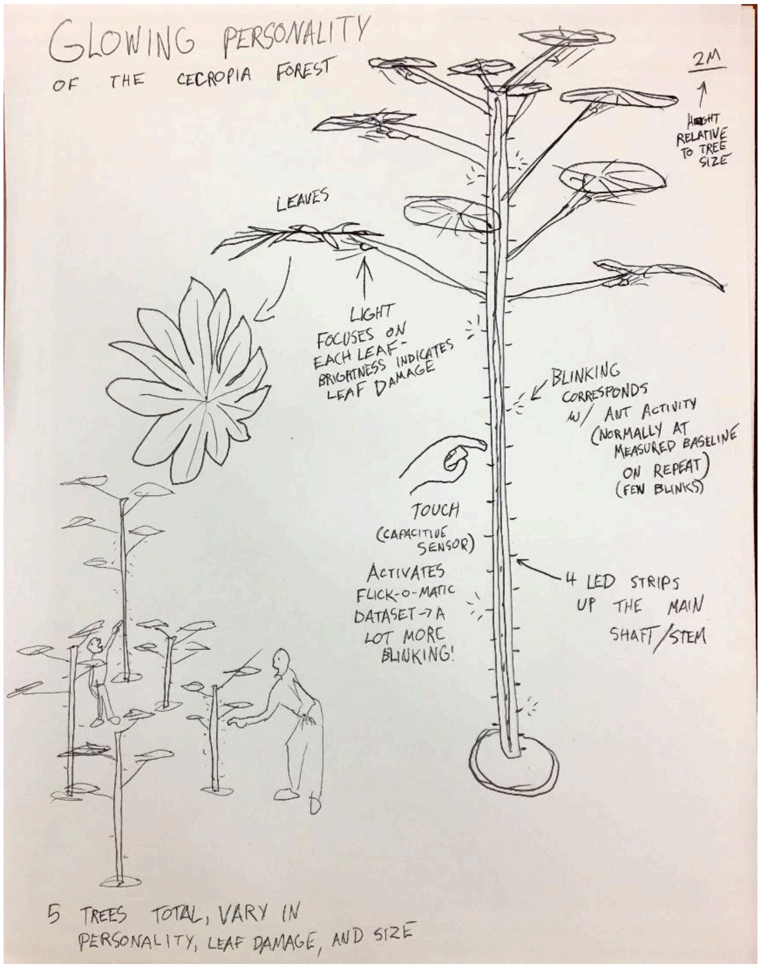


First draft sketch:

2 ideas, one conservative, one ambitious



Second draft sketch - glowing forest:

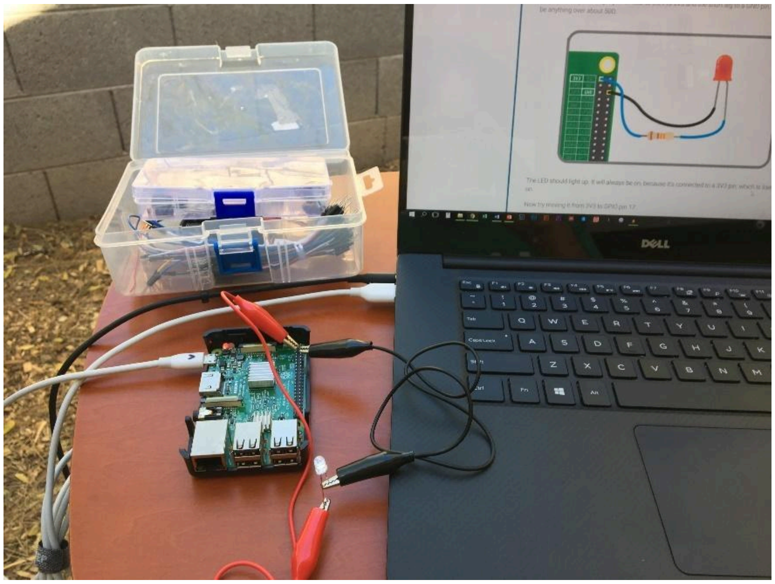


Materials Checklist:

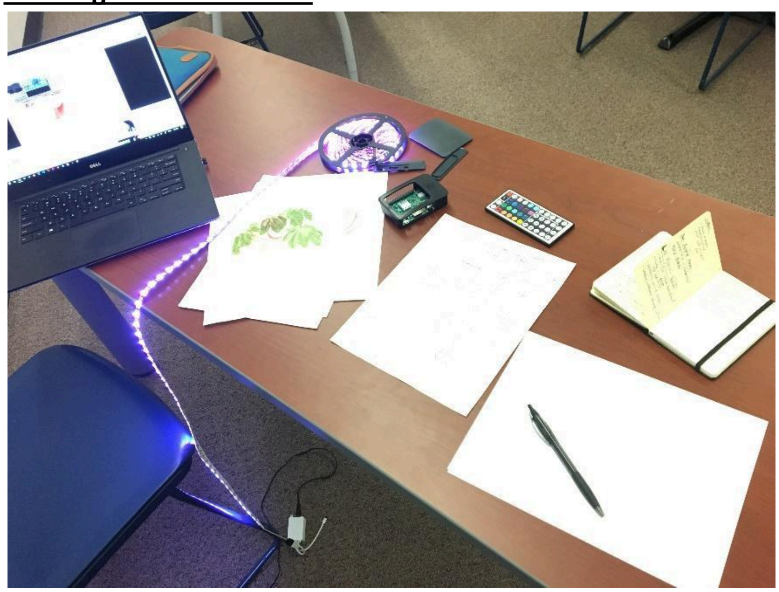
raspberry pi / arduino
LED strip for stem, individually addressable
power supply, 12V AC
jumper wires
resistors
breadboard
focal LEDs, for leaves
leaf material - laser-cut Plexiglas or thin metal?
central stem - metal conduit?
petiole material - also metal (shelf elbows)?
outer cover layer (for light diffusion and internode simulation) - paper and wire rings?
control box with knobs - definitely 3D print
light-defusing skin

Modest beginnings:

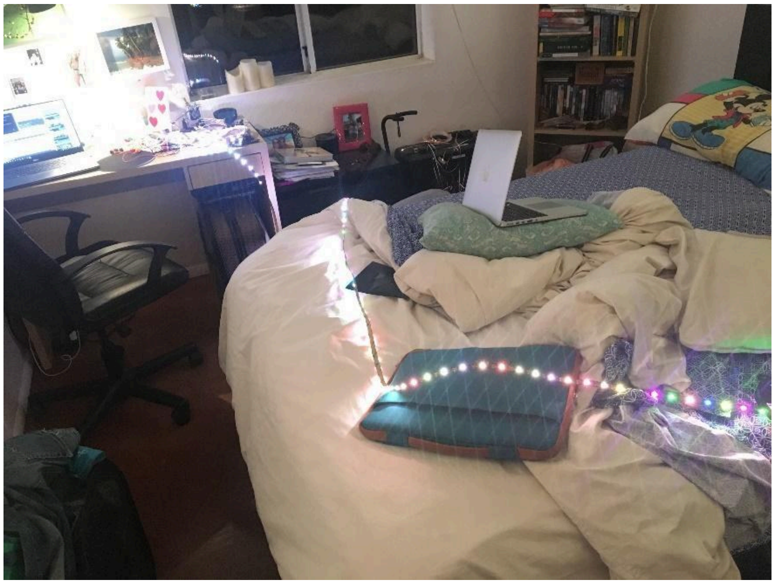
I got a single LED to blink!



Working out what I need:



ADDRESSABLE LED STRIP IS FINALLY WORKING:



Capacitive touch switch update:

I feel like I'm a few lines of code away from making it work. I'm learning a lot more about theoretical physics than I thought I would.

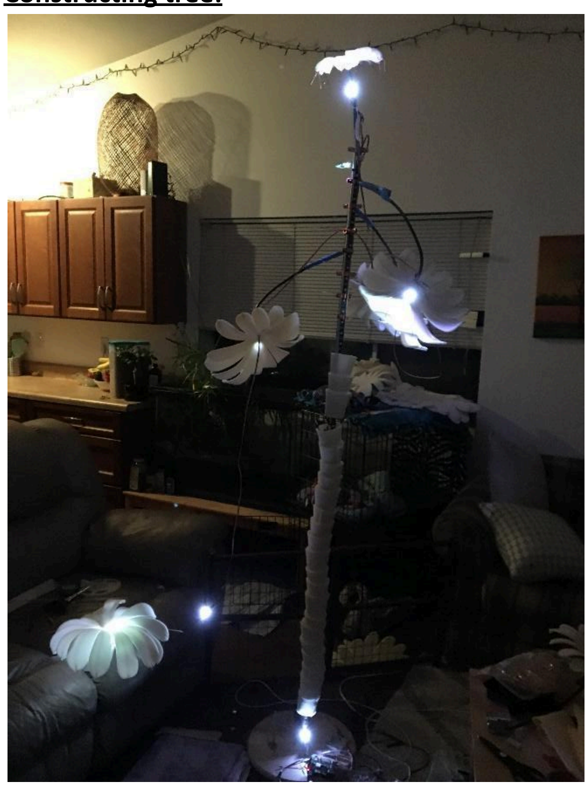
Cap sense working!

I've tried many types of cap sensors for the interactive component of my trees. This, my friends, is by far the best capacitive touch sensing library for the arduino. I'm not quite sure how it works yet, but it definitely works: http://playground.arduino.cc/Code/ADCTouch

Laser-cut leaves:

Installing leaf veins:

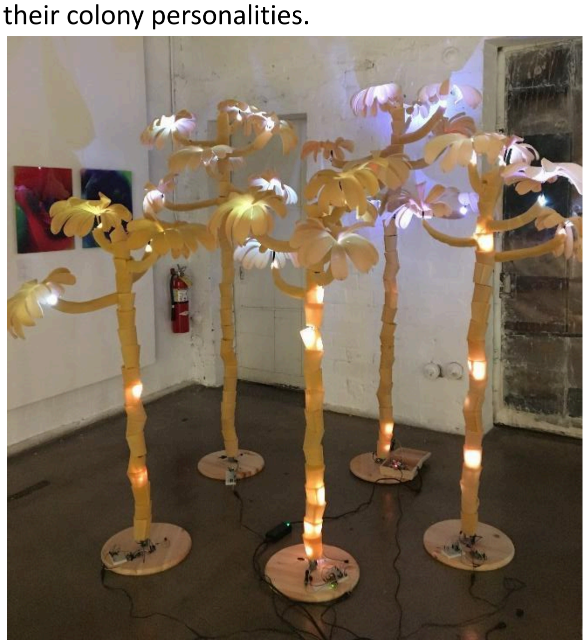
Constructing tree:



Finished: single tree

Forest of the Glowing Symbionts

Placard: Azteca ants constantly patrol their Cecropia tree, looking for intruders. When a large vertebrate, like a sloth or monkey, climbs onto the tree to eat its leaves, the vibrations alarm the colony and the ants fiercely swarm the tree, aiming to sink their sharp mandibles into the intruder to defend their host. I conducted a field experiment to test how colonies respond to vibration differently. To simulate a large intruder, I flicked the trees with a home-made flicking device (called the Flickomatic) and quantified the change in ant activity. This piece embodies actual trees and their colonies from this experiment. The lights within the trunk symbolize the ant colony, and the blinking corresponds to a quantified dataset on baseline ant patrolling behavior. When disturbed, the lights respond and the blinking switches to the dataset just after the tree was flicked. The colony eventually calms back down to its normal patrolling behavior. A keen eye may detect how colonies have different responses to disturbance, which reflects their colony personalities.



Gallery Requirements
10x10ft floor space
8ft tall trees
5 trees, need room to walk between them
low light (trees produce their own)
no wall space needed
5 outlets

Booking the exhibition venue

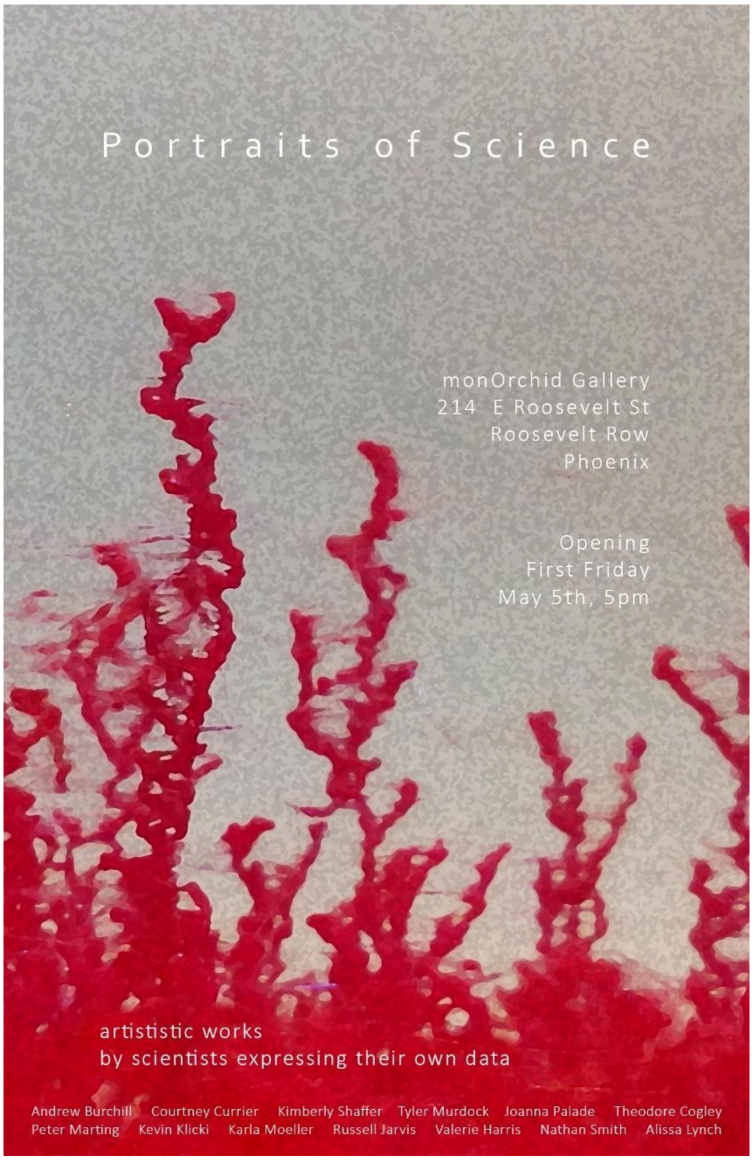
The venue you and your class want to book to exhibit your work may take some thought and discussion about the type of event, duration, and audience you want to reach. Venues that could work range from museums, to zoos, to public spaces, to campus venues, to fine art galleries. Longer shows have the potential of more random exposure, but single night events can be great for maximizing interactions between the science-artists and the audience.

We decided to target fine art galleries during Phoenix's monthly First Friday event, where galleries are free, open late, and visited by the general public en masse. It's never too early to start contacting venues as they often book up months, sometimes years in advance. To identify potential galleries, I asked artists who I had met over the course of the class and searched online in key art district areas. I sent out emails to about 7 galleries and heard back from 4 that were potentially interested in hosting the event. Here's the initial email I sent to the gallery we ended up choosing:

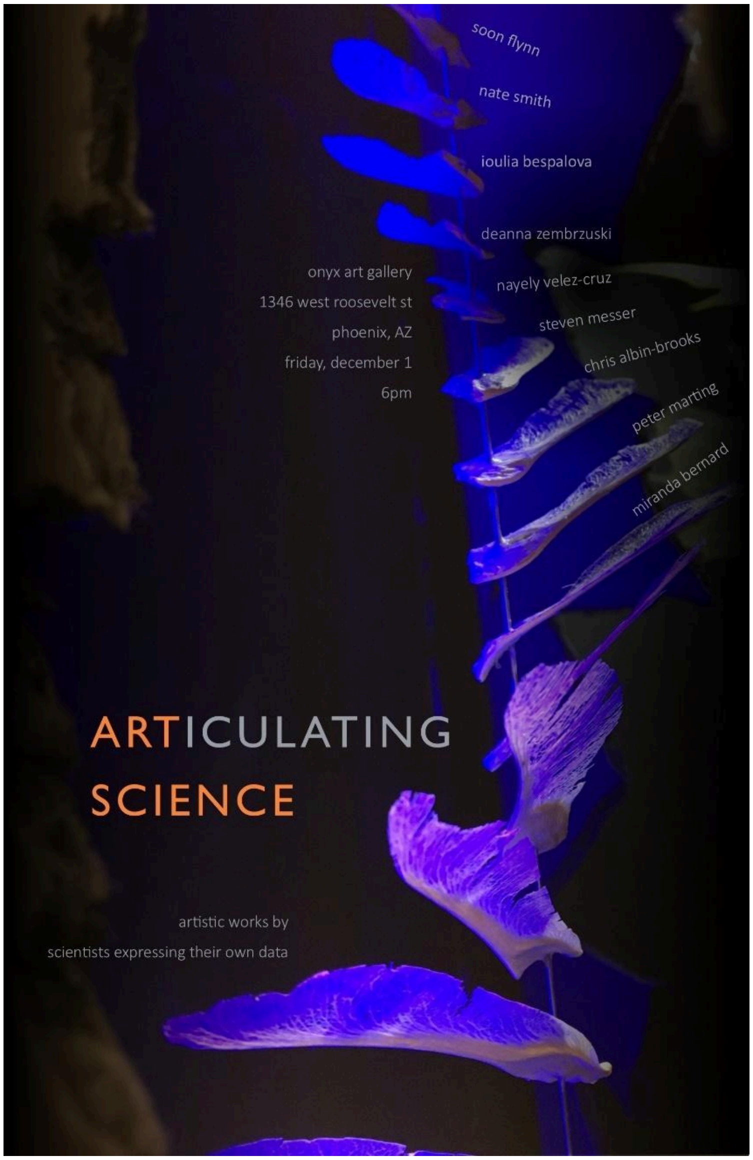
> Subject: Gallery Space for Art-Science Exhibit at monOrchid?
>
> Dear monOrchid,
>
> My name is Peter Marting and I'm a grad student at ASU studying ant behavior. This semester, I created a course for other biology graduate students entitled "Artistic Expression of Original Research" where students express their own research data artistically through a medium of their choice. We have about 10 students with pieces as diverse as their research - fluorescent paintings of muscle cell damage, robotically generated poetry about cancer, Light-up tree sculptures depicting their ant colony symbionts, timescale paintings of deserts responding to rain, knitted quilts representing insect dietary choices, musical performance about the merits of science, and more.
>
> We are looking for a venue to exhibit our work. Ideally, we would like to display during the First Friday in May, although I know I'm pretty late in the game for this now. Later this summer would also work. Do you have any ideas for us? I've copied Kim Shaffer here who is helping me coordinate the exhibition.
>
> Here's an example: http://aztecacecropia.com/treesongs
>
> Thanks for your consideration,
> Peter

After visiting all of venues to discuss details, we got lucky with a prominent gallery and booked it for a month, including opening on a First Friday, for $500. I was able to get a small grant from our university's Research and Training Initiative to cover the booking cost.

We voted on a name for the exhibit as a class and created posters from the student's projects. To advertise the event, we sent out announcements to different departmental listservs and put up the posters around campus and around the venue downtown. We worked closely with the gallery's art curator to set up the exhibit – I asked students to describe what they might need to show their piece in the space and relayed the information. The exhibit was a huge success - we received over a thousand visitors and had many meaningful interactions with the public audience.



For the second iteration of the course, we booked a different venue, one we toured the first round that remembered us. This was also an excellent venue that gave us a First Friday slot for free, though it was a one-night-only event. It was also a huge success.



Projects and placards

Ant Tapestries
Andrew Burchill

Complex adaptive systems science (CASS) is a field that seeks to explain how unforeseen properties can emerge from collections of simple individuals following very simple instructions. These “ant tapestries” are a direct—albeit somewhat opaque—representation of the data I’ve been collecting along this line of inquiry. I chose to do knitting partly because I have no experience in textiles: without understanding what the final piece would be like, could I follow a set of simple, repeated rules and create a highly ordered whole? My decisions to either knit stitch or purl stitch at each point were guided by whether my ant colonies chose either carbohydrates or protein food sources at time points over a 30-day experiment. The ants are somehow coordinating how they choose food to maintain a healthy colon-level diet. At any small scale, the pattern may seem random, noisy, unmeaningful, but over time, a consistent ratio emerges. Following the individual threads’ transition from looping mess to regular aggregation mimics the work I do as a scientist.

Aside from the yarn, all the materials I used came directly from my laboratory. Dental plaster used to create their nests, the coffee that fuels so many late-night experiments, the glue that holds specimens on their pins: these tapestries contain the history of my day-to-day work.

The threads that unite to form a thicker strand represent the individual ants within the colony: brown and black are workers, white threads are the developing pupae (the young ants), and the queens are marked with purple. As you can see, my colonies have very different compositions and have undergone very different histories since I dug them out of a clearing in the Panamanian rainforest: some are robust and growing, while others are sick, suffering a breakdown in internal order.

Composite: Gila Monsters at the Owl Head Buttes
Karla Moeller

Studying the physiology, behavior, or ecology of a species can be a long process. You patiently collect information that may come in small bits and pieces across time, adding it to data collected by others. *Composite* is a representation of a small section of data from Karla Moeller's research. A composite of drone images shows a roughly mile-long section of her field site; pins show tracked locations of Gila monsters; clusters of the same color represent the same animal and connections show sequential movements over seven months in 2010.

From 2008 to 2012, Karla and her colleagues studied over 20 Gila monsters at the Owl Head Buttes, where her advisor, Dale DeNardo, and his team studied Gilas for over 10 years. The team tracked tagged animals at least once a month during each active season. Information collected during 2010 relate to the physiological effects of summer droughts, the nest-selection behavior of gravid (pregnant) females, and social behaviors in this mostly solitary species. Still, all that effort only provided a small portion of a much larger picture of Gila monster natural history.

Just as Karla and her colleagues compiled bits of data over time to expand a knowledge base, *Composite* combines small contributions from various biologists and makers to form the larger whole. Dale DeNardo and Jon Davis found the animals represented here; Karla, Christian Wright, and Dale DeNardo recorded presented locations; Will Shaw photographed and compiled 27 drone images of the site; Mike Lundgren printed the image; Bobby Zokaites constructed the mesquite frame; and Karla mapped movements and combined everyone's work to create *Composite.* Collaboration is an important aspect of scientific research that enables you to expand your questions, your data set, and your methodological abilities. *Composite* shows a small glimpse of that reality.

Strontium Cells
Joanna Palade

Satellite cells are stem cells that lie dormant in between our muscle fibers, until damage occurs. They then become activated, and rush to the site of injury, where they quickly multiply, elongate, and finally fuse to make new muscle fibers. In the lab, I isolate satellite cells and investigate their properties when grown on various substrates. Learning how to manipulate satellite cells in a dish will hopefully provide us with clues on how to help people with extensive muscle damage due to injury or disease.

My work includes 3 acrylic paintings of fused, differentiated satellite cells on three substrates: collagen, laminin and fibronectin. Since we often use immunofluorescence to visualize proteins expressed in satellite cells, by sending in antibodies tagged with fluorophores that emit electrons when excited with a laser, I’ve included a wash of phosphorescent strontium aluminate paint, which glows in the dark.

Rainfall Manipulation
Courtney Currier

Drylands are rapidly transforming due to various global change drivers, such as changes to precipitation amount. This painting portrays a multi-year project that examined the effects of rainfall manipulation on plant cover and photosynthetic cycles (termed 'phenology') in a Chihuahuan Desert grassland.

Because this data was collected over several years of labor-intensive work with the aggregated help, innovation, and passion of several minds, I wanted to incorporate a piece of equipment that we use to construct these large-scale rainfall manipulation experiments in the field. The plastic 'shingles' overlaying each panel are used to intercept rainfall in our experimental drought plots. Affixing 18 shingles parallel and at an angle, comparable to a roof, imposes drought over a 2.5 m x 2.5 m plot of land. This design intercepts 80% of the rainfall to the plants below.

The vegetation painted on each panel accurately portrays percent plant cover data for each rainfall manipulation treatment, where the top panel represents drought, middle represents control, and bottom represents irrigated. Data displayed for plant phenology overlays each panel on the acrylic shingles. The phenology data is temporal, represented by the green gradient, which is viewed left to right through the course of the monsoon season in New Mexico (April - October). The intensity of greenness through time for perennial grasses is painted on the top portion of each shingle and for perennial shrubs on the bottom portion. This study addresses multiple facets of the changing landscape in drylands as a result of climate change.

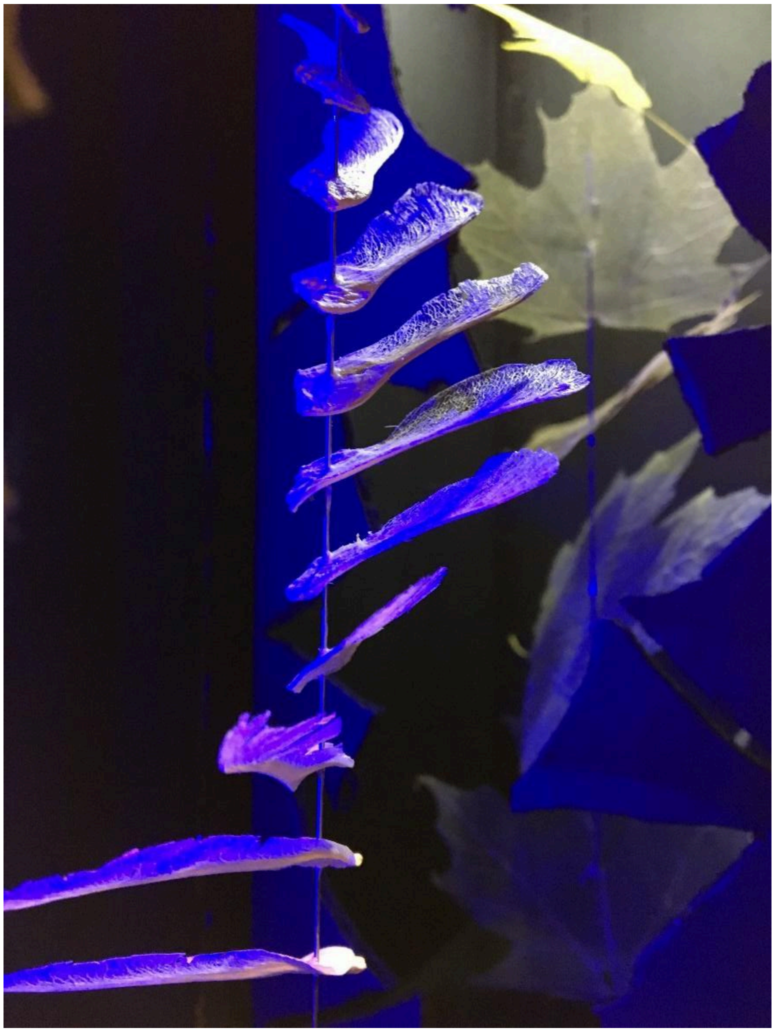
Leafcutters Are Picky Eaters
Nate Smith

Leafcutter ants are among the very few groups of animals that farm. They live in an obligate mutualism with a fungus that is their primary food source. The ants harvest bits of leaves and provide them to their fungal symbiont, which in turn produces nutritionally-dense hyphal swellings that the ants consume. As a result, leafcutter ants face unique foraging challenges; they must make foraging decisions based not only on their own nutritional needs, but on those of the ant/fungus colony system. My dissertation investigates the factors that shape the nutrient needs of the desert leafcutter ant Acromyrmex versicolor and its fungal symbiont, as well as the foraging strategies used to acquire the needed nutrients in the appropriate relative amounts.

This piece seeks to illustrate the first major finding of my dissertation: that leafcutter ants tightly regulate how much food they collect from different sources based on nutritional content. In the past, many biologists justifiably assumed that leafcutter ants are generalist herbivores that randomly select any available leaves that the fungus can digest. By providing leafcutter ant colonies with access to different pairs of diets that have altered relative protein and carbohydrate contents, I found that the ants will adjust their collection of available food sources to provide approximately 1 gram of protein for every 7 grams of carbohydrates. So when you come across a colony of Acromyrmex versicolor in the desert it looks like the ants are randomly collecting leaves from the plants around the nest, but in reality they are carefully modulating how much they collect from each plant to reach this nutrient intake target. The question mark and poorly defined underground nest represent the next step of my dissertation: untangling how the collected food is digested and distributed to meet the nutrient needs of both partners in the symbiosis.

Kevin Klicki

Kevin Klicki is a second year Ph.D. student in the molecular and cellular biology program. In the laboratory he studies the production of natural sunscreens in photosynthetic bacteria, as well as the potential applications of these compounds to biotechnology. Since long before beginning his scientific career, he has practiced music playing guitar, drums, and synthesizer in genres ranging from death metal to hip-hop. In this piece he seeks to blend these two passions into a poignant statement about the importance of scientific methodology in society and government juxtaposed with foreboding minor melodicism to convey a sense of urgency about the dystopian hellscape awaiting the nation which turns a deaf ear to the warning cries of the scientific community.



Michelle's Light
Soon Flynn

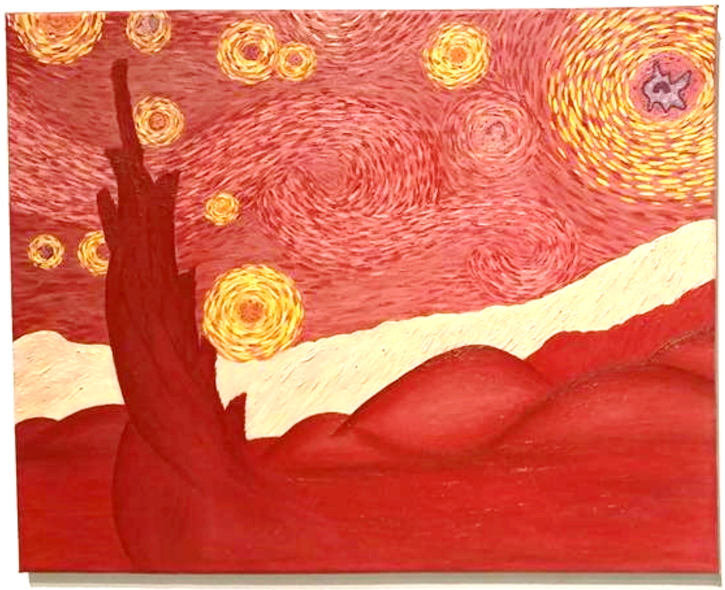
This interactive sculpture is in memory of Dr. Michelle L. Walters known to her friends as Mickey, who passed away this semester. Dr. Walters was on my Ph.D. committee and was an excellent mentor, boss, artist, friend, and scientist who worked for USDA. Michelle's courageous battle with cancer was met with the same tenacity that defined her. She found a simile even through difficult times.

In the sculpture I used skeletonized (leaving the vascular system) maple leaves and samaras (seeds) to signify how delicate, strong, connected, and beautiful life can be; only the vascular system is keeping their shape. One leaf in the sculpture has suffered from a fungus called Rhytisma acerinum, yet the leaf is still stunning. Like Michelle, the leaf's skeleton is indomitable.

The leaves and samaras are falling to the ground in a circular pattern to show the cycle of life. In this case, they become plant fossils, (paleobotany), and signify the enduring memory of Michelle. Fossil maple samaras have distinguishing features (wing shape, venation, orientation, attachment scars, nutlet shape, backbone) which we use to identify species.

Fossils are hidden in shale, hillsides, rock matrix, coal swamps etc. The silhouette cutouts are of extinct maple leaves. The lighted maple fruits and leaves in the box represent the light in which Michelle helped me see the world differently. Peek inside the box to find Michelle's light. Switch the toggle on and off to stop the rotation to appreciate different views.

Fourteen samaras represent the Geologic Time Periods (Hadean, Archean, Proterozoic, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Paleogene, Neogene) and four samaras represent the Eras (Precambrian, Paleozoic, Mesozoic, Cenozoic).



Untitled
Alissa Lynch

Muscle damage occurs from several various causes – hereditary, viral, or bacterial diseases, injuries, immune disorders, tumors, and nerve failures. Regardless of the cause of damage, healthy repair depends upon an intricate coordination between muscle tissue and the innate immune response. Throughout the course of repair, inflammatory cells aid in debris removal, activation of muscle stem cells, and reconstruction of the muscle fibers. Simultaneously, muscle stem cells undergo proliferation, fusion, and maturation to form new muscle fibers. These processes occur in a highly regulated manner and disruption of either leads to diminished muscle repair and, consequently, reduced functionality.

Using oil paint, the scene of skeletal muscle damage was illustrated on canvas. Skeletal muscle lies across the bottom, covered by a protective layer of fatty tissue. The blood stream and subcutaneous tissue encompasses a sky filled with inflammatory cells. A torn muscle fiber branches off the underlying skeletal muscle terrain.

On the Banks of an Ephemeral Stream
Deanna Zembrzuski

On the Banks of an Ephemeral Stream is a mixed media, mixed dimensional painting that aims to express a recent reconstruction of evolutionary relationships (a phylogeny). The research this piece is based off reconstructed the phylogeny of 3 genera of Mayflies (Ephemeroptera), completely revising the status of these genera, casting the 3 genera as only one genus. The streams in this presentation represent each species used in the research, and the branching patterns of the stream represent the relationships between the species. While a stream's branching patterns are opposite of phylogenetic branching patterns, a stream was selected to represent this phylogeny not only because of the habitat of the organisms but to signify the "flowing" of all the genera back into one genus. As this piece is viewed, muddy streams, tumultuous eddies, brilliant blue streams, and deep dark waters can all be found, each of these motifs was carefully chosen to signify nuances of the data. While the research used for the project has resolved many of the relationships, there are still questions left to be answered.

The title of this piece is a play on several aspects of the research. The study organisms spend the better parts of their lives living in stream habitats, and their order (Ephemeroptera) stems from the word Ephemeral. Ephemeral stream also can refer to the idea that how we understand phylogenies is never static, and one reconstructed phylogeny may be ephemeral in the grand scheme of things as new molecular data is uncovered and more pieces are placed together. Finally, this piece is on the bank of the stream, referring the "tip of the iceberg" nature of the research. Enjoy the journey floating through this stream, wading through the muddy waters, fighting to break through the eddies, and traversing the depths of this research.

Societal Enlightenment
Ioulia Bespalova

Some might think of ants as simple creatures: automatons that mindlessly act as a group, with no room for things like individualism or personality. Those are not thel ants I know. Ants are independent entities with a collective goal; they affect each other's behavior because of their close quarters and by sharing information, but generally go about their own lives making decisions to the best of their knowledge and showing as much self-determination and idiosyncrasies as you would expect from any animal. Colonies are truly societies in miniature.

This piece captures an instance of societal change, and the changes in individual behaviors that lead to it. I followed the choices of individual foragers in a colony of desert seed harvester ants (Pogonomyrmex californicus) over two days, as they collected from a mixed pile of two seeds that were new to them. As the colony learned about these seeds, it changed from being biased toward ryegrass seeds (represented in pink) to being biased towards njger seeds (represented in blue). The behavior of this colony is typical of this ant population at large – almost all the other colonies I tracked increase their bias towards the blue seeds over time. The layered colors represent the ant's choices in relation to the colony's, her preferences, her level of effort, and her presence in the process. Individual preference ranged from indifference, to bias, to meticulously picking out only one of the two seeds.

Ants have helped me get over the idea of a single way to "do the right thing". I think we as humans are too focused on finding the "best" solution, yet research on ants and bees shows that highly adaptable and efficient societies are not just groups of individuals who make the same exact decisions as each other. Combining different approaches mixes strengths and lessens weaknesses. Diversity of thought, behavior, and even mistakes are all important at the societal level, because they balance the maintenance of behaviors that are good for the current environment, with ingenuity and preparedness for inevitable changes and new situations.

Forest of the Glowing Symbionts
Peter Marting

Azteca ants constantly patrol their Cecropia tree, looking for intruders. When a large vertebrate, like a sloth or monkey, climbs onto the tree to eat its leaves, the vibrations alarm the colony and the ants fiercely swarm the tree, aiming to sink their sharp mandibles into the intruder to defend their host. I conducted a field experiment to test how colonies respond to vibration differently. To simulate a large intruder, I flicked the trees with a home-made flicking device (called the Flickomatic) and quantified the change in ant activity. This piece embodies actual trees and their colonies from this experiment. The lights within the trunk symbolize the ant colony, and the blinking corresponds to a quantified dataset on baseline ant patrolling behavior. When disturbed, the lights respond and the blinking switches to the dataset just after the tree was flicked. The colony eventually calms back down to its normal patrolling behavior. A keen eye may detect how colonies have different responses to disturbance, which reflects their colony personalities.