Outreach Activities offered through the Dynamic Genome Program

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"When deciding what I wanted for a university, all I knew was that I wanted something involving lab work and science. My high school did not have any micropipettes or PCR equipment available to us yet, but our teacher still wanted us to be able to get lab experience with it. My first taste of that was during a UCR lab workshop my sophomore year of high school. It was a great opportunity and it allowed me to see what UCR had to offer. The university became my top pick immediately after." Savannah UCR '21, Hemet High School '17

Purpose and Scope

Since the beginning in 2011, the Dynamic Genome Outreach Group (DGOG), a part of the Dynamic Genome Program[1], has brought the excitement and wonder of science to many individuals from primary school students, community college and university students, to UCR alumni and trustees. Most of the activities take place in the Neil A. Campbell Science Learning Laboratory located in the University Laboratory Building. The Campbell Lab is a recently renovated state-of-the-art facility funded in part by UCR donor and trustee Rochelle Campbell. The Lab is equipped with research lab quality equipment and supplies so that participants in DGOG activities are using authentic tools to perform experiments. They become scientists for the day and hopefully some will choose a lifetime.

[1] The Dynamic Genome Program has two major functions: Biology 20: The Dynamic Genome course and outreach. Biology 20 is a research immersion course for first-year UCR students.

Program Aims

- Provide an inclusive, immersive authentic research setting accessible to most ages.
- Engage residents of Southern California in scientific issues with social impact.
- Allow participants to carry out exciting and stimulating experiments.
- Provide stimulating interactions with scientists and UCR undergraduates.
- Promote rewarding careers in STEM[2] with a focus on the life sciences.

Learning Goals and Outcomes

Because DGOG is an educational outreach group, all workshops are associated with broad learning goals and specific learning outcomes.

Learning Goals

After completing a workshop, participants will…

- Gain a deeper appreciation of science's role in society.
- Have an understanding of the scientific process.
- Realize that they are capable of manipulating laboratory tools.
- Recognize careers in STEM beyond the medical professions.
- Understand the role of a university in society.

Learning Outcomes

The learning outcomes are specific knowledge and skills that a participant will gain during the activities and aligned to the educational level of the group. As such the specific outcomes will be address in the section below.

DGOG Activities and Workshops

A variety of activities and workshops have been developed for the diverse participants served. The DGOG leaders consult with the workshop organizers (usually a K-12 teacher) to determine which activity and level of detail that will be presented to the groups. What follows is a sampling of the menu of activities and associated learning outcomes.

Human origins

- Target Audience: Grades 6—12.
- Especially good to connect ethics, history, social issues to science.
- Duration of Activity: 3—4 hours.
- Cost per student[3]: $5.90 ($16.14 with lunch)
- Capacity: 72 students

During this activity, the participants will address the issue of whether there is a genetic basis for the various human races. The activity was derived from a publication by DGOG leader Dr. Jim Burnette called "Does Race Exist".[4] Depending on grade level a teacher can have students read a *Scientific American* article before or after the activity. During the activity in the Campbell Lab students carry out the steps in the process used to genotype a human for a specific DNA region. Thus they will have a deeper understanding of how the data were

[2] STEM: Science, Technology, Engineering, and Math

[3] Detailed budget follows. All costs include hourly wage for prep time and 10% overhead.

[4] Brickman, P and Burnette, J, (2011). Does Race Exist: *Alu* Transposable Elements and Ancestry DNA. Major Workshop Presenter. Tested Studies for Laboratory Teaching. *Proceedings of the 32thWorkshop/Conference of the Association for Biology Laboratory Education (ABLE)*.

derived that the authors of the used to draw conclusions for the magazine article.

Learning Outcomes

Students will be able to…

- Discuss genetic diversity and how genetic data can be used to trace ancestry
- Describe the steps used to generate the data
- Successfully use pipettors, extract DNA, set-up reactions, use gel electrophoresis equipment, and imaging stations to generate data
- List careers associated with genetics including research scientist, forensic scientist, and genetic counselor.
- Discuss how genetics can be used to dispel notions that race does not define a group, but is only one aspect of being human.

Phenotype to Genotype[5]: Genetic testing and uncertainty[6]

- Target Audience: Grades 6—12.
- Especially good to connect personalized medicine, ethics, history, social issues to science.
- Duration of Activity: 5-6 hours.
- Cost per student: $6.00 ($16.24 with lunch)
- Capacity: 72 students
- Location: Campbell Lab

Genetic testing is becoming more common in medical diagnoses every year. In 2013 Angelina Jolie announced she elected for a prophylactic double mastectomy of non-cancerous breasts based on genetic testing. In doing so she sparked a national debate on value of predictive genetic testing. One concern raised was the fact that most people (including medical doctors) do not know how to interpret the results of a genetic test and the role of relative risk in human health. At the time there was the realization that there are too few genetic counsellors and not enough insurance plans cover their services.[7]

This activity introduces the participants to the process of genetic testing and linking phenotype to genotype using a gene not associated with a human disease. The phenotype is the ability to taste a bitter compound called PTC.[8] There are two phenotypes: tasters and non-tasters and one taste-receptor gene linked with the phenotype called *TAS2R38*. Phenotype is determined in one of two ways: by tasting a piece of paper impregnated with PTC and/or tasting drops of liquid in a tasting panel consisting of increasing amounts of PTC until a tasting threshold is reached or none at all. Genotyping is carried out similar to the Human Origins activity: 1) students extract DNA from their own cheek cells; 2) the *TAS2R38* gene is amplified using a technique called the polymerase chain reaction (PCR); 3) the PCR sample is digested with an enzyme to distinguish

[5] Phenotype: visible attributes of an organism, *e.g.,* eye color. Genotype: the specific combination of genes that give rise to a phenotype, *e.g.,* in the case of eye color the genes responsible for pigment production.

[6] This activity is modified from "Using a Single-Nucleotide Polymorphism to Predict Bitter-Tasting Ability" Dolan DNA Learning Center. URL: http://bioinformatics.dnalc.org/ptc/animation/ptc.html Last visited 10/10/17.

[7] Link: http://www.npr.org/sections/health-shots/2016/04/18/473066953/more-people-seek-genetic-testing-but-there-arent-enough-counselors Last visited 10/10/17

[8] Phenylthiocarbamide

between the taster and non-taster alleles[9] of *TAS2R38*; 4) the sample is run on an agarose gel and the results analyzed. Participants perform all steps of the experiment except #3. Analysis of the data requires a review of heredity to understand the genotypes found in the individuals.

After the results are analyzed the activity concludes with a discussion as to whether having a no-taster allele is 100% associated with the no-taster phenotype. If the sample size is large enough there will be some individuals with the no-taster allele that can taste PTC at the highest concentrations and sometimes a taster with the non-taster allele combination. This leads to a discussion of how genetic testing does not provide a yes or no answer to whether a person will develop a disease. Rather a positive result on a genetic test predicts in an increased relative risk of developing the disease in the future.

Teachers can extend this activity in the classroom in one of two directions: the ethics of predictive genetic testing or eugenics. The example of Angelina Jolie is one of predictive testing where a non-diseased individual makes a decision based on a genetic test predicting an increased risk of the disease in the future. Students can read a paper entitled "Ethical issues in predictive genetic testing: a public health perspective"[10] and teachers can have the students present and debate the issues raised in the paper. The original description of PTC tasting and race was published in the *Annals of Eugenics* (now the *Annals of Human Genetics*). Students could read a prospective article published in the journal of *Genetics*[11] and discuss how genetics was used unethically in the past to justify racial discrimination.

Learning Outcomes

Students will be able to…

- Discuss the relationship of genotype to phenotype.
- Describe the steps used to generate the data.
- Successfully use pipettors, extract DNA, set-up reactions, use gel electrophoresis equipment, and imaging stations to generate data
- List careers associated with genetics including research scientist and genetic counselor.
- Discuss the limitations and ethics of genetic testing.

What is DNA? Strawberry DNA extraction

- Target Audience: K-6, but good for all ages (including trustees).
- Especially good for large venue events such as science discovery days.
- Duration of Activity: 2-5 minutes depending on venue.
- Cost per student: $0.20
- Capacity: Unlimited
- Location: Anywhere (even outside)

By far the most popular and used DGOG activity. Over 3000 students have extracted DNA from strawberries with DGOG. The activity was developed by the American Society of Plant Biologists as a

[9] An allele is a variant of a gene. A gene can have many alleles some of which have normal function while others may have altered or no function.

[10] K G Fulda and K Lykens (2006). Ethical issues in predictive genetic testing: a public health perspective. J Med Ethics 2006;32:143–147. doi: 10.1136/jme.2004.010272

[11] Wooding, S (2006). Phenylthiocarbamide: A 75-Year Adventure in Genetics and Natural Selection. Genetics 172: 2015–2023

simple extraction that allows students to see DNA. A frozen strawberry is thawed and mashed in a zip-top baggie with simple and safe ingredients of shampoo (detergent), table salt, and water. The mixture is placed in a small tube and cold rubbing alcohol is added. The DNA will precipitate out of solution and form a mucilaginous ball that floats. Sometimes students make a necklace and use the tube as a charm while at other times the DNA is "spooled" out with a toothpick. This activity takes around 5 minutes and excites students.

This activity has been run at every Discover Day and Highlander Day since 2011.

Learning Outcomes

Students will be able to…

- Describe that DNA is the genetic material.
- Describe the steps used to extract DNA.
- Be excited about seeing a biological molecule.

Sequencing to Success: DNA Barcoding

- Target Audience: 9-16, more mature the better.
- Especially good for recruiting.
- Duration of Activity: Four weeks. Two Saturdays on UCR campus and small meetings in between.
- Cost per student: $19.00 ($29.24)
- Capacity: 72
- Location: Campbell Lab, Genomics Lobby, and coffee shops

This four-week workshop introduces participants to the process of science from developing a question, experimentation, data analysis, and presentation of results. The program centers on the question of whether fish at the grocery store are properly labeled. The program kicks-off on a Saturday at the Campbell Lab. Participants bring a piece of fish from the grocery store and they learn basic molecular biology techniques and complete the wet lab work require for DNA Barcoding on their piece of fish. Successful reactions (usually >80%) are processed by the Dynamic Genome (DG) Staff and subsequently sequenced at the UCR Genomics Core Facility.

In the following weeks, groups of students work to analyze the results. DGOG personnel meet with the groups to go over DNA sequence analysis and demonstrate the free software called the DNA Subway. DGOG instructors offer continued guidance in person at college campuses, nearby coffee shops, or virtually through Google-Hangouts. Sequencing to Success participants are also encouraged to drop-in the Campbell Laboratory for help with data analysis and poster preparation. After their DNA sequences are disseminated, the groups produce an abstract that is reviewed and edited by the UCR instructors. Finally, each group develops a poster discussing the questions they addressed and their conclusions. The projects culminate in poster presentations at a symposium on the UCR campus attended by faculty and staff.

This workshop has been run six times with community college students. During the first four times the goal was to encourage students to apply and enroll in a STEM major at a four-year institution. The last two times the recruitment has been only for UCR. This is the most expensive of the programs and requires a large time commitment from DGOG instructors, but potentially the most successful at recruiting students for our campus.

Learning Outcomes

Students will be able to…

- Explain the process of science from posing a question, collecting data, and

analyzing the data, to presenting the results to peers and the general public.
- Use pipettors, prepare agarose gels, basic bioinformatics software to generate and analyze data.
- Gain confidence that they can "do" science, that STEM is not an area for only privileged groups.
- Identify rewarding careers requiring a STEM background.
- Apply, gain admission, and matriculate in STEM at UCR or four-year institution.

Impact of the DGOG Outreach Program

Since the beginning in 2012 DGOG has reached over 7,000 students mostly in western Riverside County and all in Southern California with the exception of one workshop for 20 teachers in Honolulu, Hawai'i. Close to 50 different public and private elementary, middle, and high schools have been served either in the Campbell Lab or at the respective school. Each year since 2014 DGOG has had a booth at the Ross-McKracken Science Learning Exposition held by Pomona USD where over 500 students do strawberry DNA extractions every year. DGOG is given the booth honoring the Sarah Ross Science Fair for this event. Sequencing to Success has been attended by 267 community college students from at least eight Inland Empire[12] schools.

In addition to the participants, UCR students benefit from the outreach. Every event is run by a UCR staff member who is assisted with an army of undergraduates. These students prepare all of the reagents for the event and afterwards clean them so that the teaching labs are "class ready" before the lights are turned off. The most important role the undergraduates have is that of lab assistant and role model. During the activity it is the UCR undergraduates that help students and answer most of their questions. The majority of UCR undergraduates graduated from an Inland Empire high school who have successfully matriculated at UCR and match the socioeconomic backgrounds of the participants. Many are successful third and fourth year students who are deciding on career paths. Thus the participants can ask the UCR students questions that no-one at their home can answer since many are first-to-college. The DGOG instructors find this to be a major component of the activity and often plan a panel discussion with the UCR students. They also find this to be the most lasting outcome of the activity, but only because it is embedded in a non-threatening way within the workshop. Lastly, the UCR students benefit by learning to teach students science skills and process and learn how to mentor near peers. These are skills that can be put on a resume and set them apart from the crowd because they have soft skills most students do not develop while giving back to their communities. Most of the relationships DGOG has with high schools were formed by UCR students inviting former teachers to schedule workshops. The DGOG instructors have written numerous letters of recommendation highlighting service learning aspects of the students' time at UCR. Over 40 UCR students have participated in DGOG events.

DGOG is starting to have an impact with the graduate students at UCR. Currently there are two active students who participate in events and serve as more general role models of students who

[12] The Inland Empire is defined by the U.S. Census Bureau as Riverside-San Bernardino-Ontario metropolitan area.

succeeded in college and have gone on to advanced education.

Expanding the DGOG Outreach Program

As of 2017, DGOG has reached maximum capacity in three ways: funding, physical space, and personnel. The DGOG Outreach Program is mostly unfunded. The reagents used are left overs from the Biology 20 course. All weekend personnel hours are volunteer including the UCR Staff, who, whiled salaried, work full 40 hour weeks. It is the onus of the teachers who request a workshop to get the students to campus and provide funds for lunch. A school bus costs $500 for a day. Very few school boards have the funds for sending students to UCR and lunchrooms do not provide meals on weekends. To sustain the DGOG Outreach Program funding must be secured. Because the benefit is to mostly K-12 students there is little federal funding for these programs and the DGOG instructors are not savvy about the state or county level funding. Budgets are provided for each activity to show that these are inexpensive, high impact activities. It would be most desirable to attract a donor to endow the program. A donor who would be engaged in the program, visit during some of the activities, and take pleasure in knowing they have touched a local student by giving them the opportunity to learn that yes, they can "do" science!

The Campbell Lab currently has three teaching labs each of which holds 24 students for a maximum of 72 total. There is no room in the Campbell Lab to assemble 72 students in a single room. Outreach events can be held only on Saturdays as one or all labs are in use for UCR courses during the week. Further we are limited to schools within a radius of about 30 miles or less. To increase our impact and involve very underserved areas, DGOG instructors would like to take advantage of the Palm Desert Campus. We have entertained this idea for several years, but not pursued it. Since we have reached capacity on the Riverside Campus it is time to start discussions about access to the other campus.

The major limitation to expanding the DGOG Outreach Program is UCR staff. The campus requires a UCR staff member to be present during all laboratory activities. Currently there are three Academic Coordinators who lead the outreach activities: Dr. Jim Burnette (CNAS), Dr. Katie Burnette (Biology), and Mr. Alex Cortez (Botany and Plant Sciences). Dr. Burnette and Mr. Cortez are instructors for the Biology 20 course taught in the Campbell Lab and Dr. Burnette is the director of the Dynamic Genome Program and the Campbell Lab. Dr. Clark oversees the Biology 2, 3, and 5B laboratories. The three dedicate their time because they see the effect of the program on the students and it is part of their service to the greater community. That said Mr. Cortez runs two to three activities per quarter and Drs. Burnette participate in one to two. These are eight to ten uncompensated hours per activity. With two to three more staff we could run a workshop every weekend in the Campbell Lab. While staff cannot be compensated momentarily, increasing the numbers would lessen the load on any one person.

Budget

Typical Workshops for 72 participants

Phenotype to Genotype		
Pipetting Exercise	$113.81	
PTC Activity	$153.41	
Lunch	$738.00	
5 hours prep	$75.00	
Total without lunch	$410.67[13]	$5.70[14]
Total	$1,188.25	$16.50

Human Origins		
Pipetting Exercise	$113.81	
Alu Activity	$149.81	
Lunch	$738.00	
5 hours prep	$75.00	
Total without Lunch	$406.35	$5.64
Total with lunch	$1,291.95	$17.94

Sequencing to Success		
Pipetting Exercise	$113.81	
Barcoding	$928.11	
Lunch	$738.00	
10 hours prep	$150.00	
Total without lunch	$1,430.31	$19.87
Total with lunch	$2,315.91	$32.17

Detailed Budgets for each exercise

Pipetting Exercise		
Item	No. Units	Cost
1.5 ml tubes	13	$0.42
Tips	10	$0.96
Gloves	1	$0.20
Sub Total/student		$1.58
No. Students	24	$37.94
Prep[15]	1	$15.00
Total for Exercise		$63.53

Barcoding		
DNA Extraction	2	$2.66
PCR Sample	8	$1.37
Tubes	12	$0.39
Strip tubes	8	$1.41
Agarose Gel	0.25	$0.90
PCR clean-up	2	$2.16
Sequencing	1	$4.00
Sub total/student		$12.89
No. Students	24	$309.37
Prep	2	$30.00
Total for exercise		$407.24

PTC/Phenotype to Genotype		
Taste strip	1	$0.03
Control strip	1	$0.03
Cheek swab	1	$0.22
Instagene	0.1	$0.28
1.5 ml Tube	6	$0.19
PCR Sample	4	$0.69
0.2 ml tube	4	$0.70
Agarose Gel	0.25	$1.17

[13] All totals include 20% overhead for supplies needed for prep, etc.
[14] Cost per student

[15] Hourly wage for UCR undergraduates to prepare reagents for the workshop.

Digest	4	$0.81
subtotal/student		$2.13
No. Students	24	$51.14
Prep	2	$30.00
Total for exercise		$97.36

ALU/Human Origins		
Cheek swab	1	$0.22
Instagene	0.1	$0.28
1.5 ml Tube	6	$0.19
PCR Sample	4	$0.69
0.2 ml tube	4	$0.70
Agarose Gel	0.25	$1.17
subtotal/student		$2.08
No. Students	24	$49.94
Prep	2	$30.00
Total for exercise		$95.92