Failure Monitoring and Detection System for Hydrocephalic Shunts

The (Dr. Matthew) Walker Texas Rangers:
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Vanderbilt University
Major: Biomedical Engineering
Expected Graduation: May 2017

Contents

Executive Summary

Hydrocephalus, or the excessive collection of cerebrospinal fluid (CSF) in the brain, is currently treated by the surgical insertion of a ventriculoperitoneal shunt into the third ventricle of the brain, which functions as a pressure valve, allowing for excess CSF to drain, relieving intracranial pressure. Unfortunately, failure is extremely common, as up to 50% of these shunts fail within two years of insertion, causing increased intracranial pressure (ICP) and inducing potentially life-threatening symptoms, often times without the patient knowing their shunt has failed. While other implanted devices such as cardiac pacemakers or implantable defibrillators have seen significant advancements over the last 50 years, the basic shunt design has remained relatively constant, and there is still no surefire way of detecting whether or not the shunt has failed. Thus, there is an urgent need for a shunt failure detection mechanism that not only detects failure, but communicates that failure to either the patient, the physician, or both.

To solve this problem, a strain gauge differential pressure-sensing mechanism has been incorporated into the proximal tip of the shunt, which acts to detect the increased ICP values characteristic of proximal shunt failure. Using an implanted integrated circuit to process the signal and near-field communication technology to communicate the signal, ICP readings can be read by a physician or the patient themselves using a smartphone app.

Our “Smart Shunt” design has the potential to make critical advances beyond existing mechanical designs as it will be the pioneer shunt that detects its own failure through measurement of ICP and remotely communicates it to the patient/physician. While methods to measure ICP invasively in the clinic exist (such as the Integra Camino ICP Monitor), there are no commercial shunt systems that allow for noninvasive, continuous pressure sensing with remote communications. Thus, we believe a successful rendition of our design will be in high demand by both physicians and patients.

In terms of design specifics, a micro-strain gauge is sandwiched between layers of PDMS and placed into the wall of the catheter at the proximal tip of the shunt. As ICP values rise in coordination with a failed shunt, pressure on the exterior catheter wall will build up, causing the PDMS window to deflect inward, inducing a measurable strain on the strain gauge. This strain value (in terms of a voltage reading) will be amplified via circuitry and written to an NFC chip. Via standardized calibration curves, a given strain measurement will be correlated to a certain ICP in mmHg. When the NFC chip is interrogated by an external smartphone, the pressure will be displayed.

To date, the FDA has not required a PMA application for any CSF shunt, and despite its substantial importance in patient health, the FDA does not require the intense scrutiny applied to Class III life-saving devices. As our design will simply monitor shunt function without drastically changing how it functions, it is safe to say that our device will be treated as all past devices have been, and will be a Class II device achieving clearance through the 510(k) process.

There are two potential marketing realms for our design. The first route would be to market our device as an add-on to an existing shunt, in which our customers would be the leading medical device companies who currently manufacture "gold standard" devices. An alternate route would be to develop and manufacture a complete shunt/catheter/shunt valve system, in which our customers would be hospitals that stock shunts for regular neurosurgical procedures. In order to ensure maximum market capture, it will be necessary for our device to be reimbursable by most insurance companies.

1. Problem Description

Hydrocephalus, or the excessive collection of cerebrospinal fluid (CSF) in the brain, affects 1 in 1000 live births and is one of the most frequent indications for neurosurgery in children (pediatric neurosurgery) [1]. The mainstay of treatment is the insertion of a ventriculoperitoneal shunt, which functions as a pressure valve for the brain allowing for excessive fluid to drain to other parts of the body. Unfortunately, failure is extremely common, as up to 50% of these shunts fail within two years of insertion, causing increased intracranial pressure (ICP) [2]. Currently, the only indication of shunt failure is presentation of symptoms of brain swelling and compression. Due to the high failure rate of the shunts, many patients will suffer from brain swelling and damage before failure detection. On the flipside, neurosurgeons, having no surefire way to tell whether the shunt has failed or not, will perform precautionary shunt replacement surgeries, leading to more exposure and risk. Therefore, there exists a dire need for timely shunt failure detection, so that a replacement can be installed, if needed, before symptoms manifest.

2. Project Objective Statement

Deriving from the need to failure detection, the project objective statement has two main components: the design has to detect shunt failure via measurement of the differential pressure between the brain tissue and shunt tubing, and then communicate this failure remotely to a device external to the body. The idea behind measuring the differential pressure is simple: most failure occurs proximally when the holes of the shunt tubing get clogged by proteins or tissue, and it is this type of failure which is most dangerous and hard to detect. If there is no proximal failure, there will be free flow of CSF between the brain and shunt, and the pressure will be the same in both. However, if there is proximal failure, fluid will build up inside the ventricle and will not flow into the shunt, leading to a differential pressure between the two compartments. Detection of this differential pressure will therefore be an indication of proximal failure.

3. Final Design Description

The final design will use a strain gauge for measurement of differential pressure between the brain and the shunt tubing, and a Near Field Communication (NFC) writable chip for communicating the differential pressure to an NFC enabled smartphone held within 10cm of the head. A rectangular section at the tip of the shunt will be cut out, and the strain gauge incorporated into a "PDMS window" will be inserted into this hole. Application of pressure on one end will cause the PDMS window to deflect, and the strain will be captured by the strain gauge and output as a voltage value. This will then be amplified by an op-amp and the final amplified voltage will be written to the NFC chip.

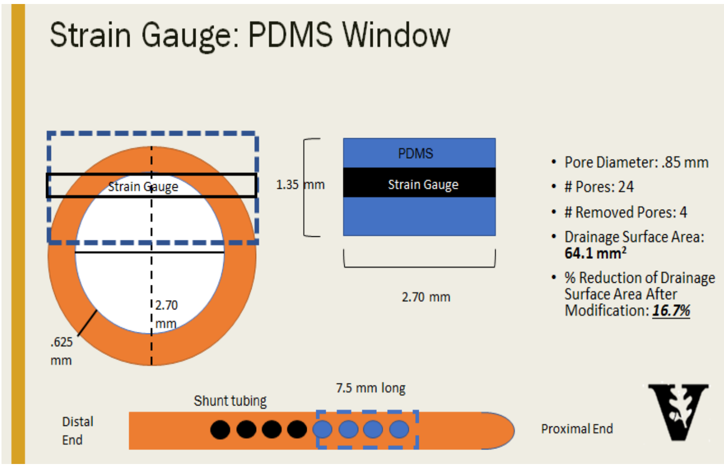

Figure 1 The longitudinal and cross-sectional views of the shunt design are shown with the PDMS window and embedded strain gauge.

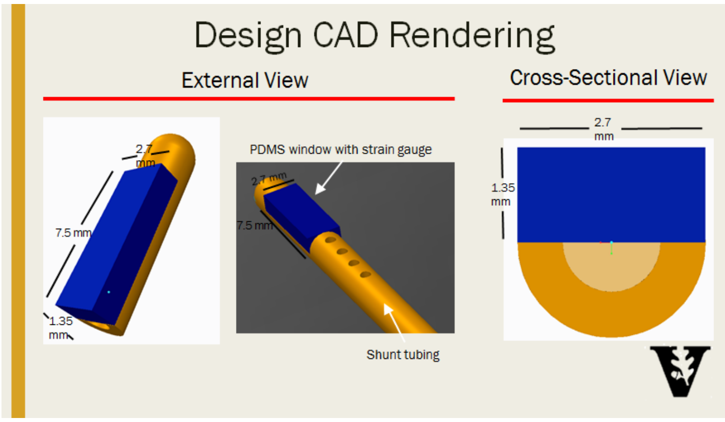

Figure 2 The CAD rendering of the design is shown.

Several risks accompany this design. First and foremost, there must not be any leakage of electrical current into CSF. for this purpose, all components must be thoroughly insulated and sealed, especially the strain gauge and all the wiring. Secondly, all material used in the design must be bioinert and compatible. PDMS was chosen for this purpose as it has been shown to be bioinert, does not swell up, and can be functionalized in many ways to different degrees of hydrophobicity. Another risk would be hindering CSF flow by replacing 4 holes with the window instead - however, our initial testing has shown this to not be a problem.

4. Final Design Prototype

The prototype will be made for in-vitro, proof-of-concept testing. The strain gauge will be embedded in the PDMS window and heat-sealed into the shunt tubing. The wiring and NFC circuitry will be left external to the shunt. The proximal tip of the shunt, with the strain-gauge window, will then be held horizontally inside a water column filled with CSF simulant (saline+albumen). The height of fluid will exert pressure onto the window, which will be captured by the strain gauge and output to the NFC chip, which will then be read by a smartphone held ~10cm away. In order to make this proof-of-concept more robust, the fluid height will be calibrated and varied from 0-5 mmHg, which is the clinically significant differential pressure range expected in vivo. This has not yet been constructed.

5. Proof of Design

Since our design involves replacing 4 holes (out of a total of 24) with the strain-gauge/PDMS window, it is important to ensure that this will not have any significant impact on CSF flow rate into the shunt. An experiment was conducted to measure flow rates through the shunt tubing with different numbers of holes clogged using parafilm. The shunt was then held upside down at the bottom of a graduated cylinder filled with CSF simulant (saline+albumen), and the flow rate into the shunt was measured. The data showed no significant decrease in flow rate when up to 6 holes were blocked, which is proof that covering just 4 will not hinder CSF flow.

# Pores Open	***% Area Remaining***	***Relative Flow Rate***
24	100%	100%
18	75%	98%
12	50%	86%
3	13%	75%
0	0%	0%

Further testing is still underway.

6. Patentability Assessment

The shunting technology has seen incremental improvement in recent years. Shunt development includes activity from major multinational companies, labs at academic research institutions, and smaller individual research groups. Improvements have ranged from adaptations of existing implanted devices to novel valves incorporating MicroElectricalMechanicalSystems (MEMS). A patent search shows increased activity from major shunt manufacturers [(9)]. In patents from 2006 to 2008, Medtronic described a smart shunt operated on a preprogrammed schedule involving the use of feedback control, which could be easily incorporated into their existing marketed designs. A 2012 patent by Codman and Shurtleff described a mechanical valve with a pressure sensor and an actuator to replace the magnetic adjustment mechanism previously employed in the Codman-Hakim. In academia, many groups are developing sensors and dynamic models for the CSF-shunt system, but few groups stand out in terms of failure monitoring, and smart shunts are often described at the conceptual level [(9)].

The only promising patent found for detecting shunt failure for hydrocephalus on the USPTO website is US patent number 9427305. This device utilizes a first tubular prosthesis with a proximal and distal end, a non-optical sensor that measures the flow in this tubular prosthesis, and a second tubular prosthesis which is coaxially mounted onto the first prosthesis. The non-optical sensor is attached, not embedded, onto the first tubular prosthesis and coated with a material to decouple it from the actual material in the first tube. It detects through either a piezoelectric or doppler sensor, and claims to detect flow through, strain, pressure, and stress on the first tube. However, the actual competition from this device for failure detection in hydrocephalus is unclear due to the fact that it is meant for monitoring blood flow through synthetic vascular grafts in the heart. Flow through vascular grafts are many times faster and displace magnitudes more volume than ones in shunts for hydrocephalus. Therefore, the detection method for blood flow might not have the required the same sensitivity as that for detection of flow of CSF[10].

Our Smart Shunt design, using a strain-gauge, is novel and is not anticipated to have IP overlap with existing patents. It has the potential to make critical advances beyond existing mechanical designs as it will be the pioneer shunt that detects its own function through measurement of differential ICP and remotely communicates it to the patient/physician. Due to its focus on failure detection, it will be in high demand by both physicians and patients. Therefore, it should be patentable.

7. Anticipated Regulatory Pathway

Although CSF shunts are necessary to aid/sustain life in many hydrocephalus patients and shunt failure can lead to death unless quickly detected and treated, CSF shunts have been classified as **Class II** in the Code of Federal Regulations -21 CFR 882.5550 [3]. According to the

1999 Systemic Technology Assessment of Medical Products Conference, the decision to classify shunts as Class II devices was based upon the ideas that standards could be written to assure the safety and effectiveness of marketed shunts, and that the clinical experience over the years had proven shunts to be reasonably safe and effective [(4)]. Class II devices do not generally require PMA, but premarketing notification via the 510(k) pathway must be submitted to and cleared by the FDA, giving the FDA the chance to assure that both general and specific controls are met.

In order to move through the 510(k) pathway, shunts must demonstrate the device is substantially equivalent to a currently or previously marketed predicate device. A search of the FDA database of devices classified under the code JXG (reserved for central nervous system fluid shunt and components) shows that all devices, including those of leading manufacturers Aesculap, Codman, Integra, Medtronic, were cleared as substantially equivalent [(3)]. To date, the FDA has not required a PMA application for any CSF shunt, and despite its substantial importance in patient health, the FDA does not require the intense scrutiny applied to Class III life-saving devices. As our design involving the detection of failure in a shunt apparatus will just monitor its function without changing how it functions, it is safe to say that our device will be treated as all past devices have been, and will be a Class II device achieving clearance through the 510(k) process.

8. Reimbursement

Currently, ventriculoperitoneal shunting procedures fall under Current Procedural Terminology (CPT) code 62223[(5)]. Procedures which fall under CPT code 62223 are eligible for federal reimbursement, and, in 2000, roughly 51% of ventricular shunting procedures were covered by either Medicare or Medicaid (with the rest being covered by private insurers)[(6)]. Our proposed device adds on functionality to current shunt designs. Thus, it is not anticipated to dramatically alter or fundamentally change the nature of the shunting procedure. Because of this, we do not anticipate our design introducing disqualifications for federal reimbursement or requiring reclassification under a new CPT code. Hence, we expect it to be reimbursable by Medicaid/Medicare.

9. Anticipated Manufacturing Costs

The valve, catheter, and shunt tubing should be consistent with current costs of the individual components. The strain gage from Omega Engineering cost about 140 dollars for 10 units, equalling a total cost of 14 dollars per unit. If bought in bulk, the total cost of strain gages is estimated to drop to about 8 dollars a unit. The cost for the microcontroller, in our case the Arduino, should range from 30-50 dollars per unit. However, the use of a much smaller microcontroller is needed for implantation, which would increase the cost of the microcontroller. The battery components should be rather inexpensive due to the capacity of the battery only needing to be about that of a phone battery. With wiring and installation, we estimate the battery cost to be around 15 dollars per unit. The NFC shield component would be about as expensive as the microcontroller since the shield needs to be able to constantly write data to an NFC tag. This should be similar in cost to the microcontroller of about 50 per unit. The total cost of installation of components and materials would add only a slight cost of about 40 dollars per unit, including the PDMA backing. Finally, quality assurance would be the most expensive aspect of the unit, however it is hard to predict the actual cost of this aspect. Overall, we estimate the cost to be about 350 dollars per unit on top of the cost of the shunt tubing, valve, and catheter.

10. Potential Market

We are aiming to make a new shunt with a failure detection system embedded into it. Since this will be a complete design, ready to be implanted into patients, our direct customers would be the hospitals that stock shunts for neurosurgical procedures. Ultimately, physicians will administer the product, and the end user will be the patient who is having the shunt and shunt monitoring mechanism implanted. The patients will be children mostly under 5 years of age.

The prevalence of congenital and infantile hydrocephalus in the U.S. and in Europe is estimated to be between 0.5 and 0.8 per 1000 still and live births(7). According to the CDC there are approximately 3.9 million live births per year in the U.S. and 5.09 million in Europe(8). Using these numbers, there are approximately 5,800 cases of congenital and infantile hydrocephalus per year. Additionally, as much as 50% of the shunts used to treat this condition fail within two years. It is then reasonable to assume that 25% of the shunts implanted in patients will fail annually. If tis 25% is assumed to be of 5,800, then the total number of shunts used on patients in a year will be 5,800+1,450, which equals 7,250 shunts. Even without drastic assumptions and with the knowledge that a non-negligible portion of the current patient population utilizing these shunts will experience failure in a given year, we can be sure that the market size is represented by more than 5,800 cases per year.

References

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4. United States, FDA, Office of Device Evaluation. (n.d.). Product Classification: Shunt, Central Nervous System And Components. Retrieved October 25, 2016, from https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfTPLC/tplc.cfm?id=3525.
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8. "Births and Natality." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 07 Oct. 2016. Web. 25 Oct. 2016.
9. Lutz BR, Venkataraman P, Browd SR. New and improved ways to treat hydrocephalus: Pursuit of a smart shunt. Surg Neurol Int 2013;4:S38-50.
10. Kuraguntla. Device to measure flow through lumen. U.S. Patent 3,597,875 filed January 24, 2014, and issued August 30, 2016.

Required Letter of Support

Zoha Abdullah Malik

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Education

Vanderbilt University, Nashville, TN, USA May 2017

- Bachelor of Engineering in Biomedical Engineering, Minor: Engineering Management
- **Cumulative GPA: 3.97/4.00 SAT: 2230/2400**
- **Charles III University of Madrid**, Semester Abroad through IES Spring 2016

Honors: Dean's list: Fall 2013 – Spring 2016, Vanderbilt; Best across 4 A'level subjects in Pakistan, 2013; **World Distinction** in O'level Biology (Top score in the world), 2011

Work Experience

McKinsey and Company, Dallas, TX June 2016 - August 2016

Summer Business Analyst

- Collaborated with a McKinsey team of 5 onsite members and 3 partners to formulate a customer experience strategy for a Fortune 500 Company, which was approved by the client and moved on to Phase 2 – Implementation
- Independent work-stream: leading a McKinsey internal customer experience survey from writing the questions through detailed analyses in collaboration with an analysis team in India, producing meaningful results that steered workflow and became an integral part of the team's final recommendation to the client
- Received positive feedback and an offer to return full-time in 2017

Biomedical Engineering Department, Vanderbilt University, Nashville, TN Spring 2015

Research Assistant

- Project: Use of Hydrogel in Drug Delivery and Pancreatic Cell Replacement
- Designed experiments to find out the optimum amount of collagen that can be added to the hydrogel and cell culture, effectively narrowing down the range by more than 50%
- Performed statistical analysis of the collected data on Microsoft Excel, identifying potential problems and risks associated with the hydrogel that needed to be addressed, such as the inability of cells to adhere to it
- Brain-stormed ideas resulting in more focused experiments that shifted results in the project's favor

Vanderbilt University Student Centers, Nashville, TN Fall 2013 – Spring 2016

Reservations and Events Manager (Fall 2015)

- Manage event reservations and assist in setting up and supervising events – with a focus on client satisfaction – across Vanderbilt's campus facilities, which host an average of 30,000+ events annually
- Helped develop and expand the brand "Meet at Vanderbilt" for Vanderbilt University's student centers
- Promoted from Box Office Associate (2013-2015) to Manager due to good work ethic and effectiveness

Leadership

Vanderbilt University, Multicultural Leadership Council, Nashville, TN Fall 2015 – Spring 2016

Community Outreach and Publicity Co-chair

- Lead community outreach and publicity for MLC's mission, programs and 10 annual events with 500-1000 attendees each, successfully recruiting 8 new organizations within one month
- Promote cross-cultural dialogue and programming between 30 organizations, with a total constituency of 35% of Vanderbilt's total undergraduate student body, leading to higher member organization satisfaction
- Manage MLC's social media and a cohort of 3 organizations, enabling better event planning and advertisement

Vanderbilt University, Pakistani Students Association, Nashville, TN Spring 2015 - Present

Secretary (Fall 2016 – Present), President (Fall 2015 – Spring 2016)

- Cofounded the PSA chapter at Vanderbilt University
- Organize cultural, philanthropic and political events to spread awareness about Pakistan and initiate outreach programs in Nashville and Pakistan

Community Service

Alternative Spring Break, Los Angeles Spring 2015

- Served homeless people in St. Vincent's Cardinal Manning Center, prepared over 3000 meals, and helped in outreach and awareness regarding HIV and AIDS as part of a 12 people team

Miscellaneous

- Fluent written and oral communication – English and Urdu; basic proficiency - Spanish
- Proficiencies: MATLAB data analysis, Wolfram Mathematica

Alvin Mukalel

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EDUCATION

VANDERBILT UNIVERSITY **Nashville, Tennessee**
Bachelor of Engineering in Biomedical Engineering *May 2017*
GPA: 3.624

PROFESSIONAL EXPERIENCE

Vanderbilt Advanced Therapeutics Lab **Nashville, Tennessee**
Undergraduate Researcher *May 2015 – present*

- Focus on optimization of nanoparticles composition for the delivery of peptides as a therapy for pathological vasoconstriction
- Characterize physical properties of nanoparticles using dynamic light scattering (DLS), zetasizing, and transmission electron microscopy (TEM).
- Determine cellular interactions of nanoparticles using flow cytometry, hemolysis, Galectin8-YFP imaging, and confocal microscopy.
- Investigate *ex vivo* tissue-nanoparticle interactions using human saphenous vein muscle physiology studies.
- Establish and maintain cell lines

Vanderbilt Student Recreation Center **Nashville, Tennessee**
Student Supervisor *January 2014 – January 2016*

- Staff Coordination. Coordinated a staff of 12 workers to perform and excellent customer service.
- Facility Management. Directed communications between facility managers, support staff, and trainers to ensure proper equipment functioning and to improve overall facility condition.
- Ensure functioning of various departments i.e. Aquatics, Intramurals, by maintaining communication with various departments and directing staff to appropriate tasks.
- Preparation of facilities for Sports Clubs, Intramural Teams, Fitness Classes, etc.
- Provided excellent customer support by resolving membership disputes.

Vanderbilt Student Recreation Center **Nashville, Tennessee**
Front Desk Clerk *August 2013 – January 2014*

- Assist customers with questions regarding classes, intramural sports, aquatics, etc.
- Assist in upkeep of facility

Kumon Math and Reading **Union, New Jersey**
Tutor *May 2012 – Jun 2013*

- Administer, proctor, or score academic or diagnostic assessments.
- Collaborate with students, parents, teachers, school administrators, or counselors to determine student needs, develop tutoring plans, or assess student progress.
- Develop teaching or training materials, such as handouts, study materials, or quizzes.
- Identify, develop, or implement intervention strategies, tutoring plans, or individualized education plans (IEPs) for students.
- Prepare lesson plans or learning modules for tutoring sessions according to students' needs and goals.
- Monitor student performance or assist students in academic environments, such as classrooms, laboratories, or computing centers.

SKILLS

- Computer: MATLAB and Java
- Laboratory: Cell Culture, Nanoparticle Fabrication, Flow Cytometry, Dynamic Light Scattering, Zeta Sizing, Galectin8-YFP imaging, Confocal Microscopy

Cole Pickney

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Education

Vanderbilt University – Nashville, Tennessee
Bachelor of Engineering, Biomedical | May 2017
Minor: Engineering Management

GPA: 3.448/4.0
Test Scores: SAT - Reading 800, Math 770, Writing 750

Experience

Point72 Asset Management — June 2016 – August 2016
Hedge Fund Fundamental Research Analyst — Stamford, CT

- Performed fundamental industry research spanning healthcare, industrials, retail, energy, and foodservice
- Analyzed public companies' financial statements, earnings calls, and annual reports to examine business models, the impact of state and federal regulations on operations, and firm-specific drivers of revenue growth
- Wrote extensive reports detailing companies' supply chains, distribution networks, and economic drivers on a bi-weekly basis
- Presented my research to my manager, numerous full-time analysts, and the director of the Fundamental Research Group at the end of each two week round

Amputee Associates, LLC — June 2015 – August 2015
Prosthesis Design & Fabrication Intern — Nashville, TN

- Designed a stance phase flexion mechanism for a multi-function knee prosthesis
- Utilized CAD software (Creo Parametric 2.0) to model the mechanism and to ensure its proper mechanical functionality
- Tested the mechanical properties of the models with Creo Simulate
- 3D printed the designed models as a further step toward eventual prototype phase of the design
- Collaborated both in person and via Internet with engineers at Fillauer, a leading prosthetics and orthotics company

Vanderbilt University – Cone Research Lab — August 2012 – December 2013
Research Assistant — Nashville, TN

- Aided in doctoral research, studying the histology of fat cells in mice through microscopy and image analysis
- Performed data input and analysis with Microsoft Excel
- Ran genotyping reactions, cleaned and maintained the lab, prepared solutions, and generally helped ensure the continual proper functioning of the lab
- Maintained the lab's mouse colony, including ear tagging and clipping and cage maintenance

Leadership

Sigma Chi Fraternity – President — 2016 - present

- Responsible for coordinating and communicating with the University's Office of Greek Life and the national organization on behalf of all chapter members
- Lead weekly chapter meetings to discuss the current state of affairs for the chapter

Club Lacrosse – Vice President — 2015 - present

- Involved in all club activities including recruiting new players, managing the budget, buying gear and equipment, and communicating with the University's club athletics director
- Participate in planning and coordinating team's away trips, including booking transportation and lodging

'Dore For A Day – Host — 2015 - present

- Host high school juniors, seniors, and admitted and wait-listed students for a half-day visit to Vanderbilt's campus
- Interact one on one with prospective students and provide them with insight into day to day campus life

Skills & Achievements

- Proficient in MATLAB
- Excellent English writing skills
- National Merit Finalist and National Merit Scholarship recipient
- PADI open water diver certified

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EDUCATION

Vanderbilt University Nashville, TN
Bachelor of Biomedical Engineering
Minor in Computer Science
Class of 2017
Cumulative GPA 3.5/4.0

Oklahoma School of Science and Math, Oklahoma City
High School Diploma
Class of 2013
No Cumulative GPA

EXPERIENCE

Research Assistant, Oklahoma City, OK Summer 2012 - May 2013
Research Assistant in the Department of Physiology

- Prepared solutions, prepared slides of samples, followed various protocol for PCR, gels, etc., washed glassware

Research Assistant, Norman, OK Summers of 2014, 2015
Research Assistant in the Department of Biochemistry

- Followed various protocol for preparing solutions, gels, etc.
- Ran protein assays to determine inhibitor efficiency
- DNA analysis of CRISPR-Cas system bacteria to determine group relationships
- Bioinformatics research determining DNA and RNA patterns in Streptococcus and other bacteria types
- Began trying to crystallize Csn1, Csn2 of Streptococcus to find protein structure

Get Me on Track Foundation, Oklahoma City, OK April 2012 - Present
Founding Member

- Partnered with the Boys and Girls Club of America in Edmond, OK to teach students ACT and SAT exam preparation
- Presented information on the college process to students at various Boys and Girls Club of America locations and the Enid, OK public library

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CAMPUS INVOLVEMENT

Design for America Fall 2013 – 2015
Team Member

- Work on various projects that are collectively agreed upon by the team
- Last semester: explored ways to reduce Vanderbilt's water usage
- Currently working on getting Vanderbilt to start composting food and paper waste

Liberty in North Korea Fall 2013 - Present
Board Member

- Raise awareness about the people rather than the politics of North Korea
- Donate resources to help refugees who have escaped North Korea

Colin Sweeney

Mobile: 619-261-0201 E-Mail: colin.j.sweeney@vanderbilt.edu
Campus Address: 2301 Vanderbilt Place, PMB 355941, Nashville, TN 37235

Education

Vanderbilt University: Nashville, TN — *Expected Graduation: May 2017*
Major: Biomedical Engineering;
Minor: Nanoscience and Nanotechnology
GPA: 3.827

- Dean's List: All Semesters

Universidad Carlos III de Madrid: Madrid, Spain — *Spring 2016*

- Achieved working proficiency in Spanish language
- Shadowed physicians at University Hospital Gregorio Marañón bi-weekly

Employment

Putnam Associates, Boston, MA — *Summer 2016*
Summer Associate Consultant

- At Putnam, a leading life-sciences management consulting firm and #1-ranked boutique consulting firm by Vault, provided high impact strategic advice and analytical services to a top bio-pharmaceutical company with a promising hemophilia asset
- Conducted market research for 20+ international markets to inform estimates on asset's potential pricing, access, and reimbursement, and conducted primary research to gather physicians' views on asset's clinical profile, expected use, and estimated market share
- Performed extensive research to update a firm database capturing the entirety of Cell and Tissue-based therapies currently in clinical development, analyzed notable trends in the field, and presented findings to the firm

Vanderbilt University Residential Education, Nashville, TN — *Spring 2015 – Spring 2016*
Resident Advisor (RA) of Freshman Residence Hall

- Mentored and supported 85+ first-year students
- Fostered an environment promoting academic and personal development
- Worked with Residential Education Team to create programs, manage budget, and enforce campus policy

Vanderbilt University School of Engineering, Nashville, TN — *Fall 2015*
Teaching Assistant to Dr. Kenneth Pence – Department of Engineering Management

- Provided group and individualized instructional support to 40+ students in Engineering Economics
- Attended all class sessions, held weekly office hours, created and evaluated weekly assignments, 3 Mid-Terms, and Final Exam

Camp Stevens Episcopal Summer Camp, Julian, CA — *Summer 2014, 2015*
Resident Staff Member

- Planned for, supervised, and led groups of elementary, middle, and high school-aged campers for weeklong overnight sessions
- Led 12 counselors-in-training in an intensive 10-day program to teach group dynamics, positive forms of communication, conflict resolution, and interpersonal relations to actively facilitate their development as successful counselors
- Cultivated campers' knowledge of sustainability and environmental stewardship by working at an on-site organic farm and garden, educating about the local flora and fauna, and practicing Leave-No-Trace philosophy

Community Involvement & Leadership

Big Brothers Big Sisters of Middle Tennessee, Nashville, TN — *Fall 2013 – Fall 2015*
Mentor to 3rd Grader at Kirkpatrick Elementary

- Mentored "Little Brother" weekly at his elementary school and helped to greatly improve his literacy

'Dore for A Day: Vanderbilt University, Nashville, TN — *Fall 2013 – Fall 2015*

- Hosted prospective students and provided a unique and informative Vanderbilt campus tour

Vanderbilt Eco 'Dores Peer Residential Education, Nashville, TN — *Fall 2013 - Spring 2014*
Eco 'Dore Council Member

- Created and implemented sustainable practices on Vanderbilt's campus by increasing the amount of recycling containers, installing low-flow showerheads, and setting up water bottle filling stations in academic buildings

Technical Skills & Relevant Coursework

Computer:

- Mathworks MATLAB, Wolfram Mathematica, Microsoft Excel, Microsoft Word, Microsoft PowerPoint

Biomedical Engineering:

- Biomechanics, Biomedical Materials, Physiological Transport Phenomena, Applications of BioMicroElectricalMechanical Systems (BioMEMS), Systems Physiology, Biomedical Data Analysis, Biomedical Instrumentation

Mathematics:

- Multivariable Calculus, Methods of Ordinary Differential Equations, Linear Algebra