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1. Executive Summary

The 2016 California State University San Marcos (CSUSM) Fully Employed Master of Business Administration (FEMBA) cohort conducted research as a first step to positioning San Diego County as an internationally recognized hub for Health Sciences. Health Science San Diego 1.0 (HSSD 1.0) is an analysis of the current landscape of the Health Sciences industry of San Diego County. Though there have been multiple reports and studies that discuss San Diego County in terms of it being a hub of biomedical technology, this report will serve as the foundation for HSSD 2.0 and HSSD 3.0 which will be completed by future CSUSM FEMBA cohorts. HSSD 1.0 will provide comprehensive information related to the different industries that make up all of San Diego County’s Health Sciences. The information gathered will help guide future cohorts to determine how to maintain San Diego County as one of the leaders in the industry, and ultimately how San Diego County can become the number one leader for innovation and job creation. Currently, San Diego County is an internationally recognized region for Health Sciences, but is only ranked fourth in California for jobs related to the industry and second in the nation as a Life Sciences hub.

This study presents findings from an analysis of the current Health Sciences industry in San Diego. Through preliminary research, we have categorized the Health Sciences industry into four major categories: Healthcare, Biotechnology, Biomedical Devices, Education and Research Institutes. The key components of each category will include the following topics:

- Critical Factors: An examination of leadership and an assessment of which critical factors are involved in making a company or entity an industry leader.
- Key Players: Current key players will be identified in each particular industry. This section will compare and contrast the various key player's strengths and weaknesses in depth. Most importantly, it will provide insight into how the competing companies interact with each other and how their relationships foster advancements in the industry.
- Industry Developments: This area analyzes the industry developments in San Diego for each category. Specifically, we will address the current state of each industry in terms of size, presence, and growth. Included is an explanation of how these developments are pushing the local industry into the national forefront. Following this analysis will be the topic of industry trends.
• Challenges: The challenges for each industry will be identified and will be specific to San Diego. Challenges can include anything from funding, legal issues, research, talent acquisition, and government regulations.

Within the past 10 years, San Diego County's Life Sciences sector has grown faster than any other counties in California. While other counties saw a decline in Life Sciences and Health Care during the Great Recession, San Diego County had significant growth in these fields. It is quite clear from the research conducted in this study that UCSD plays a major role in San Diego’s Health Sciences industry. It is one of the main accelerators of innovation and job creation for the Health Sciences industry in San Diego. Education and academic research is the cornerstone of innovation and industry clustering as explained by Porter’s cluster theories and models.

The number of schools and the size of the region may limit San Diego, but research institutes and incubator programs can be created at any time. After evaluating the research in this study, it is clear that UCSD plays a major role in San Diego’s Health Sciences industry. It is one of the main accelerators of innovation and job creation for the Health Sciences in San Diego. Though there are a number of research institutes that partner with the various industries discussed in this study, UCSD is a huge influence. Education and academic research are the cornerstone of innovation and industry clustering.

In order for San Diego to continue growth in the Health Sciences industry, additional funding for education is critical. First, it needs to be established that schools in San Diego are keeping up with the current demand in population growth as it pertains to healthcare. Our analysis indicates there is a direct correlation between funding available for research institutes and job growth in that same region. Second, it is imperative for academia to continue advancing innovation and development in order to sustain brilliant minds, ideas, and job growth in San Diego. In addition to UCSD contributing to this industry, the California State Universities, such as CSUSM are doing their part to provide programs to help students get the education needed to succeed in this rapidly growing industry. CSUSM recently added Health Science programs that combine science with business. Currently, there are no research institutes tied to CSUSM that can help bridge the gap to the Health Science Industry. Therefore, additional funding would be beneficial by providing more research institutes and incubator organizations dedicated solely to the business of Health Sciences particularly in the North County San Diego area.

The HSSD 1.0 study will conclude with overarching challenges that San Diego faces as a region, followed by a short conclusion of the analysis gathered.
1.1. Key Demographics

Key demographics were identified in the beginning of our research. These demographics are general to the overall scope of the report and provide a basic understanding of the current layout of San Diego’s Health Sciences industry.

As stated, this report presents findings from an analysis of the current Health Sciences landscape in San Diego. San Diego County’s population was approximately 3,262,531 in 2014 and is estimated to grow to 4 million in the next five years. San Diego County’s population increased approximately 5.4% in 2010 to 2014. As of 2011 Census, 31.78% of residents had some college education or an Associate Degrees, 21.36% had a Bachelors Degree, and 12.81% had a Graduate Degree. San Diego County’s Life Sciences sector has grown faster than any other county in the past ten years in California. The Life Sciences sector grew 53 percent between 2004 and 2014. While other counties saw a decline in Life Sciences and Health Care during the Great Recession, San Diego County had significant growth in these fields. The growth in San Diego County was driven by the expansion of research and development in the county (Life Sciences - Labor Market Analysis San Diego County, 2014).

There are about 700 medical device companies in the region (BIOCOM, 2014). To provide perspective, of the 1,100 companies in the San Diego region, there were 34,000 jobs related to life sciences, which include medical devices (San Diego Regional EDC, 2014). There is growth in medical device manufacturing jobs; in 2014, there were 11,300 jobs related to biomedical devices in San Diego compared to 2,300 jobs from 2009 to 2011.

Currently, there are approximately 121,500 San Diego residents working in healthcare, which contributes $17.2 billion annually to the region’s economy. Employment in the private healthcare sector has increased steadily in recent years. It grew from 44,000 jobs in 2003 to nearly 60,000 jobs in 2012, while the hospital sector remained relatively steady. The healthcare industry also indirectly contributes to 29,200 additional jobs in the county. The healthcare industry in San Diego County provides more than $9.3 billion in gross domestic product (GDP) to the region. In addition, healthcare employment in San Diego County grew by 18.6 percent from 2007 to 2011 while the rest of the nation’s healthcare employment grew by only 10.8 percent.
HEALTHCARE INDUSTRY

Alexander Anton

Nichole Baker

Cathi Bass

Jorge Gaspar

Alma Palencia

Health Sciences San Diego 1.0
2. Healthcare Industry

San Diego is home to more than twenty-five hospitals. The key players in the San Diego healthcare industry were identified as the top five “Best Hospitals in San Diego, Calif.,” as ranked by U.S. News (Health, 2015). These top ranking hospitals include: UCSD, Scripps La Jolla, Scripps Mercy, Kaiser Permanente, and Sharp. Along with these five top-ranked hospitals, Rady Children’s Hospital and the Veterans Hospitals offer additional notable services. San Diego also has several other smaller healthcare systems and providers, which include: the Palomar Health system, Tri-City Medical Center and Alvarado Hospital. Table 1 shows the top hospitals in the county and their national specialty ranking.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Specialty</th>
<th>National Ranking</th>
<th>Total Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCSD</td>
<td>Adult Cancer</td>
<td>23</td>
<td>902</td>
</tr>
<tr>
<td></td>
<td>Pulmonology</td>
<td>6</td>
<td>1674</td>
</tr>
<tr>
<td></td>
<td>Nephrology</td>
<td>20</td>
<td>1669</td>
</tr>
<tr>
<td>Scripps</td>
<td>Cardiology/Heart Surgery</td>
<td>19</td>
<td>694</td>
</tr>
<tr>
<td></td>
<td>Diabetes/Endocrinology</td>
<td>13</td>
<td>1114</td>
</tr>
<tr>
<td></td>
<td>Ears, Nose, Throat (ENT)</td>
<td>37</td>
<td>738</td>
</tr>
<tr>
<td></td>
<td>Geriatrics</td>
<td>18</td>
<td>1538</td>
</tr>
<tr>
<td></td>
<td>Gynecology</td>
<td>14</td>
<td>1059</td>
</tr>
<tr>
<td></td>
<td>Orthopedic</td>
<td>23</td>
<td>1646</td>
</tr>
</tbody>
</table>

Note. Adapted from US News Best Hospital

2.1. Key Players

2.1.1. UC San Diego Health

University of California San Diego (UCSD) is the only academic health system serving San Diego County. It is also one of only two Level I trauma centers in the region. UC San Diego Health is comprised of UC San Diego Medical Center in Hillcrest, and UC San Diego Thornton Hospital, Moores Cancer Center, Shiley Eye Center, Sulpizio Cardiovascular Center and Jacobs Medical Center (opening in 2016) in La Jolla. The UC San Diego Medical Group provides primary and specialty care. UCSD provides medical care as a contract provider for insurance companies, as well as the under-insured.
UCSD is home to several nationally ranked programs in multiple specialties and the following tables indicate the variety of medical services and programs offered.

**Table 2. UCSD Health**

<table>
<thead>
<tr>
<th>Medical Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIDS/HIV</td>
</tr>
<tr>
<td>Allergy/Immunology</td>
</tr>
<tr>
<td>Apheresis</td>
</tr>
<tr>
<td>Arthritis (Rheumatology)</td>
</tr>
<tr>
<td>Audiology</td>
</tr>
<tr>
<td>Burn Center</td>
</tr>
<tr>
<td>Cancer (Oncology)</td>
</tr>
<tr>
<td>Cardiovascular Services</td>
</tr>
<tr>
<td>Concierge Medicine</td>
</tr>
<tr>
<td>Critical Care Medicine</td>
</tr>
<tr>
<td>Dermatology</td>
</tr>
<tr>
<td>Emergency Services</td>
</tr>
<tr>
<td>Endocrinology &amp; Diabetes</td>
</tr>
<tr>
<td>ENT/Head &amp; Neck</td>
</tr>
<tr>
<td>Executive Health &amp; Wellness</td>
</tr>
<tr>
<td>Eye Care</td>
</tr>
<tr>
<td>Gastroenterology</td>
</tr>
<tr>
<td>Genetics</td>
</tr>
<tr>
<td>Hematology/Blood Disease</td>
</tr>
<tr>
<td>Heart Failure</td>
</tr>
<tr>
<td>Hepatology (Liver)</td>
</tr>
<tr>
<td>Infertility/Reproductive Endocrinology</td>
</tr>
<tr>
<td>Labs</td>
</tr>
<tr>
<td>Nephrology (Kidney)</td>
</tr>
<tr>
<td>Neurology</td>
</tr>
<tr>
<td>Neurosurgery</td>
</tr>
<tr>
<td>Obstetrics &amp; Gynecology (OB/GYN)</td>
</tr>
<tr>
<td>Orthopedics &amp; Spine</td>
</tr>
<tr>
<td>Pain &amp; Palliative Medicine</td>
</tr>
<tr>
<td>Pregnancy &amp; Childbirth</td>
</tr>
<tr>
<td>Primary Care</td>
</tr>
<tr>
<td>Psychiatry</td>
</tr>
<tr>
<td>Pulmonology (Lung)</td>
</tr>
<tr>
<td>Radiology (Imaging Services)</td>
</tr>
<tr>
<td>Rehabilitation Services</td>
</tr>
<tr>
<td>Sports Medicine</td>
</tr>
<tr>
<td>Surgical Services</td>
</tr>
<tr>
<td>Transplantation</td>
</tr>
<tr>
<td>Urology</td>
</tr>
</tbody>
</table>

*Note. Adapted from University of California San Diego*

**Table 3. UCSD Health**

<table>
<thead>
<tr>
<th>Centers &amp; Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bariatric &amp; Metabolic Institute</td>
</tr>
<tr>
<td>Burn Center</td>
</tr>
<tr>
<td>Center for Integrative Medicine (CIM)</td>
</tr>
<tr>
<td>Center for Mindfulness</td>
</tr>
<tr>
<td>Center for Pain Medicine</td>
</tr>
<tr>
<td>Epilepsy Center</td>
</tr>
<tr>
<td>Hemophilia &amp; Thrombosis Treatment</td>
</tr>
<tr>
<td>Inflammatory Bowel Disease Center</td>
</tr>
<tr>
<td>International Patient Services</td>
</tr>
<tr>
<td>Moores Cancer Center</td>
</tr>
<tr>
<td>Neurological Institute</td>
</tr>
<tr>
<td>Owen Clinic</td>
</tr>
<tr>
<td>Shiley Eye Center</td>
</tr>
<tr>
<td>Sleep Center</td>
</tr>
<tr>
<td>SPIN Program – Supporting Premature Infant Nutrition</td>
</tr>
<tr>
<td>Stroke Center</td>
</tr>
<tr>
<td>Sulpizio Cardiovascular Center</td>
</tr>
<tr>
<td>Trauma Center</td>
</tr>
<tr>
<td>Women’s Pelvic Medicine Center</td>
</tr>
</tbody>
</table>

*Note. Adapted from University of California San Diego*
2.1.2. **Scripps Healthcare**
Scripps Healthcare is a nonprofit healthcare system based in San Diego County. The system includes four hospitals, nineteen outpatient facilities, and treats a half-million patients annually through 2,600 affiliated physicians. Scripps Green Hospital was recognized in 2012 by Thomson Reuters, for the third consecutive year and fifth time overall, as one of the top teaching hospitals in the nation. According to US News & World Report on “Top Hospitals in San Diego County,” Scripps La Jolla ranked #2 and Scripps Mercy Hospital ranked #3.

2.1.3. **Kaiser Permanente**
Kaiser Permanente is one of the largest providers of healthcare services in the nation. In San Diego County alone, they have more than 600,000 members and care is provided in all major specialties and subspecialties. Kaiser has one hospital in San Diego, which was the only hospital in the city to receive the Consumer Choice Award from the National Research Corporation (NRC). They are currently building a centrally located, state of the art hospital. They also collaborated with the Palomar Health System to build the new Palomar Hospital in North San Diego County.

Kaiser Permanente has more than twenty-eight medical offices including: Urgent Care, Out-Patient Surgery, and Primary Care. It is one of the nation’s largest not-for-profit health plans; serving more than nine million members nationally. Kaiser Permanente also has a family medicine residency program. In addition, Kaiser Permanente was the only healthcare plan to receive Medicare’s Five Star rating. According to US News & World Report on “Top Hospitals” Kaiser Permanente San Diego is ranked #4 in San Diego County (U.S. News Best Hospitals 2015-16).

2.1.4. **Sharp Healthcare**
Sharp Healthcare is a not-for-profit integrated regional health care delivery system. Sharp offers services throughout San Diego County. Sharp includes four acute-care hospitals, three specialty hospitals, two affiliated medical groups, five urgent care centers and many other facilities. Sharp HealthCare is the recipient of the prestigious Malcolm Baldridge National Quality Award for their Quality and Excellence in 2007. Sharp Healthcare is well known for their locally televised, “The Sharp Experience”.
2.1.5. Veterans Affairs
The Veteran’s Affairs (VA) of San Diego, Balboa Medical Center and the Naval Hospital at Camp Pendleton provide an additional option for healthcare services for the military population and their families. The VA provides medical, surgical, mental health, geriatric, spinal cord injury, and advanced rehabilitation services to over 230,000 veterans and their families in San Diego County. The facility also supports three Veteran Medical Centers at the following locations: Chula Vista, San Diego, and San Marcos. These facilities collaborate with the UCSD School of Medicine and provide training for medical interns, residents and fellows. In addition to their main facility in San Diego, the VA offers services in six community-based outpatient clinics (Affairs, 2015).

2.1.6. Other Healthcare Providers
Additional healthcare providers in San Diego County include Rady Children’s Hospital, which is the largest children’s hospital in California based on admissions. It is also the sixth largest children’s hospital in the United States. Tri-City Medical Center serves San Diego County’s coastal communities of Carlsbad, Oceanside and Vista, as well as the surrounding region. Palomar Health is based in North San Diego County and it is the largest hospital district in California, covering an 850 square mile radius, which includes Pomerado Hospital in Poway (San Diego Regional EDC).

2.2. Critical Factors
“Leadership in healthcare organizations,” a guide written by the Governance Institute in San Diego, summarizes the different qualities that a healthcare provider must have in order to be considered a leader in the industry. The standards outlined include:
1. A culture that promotes safety and quality
2. The planning and provision of services that meet the needs of patients
3. The availability of resources—Human, financial, physical and information
4. A sufficient number of competent staff and other care providers.
5. Ongoing evaluation and improvement of performance.

The standards of a healthcare leader are met across all of the San Diego County healthcare facilities through the following programs, processes, or initiatives. All of the San Diego hospitals promote safety and quality within their practices, exemplified in Scripps’ patient safety motto: “Keeping Patients Safe Through Evidence-Based Practice” (Patient Safety, 2015). As demonstrated in the Key Players summary, the healthcare industry in San
Diego has a variety of medical services, programs, and hospitals that meet patient needs. UCSD and their 1,500 plus practitioners and R&D funding in the excess of $1 billion meet availability of resources and a sufficient number of staff. Finally, ongoing improvement is met by UCSD in their continuous quality improvement projects. Such projects include process improvement to discharge documentation, medication reconciliation, and inpatient documentation and billing (Current Quality Improvement Projects, 2015).

The leadership qualifiers identified were echoed in an interview by Alison Fleury. She identifies differentiators between the key players and the other Healthcare providers in San Diego County as the following: size, breadth of services, presence in the communities that they serve and the continuum of services that they each offer (Fleury, 2015). These factors are also complimented by the factors described below: county-wide collaboration, the San Diegan culture, and industry growth.

National rankings are among the factors that contribute to a leading role in the healthcare industry. “San Diego is blessed to have a wealth of high quality physicians and hospitals,” says Bill Spooner Industry Advisor and retired SVP/CIO of Sharp HealthCare. Consumers in San Diego County can select from some of the highest-ranking medical providers in the country. According to the US News & World Report, “The Best Nationally and Regionally Ranked Hospitals,” three of San Diego County’s hospitals are gold-rated and six are silver-rated, both of which are top rated. In total, San Diego County hospitals are nationally ranked in twenty-two unique specialties. To place this into perspective, more than 5,000 hospitals and more than 16 specialties in the nation were evaluated.

San Diego also has a population that embraces a healthy lifestyle culture and Forbes Magazine ranked San Diego as the eighth healthiest city in the United States. This ranking considers overall health, activity, walking trails, parks, smoking rates and nutrition, to rank the cities. It is also about the infrastructure, community assets and policies that encourage healthy and fit lifestyles (Forbes, 2014). Furthermore, healthcare delivery by the key players in San Diego County is focused on “total health.” Total Health encompasses the physical, emotional, and overall wellbeing of a person. This means that residents seeking treatment for their illnesses can trust they are receiving the best level of care possible and people outside of San Diego County might consider moving or traveling here to receive the best care, which would benefit the economy of San Diego County. According to Alison Fleury, Vice President of business development of Sharp HealthCare, “People expect high quality healthcare to be delivered to them where they live and work. Therefore, healthcare should be community based and San Diego provides that” (Fleury,
2015). These types of recognitions and projects are important for San Diego County’s healthcare leadership since they are a marketing medium when promoting San Diego as a destination for attracting premier employee talent.

According to the San Diego Regional Economic Development Corporation (EDC), San Diego is home to one of the most sophisticated healthcare industries in the nation. “San Diego focuses much more on care of the total patient (rather than competing specialists) than do many areas of the country I am familiar with. One needs to visit some of these communities in the East and Midwest to appreciate what we have in San Diego,” says Bill Spooner, Industry Advisor and retired SVP/CIO of Sharp HealthCare. The Healthcare industry is one of the fastest growing and one of the largest employers in the region. In addition to the twenty-five hospitals currently in San Diego County, there are three more under construction. There are more than 6,400 unique healthcare facilities providing service to the residents of San Diego County and its surrounding areas.

2.3. Key Player Interactions in San Diego
San Diego County’s healthcare system is synergistic. The various companies are working together with several industries from a number of clusters. For instance, healthcare, biotech, and wireless wearables companies are collaborating to create state of the art wireless medical devices. The goal in making these devices is to provide innovative and efficient healthcare.

The San Diego County healthcare industry benefits financially from partnering on projects with Epic Sciences, Illumina, Qualcomm, as well as other private investors (Robbins, 2015). The two main sources of funding for healthcare in San Diego are private investors and the federal government. Dr. Eric Topol, from Scripps La Jolla tells us that, “Google, Apple, IBM, Qualcomm, Intel, Salesforce — they’re coming into mobile health full force, which is extraordinary.”

In 2012 Qualcomm’s health center launched its first wireless diabetes management program. More recently, Qualcomm unveiled partnerships with drugstore chain Walgreens and drug maker Novartis, seeking to use its wireless technology to enable remote patient monitoring and speed up data collection in medical trials. Qualcomm hopes these technologies can help reduce healthcare costs while also offering more convenient services for patients (Rubin, 2015). Sotera Wireless and the West Wireless Foundation have also contributed financially to healthcare innovation in San Diego. (Newmarker, 2015). According to Chris Newmarker, senior editor of MPMN.com, “San Diego is fifth out of the top five areas for growth in the medtech industry.”
Because of their strong synergy, the Health Sciences hub has been able to evolve rapidly during the past 40 years. San Diego has the potential to become a forerunner in preventative care. According to Ivor Royston, a La Jolla Oncologist and Venture Capitalist who co-founded San Diego’s first biotech company, “You’re seeing the convergence of many technologies, from the Internet to wireless health to the sequencing of our genomes to Big Data” (Robbins, 2015).

As an example of San Diego County’s Health Sciences collaboration is a partnership established with biomedical companies and San Diego to launch a mobile app to: “prevent a million heart attacks and strokes as part of the million hearts initiative.” It is one of the four communities nationwide that will be building this mobile app (San Diego Business).

The San Diego Care Transitions Partnership (SDCTP) is an advanced strategic partnership project between the healthcare companies in San Diego, most notably Palomar Health, Scripps, Sharp, UCSD and the local government of San Diego. It was established in 2010 with the following set of goals in mind: to improve the transition of care from the inpatient hospital setting to the primary care setting, reduce hospital readmission rate and improve quality of care. There has been documented success of the partnership including a decrease in hospital admission rates by 3.4 percent and a reduction in readmission rates by 3 percent; this has saved San Diego healthcare companies an estimated $2.6 million in Medicare penalties.

There is another collaborative called the “Live well, San Diego” initiative. From their website:

“Live Well San Diego involves everyone. Only through a collective effort can meaningful change be realized in a region as large and diverse as San Diego County. Partners include cities and governments; diverse businesses, including healthcare and technology; military and veteran organizations; schools; and community and faith-based organizations. Most importantly, Live Well San Diego is about empowering residents to take positive actions for their own health, safety and well-being” (LiveWellSanDiego.org).

The aforementioned corroborates that San Diego is serious about its healthcare economy and that the government of San Diego is committed to working together with healthcare companies to help reduce hospital costs and increase the quality of patient care. This partnership should be encouraging to other companies that are looking for San Diego as a possible destination for their healthcare business.
2.4. Industry Development
Currently, there are several projects occurring or slated to occur in San Diego over the next ten years. We interviewed industry leaders to gain an insight into the future of healthcare in San Diego and have included excerpts from our interviews.

2.4.1. Facilities and Expansion
In San Diego County there are currently four healthcare facility construction projects underway. These projects currently account for nearly $1.5 billion in contracts and have provided 14,000 on-site jobs for area construction workers. The four large projects are: the building of the $664 million Jacobs Medical Center in La Jolla by UCSD, the $456 million Scripps Cardiovascular Institute in La Jolla, the $900 million hospital being built by Kaiser Permanente in Kearny Mesa and the massive overhaul of VA facilities also located in La Jolla. These projects are expected to add more than 25,000 new jobs to San Diego County when completed.

We learned from Chris Van Gordon, CEO of Scripps, that due to an Earthquake Modification Requirement (ERM), hospitals in San Diego have to go through massive renovation and restoration projects. Mr. Van Gordon told us that there are multiple projects starting soon. This means that the healthcare industry will be creating job growth in San Diego County for many years to come. He also shared with us that there are multiple expansion projects underway for both Scripps and Sharp health plans. The first objective is to align themselves with medical practices in San Diego County. The second objective is to increase the number of free standing clinics throughout San
Diego County. The goal is to spread hospital overhead costs generated by reimbursement changes that accompanied the affordable care act.

In an interview with Vista Community Clinic CEO Fernando Sañudo he stated: “There is a large initiative for community clinics to work together for the common good of the population they serve”. The community clinic sector in California served over 3.7 million patients in 2014 with 78 percent of these patients being of racial or ethnic minority and 28 percent being uninsured patients. Questioning him further on the subject, he informed us that at least the three largest community clinics in North San Diego County (Vista Community Clinic, North County Health Services and Neighborhood Healthcare) are looking to work together to “compete with Kaiser, Scripps and Sharp”. Since more patients have insurance than ever before they now have more options on where to go to be seen for their medical care. Community clinics need to strategize on to remain competitive in San Diego’s healthcare market. Mr. Sañudo believes that the merging of community clinics is not far off, and in less than five years we might see these mergers take place.

2.4.2. Healthcare Information Technology (HIT)

There are two large data projects currently underway in San Diego County. The first is a project titled: “Big Data and a Culture of Health”, it is led by Dr. Steven Woolf of Virginia Commonwealth University in collaboration with San Diego County. Researchers are overlaying all the available public datasets together, and are using new computing and data visualizing techniques to understand unknown correlations between patients and certain medical conditions. This data model will help his department anticipate patient’s health issues before they emerge. One of the project’s guiding principles is that researchers will focus their efforts on the public health issues which county officials and local leaders think are most important. For example, Alzheimer’s is the third leading cause of death in the region which is a much higher number than the rest of the country. So investigating what factors are correlated with Alzheimer’s will be one of the project’s tasks.

The second project is the recent implementation of the San Diego Health Information Exchange project titled “San Diego Health Connect”. This project’s aim is to connect all of San Diego’s largest healthcare providers to an online, cloud based, healthcare data center. This allows patients’ healthcare information to be accessed by any healthcare provider.
San Diego Health Connect’s main goal is to improve the quality of care and decrease medical costs. It will accomplish this by rapidly providing access to a patient’s healthcare information to any provider that may be treating that patient at any point in time and at any location in San Diego County. The future of San Diego Health Connect is full of possibilities including attracting other healthcare systems who are seeking collaborative, integrated healthcare models.

We also interviewed Sarah Neill, Senior Director of Scripps, about any upcoming HIT projects set to change the landscape of healthcare in San Diego. She mentioned that Scripps is moving its entire medical record operations over to another medical record system called EPIC. This will result in the creation of new regional HIT jobs.

2.5. Industry Challenges
The healthcare industry in San Diego faces unique challenges. The challenges include how to provide healthcare to its aging population, a rising physician
shortage, the presence of large medically underserved areas in San Diego County, and a high cost of living.

County Supervisor Dianne Jacob said that within the next 15 years, San Diego's elderly population will surge by more than 30 percent, but the county is ill-equipped to handle this rapid growth (Mento, 2014). A 2011 article by the San Diego Union Tribune stated that, according to preliminary data from the San Diego Association of Governments, the county will have more than 700,000 older residents by 2030, or about triple Chula Vista’s current population (Rowe, 2011). This will strain not only hospitals but also the entire healthcare infrastructure in San Diego. In the article Dr. Dilip Jeste of UCSD mentions that: “Rich or poor, anyone aging here should learn patience. Landing a doctor’s appointment in the future is going to take more time. Just to keep pace with the population, the number of geriatric specialists should double what it is now,” Jeste said. “But that is not happening and it can’t happen overnight. That should have happened 10 years ago.”

In November of 2014, UCSD announced the Healthy Aging Initiative, a campus wide effort to investigate and address the diverse challenges and needs of the county’s aging population. The UCSD research team will present their research at a symposium on healthy aging, slated for January 25th of 2016.

Adding to the challenge of an aging population is the mounting physician shortage. Demand for physicians continues to grow faster than supply. Although physician supply is projected to increase modestly between 2013 and 2025, demand will grow more steeply due to the aforementioned aging population. There are already areas of San Diego County with a lack of access to healthcare as depicted in Figure 3. Most of the areas that lack primary care coverage are due to geographical limitations, but there are areas close to downtown San Diego that face a physician shortage due to an imbalance between the physicians available and the population they serve.
Some of San Diego’s underserved communities face unique challenge in accessing medical care. In a recent article by KPBS news, the nearest hospital for the residents of Campo and the surrounding communities is one hour away in La Mesa, California (GOLD, 2015). These are challenges that cannot be overcome by simply hiring more physicians. These areas are commonly served by Community Clinics, but due to their lower wages and the high debt out of medical school incurred by new physicians, they find it difficult to recruit new providers for their patients (Burks, 2013).

A high cost of living is another unique challenge facing San Diego County. The current cost of living in San Diego County is one of the highest in the nation. A higher cost of living means that the healthcare industry will find it difficult to attract healthcare workers. San Diego County and California overall is well known for its sunshine tax, an increase in costs for all amenities tied to cost of living such as transportation, utilities and housing comparative to other areas. A recent study by Bankrate states that San Diego County is “the worst in wealth creation.” (San Diego Business) Wealth creation is “the accumulation of assets (especially those that generate income) over a long period of time (financialdictionary.com).” This creates an even greater challenge when attracting much needed healthcare workers to San Diego County.
3. Biotechnology Industry

3.1. Critical Factors
Biotechnology has become an essential industry for a growing number of states, where continued growth leads to high paying jobs, a better economy and quality of life. Biotechnology has been defined by the U.S. Department of Commerce and the White House Office of Science and Technology Policy as a set of enabling “technologies that use organisms or its components to make products; or to modify plants, animals, and micro-organisms to carry desired traits.” Focusing on San Diego, the biotechnology industry is highly diverse, thriving, and continues to fuel the region’s economy. For these reasons, the biotech hub in San Diego continues to be viewed as one of the leaders within this industry.

The pharmaceutical industry is equally important as the biotechnology industry. The primary function of research based pharmaceutical corporations is to create value within the related healthcare systems. This is accomplished by discovering and producing effective medicines, vaccines and services that improve patients’ well-being, and can be sold in markets at a profit. Over the past 60 years, innovation and technology have driven huge improvements in global health, ultimately improving people’s way of life and making the world a better place. Here in San Diego, branches of big pharma, such as Pfizer, Johnson & Johnson and Novartis continue to be at the forefront of drug discovery and drug development. With hopes of conducting clinical trials and gaining regulatory approval, these companies are then in a position to positively influence the well-being of future patients and the innovation process itself.

To be considered an industry leader, there are combinations of elements that lead to success. Some of these elements include top notch research and development institutions such as The Scripps Research Institute in La Jolla, local venture capital firms, a base of well-trained scientists and a pool of managers who are capable of turning an idea into information which can lead to a new product launch. Andreas Föller, an executive recruiter in the life science industry, mentioned that the secret to a company’s success is not solely focused on the idea nor the concept, but the management team. From day one, a company equipped with a strong executive team has the ability to attract and retain some of the best mid-level managers in the respective industry. “There are many more good ideas than good managers in the world. That's the pity! Whether you talk to venture capitalists, potential licensing partners in big pharmaceutical companies, or managers of other biotechnology
companies, everyone agrees—the smaller the company and the more limited the resources, the more immediate the effect of management” (Föller, 2002). To sum up the importance of strong leadership, the roles of the chief executive officer and his or her management team are particularly crucial for any biotechnology or pharmaceutical company. Having a clear vision on where the industry is heading coupled with strong supporting management and research and development teams is a great way to become or maintain the image as a leader in the industry.

San Diego’s diverse talent pool offers the region a competitive advantage in technology based fields; resulting in many companies that have started or expanded such related businesses here. The factors outlined thus far also pertain to the pharmaceutical and diagnostic industries which rely heavily on research and development work prior to releasing a final product. An executive from Merck, one of the largest pharmaceutical companies in the world, has described San Diego as a place “where scientific innovation resides” (Halverstadt, 2014). Hard-working people are passionate about the work that they do. Innovation can help a company discover what opportunities exist now, or are likely to emerge in the future. Successful businesses not only respond to their current customer or organizational needs, but also anticipate future trends. They develop an idea, product or service that allows them to meet this anticipated demand rapidly and effectively. To become or remain an industry leader a company must be innovative. Innovation will help a company stay ahead of the competition as markets, technologies or trends shift over time. Innovation should always be a main focal point when drawing up, or expanding on an existing business plan regardless of the size of an organization. San Diego’s reputation as a biotech innovation leader has received a ringing endorsement from The Scientist, a highly regarded life science magazine. Five of the magazine’s top 10 innovations for 2014, including the first-place product, came from San Diego companies. Four of them came from the fast-growing field of genomics, where San Diego dominates. Joe Panetta the chief executive of Biocom, a San Diego-based life science trade group stated

“The innovative dominance of San Diego biotech illustrates the creative power of the area’s biotech industry. To me, that’s an old-school way of looking at the strength of a life science cluster. When I look at this, and I see these five of 10 companies, with these very forward-looking areas of research, I think it says a lot more about our life science cluster relative to the others. In a way, it’s a vindication about what we think about San Diego. We don’t think so much about having the headquarters of large pharma or biotech companies, we think of San Diego as a place we do
the most cutting-edge research to develop the products of the future” (Fikes, 2014).

With all the fast technological advances, such companies are able to develop a cutting edge product faster, better, and cheaper than the competition. This results in accelerated ways of uncovering the root causes of untreatable diseases, allowing a growing number of therapies to successfully treat patients with various conditions.

Large biotechnology companies located in San Diego, such as Illumina and Thermo Fisher Scientific, are at the forefront of genetic research, developing technology and kits for use in genetic testing. These organizations are currently viewed as industry leaders. Headquartered in San Diego, California, Illumina is an American company that develops, manufactures and markets integrated systems for the analysis of genetic variation and biological function. In 2014, Illumina was named the world’s smartest company by MIT Technology Review, stating

“Illumina, the smartest of all, wowed us. The company exploits the fundamental copying mechanism of DNA in order to read the sequence of a human genome. Illumina’s technology is truly disruptive. In richer countries, everyone’s genomes will be decoded. The impact will be new categories of drugs, better matching of therapeutics to the patients who will benefit most, and startling insights into what makes us human” (Pontin, 2014).

Using its technologies, the company provides a line of products and services such as, sequencing, genotyping and gene expression. Customers for these products include; genomic research centers, pharmaceutical companies, academic institutions, clinical research organizations and biotechnology companies. Their tools provide researchers with the capability to perform genetic tests needed to extract medical information from advances in genomics and proteomics.

Thermo Fisher Scientific is known as a product development company that acquired Life Technologies Corporation for $13.6 billion dollars. The deal ultimately ranked Thermo Fisher as one of the leading companies in the genetic testing and laboratory equipment market. This company has set out to be the world leader in science focusing on enabling their customers to make the world a healthier, cleaner, and safer place.

Reflecting on the pharmaceutical industry in San Diego, companies such as Pfizer, Johnson & Johnson Pharmaceutical Research & Development, LLC, and Novartis each have a strong presence not only here, but also around the world. Each of these companies has their own set of tactics to differentiate themselves from competition and identify ways to remain industry leaders. As technology
continues to advance at a rapid pace, these institutions must keep up with the
day to day advancements. New technology in drug development has allowed
alternative routes of administration, dosing changes, various absorption
releases and tamper resistant methods to be the primary focuses of changing
the evolution of pharmaceuticals. Based on the extensive research and
development work as well as clinical trials that have been conducted over time,
new methodologies have led to a safer profile for potential patients.

3.2. Key Players

3.2.1. Thermo Fisher
San Diego’s population of 3.3 million residents represents one out of every
2,100 people on the planet, or less than .05 percent of the total. But San
Diegans make up 5 of the top 100 biotech visionaries in the world. San Diego
is particularly prominent in genomics, where companies such as Illumina and
Thermo Fisher Scientific dominate the field.

Thermo Fisher Scientific is an industry leader with revenues of $17
billion and approximately 50,000 employees in 50 countries. Not only does the
company serve its customers through their premier brands: Thermo Scientific,
Applied Biosystems, Invitrogen, Fisher Scientific and Unity Lab Services, but
equally provide investors with steady growth. Between 2010 and 2014 Thermo
Fisher Scientifics’ earnings per share increased by 103 percent, from $3.43 to
$6.96.

In efforts to create unrivaled leadership, Thermo Fisher Scientific
acquired Life Technologies for $13.6 billion in February of 2014. Marc N.
Casper, president and CEO, stated, “Our combined offering provides cutting-
edge technologies, such as genomics and proteomics, to accelerate life sciences
research and improve human health.”

Thermo Fisher Scientific has successfully differentiated themselves from
their competition by aspiring to be more than a world leader in serving science;
they also aspire to be recognized among the world’s most admired companies.
To achieve this, Thermo Fisher Scientific sets high expectations and
continuously raises the bar. They hold themselves accountable by striving to
achieve all the goals outlined in their vision, meeting and exceeding the
expectations of customers and inspiring and involving their colleagues.

3.2.2. Illumina

Much like Thermo Fisher Scientific, Illumina, a leading developer and
manufacturer of life science tools and integrated systems, also leaves a
dominating footprint in Southern California. Sixty-five percent of the
company’s global workforce is located in San Diego and the Bay Area of San Francisco. They serve a broad range of global institutions, from academic, governmental, pharmaceutical, and biotechnological.

The San Diego-based company boasted a 31 percent revenue increase from 2013 to 2014. A large contributor to this increase was due to fourth quarter sales of their DNA sequencing machines. Sales grew by 75 percent, from $89 million to $156 million. Illumina’s sequencing by synthesis technology, or SBS, is the most successful and widely adopted next-generation sequencing (NGS) technology worldwide. Illumina has 1,145 machines in place worldwide compared to the 836 for all other vendors combined. This amounts to 66 percent of the total sequencing market.

Two important ways Illumina differentiates themselves from the competition are their positioning and R&D budgeting. Illumina is uniquely positioned in the rapidly evolving sequencing market. It is the fastest-growing and most lucrative segment in the genomics field with an estimated growth in 2015 of 23.1 percent. The next generation market (NGS), currently having a net worth of $2.5 billion, is estimated to reach $8.7 billion by 2020. To sustain this growth, Illumina has more than doubled its R&D expense over the last decade. In addition to having kept its spending at the same level relative to its revenues over past years, it has also maintained a stronger commitment to R&D than any of its major competitors.

3.2.3. Pfizer

Similar to companies like Thermo Fisher Scientific and Illumina who have their roots in Southern California; Pharmaceutical companies rely heavily on San Diego’s talent pool. According to Jay Lichter of Avalon Ventures, “There are now generations of biotech companies that have essentially grown up and learned to innovate in San Diego, while other companies have sprouted to support them. They’re comfortable here. The talent pool is such that nobody wants to leave San Diego.”

The largest pharmaceutical company in the world, Pfizer, has a 25-acre campus in San Diego with more than 500,000 square feet of specialized laboratories and equipment for structural and computational biology, molecular design, drug metabolism, high throughput chemistry, and pharmacology. Pfizer’s San Diego campus is an important part of California's life sciences community and partners with academic institutions and other research organizations. In 2011, Pfizer announced that it is partnering with the University of California, San Diego Health Sciences and Sanford-Burnham Medical Research Institute through the company’s Centers for Therapeutic Innovation (CTI). CTI is a network of collaborative partnerships with top-tier
life science research institutions in California, Massachusetts and New York that aims to accelerate and transform drug discovery and development. In San Diego, CTI’s home base is located on the Pfizer San Diego campus.

There are three key strategies that Pfizer implements to differentiate itself amongst the competition and establish their competitive advantage. Firstly, they have a large diversified portfolio. With the acquisition of Wyeth in 2009, Pfizer became one of the most diversified companies in the global health care industry. The merger put Pfizer in a position for improved, consistent, and stable top-line and EPS growth. The goal was that no one drug would account for more than 10 percent of the combined company’s revenue. Secondly, Pfizer prides itself on having tremendous brand recognition. A prime example is with their “Get Old” program. This campaign targets the Baby Boomers as they head into their retirement years and is compared more to AARP programs than to a campaign or an advertisement. Lastly, Pfizer differentiates itself amongst the competition with its commitment to improving global public health. Pfizer offers quality medicine, in a range of disease areas, and allows them to be accessible to underserved populations throughout the world.

3.2.4. Johnson & Johnson

Echoing the growth and success of Pfizer is Johnson & Johnson Pharmaceutical Research & Development, LLC. Located in San Diego, this facility employs 300 scientists working in the areas of basic drug discovery aimed at creating medicines that address unmet medical needs in the areas of metabolic diseases, cardiovascular disease, inflammation and immunological disease and neuroscience.

As of May 2015, Janssen Pharmaceutical Companies of Johnson & Johnson announced plans to file for regulatory approval of more than 10 new products between 2015 and 2019, each with the potential to exceed $1 billion in revenue.

The total pharmaceutical market reached $1 trillion in 2014 with almost 40 percent of the growth coming from specialty medicines. Going forward, the total global branded pharmaceuticals market is expected to grow at a compounding rate of 3 percent between 2015 and 2019. IMS Health, the largest vendor of U.S. physician prescribing data, reports that the pharmaceutical segment of Johnson & Johnson was among the fastest growing in the U.S., Europe, and Japan in 2014, with sales of $32.3 billion, a 16.5 percent increase over 2013.

In addition to their contribution to medicine, Johnson & Johnson is viewed as a community leader for their involvement in environmental and social initiatives. J&J Companies are LEED-certified Green Facilities and the
recipients of awards from the US Environmental Protection Agency and Climate Group. They are involved and contribute to the UCSD Student-Run Free Clinic, Voices for Children, The United Way, clothing drives, blood drives and many more. They offer a smoke free workplace, health programs for employees, fitness centers and a breastfeeding nurture space on location.

3.2.5. Novartis

Equally paired with the environmental consciousness of Johnson & Johnson is Novartis Institutes for Biomedical Research, located in San Diego, CA. Novartis supports a culture of environmental stewardship and sustainability that includes energy and water efficiency, waste management and health consciousness.

Novartis is also one of the world’s largest pharmaceutical companies in terms of revenues. The company specializes in research, development, manufacturing and marketing of a broad range of healthcare products. The pharmaceuticals division accounted for $31.8 billion or 55 percent of the company’s net sales in 2014.

As of June 2015, Novartis’ pharmaceuticals pipeline had 143 active programs, including 74 new molecular entities, more than 500 trials ongoing and more than 300 trials planned to start through the end of 2016. These programs span disease areas where the unmet need is still great and where they can offer a real advance in treatment for patients, including oncology, cardio-metabolic, immunology and dermatology, and respiratory.

3.3. Key Player Interactions in San Diego

Innovation and collaboration go hand-in-hand for San Diego’s biotech industry. The industry’s key players work together to groom top talent and develop new technologies. This collaboration shortens development time and brings lifesaving technologies to market faster than ever before. This collaboration starts in the classroom at San Diego’s premier biotech institution, the University of California San Diego. As of 2015, the Jacobs School of Engineering at UCSD had 641 students enrolled in bioengineering fields, graduating 112. The leading biotech companies of San Diego all have a presence on campus in one way or another helping to develop course work and funding research and development.

Illumina, one of the gene sequencing leaders of San Diego is heavily involved with coursework development. The company has teamed with UCSD to develop certification programs designed to produce the top talent needed to support their business. The first of these programs, the bioinformatics specialization, developed between Illumina and research scientists at the
university, teaches core bioinformatics principles and concepts to biologists and computer scientists interested in analyzing and exploring genomic data. The program covers twice as much material as would normally be taught in a standard bioinformatics class at UCSD. In the capstone class of the program, Illumina provides students real world problems and allows them free access to analysis workflows and datasets designed to assist students in solution development. Illumina also allows students access to its BaseSpace cloud infrastructure where all datasets reside as well as applications for resequencing, RNA-Seq, de novo assembly, tumor/normal analysis, and several others which are available in the cloud. As Illumina strives to make the course material highly relevant to real world applications, the company is able to identify key talent for future acquisition.

Thermo Fisher Scientific also works closely with talent at UCSD to support research and technology studies. As of September 2014, the company began offering a $50,000 annual funding opportunity for sponsored research which is designed to build strong partnerships within the regions biotech industry. Its purpose is to inspire San Diego-based scientists to innovate and collaborate on research projects that ultimately drive science and technology forward to better understand human disease. This grant allows scientists at UCSD to work closely with those at Thermo Fisher Scientific to jointly advance and test groundbreaking technologies in healthcare. The company makes successful projects eligible for further funding within the first year of successful testing. Thermo Fisher is funding research focused on peripheral cancer detection including the capture, isolation and genetic analysis of cancer-associated mutations. Through this funding, Thermo Fisher also works to place graduating students with the company.

Large San Diego pharmaceutical companies such as Novartis and Pfizer can also be found on campus funding research and identifying top talent. Both companies offer postdoctoral fellowships with the school providing accomplished scholars with unique opportunities to perform innovative, interdisciplinary research. Students are able to work side by side with company scientists allowing them to learn about the drug discovery process and development. Upon working with these students, Novartis and Pfizer are able to make job offers to those who have stood out throughout the program.

As the biotech and pharmaceutical companies of San Diego collaborate at UCSD, they begin to realize that working as a team is a better strategy for success in the molecular diagnostics market than showing a strong solo performance. As the molecular diagnostics market begins to approach maturity, successful companies have begun moving to niche areas and partnering with those who do what they cannot in order to boost their
portfolios. The complexity of molecular testing encourages companies to augment their capabilities via collaboration and licensing agreements.

An example of this collaboration is with the gene sequencing company Illumina, who recently joined with Merck to develop assays that detect and measure multiple variants simultaneously to support clinical trials of universal cancer tests. The collaboration toward the testing includes test development, worldwide regulatory approvals, and global commercialization. The collaboration between Illumina and Merck around next-generation sequencing will enable them to perform genome studies at a pace unheard of just a few years back and could lead to the development of several new diagnostics. This collaboration strengthens both companies as global leaders in precision medicine and oncology.

Illumina also partners with Janssen Biotech to develop universal next generation sequencing based oncology test systems for cancer diagnosis, which are being used to conduct clinical trials for specific cancer therapies. The systems will help identify cancers that might respond to targeted therapies by assessing specific mutations within genes known to be associated with response or resistance of specific cancer therapies. The goal of this collaboration is to develop and commercialize a multi-gene panel for therapeutic selection that provides a more precise and comprehensive tool in fighting cancer.

Thermo Fisher’s Life Technologies and Merck also work together to create new companion diagnostic products. The agreement between the companies covers current and future companion diagnostics projects, with an initial oncology scheme providing the foundation for a long-term collaboration across a potentially broad range of Life technology instrument platforms and therapeutic areas.

San Diego’s biotech companies largely work together, but this is not always the case. With any technology based industry, patent infringement lawsuits are common; this is no different for San Diego’s biotech industry. Life Technologies, a branch of Thermo Fisher Scientific recently took Illumina to court alleging the company’s gene sequencing devices violated three patents asserted by life technologies. The patents in question applied to PCR diagnostics and nucleic acid amplification. Life Technologies alleged that Illumina infringed on them with its Genome Analyzers. The company looked to recoup damages and legal fees required to prosecute Illumina in the suit until 2009, when it was dismissed on the bases that Illumina did not infringe on the existing patents. A Judge ultimately ruled “‘Life Tech cannot establish, as a matter of law, that the accused Illumina systems infringe on the three patents”, leaving Illumina with a green light to keep selling the technology.
Pharmaceutical companies such as Novartis and Pfizer have also recently undergone patent infringement lawsuits claiming infringement would cause irreparable injury to the company and its ability to make a profit. Hospira Pharmaceutical and Janssen have undergone similar litigation over patents expected to continue until 2018 or longer. These litigations are typically driven by companies wanting to keep key technologies out of the competitor’s hands while blocking generic drug manufacturing. This allows companies to recuperate money spent on research and development while keeping the development of new technologies lucrative. Due to the close proximity of biotech development and manufacturing in San Diego, many of the companies struggle to keep new technologies and ideas out of the hands of the competition.

In conclusion, San Diego biotech and pharmaceutical companies are largely invested in higher learning institutions to fund new product development and talent development. As this talent enters the work place, companies use the ties and relationships developed at the college level to promote collaboration at the corporate level. This collaboration allows development of new products to happen at a speed never before seen in the San Diego area. Because of this, many new patents are awarded, some of which bring upon unwanted patent infringement lawsuits.

3.4. Industry Development
The San Diego Health Science innovations, involving hundreds of millions of dollars and thousands of workers, have earned San Diego a place in the Health Science industry spotlight. For the first time, the Advanced Medical Technology Association (AdvaMed), a major trade group, held its national convention in San Diego. The conference comes during a period of opportunity and transformation in the industry and illustrates how San Diego has made its mark on the industry (Robbins, The San Diego Union-Tribune, 2015).

3.4.1. Industry Trends – Biotechnology
San Diego has developed into a haven for innovation in the biotechnology and healthcare industries anchored by UC San Diego, San Diego State University, and the many local biotech companies. The biotechnology industry is undergoing a transformation worldwide with new ideas and technology that have changed the perspective on healthcare and created the idea of preventative medicine. San Diego’s biotech community has been a major contributor to this movement. The healthcare industry is merging with leading computing, electronics, and telecommunication technology to develop new healthcare technologies that provide real-time data from a patient’s body. Todd
Coleman, a leading UC San Diego researcher, developed a flexible electronic biosensor that is able to monitor electrical activity in the brain, helping doctors and nurses monitor patients (Robbins, The San Diego Union-Tribune, 2015).

San Diego State University perfected the first FDA approved balance-board device, BTrackS, which helps trainers’ spot concussions in athletes. Concussions have been the leading topic of concern for athletes’ safety over the past decade. Although the concussion rules have become more stringent, players have still passed concussion protocol and continued playing with a concussion. The BTrackS is a portable plate that measures the forces exerted on the ground by a body; these forces are measured by a series of sensors integrated into the plate. The BTrackS calculates the center of pressure postural sway of an individual. The BTrackS is easily set up on the sideline during any sporting event and when a player is believed to have a concussion, the player simply stands on the device with his/her eyes closed and the machine provides feedback on the player’s balance. The BTrackS compares the players balance score with a previously recorded balance score of the same player when healthy. Trainers know within minutes if the player has a concussion. The BTrackS is currently used by many large organizations and universities such as The United States Olympic Team, Louisiana State University, University of Colorado, and the U.S. Air Force. This simple device has transformed how concussions are detected nationwide (Balance Tracking Systems, 2015).

Wearable wireless technology is on the rise and forecasts show a market ranging from $6 billion to $19 billion by 2018. San Diego has been at the forefront of wearable biotechnology devices. One such wearable biotechnology breakthrough was discovered by electrical engineers at UCSD. The new wireless communication technique uses magnetic fields to transmit ultra-low power signals through the human body. The team developed an ultra-low power prototype that uses the body itself as the medium for communications between wearable gadgets. The team successfully transmitted signals from one arm to the other, using “magnetic field human body communications.” One application for this technology would be a wireless sensor network for full-body health monitoring. The engineers presented their findings at the 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society in Milan, Italy in August 2015 (Bigelow, 2015).

Another wearable wireless breakthrough came from Dexcom, a San Diego based biotech company. Dexcom recently won approval from the U.S. Food and Drug Administration (FDA) for their work on G5, the first completely mobile continuous glucose monitoring system. G5 sends readings to iPhones, enabling diabetics to constantly monitor their glucose levels and easily share
them with family and friends without the use of a separate receiver. The G5 is currently about the size of a quarter. However, Dexcom is now teaming with Google to miniaturize the G5 to about dime size and to make it flexible. The G5 Mobile has wireless Bluetooth technology built into the device transmitter. The G5 is the first and only fully mobile continuous glucose monitoring system approved by the FDA for both adults and children as young as 2 years of age. The new transmitter securely sends vital glucose information directly to the phone application for real-time diabetes management. Android applications will follow in early 2016 (Hoskins, 2015).

3.4.2. Industry Trends – Pharmaceutical

San Diego has become a Health Science industry cluster with industry leading innovations in biotechnology, diagnostics, medical devices, health care, and pharmaceutical. Ivor Royston, the La Jolla oncologist, venture capitalist and co-founder of San Diego’s first biotech company, said the following regarding the advancement of medicine in particular to the advancements made in San Diego.

“You’re seeing the convergence of many technologies, from the Internet to wireless health to the sequencing of our genomes to Big Data. We can now edit genes. We can perform gene therapy. We’re beginning to customize treatment and offering personalized and precision medicine — all leading to an exponential growth in our knowledge of medicine and biology. Medicine has now entered the digital world” (Robbins, The San Diego Union-Tribune, 2015).

Illumina, headquartered in San Diego, has reduced the cost of sequencing a person’s genome and doctors are now increasingly tailoring diagnosis and treatment to an individual’s genetic makeup. In less than a decade, Illumina dropped the cost of sequencing a person’s genome from $10 million to $1,000 while increasing accuracy. This has allowed researchers to hunt for genes believed to cause disease and examine whether those genes tend to cause problems among sizable numbers of people. Whole-genome sequencing is the most comprehensive method for analyzing the genome. Genomic information has been instrumental in identifying inherited disorders, characterizing the mutations that drive cancer progression, and tracking disease outbreaks. Rapidly dropping sequencing costs and the ability to produce large volumes of data with today’s sequencers make whole-genome sequencing a powerful tool for genomics research (Illumina.com, 2015).

Another great breakthrough in medicine in San Diego is the UC San Diego development of micro-motors that are designed to propel drugs through the bloodstream, for directed drug delivery. The research initially led to micro-
motors propelled by stomach acid but has now been developed into a 3D printed fish-shaped micro robot, “microfish”, that can propel itself through liquids while being steered by a remote operator with magnets. The robots are smaller than the width of a human hair and can propel themselves forward as a result of their complex shapes. The conceptual design of the “microfish” will inspire a new generation of "smart" micro robots that have diverse capabilities such as detoxification, sensing and directed drug delivery (EurekaAlert!, 2015).

3.4.3. Industry Trends – Diagnostics
San Diego is also at the forefront of expanding technological breakthroughs in the Health Science diagnostics industry. Once again, anchored by UC San Diego and Scripps Research Institute, San Diego is leading the charge nationwide by providing innovative tests that are not invasive and have immediate results.

Liquid biopsy is a blood test that was scarcely heard of two years ago but is quickly emerging as an alternative to the often painful practice of using needles or surgery to sample a patient’s tissues for signs of cancer. Liquid biopsies can easily detect potentially harmful tumor cells and mutated DNA traveling through the blood stream. The tests show so much promise that analysts estimate the market for liquid biopsies could soar to $12 billion within a decade. It’s now a $100 million industry that is being strongly driven by San Diego’s clutch of life-science companies. As Ivor Royston noted, “We need clinical studies that show that liquid biopsies can help doctors choose the right drug, at the right time, to stop cancer.” He added: “This is an emerging technology, but its emerging fast. It’s nice to see San Diego taking a lead in the field” (Robbins, The San Diego Union Tribue, 2015).

Genalyte, a San Diego based diagnostic company, developed a simple blood test for autoimmune disorders which will provide results within 15 minutes that can be sent to a patient’s cell phone. Genalyte’s Maverick Detection System analyzes blood samples with a disposable microchip. The privately held company now markets the Maverick system to drug companies as a research tool. The system is not approved for clinical testing at this time. Genalyte raised $44 million from venture capital firms in 2015 in order to help commercialize the diagnostic system (Fikes, The San Diego Union Tribue, 2015).

3.5. Industry Challenges
San Diego offers reasons for companies to bring their business to Southern California. There is the mild year round sunny weather, tourist attractions, universities supplying an educated and skilled workforce, medical research,
and healthcare funding support for development of projects. In the biotech and pharmaceutical industry, San Diego is home to major companies like Thermo-Fisher, Care Fusion, Illumina, Pfizer, Johnson & Johnson, Arena, Genentech, and Gilead. There is no doubt San Diego has the mix of what companies are looking for in a home, but it also comes with some challenges and downsides.

3.5.1. Competition of Biotech and Pharmaceutical in San Diego

Competition comes from San Diego having one of the top concentrations of biotech and pharmaceutical companies in the nation. Companies compete for development in new products, getting FDA approval, establishing funding with investors, acquiring a knowledgeable workforce from its local colleges and universities, and acquiring talent. Genentech’s upper level management stated during an interview that their biggest competition, Gilead Sciences, regularly scouts their talent.

Competition in the smaller companies occurs more often when they are seeking to license drugs and decide to use the local resources of academia, pharmaceutical firms, or biotechnology companies (Wetfeet, 2012). In order to get valuable technology that they do not have, big pharmaceutical companies regularly form partnerships with biotech companies or acquire them outright, similar to the recent acquisition of Carlsbad’s Life Technologies by Thermo Fisher, for $13.8 billion (Fikes, The San Diego Union Tribune, 2013). Recently, Pfizer, Roche, and Eli Lilly all signed deals with the tiny biotech firm Gene Logic to investigate their failed clinical candidates, in the hopes of making their R&D programs more productive. Big pharmaceutical companies are using a tactic called, “repositioning” to help find potential therapies for failed clinical compounds. An example of this is Pfizer’s Viagra, which started out as a pipeline experimental heart medication but is now well known to treat erectile dysfunction (Wetfeet, 2012). With the concentration of biotech companies in San Diego, this is a common occurrence within the region or in a worldwide acquisition. Companies in the same region only make this competition more common due to their geographic proximity.

3.5.2. Funding, taxes, and regulation of Biotech and Pharmaceutical in San Diego

The Pharmaceutical and biotech industry is federally regulated under the rules of the Food and Drug Administration (FDA). In order for a new product or drug to be sold it has to undergo a costly and lengthy research and approval process from the FDA. Companies usually wait to expand their marketing and sales force, until a product gets near FDA approval. This long turnaround creates a
high-risk investment that is not attractive to investors. Drug makers had agreed to pay more to the FDA to speed up marketing applications, but budget cuts keep that money from being spent. In 2013 the National Institute of Health (NIH) budget was cut by 8%, which was allocated to grants being used in Southern California. These grants help keep young researchers employed, supplementing private and state grants to universities and research facilities. The industry also states, that a newly imposed medical device tax used to help pay for the Affordable Care Act, may stifle innovation (Fikes, The San Diego Union Tribune, 2013).

Hybritech, which no longer exists, began San Diego’s life science ecosystem in 1978. Two University of California San Diego (UCSD) researchers founded Hybritech and pioneered the commercial use of monoclonal antibodies, which was responsible for the early detection of prostate cancer. Later in 1986, Eli Lilly & Co. bought them out for over $400 million, creating a group of millionaires who nurtured dozens of other San Diego startups, including the biopharmaceutical company Idec (Genetic Engineering & Biotechnology News, 2012). This is one example of how investors have carved out San Diego to become a national leader in the Health Science industry.
Biomedical Devices Industry

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Sridharan Rangachary
4. Biomedical Devices Industry

4.1. Critical Factors

In today’s competitive medical device environment, companies have to be at the forefront of innovation while faced with heightened regulatory oversight that entails a lengthy and complex product approval process. This poses a challenge for companies trying to introduce products to the market in a timely manner. Other key factors include having strong government support through grants and tax policies as well as access to capital, labor, and academic research. This chapter examines San Diego as a center for the medical device industry by analyzing those key factors that are vital in making a region an industry cluster. A review of each key factor will focus on whether trends are favorable to help support and sustain the current biomedical landscape in San Diego.

Innovation is a key component in the medical device industry and is driven by the collaboration between medical device manufacturers and end-users during the product development cycle. This approach gives manufacturers a competitive advantage by allowing the product development team to collaborate with physicians, surgeons, and research scientists in designing a medical device based on current trends, customer requirements, and advancements arising from today’s medical procedures. This process also allows for a more rapid feedback exchange between the users and the product development team which facilitates a more efficient and shortened product development cycle, thus, allowing companies to bring their products to the market quickly.

According to Johnson & Johnson’s philosophy on innovation, “Our teams of science and business experts, based in regional innovation centers, collaborate with innovators to accelerate cutting edge science into healthcare solutions.” (Johnson & Johnson, 2015) That same philosophy is echoed at a medical device company called NuVasive, discussed in more detail in the key players section of this chapter. A NuVasive employee stressed the importance of having users onsite to provide real time feedback to the product development team. This creates a short “feedback loop” which is regarded as one of Nuvasive’s key advantages over other competitors. This shortened feedback loop can be attributed to a 3D printer on-site. The printer has the capability to fabricate a prototype. The product manager stated “this allows us to get a feel of how the device looks and feels which enables the design team to make design adjustments before mass production.” The Ability to respond to customer demand is essential for progress in this industry. CareFusion,
recently acquired by Becton Dickinson, is another prominent global medical device company based in San Diego. CareFusion is known as one of the leading manufacturers of fusion pump. Like NuVasive and Johnson & Johnson, CareFusion’s success is centered on innovation as well as maintaining a diversified portfolio of medical devices (2014 Annual Report for Carefusion, 2014).

It’s apparent that San Diego is home to a cluster of biomedical devices manufacturers with more than 700 companies (Zamosky, 2012) and coming in fourth place in the biomedical device job sector at 14% in California. (California Biomedical Industry Report, 2015) While prominent companies like NuVasive and CareFusion are just a few of the hundreds of biomedical firms concentrated in the San Diego region, there are challenges related to tax policies that could impact the viability of the biomedical device community in San Diego. With the passing of the medical device tax as part of the Affordable Care Act in 2013, many biomedical manufacturers have felt the subsequent effects due to stagnant hiring, decreased budgets for R&D, and putting on hold new facility construction (Radcliffe, 2015).

Additionally, academic research is a huge contributing factor to the success of biomedical device manufacturers and their ability to innovate and remain competitive as groundbreaking research is passed onto companies through licensing agreements. (California Healthcare Institute, 2014) In 2014, UCSD was in second place in California to receive $378 million in federal grant funding from the National Health Institute; however, the last decade has shown a decrease in grant funding due to cut backs in the federal budget as this may potentially hamper the region’s biomedical industry’s progression in the future.

Furthermore, the biomedical device industry’s forward progression can be stymied not just in San Diego, but in all regions due to rigid regulations. Therefore, critical success is predicated on ensuring a delicate equilibrium between upholding safety to the highest standards without impeding innovation, progress, and quick product to market delivery. U.S. medical devices go through a process called 510K in which new medical devices must be shown to be comparable to an already FDA approved device. (Burton, 2015) Currently, the FDA’s Center for Devices and Radiological Health (CDRH) helps streamline the process for more efficiency in terms of medical device evaluation and approval and therefore, favorable in terms of supporting the industry’s overall success.

Continuous innovation and revolutionary research are incubators to attract and attain outside venture capital. In 2014, the biomedical device community in San Diego was projected to receive $647 million in venture capital but only received $48 million (California Healthcare Institute, 2014).
While there was venture capital funding in San Diego for biomedical devices, it is immensely important and pivotal for the biomedical device community in San Diego to attract more venture capital in order to develop, produce, and bring to market new life saving medical devices.

Scientific talent pool is a key factor and San Diego has an abundance of skilled labor. “There’s a lot of scientific talent here”, according to Peter G. Schultz, Ph.D., a highly esteemed research scientist and biotech entrepreneur (GEN, 2012). Similarly, one of the principal partners of a venture capital firm based in of Houston saw opportunity and potential in the life sciences labor pool and relocated his firm’s operations to San Diego (GEN, 2012). In 2015, San Diego was the fourth largest region in biomedical jobs with 36,731 jobs out of 270,289 jobs statewide. Examples like these solidify the shift in San Diego as a center where talent meets industry.

Lastly, the biomedical device industry in San Diego relies heavily on UCSD for academic research. UCSD is considered one of the top ten biomedical research institutions in the world according to the Shanghai Index and along with UCSF and Stanford, attained $1.28 billion dollars in federal grant money. (California Healthcare Institute, 2014) Furthermore, in response to a growing demand for medical device engineering in the San Diego region, UCSD offers a master’s program in medical device engineering. Local medical device manufacturers were surveyed on whether the program would add value and there was an overwhelming consensus on the need for such a program (Zamosky, 2012).

There are reasons why San Diego is home to NuVasive and CareFusion and those reasons have the potential to further position the San Diego region as a medical device hub. One of those reasons is a result of the already established medical device industry in San Diego, which accounts for a large percentage employment as there are more than 700 medical device companies in the region. To provide perspective, of the 1,100 companies in the San Diego region, there were 34,000 jobs related to life sciences which include medical devices. (Life Sciences, 2015) There is growth in medical device manufacturing jobs; in 2014, there were 11,300 jobs related to biomedical devices in San Diego compared to 2,300 jobs from 2009 to 2011. Additionally, the region’s professional, scientific, and technical job sector which includes medical devices, had notable growth here in San Diego Regional EDC, 2014).

This growth can be attributed to multiple reasons, with one being the scientific labor pool’s heightened knowledge and skill sets in core math and science disciplines. These core courses are essential in the recruiting talented individuals to take part in the industry. The other driver is based on an aging population within the next 20 years as this age group is projected to grow by
nearly 80% and would potentially drive demand for medical devices given that the aging population (50+) account for a large percentage of medical device users relative to other age groups. Lastly, it is anticipated that there will be hyper-growth in emerging markets around the world in places like India and China (Zamosky, 2012).

4.2. Key Players

4.2.1. NuVasive

NuVasive was founded in 1999 and focused on spinal fusion products. NuVasive began as a start-up company and as of 2015 is valued at approximately $9.0 billion globally. This company was selected as a key player in San Diego based on their accelerated growth, differentiation and continued innovation.

According to the 2014 annual report, NuVasive’s revenue has increased year over year as displayed in Table 4. NuVasive expects that demand for the spine market will continue to increase and will gain more market share. There is a demand for minimally invasive surgery (MIS) as surgeons shift from traditional spinal surgery to surgical applications that require less tissue disruption. The demographics of customer demand for spinal products are the “baby boomers” (ages 50 – 69). As this demographic continues to age, demand for spinal products will increase.

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenue (in millions)</th>
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<tbody>
<tr>
<td>2010</td>
<td>$ 478,237</td>
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<tr>
<td>2011</td>
<td>$ 540,506</td>
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<tr>
<td>2012</td>
<td>$ 620,255</td>
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<td>2013</td>
<td>$ 685,173</td>
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<tr>
<td>2014</td>
<td>$ 762,415</td>
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</tbody>
</table>

Note. Adapted from NuVasive 2014 Annual Report

There are several factors that differentiate NuVasive from leaders in the spine market. Industry leaders in the spine market include DePuy Sythes (a Johnson & Johnson company) and Medtronic. One factor is that NuVasive offers a surgical platform known as Maximum Access Surgery (MAS). Spinal surgery may require patient side access through the muscles. The problem with this access is that it may disrupt a nerve, causing long-term negative effects for the patient. The MAS platform offers a nerve monitoring system that surgeons can use to avoid striking the nerve. Another differentiating factor is
the responsiveness to meet customer demand. At the entrance of the facility, there is a statue of a cheetah statue and a sign, “Speed of Innovation.” Surgeon training is offered on-site and surgeons have direct access to a cadaver lab. The “Speed of Innovation” is the turnaround time for collecting customer needs to delivering the product to the customer. Surgeons are looking for innovative solutions more quickly. A prototype and testing lab provides the quick turnaround time required to perform feasibility testing. As opposed to other industry leaders, NuVasive is focused on spinal products and has not diversified. On the other hand, Medtronic and Johnson & Johnson (DePuy) have multiple business segments. Medtronic’s portfolio contains three operating segments of medical devices: cardiac and vascular group, restorative therapies (spine) group and a diabetes group. In 2014, eighteen percent of Medtronic’s revenue was generated from spine products. Johnson & Johnson not only offers a medical device portfolio, but has two other segments: consumer and pharmaceutical. The product ranges from baby care products to insulin pumps. The advantage of a specialized field such as NuVasive is the focus on the products and patient outcome. This focus is emphasized in their strategy to “selectively license or acquire complementary spine products and technologies…” (NuVasive, 2014). Although, there is no news for acquisitions at this time, NuVasive continues to distribute new products in the field.

Research and Development (R&D) pave the way for innovative products. NuVasive’s R&D expenses have increased by $5.8 million in 2014. In October 2015, the company announced that they received the first FDA 510(k) clearance of a cervical corpectomy cage (X-Core Mini VBR). In a corpectomy, the vertebral body is removed to alleviate decompression of the spine. This would typically involve a spinal fusion. The X-Core Mini VBR provides temporary support without a spinal fusion. The approval period of this device supports the commitment for “Speed of Innovation.”

Local competitors are considered “pure play” because the companies invest resources in only one line of business. Information from other spine companies is challenging to obtain as these competitors are privately held such as Alphatec Spine and Spinal Elements. Medical device companies are often subject to litigation from competitors. In 2013, NuVasive experienced a loss of $30 million in litigation expenses that were paid to Medtronic for ongoing royalty rates. This may have contributed to NuVasive’s loss of net income of $17.4 million for 2014.

4.2.2. Medtronic

In 1957, co-founder of Medtronic, Earl Bakken, was asked to create a battery-operated pacemaker after a hospital lost power and patients were endangered.
At the time, the pacemaker required a power source for patients recovering from open heart surgery. By 1960, the first implantable pacemaker was commercially available. By the 2000s, Medtronic has created an extensive medical device portfolio. Within the cardiac and vascular group, there are sub-segments: cardiac rhythm disease management (CRDM), coronary, structural heart and endovascular. The pacemaker falls in line with CRDM. The cardiac and vascular group accounts for 58% of Medtronic’s 2014 revenue. Medtronic was selected as a key player because this company is a global leader in medical technology. Similar to NuVasive, Medtronic has experienced growth in the last few years, actively acquiring companies such as Covidien, and continues to create innovative products.

Medtronic’s principal executive offices are in Dublin, Ireland and the operational headquarters is in Minneapolis, Minnesota. Medtronic is a key player because of its presence in San Diego. In January 2015, Medtronic completed its acquisition of Covidien. Covidien is an R&D facility that supports the development of ventilation products and is located in Carlsbad, CA. The cash and stock transition is valued at approximately $50 billion. The acquisition of Covidien aligns with their Mission of “alleviating pain, restoring health, and extending life for patients around the world.” The acquisition of Covidien has benefited Medtronic as Covidien’s emerging markets in R & D and manufacturing complements Medtronic’s clinical capability. Acquisitions are not new to Medtronic. In 2013, Medtronic acquired TYRX, a drug-device combination product for approximately $222 million and Cardiocom, LLC, integrated solutions for management of chronic diseases for approximately $190 million. In 2009, Medtronic acquired another Carlsbad based medical device company, Ablation Frontiers, Inc.

In 2014, Medtronic’s net sales were $17.005 billion. Medtronic is investing in R&D projects that are expected to generate more than $30 billion in incremental revenues over the next five years. Medtronic announced that the world’s smallest pacemaker has met clinical trial safety and effectiveness endpoints. This pacemaker is one-tenth the size of a standard pacemaker and can be delivered via catheter and directly to the heart.

4.2.3. ResMed
ResMed is a leader amongst the medical device companies located in San Diego. In 2015 its revenues totaled $1,678.9 million resulting in $1,011.4 million in profit, an 8% increase over 2014 revenues. The company employs approximately 4,340 people in over 100 countries. Specializing in devices and treatments for sleep-disordered breathing, chronic obstructive pulmonary disease, and other like diseases, they “are a global leader in the development,

Efforts in 2015 to continually grow globally and provide more for the people they serve included the acquisition of CareTouch, Curative Medical, and Jaysec. CareTouch, a firm focused on medical equipment resupply and health information communications, and Jaysec, a provider of Internet-based solutions for health providers aides in the expansion of their capacity and influence within the industry. Additionally, their acquisition of a competitor in China, Curative Medical, promotes opening sales in Asia Pacific and beginning the formation of a notable footprint in China.

ResMed has a strong emphasis on creating more of a global presence and obtaining and utilizing talent for research to promote growth and a competitive advantage as a company. Their 2015 Annual Report states, “our growth has been fueled by geographic expansion, our research and product development efforts, and an increasing awareness of SDB and respiratory conditions as a health concern among physicians and patients around the world.” Strengthening and developing the features of the healthcare informatics platform, though research and recent acquisitions is accredited for the growth this past year, further increasing their competitive advantage within the industry (Beaulieu).

4.2.4. **DJO Global Inc.**

DJO Global Inc. is another major player in San Diego’s medical device domain. Revenue for 2014 was $1,229 million, a growth from $1,175 million in 2013. DJO employs approximately 4,940 employees globally within more than 50 countries where they conduct business (2014 Annual Report for DJO Finance LLC, 2014). They are the largest orthopedic rehabilitation company in San Diego and a leader within the orthopedic industry.

As part of the strategy to increase growth, and a more global presence, DJO acquired Speetech Implante GmbH, Blue Leaf Medical CC, and Vasyli Medical Asia in 2014. These acquisitions opened up more opportunities in several countries including Germany, South Africa, Nambia, Botswana, Mozambique, Zambia, Australia, and New Zealand. Obtaining more of a global presence allows for the influence of the company to further penetrate new markets and continue establishing their standing as a leader.

DJO Global Inc. has several strengths that differentiate their company from competition in the industry. They hold leading market positions with many of the products they provide based on their reputation for quality and durability among healthcare professionals. Various attributes allow them to continue leading the way in both national and international markets:
• Comprehensive range of orthopedic products
• Extensive and diverse distribution network
• Strong relationships with managed care organizations and rehabilitation healthcare providers
• National contracts with group purchasing organizations
• Lean operations
• Ability to generate significant cash flow based on margins created by strong reputation and brand awareness
• Low cost/high yield manufacturing operations
• Highly experienced management team

San Diego is a hub for medical device manufacturing, with a range of small to medium sized companies. According to Biocom, which is a member organization in San Diego that provides resources for life science companies, San Diego is the second largest life science cluster in the United States, next to Boston. Over 700 San Diego County companies employ more than 34,000 in life sciences segment (biomedical devices, biotechnology and pharmaceuticals). According to Biocom, that number increases to more than 59,000 employees in related industries such as biofuels, alternative energy and education. There are over 7,000 Science Technology Engineering Mathematics (STEM) graduates in San Diego annually, according to the National Center for Education Statistics, EMSI and Biocom.

4.3. Trends
The life sciences industry, which includes medical devices, is a major driver of the innovation economy in the San Diego region. The region has more than 80 research institutes. One of the research institutes includes the University of California, San Diego. Many graduates stay in the area to pursue academic research or positions in industry. The medical device industry is a highly competitive arena and earning market recognition is dependent on the ability to continue innovating. To remain competitive, medical device companies are working to push products to be the first to market. There are regulatory and reimbursement issues that have made it more difficult for device companies to develop innovative new products.

There are four trends that have been shaping the medical device industry:

1. Increased Regulation
2. Healthcare Provider Consolidation
3. Shift from Innovation to Iteration
4. Emerging Markets
There are concerns for increasing requirements in regulatory compliance and medical device taxation in addition to decreasing for funding innovation. This has resulted in product iteration rather than innovation. Product iteration is an enhancement to the already existing device. Companies are focusing on more creative ways to incorporate innovation into their iterations. NuVasive, for example, continuously works on enhancements to stay ahead of competitors. NuVasive’s focus is on both innovation and iteration when it comes to budget and outcomes. According to NuVasive, trends depend on the outcomes. The current trend in the spine market is in preventive care. NuVasive is also working on the preventive care side with their main focus on the surgical side. Imaging technologies for NuVasive is an advantage as the current technology presents its own challenges. In addition, as big data becomes more impactful, NuVasive plans on using big data and predictive analytics to help them better understand the future of the industry.

Telemedicine technology is driving new trends in patient care by reducing the number of emergency room and office visits needed by children, elderly and the veteran community. San Diego healthcare system started a pilot program at the La Jolla VA facility. Telemedicine brings doctors to patients helping patients avoid traffic, parking, and sick waiting rooms. This trend is providing a lot of opportunities to invest in telehealth device startup companies around San Diego area.

The emerging markets on the other hand, are responding to an entirely different set of drivers. On one front, in countries like China and India, there is a large population (over $1 billion) that is waiting to be integrated with the healthcare system, thereby opening enormously large opportunities to sell medical devices. San Diego medical device companies have started to focus on the emerging economy and opportunities. There has been a stronger emphasis on Mergers and Acquisitions (M&A) among larger-scale medical device producers, paving the way for more end-to-end solutions. As emerging markets such as India, China, and Brazil shift global markets, which impacts the global economy, medical device companies around San Diego have to pay close attention to the recent trends to react quickly.

4.4. Key Developments

4.4.1. Medical Equipment Technology

The goal of integrating new innovations into medicine is to improve quality of life. The combination of medical equipment technology and telehealth has resulted in robotic surgeries. In some cases, physicians do not even need to be in the operating room with a patient when the surgery is performed. The
surgeons operate out of a “home base”, while the patient is in the hospital or clinic, eliminating the hassle of health-related travel. In other robotic surgeries, the surgeon is still in the room, operating the robotic devices, but the technology allows for a minimally-invasive procedure that leaves patients with less scarring and less recovery time. All major hospitals in San Diego use robotic surgeries. SpectraScience is a San Diego based medical device company that manufactures a device that can detect cancerous tissues without the need for biopsy. Medipacs® is another San Diego medical devices company that developed a very unique and innovative, portable and wearable infusion device Mini-Infuser™. The Mini-Infuser™ delivers an accurate rate of medication and is a wearable device.

4.4.2. The 3D Printing Revolution
3D printers can manufacture medical equipment, prostheses, or even drugs. They will also play a vital role in regenerative medicine, to create tissues with blood vessels, bone, heart valves, ear cartilage, synthetic skin, and even organs. With its increasing affordability and open source engineering, the applications for 3D printing are incredibly vast and beneficial. San Diego based Organovo Holdings Inc. (NYSE MKT: ONVO) design and create functional human tissues using their proprietary 3D bio printing technology. Using a combination of cells in what it terms "bio-ink," Organovo already has 3D-printed blood vessels as well as liver, lung and breast-tumor tissues for laboratory studies of potential treatments for cancer, Parkinson's disease and pulmonary hypertension.

Recently University of California San Diego has created 3D printed “micro fish” robots, 120 microns long and 30 microns thick, thinner than a strand of human hair. These micro robotic fish can maneuver in fluids and can detect and neutralize toxins. If they can be made sufficiently small, the next task for these micro fish after detecting and neutralizing toxins might be acting as drug delivery agents within the human body. One sample of 3D printing ability from San Diego, which has every potential for a San Diego start up to produce these micro robots with the combination of 3D-printing technology and latest advances in nanomedicine (3D Printing of Movable Micro-Fish, 2014).

4.4.3. Boosting Medical Device Safety with Big Data Analytics
Medical device production is on the rise. The market has been forecasted to continue to grow in the next five years. Finding the best manufacturing process conditions to achieve high efficiency can be addressed by applying predictive analytics. Hospitals across the world are making significant IT
infrastructure upgrades. In addition, computer giant IBM is beginning to apply its Jeopardy!-winning Watson into the healthcare space, where it could be used to augment diagnoses and for other applications. As these technologies evolve and IT infrastructures improve, so will the number of medical devices that are linked to them, making them 'smarter' and better at optimizing treatment. The rise of Big Data in healthcare is being partially fueled by cost pressures and demand for more cost efficiency in treatment.

4.4.4. Outlook

As previously mentioned, San Diego is one of the country's largest medical device industry hubs. Local universities play a major role in establishing San Diego’s medical devices industry. Universities are expanding course offerings and degrees. In 1997, San Diego State University introduced its Center for Bio/Pharmaceutical and Bio device Development program. In 1999, the University of Southern California opened a Medical Device Development Facility, which focuses on neural engineering.

University of California, San Diego’s (UCSD) Jacobs School of Engineering is enrolling its second class for its Master of Advanced Study Program in Medical Device Engineering. Companies increasingly need engineers with interdisciplinary experience and perhaps just as important, a broader understanding of the regulatory and financial environment that the devices require.

4.5. Challenges

The success of a medical device company depends on its ability to develop, manufacture, and market innovative products. These newly developed medical devices undergo rigorous testing by medical researchers and regulatory specialists to ensure their safety and effectiveness for consumers. Alongside developing innovative new products and operating in San Diego, there are challenges that cannot be overlooked. In this section, these challenges will be focused: capital and funding, changing regulations, and the high cost of living in San Diego.

4.5.1. Capital and Funding

According to the 2015 Medical Device Industry Survey conducted on 636 executives by Emergo, capital and funding was ranked number one as the biggest challenge facing executives (Resource Library for Medical Device Professionals, 2015). However, when sorted by the size of company, smaller companies are more affected by the lack of funding and capital than larger companies. During an interview with a senior product manager at NuVasive,
he stated that the lack of capital was one of the company’s top challenges. NuVasive employs more than 500 people in its corporate headquarters in San Diego.

For a medium to large size company, ample resources are crucial for a company to compete successfully in its industry. A medical device company needs greater financial, research and development, manufacturing, and marketing resources in order to avoid takeover or acquisition. Industry consolidation could result in greater competition if competitors combined their resources. Competition could cause a company to lower its selling price and increase its investments in research and development, sales, and marketing.

For start-up companies, the challenge is attracting venture capitalists to fund their innovative ideas. San Diego weather draws in many entrepreneurs from out of state as well as PhDs and scientists from nearby universities such as the University of California, San Diego and Salk Institute for Biological Studies. Start-ups of medical device companies can be found in the San Diego County area such as Sorrento Valley and North County. Besides acquiring funds through venture capital, there are other funding sources such as borrowing funds, angel investors and investment banks. Obtaining funds can be challenging when the company’s reputation is unproven or unknown. Thus, an entrepreneur’s role is to develop a compelling business plan to attract investors.

4.5.2. Changing Regulations

4.5.2.1. Medical Device Tax

As part of the Affordable Care Act effective in 2013, all medical device companies are subjected to a 2.3% tax on the sale price of all medical devices sold in the United States, regardless of a company’s profitability. This $20 billion tax on the industry is expected to have a deep impact to the medical device industry. Medical device manufacturers say the tax will increase their costs and the costs to the patient. The tax is pushing jobs overseas and is discouraging innovation in the medical device industry. Companies are projecting to lay-off employees or reduce their R&D expenses in order to pay for this tax. The San Diego Union Tribune Editorial wrote:

“This [medical device tax] impact has been to discourage job creation and innovation. This damage will only increase with time. California, with 75,000 jobs in the industry, can expect to get hit the hardest, and San Diego County will be among the worst hit in California.”

(Board, 2015)
Per the Washington Post, large companies that announced layoffs related to the tax included Abbott Laboratories, which laid-off 450 employees from its Temecula plant. Metronic laid-off 1,000 jobs in the heart rhythm device units, and Boston Scientific laid-off 1,000 jobs, or 10% of its workforce. (Lee, 2015)

4.5.2.2. 510(k) Approval Process
Products are subject to regulations by the FDA and other federal and state government authorities. All new medical devices and modifications and enhancements of existing products are required to obtain 510(k) pre-market clearance or approval before products can be sold in the United States. The approval process can be costly and time consuming for companies because of FDA’s stringent guidelines.

Recent changes to the FDA’s 510(k) clearance process increases process’ fees by 17% for companies seeking premarket approval. More companies have to register and go through the process because the FDA has broadened the definition of who needs to apply for regulatory control and approval. This change is attempting to better manage device recalls after device approvals. The advantage to this is that the approval process is shortened by 11 days. The disadvantage is that FDA will have more control post market. Critics argue that increased control will stifle innovation.

4.5.2.3. The Budget Control Act
A medical device company’s ability to sell its products depend mostly on the extent to which coverage and reimbursement for the products will be available from Medicare, private health insurers, and other organizations. Two recent changes in the legislation affect reimbursements for those on Medicare, The Budget Control Act of 2011, which came into effect on April 1, 2013, and The American Taxpayer Relief Act of 2012. The Budget Control Act set forth to reduce Federal spending and as a result, reduce Medicare payments to providers by up to two percent.
5. Education and Research Institutes

5.1. Key Players
San Diego County is home to twelve universities and eight colleges. A majority of these offer a nursing or medical program (List of San Diego Universities and Colleges, 2015). Of the twenty schools in the county, there is only one medical school, offered by University of California San Diego. There are a wide variety of nursing programs within San Diego. Table 5 identifies the current accredited nursing schools. The accreditations are defined as the Accreditation Commission for Education in Nursing (ACEN) and the Commission on Collegiate Nursing Education (CCNE).

Table 5. Accredited Nursing Programs, San Diego

<table>
<thead>
<tr>
<th>University Name</th>
<th>Accreditation</th>
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<tbody>
<tr>
<td>Grossmont-Cuyamaca Community College</td>
<td>ACEN</td>
</tr>
<tr>
<td>Palomar College</td>
<td>ACEN</td>
</tr>
<tr>
<td>San Diego City College</td>
<td>ACEN</td>
</tr>
<tr>
<td>Southwestern College</td>
<td>ACEN</td>
</tr>
<tr>
<td>California State University San Marcos</td>
<td>CCNE</td>
</tr>
<tr>
<td>National University</td>
<td>CCNE</td>
</tr>
<tr>
<td>Point Loma Nazarene University</td>
<td>CCNE</td>
</tr>
<tr>
<td>San Diego State University</td>
<td>CCNE</td>
</tr>
<tr>
<td>United States University</td>
<td>CCNE</td>
</tr>
<tr>
<td>University of San Diego</td>
<td>CCNE</td>
</tr>
</tbody>
</table>

Note. Adapted from Accreditation Commission for Education in Nursing and Commission on Collegiate Nursing Education

In order to narrow the list within the Health Sciences education industry in San Diego County, we defined our key players as an accredited college, a ranked college, and a college that is connected to other Health Sciences industries. This narrowed our list to five key colleges: University of California San Diego (UCSD), University of San Diego (USD), San Diego State University (SDSU), Point Loma Nazarene University (PLNU), and California State University San Marcos (CSUSM).

5.2. Critical Factors
The critical factors of this study are determined by identifying what it takes to be a leader in the Health Sciences education industry. We defined a leader in the Health Sciences education industry in San Diego County by the following five factors.
1. University Accreditation
2. University Ranking
3. Partnerships within the Health Science Industry in San Diego
4. University Affiliated Research within the Nursing or Medical Field and Recognized Staff
5. University Disciplines and Specialized Programs

5.2.1. University Accreditation

University accreditation ensures that the education that is provided by the college meets quality standards. Accrediting agencies are private intuitions that offer accreditation at the regional and national scope. Each accrediting body develops the criteria and conducts a peer evaluation to assess if the college meets the criteria. The U.S. Department of Education (USDE) publishes a list of nationally recognized accredited agencies. These agencies are considered reliable authorities as is the quality of education of the colleges they accredit (The Database of Accredited Postsecondary Institutions and Programs, 2015).

5.2.1.1. The Liaison Committee of Medical Education (LCME)

The University of California San Diego is the only college in San Diego County that has a Medical Doctor (MD) program. The MD program is accredited by The Liaison Committee of Medical Education (LCME). Leading MD programs in the United States and Canada are accredited by the LCME, such as Yale School of Medicine and Harvard Medical School. The LCME is sponsored by the Association of American Medical Colleges and the Council on Medical Education of the American Medical Association. The LCME is limited to complete and independent medical education programs that are operated by universities and medical schools in the United States and Canada. The LCME is recognized by the USDE as an accrediting agency for medical education programs. By receiving accreditation by the LCME, the MD programs are eligible for federal grants and programs (About the LCME, 2015).

The majority of state boards for licensure require medical schools to be accredited by the LCME. Students are required to have attended a LCME accredited school to be considered eligible to take the Medical Licensing Examination. Graduates of LCME accredited schools are also eligible for residency programs accredited by the Accreditation Council for Graduate Medical Education. Having the LCME accreditation puts UCSD in a position to produce high quality medical doctors (About the LCME, 2015).
5.2.1.2. Commission on Collegiate Nursing Education (CCNE)

The nursing programs at University of San Diego, San Diego State University, Point Loma Nazarene University, and California State University San Marcos are accredited by the Commission on Collegiate Nursing Education (CCNE). CCNE is recognized as a national accreditation agency by the USDE. CCNE is an autonomous accrediting agency that ensures that quality of nursing programs. CCNE accreditation was created by The American Association of Colleges of Nursing (AACN). AACN is the national voice for nursing education and strives to establish quality standards for nursing education, to assists in implementation of the standards, to influence nursing profession to improve health care, and to promote public support of education, research, and practice in nursing (CCNE Mission, Values, & History, 2015).

5.2.2. University Ranking

U.S. News and World Report earned a reputation as being the leading provider of news and information. U.S. News focuses on health, personal finance, education, travel, cars, news and opinion. News You Can Use®, a franchise of U.S News and World Report, publishes its “Best” series of consumer guides which include rankings of colleges, graduate schools, and more (About U.S. News and World Report, 2015). Ranked colleges attract more students, and can provide a higher quality education.

The rankings are based on the following categories, assessment by administrators at peer institutions, retention of students, faculty resources, student selectivity, financial resources, alumni giving, and graduation rate performance. These categories are measured by the following criteria and weights (U.S. News Ranking Model Indicators, 2015):

1. Undergraduate Academic Reputation (22.5%)
2. Retention (22.5%)
3. Faculty Resources (20%)
4. Faculty Salary (35%)
5. Financial Resources (10%)
6. Graduation Rate Performance (7.5%)
7. Alumni Giving Rate (5%)

San Diego County has several universities and colleges that offer education in the Health Sciences industry. The U.S. News and World Reports helped to narrow down colleges that are ranked in San Diego County. San Diego County colleges are found on two U.S. News Best Colleges reports, in the National Universities and Regional Universities categories. Colleges in the National Universities category offer a full array undergraduate, masters, and
doctoral programs (National Universities Rankings, 2015). Table 6 shows the U.S. News National Universities Ranking of San Diego County colleges.

<table>
<thead>
<tr>
<th>University Name</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of California San Diego</td>
<td>39</td>
</tr>
<tr>
<td>University of San Diego</td>
<td>89</td>
</tr>
<tr>
<td>San Diego State University</td>
<td>149</td>
</tr>
</tbody>
</table>

Note. Adapted from U.S. News & World Report

Colleges in the Regional University category offer a full range of undergraduate programs, some master’s programs, and very few doctoral programs (Regional Universities Rankings, 2015). Table 7 shows the U.S. News Regional Universities Rankings of San Diego County colleges’ rankings as per U.S. News Regional Universities.

<table>
<thead>
<tr>
<th>University Name</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Loma Nazarene University</td>
<td>17</td>
</tr>
<tr>
<td>California State University San Marcos</td>
<td>87</td>
</tr>
</tbody>
</table>

Note. Adapted from U.S. News & World Report

5.2.3. Partnerships with Health Science Industries

The third factor that defines a leader in the Health Science education industry is the college’s connection to other Health Sciences industries such as healthcare, pharmaceutical, diagnostics, biotechnology, biomedical and medical devices. A college that is well connected to the Health Science industry will have more resources available to them. With additional resources and connections, the college will be able to produce graduates that will excel in the Health Science industry.

5.2.3.1. University of California San Diego

The Medical School at the University of California San Diego engages students in clinical experiences and faculty-student interaction to prepare students to become well-trained, scientifically informed, and conscientious physicians. Medical students receive clinical training and research opportunities at other Health Sciences industries in San Diego County. These include UC San Diego Medical Center, UCSD Thornton Hospital, Veterans Administration, Rady Children’s, Naval Medical Center, Scripps Green Hospital, and Scripps Mercy Hospital (UCSD General Catalog 2015-16, 2015).
The UCSD Medical Scientist Training Program (MSTP) is designed for students who chose to pursue a MD/PhD. The MSTP is positioned to create leading physician scientists. The MSTP partners with leading-edge research labs in San Diego County. These research institutes include Scripps Research Institute, Salk Institute for Biological Sciences, Sanford-Burnham Medical Research Institute and the La Jolla Institute for Allergy and Immunology (Paul A. Insel, 2015).

5.2.3.2. University of San Diego
The University of San Diego does not have an undergraduate pre-medical program. Instead, they provide pre-health advising through the College of Arts and Science. The Pre-Health Advising office assists students who plan to attend health professional schools with the understanding of the application process, proper prerequisites, and courses required by each health professional school. In addition, they provide students with volunteer and community service opportunities (USD Pre-Health Advising, 2015). The following table is a list of the volunteer opportunities within San Diego County the USD Pre-Health Advising program offers:

<table>
<thead>
<tr>
<th>Medical and Nursing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scripps Medical Center</td>
</tr>
<tr>
<td>Rady Children’s Hospital</td>
</tr>
<tr>
<td>Sharp Medical Centers</td>
</tr>
<tr>
<td>UCSD Health System</td>
</tr>
<tr>
<td>UCSD Student Run Free Clinic</td>
</tr>
<tr>
<td>Research Associates Program (UCSD)</td>
</tr>
<tr>
<td>Clinical Care Extender Internship Program (Palomar Pomerado Health Centers)</td>
</tr>
<tr>
<td>Volunteers in Medicine - El Cajon</td>
</tr>
<tr>
<td>VA San Diego Healthcare System</td>
</tr>
<tr>
<td>Family Health Centers of San Diego</td>
</tr>
</tbody>
</table>

Note. Adapted from University of San Diego

5.2.3.3. San Diego State University
The College of Health and Human Services (CHHS) at San Diego State University is affiliated with many health centers and institutes. These centers and institutes are able to provide valuable research to the health and human services community (CHHS Research Centers and Institutes, 2015). Below is a list of some of the research institutes CHHS at SDSU partner with:
Table 9. SDSU Partnerships

<table>
<thead>
<tr>
<th>Research Institutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Sensor motor Laboratory</td>
</tr>
<tr>
<td>Center for Behavioral Epidemiology and Community Health</td>
</tr>
<tr>
<td>Cognitive Neuroscience Laboratory</td>
</tr>
<tr>
<td>Heart Institute</td>
</tr>
<tr>
<td>Institute for Public Health</td>
</tr>
<tr>
<td>Institute for Public Security and Health</td>
</tr>
<tr>
<td>Language and Neuroscience Group</td>
</tr>
<tr>
<td>Neuromechanics and Neuroplasticity Laboratory</td>
</tr>
<tr>
<td>Pelvic Health and Rehabilitation Laboratory</td>
</tr>
<tr>
<td>Rehabilitation Biomechanics Laboratory</td>
</tr>
<tr>
<td>Sharp Healthcare Professional Education and Research Institute</td>
</tr>
<tr>
<td>Sports Injury Prevention &amp; Research Laboratory</td>
</tr>
</tbody>
</table>

Note. Adapted from San Diego State University

5.2.3.4. **Point Loma Nazarene University**

Point Loma Nazarene University has a Pre-Health Program available since they do not have a Pre-Medical major. This program assists students who plan to attend health professional schools. The Pre-Health program serves as a resource to students (PLNU Pre-Health Program, 2015). This program also provides assistance in obtaining volunteer opportunities with the following hospitals and medical centers in San Diego County:

Table 10. PLNU Volunteer Opportunities

<table>
<thead>
<tr>
<th>Medical Centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharp Hospitals</td>
</tr>
<tr>
<td>Scripps Hospitals</td>
</tr>
<tr>
<td>UCSD Health System</td>
</tr>
<tr>
<td>Rady Children’s Hospital</td>
</tr>
</tbody>
</table>

Note. Adapted from Point Loma Nazarene University

5.2.3.5. **California State University San Marcos**

The Nursing Programs at California State University San Marcos offers Bachelors (BSN) and Masters (MSN) of Science Degree in Nursing. Upon completion of a BSN, graduates are eligible for licensure as a Registered Nurse in California and certification as a public health nurse. The MSN program prepares nurses in general and advanced practice roles within the health care industry, academia and may continue at the doctoral level (CSUSM School of
Nursing, 2015). The School of Nursing at CSUSM has partnerships with the following (CEHHS Partnerships and Giving, 2015):

<table>
<thead>
<tr>
<th>Clinical Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alvarado Hospital</td>
</tr>
<tr>
<td>Aurora Behavioral Health</td>
</tr>
<tr>
<td>Elizabeth Hospice</td>
</tr>
<tr>
<td>Escondido Public Health</td>
</tr>
<tr>
<td>Hemet Valley Medical Center</td>
</tr>
<tr>
<td>Kaiser Permanente Medical Centers</td>
</tr>
<tr>
<td>Naval Hospital Camp Pendleton</td>
</tr>
<tr>
<td>Naval Medical Center San Diego</td>
</tr>
<tr>
<td>Oceanside Public Health</td>
</tr>
<tr>
<td>Palomar Health</td>
</tr>
</tbody>
</table>

Note. Adapted from California State University San Marcos

The Biotechnology Program at CSUSM is designed to prepare graduates to excel in either a laboratory or management position in the biotechnology industry. The program partnered with leaders of the biotechnology industry to start this program. Some of these companies include, BILCOM, Genentech, and Thermo Fisher Scientific. The Biotechnology Program collaborated with biotechnology companies to design a program that would provide students with knowledge about scientific fundamentals as well as general business concepts (Biotechnology Program, 2015).

5.2.4. University Disciplines

The fourth differentiating factor among universities is the unique disciplines offered at each university. Diversification of programs offered at each university provides a solution to a specific market need within the Health Sciences industry. Specialties or programs within a medical or nursing school can draw students from around the world that are interested in that specific discipline. According to the Princeton Review website, the criteria used in choosing the right medical school should be based on the specialty the applicant plans to focus in. The example provided by Princeton Review is:

Some medical programs emphasize research or specialty medicine, while others focus on primary care. If you’re interested in the latter, you may not be happy at a school that gives you little patient contact in the first two years. On the other hand, if you want to become a researcher or an
academic, a school whose mission is to educate family practitioners may leave you pining for the lab (How to Choose a Medical School, 2015).

San Diego County universities have a variety of degrees within the Health Sciences field which offer educational opportunities that are in line with the industry attracting students, professors, and professionals to San Diego.

5.2.4.1. University of California San Diego

UCSD’s differentiator within San Diego is that it is the only medical school and it offers both undergraduate and graduate level programs. Table 12 provides a summary of the specialty programs offered within the Health Sciences Industry (UC San Diego School of Medicine, 2015).

Table 12. UCSD Programs

<table>
<thead>
<tr>
<th>Health Science Related Programs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesiology</td>
<td></td>
</tr>
<tr>
<td>Audiology</td>
<td></td>
</tr>
<tr>
<td>Bioengineering</td>
<td></td>
</tr>
<tr>
<td>Bioinformatics</td>
<td></td>
</tr>
<tr>
<td>Biomedical Sciences</td>
<td></td>
</tr>
<tr>
<td>Cancer Center</td>
<td></td>
</tr>
<tr>
<td>Cellular and Molecular Medicine</td>
<td></td>
</tr>
<tr>
<td>Chemistry &amp; Biochemistry</td>
<td></td>
</tr>
<tr>
<td>Clinical Psychology</td>
<td></td>
</tr>
<tr>
<td>Clinical Research</td>
<td></td>
</tr>
<tr>
<td>Cognitive Science</td>
<td></td>
</tr>
<tr>
<td>Cognitive Science Interdisciplinary</td>
<td></td>
</tr>
<tr>
<td>Dermatology</td>
<td></td>
</tr>
<tr>
<td>Emergency Medicine</td>
<td></td>
</tr>
<tr>
<td>Family &amp; Preventive Medicine</td>
<td></td>
</tr>
<tr>
<td>Genetics</td>
<td></td>
</tr>
<tr>
<td>Global Public Health</td>
<td></td>
</tr>
<tr>
<td>Health Care &amp; Social Issues Minor</td>
<td></td>
</tr>
<tr>
<td>Health Law</td>
<td></td>
</tr>
<tr>
<td>Human Development</td>
<td></td>
</tr>
<tr>
<td>Leadership of Healthcare Organisations</td>
<td></td>
</tr>
<tr>
<td>Medical Genetics</td>
<td></td>
</tr>
<tr>
<td>Medical Scientist Training Program</td>
<td></td>
</tr>
<tr>
<td>Medicine</td>
<td></td>
</tr>
<tr>
<td>Neurosciences</td>
<td></td>
</tr>
<tr>
<td>Ophthalmology</td>
<td></td>
</tr>
<tr>
<td>Orthopedic Surgery</td>
<td></td>
</tr>
<tr>
<td>Pathology</td>
<td></td>
</tr>
<tr>
<td>Pediatrics</td>
<td></td>
</tr>
<tr>
<td>Pharmacology</td>
<td></td>
</tr>
<tr>
<td>Psychiatry</td>
<td></td>
</tr>
<tr>
<td>Psychology</td>
<td></td>
</tr>
<tr>
<td>Public Health</td>
<td></td>
</tr>
<tr>
<td>Radiation Oncology</td>
<td></td>
</tr>
<tr>
<td>Radiology</td>
<td></td>
</tr>
<tr>
<td>Reproductive Medicine</td>
<td></td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
</tr>
</tbody>
</table>

Note. Adapted from University of California San Diego

5.2.4.2. University of San Diego

At USD, the Hahn School of Nursing and Health Science offers Masters Programs in Nursing for both Registered Nurses and non-Registered Nurses. USD also has two Doctorate programs in the Philosophy in Nursing and Nursing Practice. Table 13 provides a summary of the specialty programs offered within the Health Sciences Industry.
Table 13. USD Programs

<table>
<thead>
<tr>
<th>Health Science Related Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
</tr>
<tr>
<td>Chemistry</td>
</tr>
<tr>
<td>Foods and Nutrition</td>
</tr>
<tr>
<td>Gerontology</td>
</tr>
<tr>
<td>Health Communication</td>
</tr>
<tr>
<td>Kinesiology</td>
</tr>
<tr>
<td>Microbiology</td>
</tr>
<tr>
<td>Nutrition</td>
</tr>
</tbody>
</table>

Note. Adapted from University of San Diego

5.2.4.3. San Diego State University
SDSU offers several different programs and educational paths for a degree in nursing. These programs include the BSN, a RN to BSN, a MS in Nursing, and a LVN to RN. Outside of the School of Nursing, SDSU also offers academic programs in Health Sciences and Public Health. Table 14 provides a summary of the specialty programs offered within the Health Sciences Industry.

Table 14. SDSU Programs

<table>
<thead>
<tr>
<th>Health Science Related Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
</tr>
<tr>
<td>Chemistry</td>
</tr>
<tr>
<td>Foods and Nutrition</td>
</tr>
<tr>
<td>Gerontology</td>
</tr>
<tr>
<td>Health Communication</td>
</tr>
<tr>
<td>Public Health</td>
</tr>
<tr>
<td>Kinesiology</td>
</tr>
<tr>
<td>Microbiology</td>
</tr>
</tbody>
</table>

Note. Adapted from San Diego State University

5.2.4.4. California State University San Marcos
CSUSM offers five different programs within the School of Nursing: a “traditional” Bachelor of Science Nursing (BSN), Licensed Vocational Nurse (LVN) to BSN, an accelerated BSN, Registered Nurse (RN) to BSN, and a Master in Science Nursing (MSN). The variety of paths allow for students of varying experience and backgrounds to have an opportunity to receive a degree in nursing. CSUSM also offers various disciplines within their Health and Human Services department. Not only do they offer a MSN, but there are such
specialties as a MS in Speech-Language Pathology, Masters in Health Information Management, and BS in Kinesiology.

CSUSM also offers Biotechnology, Biochemistry, and Biological Sciences degrees at both the undergraduate and graduate level through the College of Science and Mathematics. Table 15 provides a summary of the specialty programs offered within the Health Sciences Industry.

<table>
<thead>
<tr>
<th>Health Science Related Programs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemistry</td>
<td>Nursing</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>Advanced Practice Nursing</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>Clinical Nurse Leader</td>
</tr>
<tr>
<td>Health Information Management</td>
<td>Nursing Education</td>
</tr>
<tr>
<td>Kinesiology</td>
<td>Psychology</td>
</tr>
<tr>
<td>Pre-Health</td>
<td>Public Health</td>
</tr>
<tr>
<td>Pre-Nursing</td>
<td></td>
</tr>
</tbody>
</table>

Note. Adapted from California State University San Marcos

5.2.4.5. Point Loma Nazarene University

PLNU also offers a variety of educational paths to a degree in nursing: BSN, MSN with the option for a Clinical Nursing Specialist emphasis, and a RN to BSN. In addition to the four year BSN program, PLNU also partners with a local community college, Grossmont College, to provide access for community college students to obtain their BSN. Through this unique program, community college students are able to obtain a bachelor’s degree through Grossmont and resources provided by PLNU. Table 16 provides a summary of the specialty programs offered within the Health Sciences Industry.

<table>
<thead>
<tr>
<th>Health Science Related Programs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Health Sciences</td>
<td>Exercise /Science</td>
</tr>
<tr>
<td>Athletic Training Program</td>
<td>Exercise and Sport Medicine</td>
</tr>
<tr>
<td>Clinical Nurse Specialist</td>
<td>Kinesiology</td>
</tr>
<tr>
<td>Adult/Gerontology</td>
<td>Nursing</td>
</tr>
<tr>
<td>Family/Individual Health</td>
<td>Pre-Health</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>Psychology</td>
</tr>
<tr>
<td>Psychiatric Mental Health</td>
<td></td>
</tr>
</tbody>
</table>

Note. Adapted from Point Loma Nazarene University

5.2.5. University Research and Recognized Staff

The fifth factor that defines a leader is the expertise and industry recognition of the educational staff and the research that the university participates in. There are various awards across counties, states, and countries for academic...
teaching awards and employing a recognized professor at your university brings notoriety. Most of the nursing and medical school staff at the aforementioned universities engage in ongoing research within their field. Many obtain outside funding and grants to continue their work. The research at the various San Diego schools has the potential to attract industry to the region.

5.2.5.1. University of California San Diego
UCSD Medical School faculty focuses their research across 36 core areas of interest. UCSD also engages with local companies to provide research services, such as their 2015 partnership with ResMed, a San Diego based medical device company, that donated $5 million to fund continued sleep medicine research (Griffin, 2015). As part of the goals of the School of Medicine, UCSD focuses on “continuing to design (their) research agendas to address the most urgent needs in today’s hospitals and clinics,” as well as “moving ahead in international research and education partnerships that hold great promise.”

UCSD’s School of Medicine and the Department of Medicine employs more than 480 physicians and scientists and of these professionals, many are being recognized both regionally and nationally for their achievements. UCSD consistently has forty-plus doctors that teach in the medical school recognized on “San Diego’s Top Doctors” list. In October 2015, UCSD had three School of Medicine staff members elected to the National Academy of Medicine, an elite group of health and medicine professionals that work to address and remedy issues within the areas of health, medicine, and policy throughout the world. In total, UCSD has 50 active and alumni members nominated to this organization.

5.2.5.2. University of San Diego
USD’s staff consists of ten professors that have performed various research studies within the field of nursing. USD also has the first Nursing Research Institute in the country, which includes “four research units with special emphasis on the mental and physical health of mothers and children, the military and veterans, older adults, and end-of-life patients.”

USD’s Nursing School employs seven faculty members that are Fellows in the American Academy of Nursing, along with one member of the American Academy of Nursing Practitioners. Along with these national accreditations, each of the faculty on staff holds a doctoral or post-doctoral degree and has achieved some level of publication or higher certification.
5.2.5.3. **San Diego State University**

SDSU also has numerous current and past faculty members within the School of Nursing that have published research within the field. Areas of research include preventative health care practices, diagnosis and management, and rehabilitation nursing. (School of Nursing, 2015) The school website also spotlights four of the faculty member’s current research interests and associated projects.

5.3. **Industry Development**

In most recent years the San Diego Health Science industry has made significant strides in stimulating economic development and world-renowned discoveries to be utilized all over the globe. In order to support the various breakthroughs within the industry, San Diego has needed to build upon the scientific research and development (R&D) segment conducted in the area. The driving force behind this has become the flourishing group of robust research focused institutions and universities catering to a wide spectrum of disciplines. "From Ebola to Alzheimer's to HIV, San Diego's research institutions are developing breakthrough therapies that are advancing healthcare and quality of life on a global scale," said City of San Diego Mayor Kevin Faulconer. Despite being deficient in certain areas, this elite community has succeeded in recruiting the most talented and revolutionary graduate students, postdoctoral trainees, scholars, and scientists from all over the world to assist in making the region a powerhouse hub for Health Sciences (San Deigo Regional Economic Development Corporation, 2015).

5.3.1. **Research Institutions and Universities**

While Health Science corporations create jobs and facilitate innovations, the higher education system in San Diego provides the skilled human capital required to recruit and sustain the prominent global talent. Collectively, the universities and research institutes in the region acquire more funding from the National Institute of Health (NIH) than any other location in the United States (San Diego Region Regional Economic Development Corporation, 2013). Notably, The Scripps Research Institute (TSRI) has become the top independent research institute in the nation and is housed on over 35 acres of land in the coastal neighborhood of Torrey Pines Mesa in San Diego County. The area is also home to other major academic universities and institutions such as: UCSD, Salk Institute for Biological Sciences, La Jolla Institute for Allergy and Immunology and Sanford Burnham Medical Research Institute, among others,
making it the most concentrated area for the Health Science industry in the nation (San Deigo Regional Economic Development Corporation, 2015).

The residents of San Diego County decided over a century ago, with the establishment of The Scripps Institute of Oceanography in 1907, that this wide stretch of coastal land would be made the epicenter of the biotech hub in San Diego, producing an area exclusive to scientific R&D. As the concentration of organizations has grown, so have the facilities prompting proposals for further expansion along the coast. TSRI is currently in the early stages of their own prominent building initiative in which two cutting edge buildings, solely for biomedical research laboratories, will be built on the outstretched campus. These two new buildings will enable the concerted efforts in Alzheimer’s treatments and stroke related illnesses. While only initial development planning has begun, building is expected to be completed by the second quarter of 2019 (Building Initiative, 2015).

The San Diego based universities and research institutions continue to receive massive donations, grants, and other philanthropic funding for their sustained effort and revolutionary advancements. However, federal R&D funding remains the most significant overall, with NIH being the largest contributor; together, they have acquired nearly $1 billion in funding from NIH. The top organizations in the region according to funding are listed in Table 17.

Table 17. NIH Funding by Institution (2015)

<table>
<thead>
<tr>
<th>School</th>
<th>Awards</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of California, San Diego</td>
<td>836</td>
<td>$387,576,202</td>
</tr>
<tr>
<td>Scripps Research Institute</td>
<td>272</td>
<td>$166,800,586</td>
</tr>
<tr>
<td>Sanford-Burnham Medical Research Institute</td>
<td>112</td>
<td>$48,784,151</td>
</tr>
<tr>
<td>Salk Institute For Biological Studies</td>
<td>67</td>
<td>$33,804,819</td>
</tr>
<tr>
<td>La Jolla Institute For Allergy &amp; Immunology</td>
<td>47</td>
<td>$27,408,291</td>
</tr>
<tr>
<td>San Diego State University</td>
<td>70</td>
<td>$22,593,407</td>
</tr>
<tr>
<td>Ludwig Institute For Cancer Res Ltd</td>
<td>22</td>
<td>$11,478,691</td>
</tr>
<tr>
<td>Veterans Medical Research Foundation</td>
<td>13</td>
<td>$6,975,386</td>
</tr>
<tr>
<td>Proteogenomics Research Institute</td>
<td>4</td>
<td>$3,962,505</td>
</tr>
<tr>
<td>San Diego Biomedical Research Institute</td>
<td>5</td>
<td>$2,332,481</td>
</tr>
<tr>
<td>Scintillon Institute For Photobiology</td>
<td>3</td>
<td>$1,454,514</td>
</tr>
<tr>
<td>La Jolla Bioengineering Institute</td>
<td>1</td>
<td>$722,402</td>
</tr>
<tr>
<td>California Medical Innovations Institute</td>
<td>1</td>
<td>$612,226</td>
</tr>
<tr>
<td>La Jolla Infectious Disease Institute</td>
<td>2</td>
<td>$587,500</td>
</tr>
<tr>
<td>Vaccine Research Institute Of San Diego</td>
<td>1</td>
<td>$269,483</td>
</tr>
<tr>
<td>School</td>
<td>Awards</td>
<td>Funding</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td>San Diego Mesa College</td>
<td>1</td>
<td>$216,450</td>
</tr>
<tr>
<td>University Of San Diego</td>
<td>1</td>
<td>$154,015</td>
</tr>
</tbody>
</table>

Note. Adapted from National institute of Health

Although Torrey Pines has become a prime location for higher education, it also accommodates some of the most successful corporations in medicine, biotechnology, and pharmaceutical industries. The close proximity to academic institutions allows many organizations, such as Pfizer and Illumina to make critical strategic partnerships with students and faculty for prolonged advancements and discoveries. These partnerships also assist with development of the intellectual and highly skilled scientific professionals that remain in high demand (San Deigo Regional Economic Development Corporation, 2015).

5.3.2. Emerging Industry and Educational Developments

5.3.2.1. Molecular and Cellular Neuroscience

In 2013, President Obama launched the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative in order to put a spotlight on neuroscience and continued research into the development of the human brain. This new initiative, expected to last nearly a decade, seeks to employ revolutionary technologies to further examine and understand brain functions and disorders such as Parkinson’s Diseases, Alzheimer’s, depression and other related brain illnesses and injuries. NIH, National Science Foundation (NSF), academic institutions, large biotech corporations, and other federal organizations have invested millions in this new challenge. The hope is that new developments will help to conquer and treat neurological illnesses that have been a challenge for the Health Science community. The NIH director, Francis S. Collins stated:

“The human brain is the most complicated biological structure in the known universe. We’ve only just scratched the surface in understanding how it works – or, unfortunately, doesn’t quite work when disorders and disease occur... This is just the beginning of a 12-year journey and we’re excited to be starting the ride” (The White House BRAIN Initiative, 2013).

Immediately following the administration’s announcement, UCSD created the Center for Brain Activity Mapping (CBAM), which is the first of its kind, devoted to creating a partnership with various Health Science professionals including: neuroscientists, physical scientists, medical professionals and engineers. The aim of this program, much like the BRAIN initiative, is to essentially integrate
neuroscience with engineering to foster new comprehensive research and development into the brain’s activity and capability. In 2014, NIH awarded UCSD scientists over $10 million in grants for their effort in the research, visualization, and mapping of the brain and its functions. Additionally, the NSF awarded several other teams of UCSD scientists over $1 million in grant funding for their own research due to the BRAIN initiative. UCSD has been committed to this initiative from the very beginning by being a major contributor of the original proposal and the first institution to establish the academic center utilized for the implementation of the study (UC San Diego Bolsters Reputation As Top Neuroscience Research Center With More Than $10 Million In New Federal Grants, 2014). This news came just after US News & World Report ranked UCSD #2 in the nation for their graduate programs in neuroscience and neurobiology because of their highly skilled neuroscience faculty and continued contributions to the research (U.S. News & World Report LP, 2015).

5.3.2.2. 4D Nucleome Program
In 2015, NIH began a 4D Nucleome program for research into the dynamic structure of DNA formation within the nucleus. Consequently, UCSD was granted over 25 percent of the total funding for their research and leadership of the program’s organizational hub in San Diego.

Six initiatives comprise the $120 million NIH 4D Nucleome Program, three of which are led by or involve UC San Diego researchers. The 4D Nucleome Program is a collaborative research initiative aimed at better understanding how DNA is arranged within the cell’s nucleus in four dimensions (three-dimensional space plus time) and how changes in that nuclear organization affect human health and disease (Buschman, NIH Establishes 4D Nucleome Research Centers and Organizational Hub at UC San Diego, 2015).

Similar to the BRAIN initiative, the Nucleome program seeks to integrate the cooperation of various Health Science professionals and all aspects of the six varying initiatives. This new cutting edge program will eventually lead to the utilization of a variety of new sequencing tools, and the development of a new comprehensive approach to understanding the nucleome and the affect it has on the treatment and prevention of diseases. Nucleome research is a segment with great potential that can make a significant impact on Health Science. Thus, there is a substantial need for new discoveries and extensive research to be conducted in the field. (Buschman, NIH Establishes 4D Nucleome Research Centers and Organizational Hub at UC San Diego, 2015).
5.3.2.3. **Microbiome and Microbial Sciences**

Another rapidly emerging market for research has been the study of microbiomes and the microbial ecosystems of the human body. The developments in this segment have reached levels well beyond the breadth of smaller research facilities. This has created an opportunity for UCSD to propose the implementation of a new educational program called the Microbial Sciences Initiative. The extraordinary capabilities of UCSD make it a perfect location to facilitate the prominent study. “This new initiative will place our faculty, researchers and students at the forefront of a rapidly emerging and diversifying field that holds great potential for widespread social and economic benefits,” said UCSD Chancellor, Pradeep K. Khosla.

The execution of this program gives UCSD a competitive advantage as they will have the ability to utilize the combination of their strengths in Health Sciences and engineering. Concurrently, there will be a new Microbial Sciences Graduate Research Initiative focused specifically around the students. This program will also support the research and collaboration of various scientific fields from other academic institutions in the area as well as hospitals, clinics, and corporations. The interdisciplinary groups working collectively across the Torrey Pines Mesa region will allow students and faculty to expand their microbiome research and discover new patient care models. The results likely to lead to treatment of the microbes catalyzing disease and illness (Buschman, UC San Diego Unveils Campus-Wide Microbiome and Microbial Sciences Initiative, 2015).

5.3.3. **Competitive Advantage**

A report from Thomson Reuters, the world’s leading source of intelligent information for businesses and professionals, named San Diego a hub for 48 of the world’s most influential scientific minds. While 93 percent of those individuals conduct their work in the exclusive Torrey Pines Mesa neighborhood of San Diego, 60 percent of them remain at UCSD. The report also found the same area to be ranked 6th in number of top scientific scholars surpassing both San Francisco and Los Angeles. While there remain areas to improve, this is a remarkable feat for San Diego in such an exceedingly competitive industry (Robbins, SD home to 48 of world’s top scientists, 2014).

As elements of the Health Science industry change sporadically with new discoveries and advancements, all of the major universities and institutions focus heavily on investments in R&D. Capitalizing on the partnerships between academic institutions and leading corporations will assist in expanding the R&D sector and providing the delivery models to enhance high
quality patient care. Thus, it is essential that the region continue to create innovative ways to cultivate and retain skilled talent, as well as build more state-of-the-art research facilities necessary to thrive and compete internationally (San Diego Regional Economic Development Corporation, 2015).

One way UCSD achieves this is by bridging the gap between academia and business. In 1985, UCSD started a spin off organization to assist the start-up sector within the technology and biomedical industries. CONNECT is a non-profit 501(3)(c) organization known as an accelerator for this unique part of the industry. The website is a major factor in facilitating this initiative, and the executive board is comprised of a diverse array of San Diego’s most prominent leaders in the field. The organization’s focus is to provide start-ups with the resources necessary to thrive in this competitive landscape. They provide funding and critical industry knowledge as it relates to policy and regulations. Irwin Jacob is one of the founders of this organization and his affiliation with UCSD led him to CONNECT. He later became one of the co-founders of Qualcomm, one of the most successful global semi-conductor companies. Biocom, a life sciences trade organization, is operated by Joe Panetta and also began with the help of CONNECT. It is referenced in other sections of this report as a leader in the biomedical industry in San Diego. Although CONNECT has a strong dedication to the biomedical industry, they are a significant force in preserving innovation clustered around academia.

5.4. Industry Challenges

When assessing the challenges in relation to academia, it must be noted first why and how academia plays a role in the overall Health Sciences industry. As stated previously in the Biotechnology portion of this study, the start of biotechnology in San Diego can be traced back to Hybritech, a company founded in 1978 by two UCSD researchers. This spin off is in-line with the concept of Michael Porter’s diamond model such that industry clusters have a tendency to start at the academic and research level for-profit ventures. This can be seen in the case of the Bay Area and their Health Sciences industry.

To view this effect in more detail, the Bay Area region is a perfect comparison to the San Diego region. The Bay Area Health Sciences region started in 1973 when two professors, one from Stanford University and one from University of California, San Francisco, patented a recombination technique. They founded Genentech in 1976, which catapulted the area in Biotechnology.
Currently the Bay Area is the largest of all the biotech clusters. Below is a comparison of the Bay Area to the San Diego region.

![California Counties](image)

**Figure 4. California Counties**

<table>
<thead>
<tr>
<th>Comparisons</th>
<th>San Diego</th>
<th>Bay Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual Money Research Institutes Receive</td>
<td>$540 million</td>
<td>$1.23 billion</td>
</tr>
<tr>
<td>Total Amount of Employees Related to Biomed</td>
<td>36,731</td>
<td>60,636</td>
</tr>
<tr>
<td>Total Population</td>
<td>3.1 million</td>
<td>7 million</td>
</tr>
<tr>
<td>Amount of Counties</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Medical Schools</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note: Adapted from California Healthcare Institute*

When comparing the two regions, it must be noted that the Bay Area has a clear advantage in that it has more schools to promote spin offs, and innovation. Moreover, it has two medical schools to one in San Diego. As shown in Table 18, there is a correlation between the number of medical schools and the amount of jobs and research funding. Ultimately, it can be considered a challenge as the Bay Area consists of nine counties to our one county in San Diego.

Another challenge that San Diego faces is how well its academia is prepared to train the number of scientists and researchers needed to continue to fuel the Health Sciences field and keep companies here in San Diego. During an interview with Dr. AL Kern, head of the Biotechnology program at CSUSM, Dr. Kern indicated that one challenge is making the programs relevant
to what is currently going on in the industry. Collaboration between academia and the Health Sciences industry is a key to making sure education remains relevant. Further research needs to be conducted to analyze this challenge as it relates to San Diego. Benchmarking of historical data and projected growth trends from other Health Science cluster regions would help with this potential challenge to see if there are gaps in the San Diego education system.
6. Overall Challenges Affecting HSSD 1.0

6.1.1. Cost of Living
Similar to the other leading Health Science hubs in the country like Boston and San Francisco Bay area, San Diego has a high median cost of living. San Diego ranks the fourth most expensive city for housing in the U.S. according to the Bureau of Labor Statistics. The cost of living is around 30 percent higher than the national average. Housing is around 100% greater than the national average. The median salaries for engineers working in a biotechnology company in San Diego is over $70,000 according to payscale.com. In order for biomedical companies to operate in San Diego, they must pay higher than median salaries to their employees. Paying for highly qualified and skilled workforce adds to the expenses when operating in this region of the country. In order for companies to attract or retain the right talent, companies need to pay a higher rate as they would in other regions of the country. Since the cost of real estate is high, more capital outlays are needed if a company plans to purchase its facility. If leasing, then a company will pay a higher dollar per square foot to rent office and facility spaces.

6.1.2. Geographic Location
San Diego is located in the furthest Southwest corner of the lower forty-eight states of the United States. This location leaves its resources fewer and further to reach. Within San Diego County there is a concentration of biotech and pharmaceutical companies in the Sorrento Valley, Torrey Pines Mesa, and North County regions. Sorrento Valley is home to smaller startup companies like Althea Technologies with some larger companies like CareFusion and Illumina. Torrey Pines is another concentration nearby with larger companies like Pfizer, Johnson & Johnson, smaller companies like Pacira Pharmaceuticals, and a few medical research facilities like Scripps Research Institute, Salk, and UCSD which are considered the city’s academic powerhouses. Finally in North County San Diego there is Genentech, Thermo Fisher Scientific, ISIS Pharmaceuticals, and similar smaller companies like Gilead Sciences. In an interview with the Director of Engineering Service of Genentech Oceanside, it was expressed that one of the biggest contributors to San Diego being a national leader in the Health Sciences Industry was; “Its healthy supply of intellectual property, supported by the region’s leading colleges focusing in the industry.” San Diego is home to some of the top colleges with Health Science programs like, UCSD, Mira Costa, and even high
schools have a focus in medical fields like Poway Unified and Health Science High.

The San Diego International Airport has limited flights to other key locations in the world, and local companies are forced to use and travel to larger airports like LAX and SFO. The research of CSUSM’s 2015 FEMBA cohorts’ graduate airport project, stated clearly from other emerging markets in the world that, “We cannot get to San Diego easily” which can pose a problem when working on a project or even trying to launch a new startup company. When a company is looking to reach a worldwide market or use resources in other parts of the globe, it will need to consider how connected it can be to other international locations.

6.1.3. Utility Constraints in San Diego

The recent drought and power grid constraints experienced in Southern California have been a challenge to larger industrial processes, which support the industry. Electricity is used in powering the medical research labs, chillers and cooling towers for cooling processes and medical storage, high pressure pumps for micro filtration reverse osmosis and distilling ultra-pure water, used in the medical grade water to make injections for the human body.

California is currently experiencing its worst drought in 1,200 years. Local water authorities are starting to place restrictions and fines for excessive water usage, and forcing users to find alternative methods in conserving. Water usage supports the medical research laboratories, drug production, and evaporative cooling tower makeup water for HVAC cooling. Companies are being forced to invest more capital for water conservation methods to reduce their footprint in the local consumption. North County San Diego is planning the opening of the newest and largest desalination water plant for the Western hemisphere in Carlsbad, CA at the end of 2015, to convert seawater to supply 50 million gallons of fresh water per day. This should lessen the effects of the region, but places additional constraints on the electrical grid to support the water plant.

All of these electrical usages require an enormous amount of power. The electrical grid in California is currently undergoing changes due to Environmental Protection Agency (EPA) regulations that allow seawater cooling of coastal power plants. The EPA has implemented a plan to slowly phase out single pass seawater cooling on aging power plants, similar to the Encina power plant in Carlsbad, CA due to the effects of marine life. The consequences of this restriction cause a ripple effect to the utility companies of spending the capital to comply or to pay fines, and onto the consumers of electrical power. Recently in 2012 Southern California suffered the loss in the
decommissioning of San Onofre Nuclear Generating Station (SONGS) from a primary to secondary coolant leak of its steam generators. The result is a loss of over 2,000 MW of electrical capacity to the Southern California grid, in which California Independent System Operator (CAISO) has to re-allocate, along with the affected power plants of the new EPA standards. San Diego Gas and Electric (SDG&E) has to resort to rolling blackouts on days when they are experiencing peak load. Large Pharmaceutical companies like Genentech are implementing energy efficiency, reduction, and production projects like the solar array covering the main parking lot at their Oceanside facility. Water and electricity are the largest utility constraints for the San Diego region and what the industry mainly relies on to make its products. These restrictions pose a greater challenge to the local industry as they would if companies were located in other areas of the country.
7. Conclusion

As outlined in each chapter of the HSSD 1.0 study, San Diego County has a strong foundation of success within the Healthcare, Biotechnology, Biomedical Devices, Education and Research Industries of Health Sciences. Funding provided to San Diego Health Sciences industries is growing and there is a strong infrastructure established, which is apparent in the detailed company analyzes provided in each report chapter. The key demographics set forth in the beginning of this report indicate that San Diego County is expected to see growth within the Health Sciences industry.

Though San Diego County has challenges, they are the same for many other regions and industries. However, there are a couple of challenges for San Diego that are worth noting as it relates to the capability of continued growth. San Diego County is one of the furthest states in the US and is surrounded by mountains and Camp Pendleton, which geographically limits outward growth. This limitation is apparent when comparing the San Diego Health Sciences region to the Bay Area. The Bay Area, which is currently the number one Health Sciences region in California, is comprised of nine counties that all contribute to their cluster of Health Sciences. In addition to the geographic differences, the Bay Area is home to two medical schools while San Diego only has one, UCSD.

It is quite clear from the research conducted in this study that UCSD plays a major role in San Diego’s Health Sciences industry. It is one of the main accelerators of innovation and job creation for the Health Sciences industry in San Diego. Though there are a number of research institutes that work with the different industries discussed in this study, they mainly draw from UCSD. Education and academic research are the cornerstone of innovation and industry clustering as explained by Porter’s cluster theories and models.

In order for San Diego to continue growth in the Health Sciences industry, additional funding for education is key. First, it needs to be established that schools in San Diego are keeping up with the current demand in population growth as it pertains to healthcare. Second and most important, academia needs to continue to foster innovation and growth in order to keep brilliant minds, ideas, and job growth in San Diego. Currently CONNECT is helping to bridge this gap between academia and business; this program is designed to help start-ups with funding and additional resources. Though this program is not directly tied to Health Sciences as a whole, it can be looked at as a model to establish more programs that help bridge the gap between academia and business as it does play an important role as an incubator type
organization to technology in the area. In addition to UCSD contributing to this industry, the California State schools, such as CSUSM are doing their part to provide programs to help students get the education needed to succeed in this growing industry. CSUSM recently added Health Science programs that combine science with business. Currently, there are no research institutes tied to CSUSM that can help bridge the gap to the Health Science Industry. Therefore, additional funding would be beneficial by providing more research institutes and incubator organizations dedicated solely to the business of Health Sciences particularly in the North County San Diego area. As show above in the education section of the paper, it can be seen that there is correlation between the amount of money the research institutes have to spend in a given region is tied directly to jobs within that same region.

The number of schools and the size of the region may limit San Diego, but research institutes and incubator programs can be created at any time. As an example, San Diego-based Irwin Jacobs, founder of Qualcomm, just recently donated $133 million in 2013 to Cornell University to create the Joan & Irwin Jacobs Technion-Cornell Institute. In addition to this institute, the Jacobs have donated to UCSD as well as many other San Diego health and technology ventures (Cornell University, 2015). There are many opportunities through contributions to help propel this industry further and keep current with the trends of the industry.

This study concludes with limitations and recommendations for the next two cohorts to determine how to keep San Diego growing in the Health Sciences Industry through research institutes collaborating with academia and the industry.

Limitations
The main limitation to this study is that this is only the beginning of a three-year project for the CSUSM FEMBA program. Being that this portion of the study lays the foundation for future groups, it is not capable to stand on its own in addressing the initial scope of this project. The initial question being; what needs to be done to elevate San Diego County to the forefront of Health Sciences. One tool for doing this is benchmarking other industry clusters to better understand why they succeed. It will be the responsibility of the next two cohorts to take the information from this study and apply it to the overall scope of the project.
8. Recommendations

Based on the HSSD 1.0 information gathered, initial recommendations for future cohorts include:

1. Benchmarking other national and potentially international Health Science clusters to San Diego and how they collaborate with academia.
2. Analyzing the successful technology clusters and determine if or how they bridge the gap between academia and industry.
3. Understanding the requirements to fund another institute of research in North County San Diego.
4. Proposing investment opportunities for CSUSM to add a research component for innovation and start up support.
5. Analysis the ROI analytics related to real estate and job creation by bringing a research institute to North County San Diego that merges science and business.
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