

# CRACKING THE CODE:

THE ECONOMIC IMPACT OF  
SAN DIEGO'S  
GENOMICS INDUSTRY

PRODUCED BY



SAN DIEGO  
REGIONAL  
**EDC**

EXECUTIVE SUMMARY

# SAN DIEGO IS THE EPICENTER OF GENOMICS

The region has provided the fundamental genomic research that has galvanized scientific discovery across the globe.

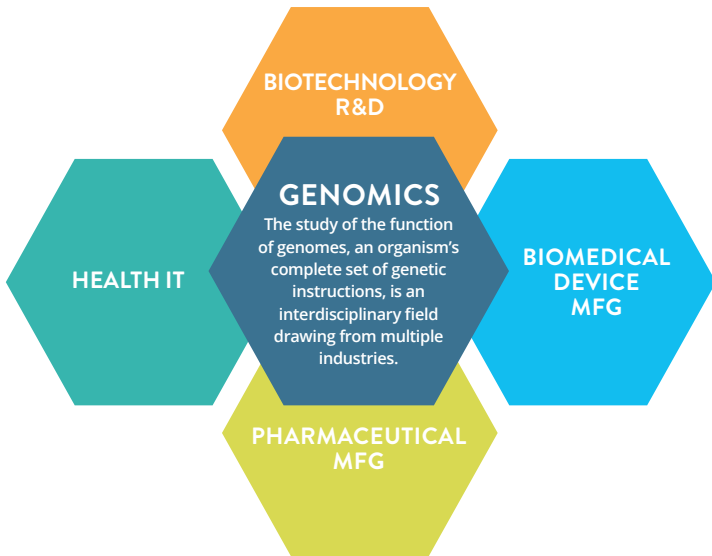
As we enter into an era of personalized medicine and technology, San Diego's companies, research institutes and universities will continue to pioneer discoveries across the interdisciplinary field of genomics.



## 3.5

**JOB MULTIPLIER:** FOR EVERY DIRECT JOB IN THE GENOMICS INDUSTRY, ANOTHER 2.5 ARE SUPPORTED ELSEWHERE IN THE ECONOMY

## MAPPING THE GENOMICS INDUSTRY



## A HISTORY OF GENOMICS

Orange indicates a San Diego milestone

**1998**

Illumina is founded, launching a new era of gene sequencing technologies

**1994**

Sequenom is founded, pioneering DNA-based prenatal testing

**1999**

Genomics Institute of the Novartis Research Foundation is launched

# WHY SAN DIEGO?

## FUNDING THE FUTURE

San Diego has an exceptional track record for creating intellectual property and strong life sciences companies, which allows the region to command a large share of genomics-related venture capital. In 2016, San Diego received nearly a quarter of all genomics VC in the U.S.



**\$292M**

VC RECEIVED  
2016



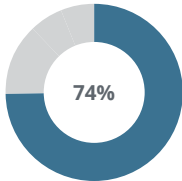
**371**

PATENTS IN GENOMICS  
2014-2016

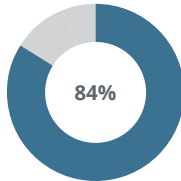


**SAN DIEGO IS THE MOST PATENT INTENSIVE GENOMICS MARKET IN THE U.S.**

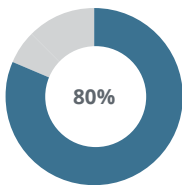
**SURVEY SAYS:  
LOCAL FIRMS ARE  
SATISFIED WITH ACCESS TO...**



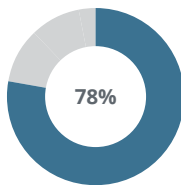
CUSTOMERS



SUPPLIERS



OTHER FIRMS  
WITHIN INDUSTRY



RESEARCH  
INSTITUTES



**\$38M**

FEDERAL FUNDING  
2016

*“Government is in the business of stimulating new discoveries. Even if only a fraction of projects succeed, the economic impacts are huge. San Diego’s genomics ecosystem is successful because of the initial investment of government, the hard work of researchers and the inventiveness of entrepreneurs.”*

Dr. Bing Ren, Director, Center for Epigenomics at UC San Diego

## A COLLABORATIVE BUSINESS CLIMATE

*“There’s a mindset here that if one of us succeeds, we all succeed; the collaboration within San Diego’s genomics industry is amazing.”*

Chrisa Mott, Head of Human Resources, Human Longevity, Inc.

**88%**

OF FIRMS RATE SAN DIEGO AS EITHER  
A GOOD OR EXCELLENT PLACE TO  
DO BUSINESS

**2003**

The Human Genome Project is completed

**2005**

Craig Venter co-founds Synthetic Genomics

**2008**

Invitrogen and Applied Biosystems combine to form Life Technologies

**2003**

Craig Venter sequences genome using shotgun method

**2007**

Introduction of Next Generation Sequencing (NGS) increases output 70x

**2013**

Life Technologies is acquired by Thermo Fisher Scientific

# LIFE CHANGING TALENT

The genomics industry benefits from the talent graduating from the region's top academic institutions. San Diego's quality of life and abundant job opportunities are among the top reasons the region has a higher-than-average concentration of genomics talent; a fundamental ingredient for a healthy ecosystem.



1,968

AVERAGE ANNUAL  
GENOMICS-RELATED  
DEGREES CONFERRED



2,939

UNIQUE GENOMICS-RELATED  
JOB POSTINGS  
IN 2016



3.1X

MORE CONCENTRATED  
THAN U.S. IN KEY  
GENOMICS OCCUPATIONS



**1** SAN DIEGO UNIVERSITIES GRADUATE MORE GENOMICS  
TALENT THAN ANY OTHER U.S. REGION\*

\* MEASURED PER 10K JOBS

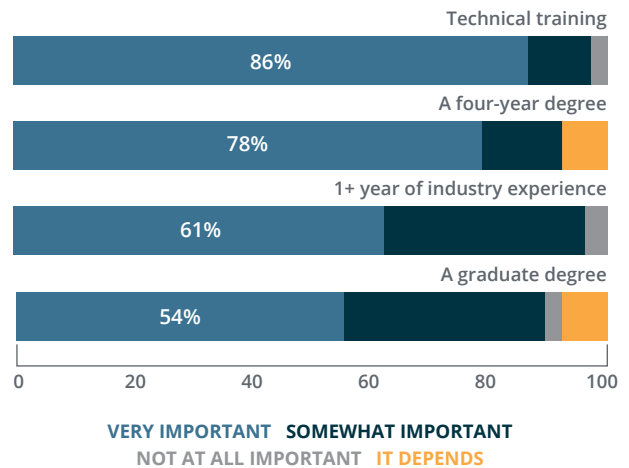
## EMPLOYERS SEEK SPECIALIZED SKILLS AND TRAINING

Companies value candidates with technical training and work-related experience. Additionally, employers in the genomics industry are more likely to recruit advanced degree holders.

55%

OF FIRMS SAY IT IS VERY IMPORTANT FOR CANDIDATES TO HAVE SOFTWARE SKILLS SUCH AS PROGRAMMING AND DATA ANALYTICS; AN INDICATOR OF THE INCREASED IMPORTANCE OF DATA-DRIVEN HEALTH SOLUTIONS

**SURVEY SAYS:  
EDUCATION AND EXPERIENCE MATTER**



2014

Cost to sequence a genome falls below \$1K

2017

Edico Genome takes rapid genome analysis technology into the cloud

2016

The Scripps Research Institute is awarded \$120M grant for large-scale genomics study

## THE FUTURE

“Five years from now the discussion won't just be about genomics, but how we are using our personal genetic data to drive health and wellness.”

Michael Heltzen, CEO, BlueSEQ

# HOW SAN DIEGO STACKS UP

The genomics scorecard uses innovation, talent and growth metrics to compare the top ten life sciences U.S. metros with populations over one million. San Diego's composite score ranks it as the number two genomics market in the nation.



## SAN DIEGO RANKS

#2

### INNOVATION

PATENT INTENSITY,  
FEDERAL FUNDING,  
VENTURE CAPITAL  
INVESTMENT

#2

### TALENT

GRADUATE PIPELINE,  
TRANSFERABLE  
SKILLS,  
OCCUPATIONAL  
CONCENTRATION

#4

### GROWTH

UNIQUE JOB  
POSTINGS, FIVE-YEAR  
OCCUPATIONAL  
GROWTH, PROJECTED  
OCCUPATIONAL  
GROWTH

## INDUSTRY VOICES

*“One thing you immediately discover when you come to San Diego is this collaboration not seen anywhere else; it’s collaboration to combine the parts and pieces across industries, make sense of the data and apply it to solve problems.”*

Dawn Barry, Vice President, Applied Genomics, Illumina

*“Boston has the pharmaceutical industry and the Bay Area has Silicon Valley, but San Diego is where the fundamental research that drives precision medicine is happening. Here, genomics has its own identity.”*

Dr. Jorge Garces, President & CEO, AltheaDx



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PRODUCED BY



FULL REPORT



## FOREWORD

Fifteen years ago, if I walked into a room of non-scientists, the term genomics was not part of the everyday lexicon. And perhaps it still isn't. But today, genomics is becoming recognized as an industry that is shaping the future of medicine, science and quality of life across the globe - and San Diego has played a defining role in its growth and progress. When I travel internationally and tell people that I am from San Diego they often first remark about our beautiful weather. Yet with each passing year, they are recognizing us more and more as a world-class destination for biotechnology, scientific research and innovation.

At San Diego Regional EDC, this is something we are very proud of - proud to live in a region that is at the forefront of developing cures for diseases, proud to be one of the most patent intensive regions in the country and proud to be home to world-changing genomics companies like Illumina and scientific pioneers like J. Craig Venter. Yet with all of our assets and resources, we simply cannot call San Diego the epicenter of genomics without the data to back it up.

This is why EDC and our partners, investors and sponsors embarked on this economic impact study. For months, our research team has pored over data, conducted surveys and interviews with industry experts and condensed the information so that San Diegans - and those looking to learn more about our region - can make informed decisions about our economy. It has not been easy work. But with this study, we are one of the first regions in the country to quantify the economic impact of a specific, regional genomics industry.

At a time when NIH funding is in jeopardy and fundamental science is being called into question, we must prioritize understanding the real facts around genomics and the life sciences. Part of this is better understanding the industry's impact on jobs, business growth and economic opportunities. Our hope is that policy makers, economic development groups and companies can use this information to plan for the future - to ensure that our children are better equipped for jobs and careers, and that we understand the long-term importance of investing in this work.

When all is said and done, San Diego may not be number one in genomics (but we are pretty close). We care deeply about the integrity of this data and we must remain true to that. But through the many executive interviews we conducted, we came to realize that there was something else happening here that the data and research cannot quite do justice to. What came through in opinions, documents and data alike, was that an unmistakable 'culture of collaboration' is the cornerstone San Diego's growing industry - much like it is the cornerstone of our region.

Simply put - San Diego businesses and institutions work together to conduct the fundamental research that powers global innovation and changes the world around us. This is why Jonas Salk first came to San Diego. It is why companies like Thermo Fisher Scientific, Illumina and Human Longevity, Inc. continue to grow here.

There is just something special about San Diego. And that is something that no economic impact study can ever truly measure and that few other regions will ever be able to replicate.

**Mark Cafferty, President & CEO, San Diego Regional EDC**

**ONE**

**PART 1: INTRODUCTION**

**THREE**

**PART 2: OBJECTIVES**

**FOUR**

**PART 3: A BRIEF HISTORY OF GENOMICS**

**SEVEN**

**PART 4: ECONOMIC IMPACT**

**THIRTEEN**

**PART 5: EVALUATING OUR ECOSYSTEM**

**FIFTEEN**

**INNOVATION**

**NINETEEN**

**TALENT**

**TWENTY-THREE**

**GROWTH**


**TWENTY-SIX**

**PART 6: FUTURE OF THE INDUSTRY**

**THIRTY**

**APPENDICES**





*“ One thing you immediately discover when you come to San Diego is this collaboration not seen anywhere else – it’s collaboration to combine the parts and pieces, make sense of the data and apply it to solve problems.”*

**Dawn Barry**, Vice President, Applied Genomics, Illumina

## THE MAKING OF AN INDUSTRY

In 1953, two young scientists at Cambridge University, James Watson and Francis Crick, finally found “the secret of life,” identifying this double-helix structure of DNA. More than 5,000 miles away and 40 years later, this fundamental discovery would spawn an industry that has redefined a region and, more importantly, significantly impacted both humanity and the global economy.

At the time of Watson and Crick’s discovery, the San Diego region was home to a little more than 500,000 individuals and known primarily as a fishing and military town. UC San Diego and the Salk Institute would not open their doors for another decade, sparking a local scientific revolution and an ethos of public-private collaboration that would set San Diego up for success in the genomics industry.

Fast forward to today, and the San Diego region is home to 3.4 million people and has consistently been identified as a top life sciences market in the country.<sup>1</sup> In recent years, a major driver of scientific innovation has been the genomics industry. With anchors such as Illumina and Thermo Fisher Scientific, research institutes and startups that help interpret and store genomic data, San Diego companies have collaborated to propel this once-nascent industry into a global powerhouse.

## THE HUMAN GENOME PROJECT

The Human Genome Project, an international and collaborative scientific endeavor led at the National Institutes of Health (NIH) by the National Human Genome Research Institute (NHGRI), is credited with identifying and sequencing all genes in the entire human genome. Successfully completed in 2003, the Human Genome Project produced a very high-quality version of the human genome sequence that is freely available in public databases and essentially serves as the foundation for all subsequent research and advancements in the field of genomics. The sequence was not of one person, but rather a composite derived from several volunteers to ensure anonymity. This produced a “representative” or generic sequence. The Human Genome Project was designed to generate a resource that could be used for a broad range of biomedical studies, such as to look for the genetic variations that increase risk of specific diseases, or to look for the type of genetic mutations frequently seen in cancerous cells.<sup>2</sup>

For an interactive timeline of San Diego’s genomics industry, please visit [GenomicsSD.org](http://GenomicsSD.org)

### A HISTORY OF GENOMICS

Orange indicates a San Diego milestone

1865

Gregor Mendel, the father of modern genetics, presents his research on experiments in plant hybridization

1953

James Watson and Francis Crick discover the double helix structure of DNA

1977

Frederick Sanger develops rapid DNA sequencing technique

1961

Genomics Institute of the Novartis Research Foundation is launched

1983

Huntington’s disease becomes the first genetic disease mapped using DNA polymorphisms

## UNDERSTANDING GENOMICS

Genomics is the study of the function and structure of genomes, which comprise the complete set of DNA within a single cell of an organism. A genome contains 3.2 billion base pairs. Each DNA strand is made of four chemical units, called nucleotide bases: adenine (A), thymine (T), guanine (G) and cytosine (C). The order of the base pairs determines the meaning of the information encoded in that part of the DNA molecule, just as the order of letters determines the meaning of a word. To write all those letters out, it would require a person to type 60 words per minute, for eight hours each day, for nearly 60 years. This is different from genetics, which is the study of heredity and impact of individual genes. Genomics uses DNA sequencing techniques and bioinformatics to decode, assemble and analyze genomes. In the simplest terms, the genome is the “code book of life.”

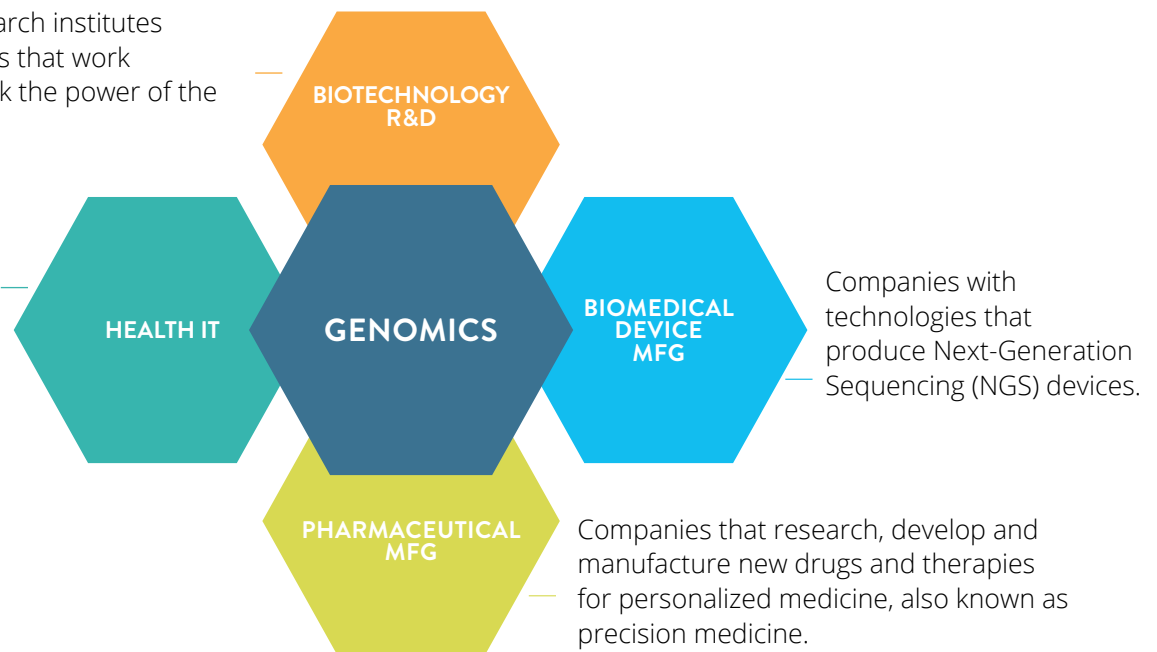
Understanding an individual's genetic make-up can reveal predispositions toward certain genetic diseases, such as cancer or Alzheimer's, while also enabling healthcare practitioners to tailor medical treatments and find the best course of intervention based on an individual's unique genetic composition. Pinpointing the exact gene responsible for a medical ailment is the equivalent of searching through 14 sets of the 32 volume Encyclopedia Britannica for one typo.

Genomics as an industry is less well-defined. It is an interdisciplinary field that cuts across multiple industries: biotechnology research and development, biomedical device manufacturing, pharmaceutical manufacturing and healthcare information technology. It also represents a number of different professions with varying skills and

### FIGURE 1.1: GENOMICS IS AN INTERDISCIPLINARY FIELD

Local universities, research institutes and commercial entities that work collaboratively to unlock the power of the human genome.

Tech companies that provide data storage and software solutions, enabling practitioners to deliver data-driven personalized medicine.



**1983**

Kary Mullis invents the polymerase chain reaction (PCR) technique for amplifying DNA

**1987**

Invitrogen is founded in Cardiff, CA

**1994**

Sequenom is founded in San Diego, pioneering DNA-based prenatal testing

**1985**

FDA clears first nucleic acid test, which detects pathogens and allows for more timely and accurate diagnoses

**1990**

The Human Genome Project launches as an international effort to sequence the human genome

## STUDY OBJECTIVES

This study produced by San Diego Regional EDC examines the role and impact of the San Diego region's genomics industry, which is simultaneously predicting and changing the future. This study focuses on genomics in a medical and clinical setting, but it is important to note the industry's influence on industrial biotechnology, agricultural biosciences, veterinary sciences, environmental science, renewable energy development and forensic science.

This study has three major objectives:

### ECONOMIC IMPACTS

Quantify the economic impact of the genomics industry on San Diego's regional economy.

### LOCAL ECOSYSTEM

Uncover the components of the local ecosystem that have aided San Diego in becoming a global leader in the field of genomics.

### OUR STANDING

Understand San Diego's genomics standing relative to other U.S. regions.

## A CULTURE OF COLLABORATION

Measuring the economic impact of the genomics industry is important, but it does not tell San Diego's whole story. There are many aspects, intangible in some cases, that contribute to the overall success of an industry's ecosystem. For San Diego, deeper industry insight was obtained through a survey of more than one-quarter of known genomics firms, as well as through executive interviews with local leaders in the field. The familiar themes of quality of life and cost of living arose in these discussions. However, a more important revelation emerged: San Diego's competitive advantage lies in its ability to collaborate; players across the entire genomics ecosystem regularly come together to solve complex problems for the sake of the greater good and in the name of science. This idea - that collaboration is the underpinning of the local genomics ecosystem - is reflected throughout the study in the form of spotlights which highlight stories of innovation and collaboration throughout the region.

*“There's a mindset here that if one of us succeeds, we all succeed; the collaboration within the genomics industry here is amazing.”*

**Chrisa Mott**, Head of Human Resources,  
Human Longevity, Inc.

1996

Leaders of the Human Genome Project draft the “Bermuda Principles,” allowing free data access to the public

1999

Chromosome 22 becomes the first human chromosome to be decoded

1995

Haemophilus influenzae becomes first genome sequenced

1998

Researchers from Tufts University found Illumina and locate its headquarters in San Diego, launching a new era of gene sequencing technologies

1999

Genomics Institute of the Novartis Research Foundation is launched in San Diego

## IMPLICATIONS FOR MEDICAL SCIENCE

Virtually every human ailment has some basis in our genes. Until recently, doctors were able to take genetics into consideration only in limited cases when treating disease. With the vast trove of data about human DNA generated by genomic research, spawning a whole new era of computational science and sequencing technologies, scientists and clinicians now have more powerful tools to study the role that genetic factors have in complex diseases.

Cardiovascular disease, cancer and even diabetes continue to rank among the top causes of death in the United States.<sup>3</sup> Genomics research is already enabling medical researchers to develop improved diagnostics, more effective therapeutic strategies, evidence-based approaches targeting these chronic diseases. With the rise of personalized (also known as precision) medicine, future healthcare treatments will be tailored to a patient's particular genetic makeup.

However, it takes considerable time, effort and funding to move discoveries from the laboratory into the medical clinic. Most new drugs derived from genome-based research are not expected to become available for another ten to 15 years.<sup>4</sup> Screening and diagnostic tests, however, are already being implemented. And rapid progress is being made in the emerging field of pharmacogenomics - using information about a patient's genetic make-up to better tailor treatment using already existing drug therapies.

## SAN DIEGO'S ROLE IN ADVANCING GENOMICS

As a region, San Diego has galvanized the genomics industry. While it is nearly impossible to account for every innovation and discovery, there are a few catalyzing events that have catapulted the industry.

The genesis of San Diego's genomics industry can be traced to the founding of Invitrogen in 1987. Invitrogen's success began with molecular cloning kits. The company went on to merge with Applied Biosystems in 2008, forming Life Technologies, before being acquired by Thermo Fisher Scientific in 2014.<sup>5</sup> Squenom was founded in 1994, pioneering DNA-based prenatal testing, and was acquired by LabCorp in 2016.

Following the successful completion of the sequencing of the first human genome, Dr. J. Craig Venter moved his lab to San Diego in 2003. Dr. Venter has created or co-founded a host of local genomics enterprises, including Synthetic Genomics and the J. Craig Venter Institute. The institute sequenced a variety of important infectious disease agents, such as the mosquito species, *Aedes aegypti*, and in 2010, it created the first minimal synthetic bacterial cell.

In 1998, Illumina was founded and then headquartered in San Diego, built on research and technology developed at Tufts University. In 2007, Illumina acquired Solexa, a sequencing company with roots in Cambridge, U.K. Today, the genomics behemoth, is the preeminent developer of sequencing technologies, generating 90 percent of all DNA sequencing data<sup>5</sup>, and valued at more than \$25 billion.

**2003**

Both the Human Genome Project and J. Craig Venter successfully sequence the human genome

**2006**

Illumina acquires Solexa, cementing its position as the largest DNA sequencing company

**2008**

Invitrogen and Applied Biosystems combine to form Life Technologies

**2005**

J. Craig Venter co-founds Synthetic Genomics to develop and commercialize synthetic biology for biofuels and medicine

**2007**

Introduction of Next Generation Sequencing (NGS) increases output 70x

## THE FALLING COST OF SEQUENCING

Advances in technology over the past two to three decades have led to substantial reductions in the cost of genome sequencing. It is estimated that the cost of sequencing under the Human Genome Project was between \$500 million and \$1 billion.<sup>6</sup> Ten years ago, the cost of sequencing plummeted to \$10 million, and today, the cost to sequence a genome is roughly \$1,000.<sup>7</sup> In early 2017, Illumina announced NovaSeq, a scalable sequencing architecture expected to one day enable a \$100 genome.

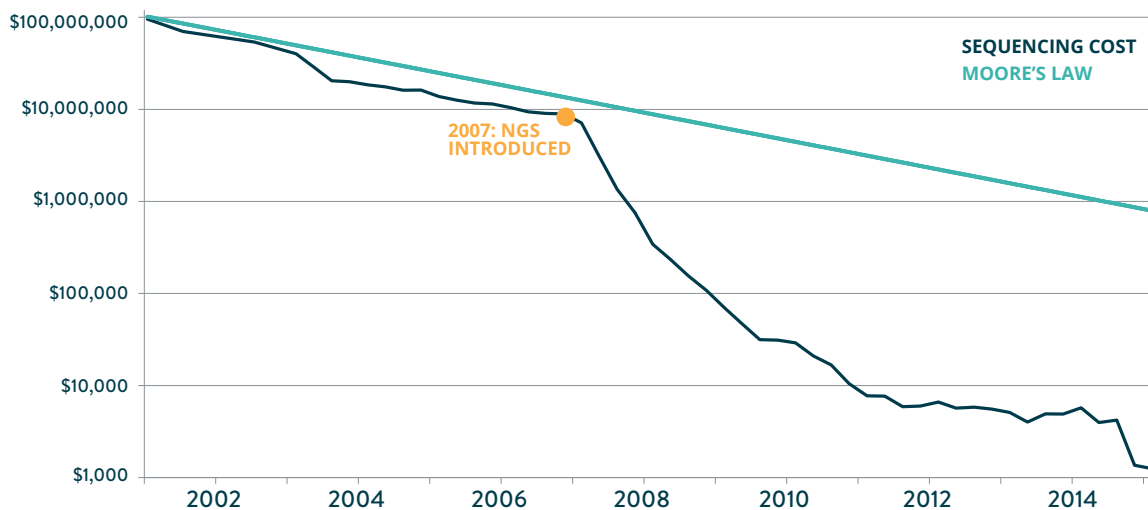
*“Five years from now the discussion won’t just be about genomics, but how we are using our personal genetic data to drive health and wellness from birth.”*

Michael Heltzen, CEO, BlueSEQ

But sequencing a genome is only the tip of the iceberg. The dramatic reduction in cost and time to sequence has shifted the attention beyond the conversion of physical samples into raw data, and toward the organization of that raw data into a genome. The value now lies in the ability to evaluate this data and extract insights, particularly as it applies to healthcare. Imagine searching for that same typo in those same 14 sets of Encyclopedia Britannica, but now with the help of a word processing program. This is a big data problem with a countless number of software solutions.<sup>8</sup> And the applications are numerous, from personalized medicine to personalized nutrition.

This characteristic, the ability to take genomics and tailor personalized solutions, has led to a large influx of private investment from the pharmaceutical industry, as well as venture capital.

FIGURE 3.1 SEQUENCING COST PER GENOME



Source: NHI NHGRI, 2016; San Diego Regional EDC

**2013**

Genomics England set up to deliver the 100,000 genomes project

**2014**

Cost to sequence a genome falls below \$1,000

**2017**

Edico Genome takes rapid genome analysis technology into the cloud

**2010**

J. Craig Venter Institute creates first minimal synthetic cell

**2013**

Life Technologies is acquired by Thermo Fisher Scientific

**2016**

The Scripps Research Institute is awarded \$120 million grant for large-scale genomics study with 1+ million participants

## GLOBAL INITIATIVES

Several global initiatives have invested heavily in precision medicine projects featuring genome sequencing of individuals in the population or health systems, among other things.

### ALL OF US

All of Us, formerly the Precision Medicine Initiative, is a private-public collaboration that will leverage advances in genomics, data science and health information technology to accelerate biomedical discoveries. The initiative will also engage one million Americans to volunteer their health data to improve health outcomes, fuel development of new treatments and spark a new era of data-driven precision medicine. Complementing existing investments that broadly support research and development, President Obama's 2016 Budget proposed a \$215 million investment for the National Institutes of Health (NIH), including \$70 million to the National Cancer Institute (NCI), to scale efforts to identify genomic drivers and develop more effective treatment approaches for cancer.<sup>9</sup>

### PERSONAL GENOME PROJECT - HARVARD

Harvard's Personal Genome Project is the pilot project and member of the Global Network of Personal Genome Projects (PGP), a group of research studies creating freely available scientific resources that bring together genomic, environmental and human trait data donated by volunteers. Initiated by George Church at Harvard Medical School in 2005, the PGP has pioneered ethical, legal and technical aspects related to the creation of public resources involving sensitive data like human genomes. PGP Harvard hosts publicly-shared genomic and health data from thousands of participants.<sup>10</sup>

### GENOME PROJECT-WRITE

In 2016, Genome Project-write was launched with the goal of raising \$100 million to form a Center of Excellence for Engineering Biology to drive down the cost of genome engineering 1,000-fold in ten years. The Center will create a neutral environment for international participants and will accept funding from the public, private, philanthropic and academic sectors. This new, independent nonprofit organization will manage initial planning and coordination efforts, including supporting the formation and work of multi-institutional and interdisciplinary research teams that will be responsive to and engaged with the broader public.<sup>11</sup>

### 100,000 GENOME PROJECT

The U.K. Prime Minister launched the 100,000 Genomes Project in late 2012 to bring the predicted benefits of genomics to National Health Service (NHS) patients. Genomics England, a company wholly owned and funded by the Department of Health, was set up to deliver this flagship project, which will sequence 100,000 whole genomes from NHS patients by 2017. The project focuses on patients with rare diseases and their families, as well as patients with cancer. It aims to create an ethical and transparent program to bring benefit to patients and set up a genomic medicine service for the NHS, to enable new scientific discovery and medical insights and to spur the development of a U.K. genomics industry.<sup>12</sup>

# 4

# ECONOMIC IMPACT

## HIGHLIGHTS

**\$5.6B**

SAN DIEGO'S GENOMICS INDUSTRY HAS \$5.6B ANNUAL ECONOMIC IMPACT

**10K**

SAN DIEGO HAS 115+ CORE GENOMICS FIRMS, EMPLOYING OVER 10,000 PEOPLE

**3.5**

FOR EVERY DIRECT JOB IN GENOMICS, ANOTHER 2.5 JOBS ARE SUPPORTED IN THE ECONOMY

**2.4%**

IN 2016, GENOMICS ACCOUNT FOR 0.7% OF TOTAL EMPLOYMENT BUT 2.4% OF GRP

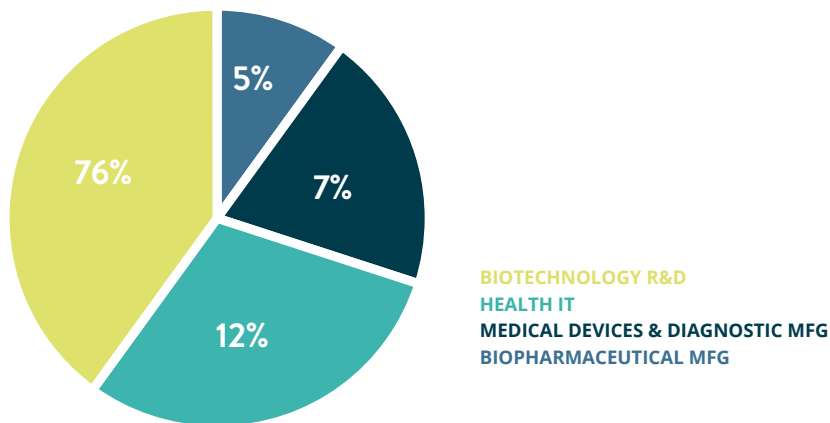


## INDUSTRY OVERVIEW

At its core, genomics is an interdisciplinary field drawing from multiple industries including biotechnology, biomedical devices, biopharmaceutical manufacturing and health IT.

In this section, the emerging industry will be deconstructed, providing additional detail on each contributing industry. It will also quantify total genomics employment, establishments and overall economic impact on San Diego's regional economy.

**FIGURE 4.1: GENOMICS FIRMS BY INDUSTRY**



Source: San Diego Regional EDC; BW Research

### A NOTE ON FIRM COUNTS & EMPLOYMENT ESTIMATES

Generating an estimate of genomics-related employment proved challenging, as it intersects multiple industries; employment numbers serve as the foundation for determining the total economic impact of an industry. Employment estimates were collected through the use of multiple sources and verified where possible by survey responses. For more information, see full methodology in Appendix C.

## INDUSTRY BREAKDOWN

### BIOTECHNOLOGY RESEARCH & DEVELOPMENT

San Diego's deep and powerful network of academic institutions, research institutes, laboratories and commercial entities work collaboratively on fundamental research to unlock the power of the human genome, fueling advancements in modern medicine and science. Accounting for more than 60 percent of genomics employment, research and development is the predominant driving force of the genomics industry.

### BIOMEDICAL DEVICE & DIAGNOSTIC EQUIPMENT

Medical device manufacturing is a cornerstone of the region's life sciences cluster. San Diego has emerged as a pioneer in sequencing technologies and a global leader in the production of Next-Generation Sequencing (NGS) devices.

### HEALTH IT

As society moves toward precision medicine as the standard of care, the analysis, interpretation, and storage of genetic data become increasingly vital. The region's robust tech ecosystem is driving the integration of technology into healthcare and allowing practitioners to deliver data-driven healthcare solutions.

### BIOPHARMACEUTICAL MANUFACTURING

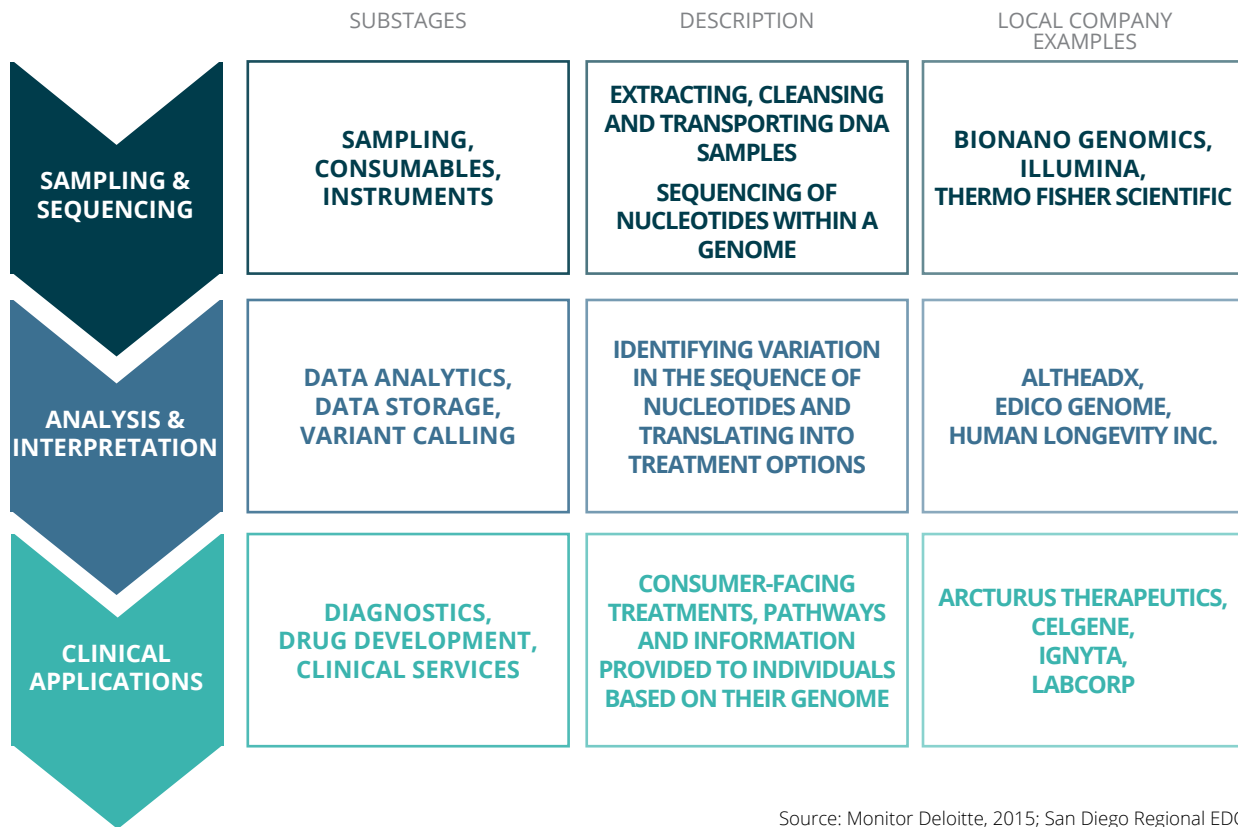
As pharmacogenomics - the study of how an individual's genetic makeup affects their response to drugs - comes to the forefront of genomic applications in medicine, San Diego's pharmaceutical industry will continue to be a key player in bringing new drugs and therapies to market.

Note: Detailed descriptions of the genomics industry, including NAICS and IMPLAN industries used can be found in Appendix C.

## THE GENOMICS VALUE CHAIN

The genomics value chain can be broken into three distinct stages: sampling and sequencing, analysis and interpretation and clinical application. Each stage builds on the previous, requiring different capabilities and offering increasing value.

**FIGURE 4.2: STAGES OF THE VALUE CHAIN**



Source: Monitor Deloitte, 2015; San Diego Regional EDC

The foundational technologies of genomics include everything from the physical sampling of DNA, through blood and saliva samples, to the sequencing of the genome itself using high-tech equipment. This requires clinicians and diagnostic laboratories, as well as specialized manufacturing capabilities. While sequencing currently represents the largest part of the value chain, it has limited growth potential as the hardware becomes commoditized.

The power of software and machine learning accelerates the value of genomics data through rapid analysis and accurate interpretation. Data scientists and medical scientists work together to identify disease-causing variants and mutations in DNA and provide useful insights for clinical treatment. Advances in computing technology are taking these capabilities into the cloud, further reducing the cost of sequencing and data storage.

The final stage of the genomics value chain is clinical applications. Pharmaceutical companies and healthcare providers are beginning to use genomic information to inform drug development and provide personalized therapies. This is where the true potential lies. As technologies improve and economies of scale are reached, commercialization will accelerate. More importantly, humanity will have personalized medicine that treats each individual with the distinct care that they require.<sup>13</sup>

## SAN DIEGO IS END-TO-END GENOMICS

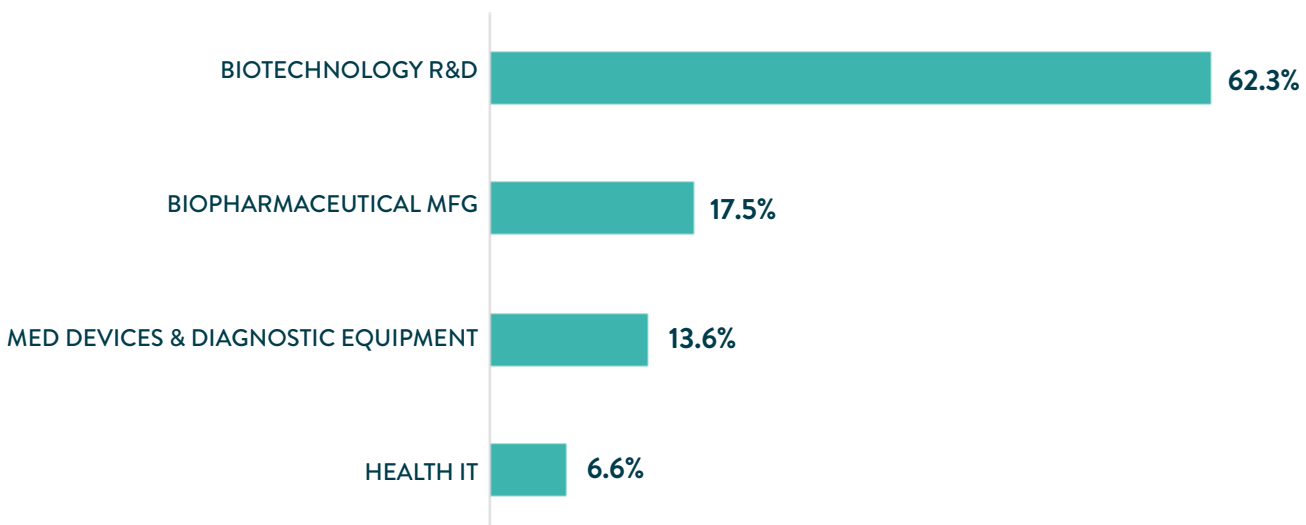
As the most genomics patent-intensive region in the U.S.<sup>14</sup>, San Diego has created fundamental technologies that have helped advance genomics-related industries, both locally and around the globe, as well as the supply chain. Moreover, San Diego's genomics ecosystem covers the industry from end-to-end; it begins with the local research institutes that make revolutionary discoveries. One such example being Salk Institute, which genetically engineers viruses for use in gene therapies. One by-product of the ongoing research at universities and research institutes is valuable intellectual property. These patents are the kernel for innovative technologies and therapies, providing the first concrete step to commercialization. The research community, in conjunction with local incubators and accelerators, also serves as an entrepreneurial hotbed, spawning the next generation of genomics startups. It is often these new companies that develop cutting-edge technologies, such as Edico Genome's DRAGEN NGS bioinformatics processor. Translational medicine bridges the gap between the lab and the clinic, with institutes such as Scripps Translational Science Institute or Rady Children's Institute for Genomic Medicine putting these novel technologies and therapies to work in a clinical setting that improve health outcomes for people suffering from chronic and life-threatening diseases.

## INDUSTRY EMPLOYMENT

In 2016, an estimated 10,055 people were directly employed in the local genomics industry. The overwhelming majority - approximately 62 percent - were employed in biotechnology research and development. Approximately 18 percent of employment was in biopharmaceutical manufacturing, 14 percent in medical devices and diagnostic equipment and the remaining seven percent in health IT.

According to a recent report released by Biocom, employment in San Diego's life sciences industry totaled 49,763 in 2016. This means that local genomics operations represent more than 20 percent of the region's life sciences cluster.<sup>15</sup> As a share of total regional employment, the genomics industry accounted for 0.7 percent of all payroll employment in the region in 2016.

**FIGURE 4.3: GENOMICS EMPLOYMENT BREAKDOWN, 2016**



Source: Reference USA; California Employment Development Department; San Diego Regional EDC

## ECONOMIC IMPACT OF SAN DIEGO'S GENOMICS INDUSTRY

The economic impacts of the genomics industry on the regional economy are tremendous. Starting with the estimated 10,055 employment base, an input-output analysis was conducted in order to quantify the industry's total impacts of the firms locally, including direct and indirect employment, value-added and multiplier effects.

### EMPLOYMENT IMPACT

In addition to the 10,055 direct jobs in the genomics industry, an additional 12,720 jobs were supported through indirect effects resulting from additional non-industry purchases in the supply chain. Another 12,240 jobs are supported from household expenditures made by employees in the genomics industry.

When considering direct, indirect and induced effects, the genomics industry impacted more than 35,000 jobs in 2016.

GENOMICS EMPLOYMENT REPRESENTED ONLY **0.7%** OF TOTAL EMPLOYMENT IN 2016 BUT ACCOUNTED FOR MORE THAN **2.4%** OF GROSS REGIONAL PRODUCT

**FIGURE 4.4: ECONOMIC IMPACTS OF GENOMICS INDUSTRY IN 2016 DOLLARS**

Impact Type	Employment	Value Added (\$ Millions)	Wages (\$ Millions)
Direct	10,055	\$2,955	\$1,577
Indirect	12,720	\$1,532	\$1,033
Induced	12,240	\$1,085	\$607
<b>Total Effect</b>	<b>35,015</b>	<b>\$5,572</b>	<b>\$3,217</b>
Multiplier	3.5	1.9	2.0

Source: IMPLAN Group, LLC; California Employment Development Department; San Diego Regional EDC

### GROSS REGIONAL PRODUCT

Genomics produces a sizable contribution to the regional economy, totaling \$5.6 billion in gross regional product in 2016. Similar to employment, the multiplier for economic activity is high, reflecting above-average wages and the high value of manufactured goods such as sequencing devices, pharmaceuticals and other diagnostic equipment produced by the industry.

**3.5X**

**JOB MULTIPLIER:** FOR EVERY DIRECT JOB IN THE GENOMICS INDUSTRY, ANOTHER 2.5 ARE SUPPORTED ELSEWHERE IN THE ECONOMY

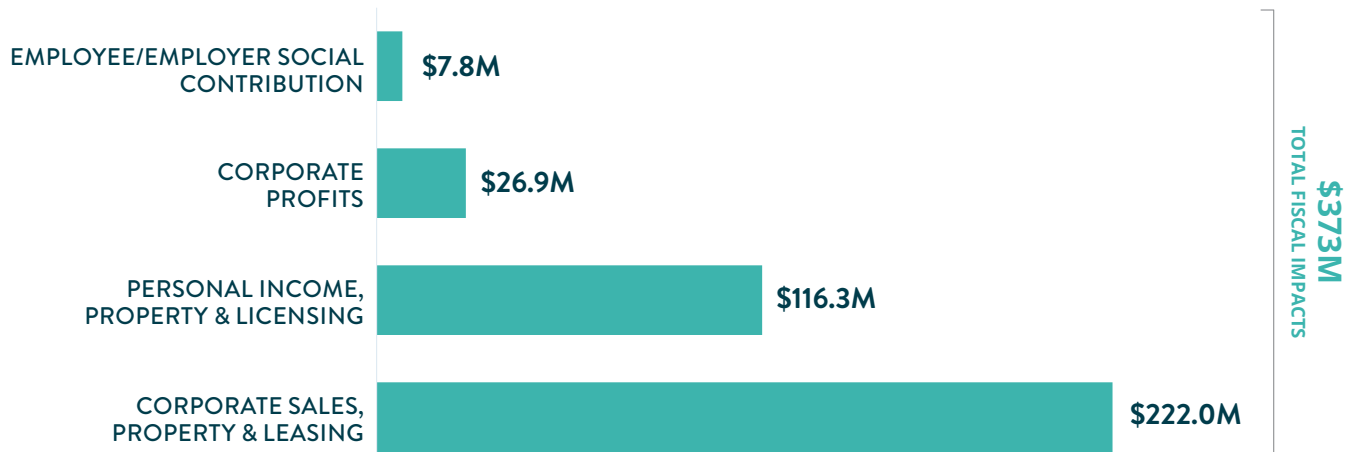
### IMPACT OF GENOMICS ON THE U.S. ECONOMY

Another 2012 study evaluating the impacts of genomics on the U.S. economy found the industry directly employs 53,594 nationwide, with another 223,767 jobs supported. This equates to a total of \$18.9 billion in wages. The study also found the national genomics industry adds \$30.7 billion to the U.S. economy, resulting in \$3.9 billion in federal tax revenues and another \$2.1 billion in state and local tax revenues.<sup>16</sup>

## FISCAL IMPACTS

Fiscal impacts, including state and local taxes, generated by the genomics industry provide an additional economic boost. The total fiscal impact in 2016 attributable to the genomics industry, including direct, indirect and induced activity, totaled \$373 million. This includes property taxes paid by firms and households, sales taxes on consumer purchases, personal and corporate income and payroll taxes paid for and by employees.

**FIGURE 4.5: FISCAL IMPACTS OF GENOMICS INDUSTRY, IN 2016 DOLLARS**



Source: IMPLAN Group, LLC; California Employment Development Department; San Diego Regional EDC

# 5

# EVALUATING OUR ECOSYSTEM

## HIGHLIGHTS

#1

SAN DIEGO IS THE MOST PATENT-INTENSIVE REGION, GENERATING 371 GENOMICS PATENTS BETWEEN 2014 AND 2016

22%

SAN DIEGO RECEIVED NEARLY 22 PERCENT OF ALL GENOMICS-RELATED VC INVESTMENT IN 2016

#1

HIGHEST CONCENTRATION OF GRADUATES WITH GENOMICS-RELATED DEGREES IN 2015

10%

KEY GENOMICS OCCUPATIONS ARE PROJECTED TO GROW 10 PERCENT FROM 2016 TO 2021

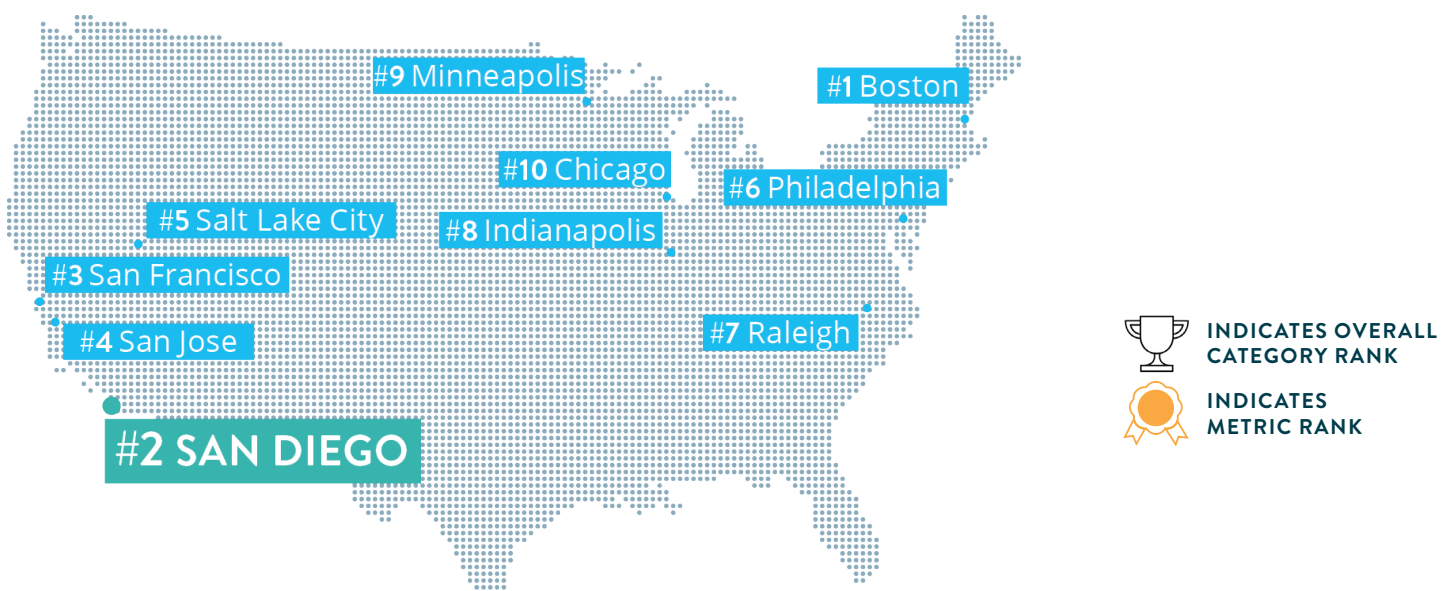
## GENOMICS SCORECARD

San Diego's genomics industry represents a growing share of the region's economy. By comparing San Diego's genomics ecosystem to that of nine other major life sciences metros, it becomes clear that there are strengths and competitive advantages that have made San Diego an internationally recognized hub for genomics. It also helps to identify opportunities for improvement. For purposes of comparison, the top ten life sciences markets<sup>17</sup> are scored and compared to one another in three categories of metrics designed to evaluate the genomics ecosystem: innovation, talent and growth. The resulting genomics scorecard grades every metro in each of the three categories, in addition to providing an overall composite score and ranking. This section elucidates the quantitative and qualitative factors that contribute to San Diego's successful ecosystem.

FIGURE 5.1: GENOMICS SCORECARD METRICS

INNOVATION	TALENT	GROWTH
<p><b>FEDERAL FUNDING</b> Avg. Annual Federal Funding for Genomics 2014-2016 (per \$mil GDP)</p> <p><b>VENTURE CAPITAL</b> Avg. Annual VC Dollars Received by Genomics Companies 2014-2016 (per \$mil GDP)</p> <p><b>PATENT INTENSITY</b> Patents in Genomic Technologies (per 100K workers)</p>	<p><b>TALENT PIPELINE</b> Degree Completions in Genomics-Related Fields (per 10k workers)</p> <p><b>TALENT POOL</b> Concentration of Genomics Occupations in the Workforce (Location Quotient)</p> <p><b>TALENT SPECIALIZATION</b> % of Genomics Occupations in Life Sciences Industry</p>	<p><b>UNIQUE JOB POSTINGS</b> Unique Genomics Job Postings in 2016 (per 10k workers)</p> <p><b>PROJECTED GROWTH</b> Projected Genomics Occupation Growth 2016-2021 (%)</p> <p><b>HISTORIC GROWTH</b> Historic Genomics Occupation Growth 2011-2016 (%)</p>

FIGURE 5.2: METRO RANKINGS



## INNOVATION

San Diego has an exceptional track record for creating incredibly valuable intellectual property, attracting large sums of both public and private investment. This is important because in a constantly evolving industry like genomics, capital fuels growth. The region's ecosystem of top-ranked universities, distinguished research institutes and high-growth startups are making the discoveries and building the technologies that change the world.

*“ Boston has a big a pharmaceutical industry, the Bay Area has Silicon Valley, but San Diego has a culture of life sciences innovation that really sets us apart.”*

**Magda Marquet, Co-Founder, Ajinomoto Althea & AltheaDx**



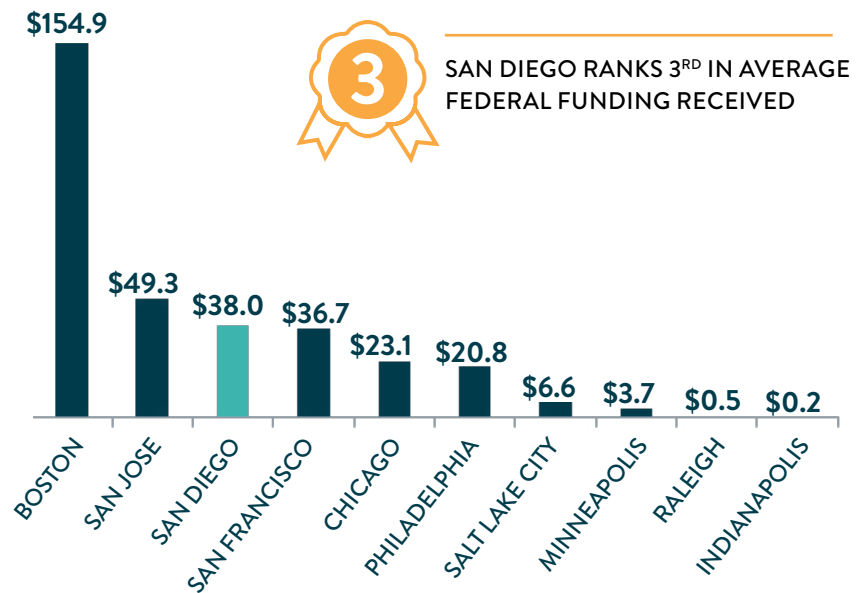
SAN DIEGO RANKS 2<sup>ND</sup> IN INNOVATION

## FEDERAL FUNDING

The caliber of San Diego's research institutions draws global recognition and, perhaps more importantly, national funding. In 2016, San Diego received \$34.2 million in federal grant funding for genomics research. This is an amount consistent with that of the previous two years, and on par with both San Francisco and San Jose. Boston, by far the largest recipient of federal grant dollars, dwarfed all other metros with \$464.2 million over the last three years.

In terms of federal contract dollars, which support term employment for specific projects from the National Human Genome Research Initiative (NHGRI), San Diego dominates, receiving \$3.2 million of the \$11.5 million awarded in 2016. In fact, since 2014, San Diego has commanded more than one out of every three dollars in federal contracts from NHGRI.

**FIGURE 5.3: AVERAGE ANNUAL FEDERAL FUNDING, 2014-2016, IN MILLIONS**



Source: San Diego Regional EDC; USA Spending.gov

*“ Government is in the business of stimulating new discoveries. Even if only a fraction of projects succeed, the economic impacts are huge. This genomics ecosystem works because of the initial investment of government, the hard work of researchers and the inventiveness of entrepreneurs.”*

**Dr. Bing Ren, Director, UC San Diego Center for Epigenomics**



## SPOTLIGHT: CLINICAL, FUNDAMENTAL & TRANSLATIONAL RESEARCH

San Diego's globally recognized research institutes are the foundation of innovation; the source of groundbreaking advances in biosciences and translational research that result in life-changing discoveries and therapies. They are also the birthplace of numerous startups and licensed technologies that have propelled San Diego's broader innovation cluster. San Diego research institutes directly employ more than 18,000 people and have a combined economic impact of \$4.6 billion, receiving more NIH research funding and generating more patents than any other U.S. metro area.<sup>18</sup> The region is home to a large number of research institutes dedicated to advancing genomics science in both basic research and clinical application.<sup>19</sup>

### THE SCRIPPS TRANSLATIONAL INSTITUTE

The mission of the Scripps Translational Science Institute (STSI) is to replace one-size-fits-all-medicine with individualized healthcare that is based on the known genetic factors influencing health and disease and that takes advantage of advances in digital technology for real-time health monitoring. Connecting the facilities of Scripps Health with the Scripps Research Institute is transforming how clinical and translational research is conducted, ultimately enabling researchers to provide new treatments more efficiently and quickly to patients.<sup>20</sup>

### SALK INSTITUTE OF BIOLOGICAL STUDIES

In the 1960s, the City of San Diego donated 27 acres to Jonas Salk to build the Salk Institute for Biological Studies and zoned the spectacular Torrey Pines Mesa for the development of science and technology. With an annual budget of \$118 million, Salk's research provides insight and potential therapies for diseases from cancer and Alzheimer's, to autism and diabetes. Salk also has three centers focused on genomics science: the Helmsley Center for Genomic Medicine investigates inflammation as the underlying cause of many chronic diseases, the Center for Nutritional Genomics employs a molecular approach to nutrition and its impact on the role of metabolism and the Center of Excellence in Stem Cell Genomics.<sup>21</sup>

### UC SAN DIEGO CENTER FOR EPIGENOMICS

The UC San Diego Center for Epigenomics is interested in understanding the molecular basis of cancer and other human diseases. The center is divided into two general areas: the development of genomics and bioinformatics tools, and the application of those tools. The former is focused on study of the regulation and function of the human genome, development of innovative technologies and computational tools, while the latter is tasked with connecting the fundamental knowledge of gene regulation to clinical research.<sup>22</sup>

### J. CRAIG VENTER INSTITUTE

The J. Craig Venter Institute was formed in October 2006 through the merger of several affiliated and legacy organizations, including The Institute for Genomic Research, The Center for the Advancement of Genomics, The J. Craig Venter Science Foundation and others. Together, they have become a multidisciplinary genomic-focused organization with more than 250 scientists and staff. The institute has many accomplishments including the sequencing of a variety of important infectious disease agents, and in 2014 was awarded a five-year, \$25 million NIH grant to establish a genome center for infectious diseases.<sup>23</sup>

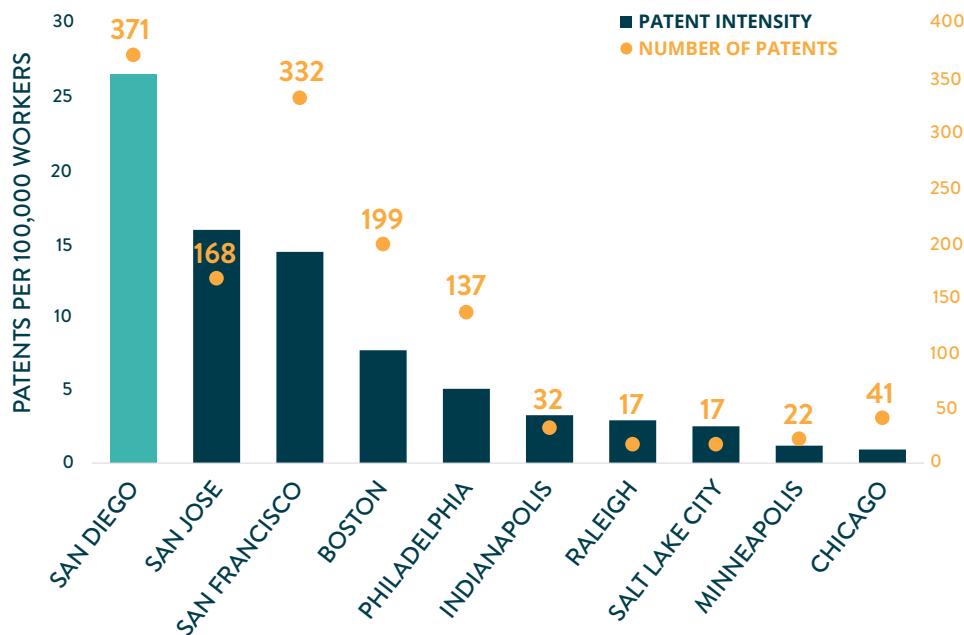
## PATENTS

Federal funding is important in supporting research and development. The millions of dollars that fund basic scientific research have resulted in breakthrough discoveries and intellectual property that underpin billion-dollar companies. San Diego is the most genomics patent-intensive metro in the country. From 2014 to 2016, San Diego led the way, generating 371 genomics-related patents. Collectively, 28 firms in San Diego generated 120 genomics-related patents in 2016 alone.



SAN DIEGO RANKS 1<sup>ST</sup>  
IN PATENT INTENSITY

FIGURE 5.4: GENOMICS PATENTS BY METRO, 2014-2016



Source: San Diego Regional EDC; CBRE Research; United States Patent & Trademark Office

## INCUBATORS & ACCELERATORS

San Diego’s nurturing environment goes beyond the foundational research, development and federal funding. San Diego is home to dozens of incubators, accelerators and nonprofits focused on helping innovators grow their new businesses. From resource-rich groups like Startup San Diego, all the way to funding networks like Seed San Diego, and everything in between, the region fosters breakthrough discoveries through their development and into market.

For a full list of incubators and accelerators please refer to Appendix B.

### SPOTLIGHT: EVONEXUS

EvoNexus is the only community-supported, fully pro-bono technology incubator that provides full services to startups where companies pay no fees and give up no equity. EvoNexus has received more than 1,500 applications, has 163 companies in its portfolio and 42 companies currently incubating. One of its graduates is Edico Genome, who recently raised \$22 million in a Series B financing from a group led by Dell Technologies Capital and Qualcomm Ventures. Edico Genome was founded in 2013 and employs 50 people, mostly engineers and software developers. It aims to revolutionize genome sequencing analysis providing unprecedented speed, scale and accuracy with its DRAGEN™ processor - the world’s first NGS reconfigurable bioinformatics processor. This processor analyzes large amounts of data, generated by NGS, rapidly, accurately and inexpensively - overcoming a key bottleneck in the DNA sequencing workflow.

## VENTURE CAPITAL

Advancements in genomics have not gone unnoticed by private investors. In 2014, VC investment in genomics sharply accelerated reaching \$1.1 billion nationally and more than double the \$450 million from the year prior. Despite representing only one percent of the U.S. population, San Diego attracted nearly 22 percent of total VC investment in the genomics industry in 2016 - a sum of \$292 million. While the dollar volume has been high in recent years, the number of deals has been relatively low and deal flow has been concentrated in three markets—Boston, San Francisco and San Diego. In 2016, these three markets accounted for 90 percent of all VC dollars in genomics, despite only receiving roughly half the deals (27 out of 47). San Diego-based Human Longevity, Inc. received \$220 million in 2016 alone, which accounted for 16.4 percent of total U.S. investment in genomics.<sup>24</sup> Given that the industry is still relatively young, deal and dollar flow in recent years has fluctuated significantly, but should become more consistent as the number of investment opportunities continues to grow.

“ San Diego has been able to achieve its status without the funding that other areas have received which is a testament to the collaborative nature of the region; as a start-up you have to band together because you don’t have this unlimited resource. It’s a culture of necessity. And everybody’s gone through that hardship so more established firms are happy to pay it forward to the next generation of startups.”

Gavin Stone, Vice President of Marketing, Edico Genome

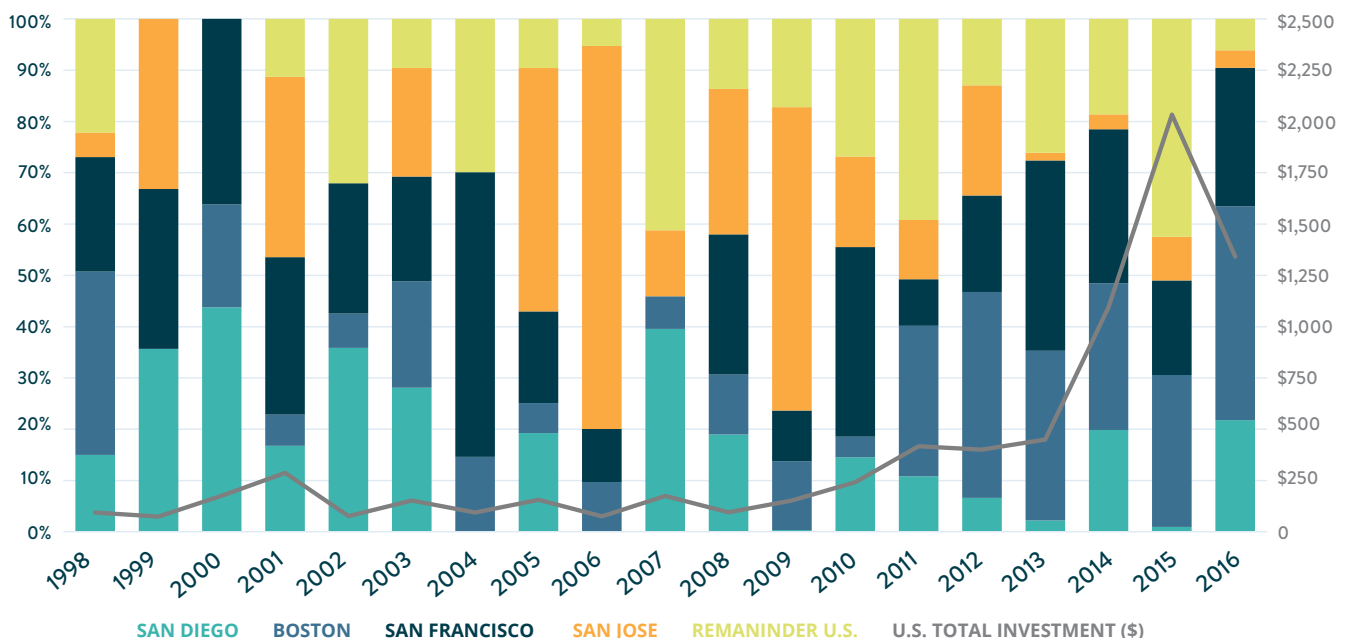
22%

OF TOTAL VC DOLLARS WENT TO SAN DIEGO IN 2016



SAN DIEGO RANKS 3<sup>RD</sup> IN VENTURE CAPITAL RECEIVED

FIGURE 5.5: DISTRIBUTION OF VENTURE CAPITAL INVESTMENT, 1998-2016



Source: San Diego Regional EDC; CBRE Research; Pitchbook Data, Inc.

Extraordinary talent is the driving force behind the genomics revolution. This interdisciplinary field is at the intersection of biological and data sciences, requiring a highly-specialized workforce with a wide range of technical skills. While rooted in the biological sciences, rigorous mathematical and programming skills are increasingly critical, as the field continues to move toward interpretation and analysis.

*“In San Diego, we’ve become known for having more molecular biology Ph.Ds. per capita than any other city in the country. We have a large, scientifically trained workforce focused on DNA sequencing and DNA-related activities. No other city has that to the same level.”*

Joseph Panetta, President & CEO, Biocom



SAN DIEGO RANKS 2<sup>ND</sup> IN TALENT



SAN DIEGO RANKS 3<sup>RD</sup> FOR OCCUPATION CONCENTRATION

includes bioinformaticians, geneticists and molecular and cellular biologists. This is not to say there are no other occupations present, but these key occupations are considered to be at the core of the industry, fueling scientific breakthroughs and technological advancements. These five occupations are held by nearly 7,000 people in San Diego, and represent the pool of available talent with the right set of skills for genomics companies. The concentration of people employed in these key occupations is 3.1 times greater than the national average.<sup>25</sup>

## A CONCENTRATION OF TALENT

Key genomics occupations were gathered by conducting a review of job postings and staffing patterns of the more than 115 genomics companies in the region. The key occupations include biological technicians, medical scientists (excluding epidemiologists) and biological scientists, which

### KEY OCCUPATIONS FOR A THRIVING GENOMICS ECOSYSTEM<sup>26</sup>

#### BIOINFORMATICIAN

Conduct research in areas such as pharmaceuticals, medical technology, biotechnology, computational biology, proteomics, computer information science, biology and medical informatics. May design databases and develop algorithms for processing and analyzing genomic information, or other biological information.

#### BIOLOGICAL TECHNICIAN

Assist biological and medical scientists in laboratories. Install, operate and maintain laboratory instruments and equipment, monitor experiments, make observations and calculate and record results. May analyze organic substances, such as blood, food and drugs.

#### GENETICIST

Research and study the inheritance of traits at the molecular, organism or population level. May evaluate or treat patients with genetic disorders.

#### MEDICAL SCIENTIST

Conduct research dealing with the understanding of human diseases and the improvement of human health. Engage in clinical investigation, research and development or other related activities. Includes physicians, dentists, public health specialists, pharmacologists and medical pathologists who primarily conduct research.

#### MOLECULAR & CELLULAR BIOLOGISTS

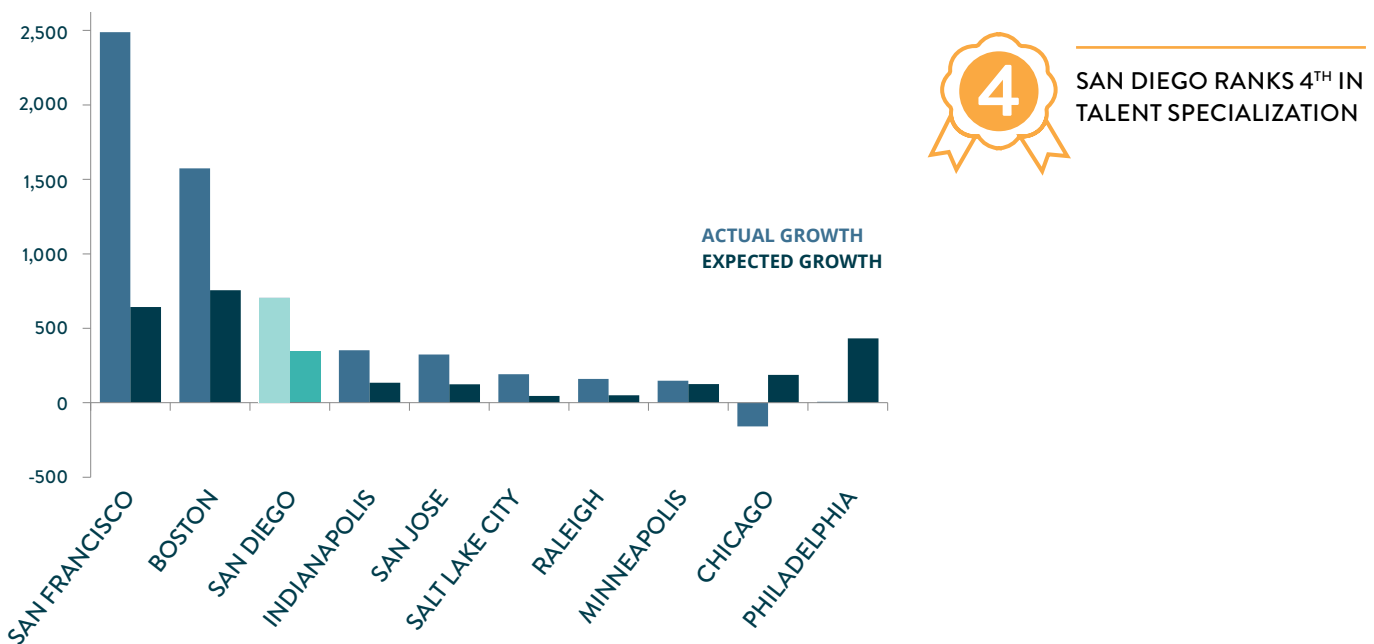
Research and study cellular molecules and organelles to understand cell function and organization.

Source: Onetonline.gov

## EXCEEDING EXPECTATIONS

The concentration of key genomics occupations rose over the past five years, a trend that is expected to continue into the future. As expected, industry growth has been widespread since 2011. The majority of the top ten markets exceeded those expectations, but not all. Both Chicago and Philadelphia fell short; in fact, Chicago saw a net decline in key genomics occupations over the last five years. Given industry trends and market size, San Diego was expected to add 343 jobs in key genomics occupations from 2011 to 2016, but instead added 704. The additional 361 jobs created cannot be attributed to national, industry or occupation-specific trends, but rather is demonstrating particular regional strengths.

FIGURE 5.6: EXPECTED VS ACTUAL GROWTH IN KEY OCCUPATIONS, 2011-2016

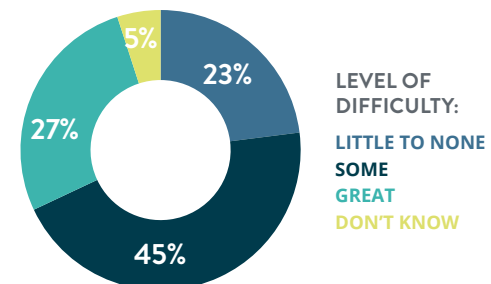


Source: San Diego Regional EDC; EMSI

## TALENT SPECIALIZATION

While the region has a large concentration of people employed in these five key occupations, not all of them are working in the field of genomics. These occupations are found across multiple industries in the physical and life sciences. Out of the roughly 7,000 people employed in the key occupations, there are 1,898 people employed directly in genomics.<sup>27</sup> This represents about 27 percent of those in possession of the key skills sought by the genomics industry. Competition for these highly-skilled employees is stiff, which may help to explain why genomics employers indicate having some difficulty finding qualified applicants.

FIGURE 5.7: ABILITY TO FIND QUALIFIED APPLICANTS



Source: San Diego Regional EDC; Survey by BW Research (n = 32)

## LOCAL TALENT PIPELINE

Companies engaged in this innovative ecosystem benefit from their proximity to world-class universities. The region's academic institutions play a vital role in supplying the talent needed to drive the industry's growth. As the field continues to grow and evolve, local universities and community colleges continue to adapt their curriculum to meet the region's demand and deliver graduates that are equipped with the necessary skills and training to enter the workforce.



**SAN DIEGO RANKS 1<sup>ST</sup> IN GENOMICS GRADUATE PIPELINE PER 10,000 JOBS**

The region's academic institutions offer 12 of the 22 identified academic programs (see appendix for complete list) that prepare students for a career in genomics.<sup>28</sup> In 2015, local institutions conferred nearly 2,000 degrees across these 12 academic programs, supplying the region with the highly-specialized talent needed to feed the industry. Responsible for nearly 55 percent of conferred degrees, UC San Diego is the predominant source of talent for the region. The university's rigorous academic curriculum, as well as its access to lab training alongside top researchers, prepares the students for a career of life changing discovery.

## THE RISE OF BIOINFORMATICS

The convergence of data and life sciences is most apparent in the field of bioinformatics - the use of computational approaches to analyze biological data. In the fall of 2001, UC San Diego formalized curriculum around bioinformatics as a specialization within a number of departments including biology, computer sciences and bioengineering.<sup>29</sup> The program has blossomed into one of the most respected in the country, offering nationwide research opportunities to undergraduate students as well as a doctorate program. In 2015, UC San Diego conferred 42 bioinformatics degrees.<sup>30</sup> Overall, the region graduated 51 students with degrees in bioinformatics in 2015, more than any other metro.

**FIGURE 5.8: GENOMICS-RELATED DEGREES CONFERRED BY INSTITUTION, 2015**

Institution	Graduates
University of California San Diego	1,073
San Diego State University	283
University of San Diego	141
California State University San Marcos	113
Other local academic institutions	346
<b>Total</b>	<b>1,956</b>

Source: San Diego Regional EDC; EMSI; IPEDS



**SAN DIEGO CONFERS THE MOST DEGREES IN BIOCHEMISTRY, COGNITIVE SCIENCE AND BIOINFORMATICS PROGRAMS.<sup>31</sup>**

## SOFTWARE: THE BRIDGE BETWEEN SEQUENCING TECHNOLOGY AND CLINICAL RESEARCH

With the ability to now rapidly sequence the human genome, companies are increasingly focused on decoding and understanding the complex interactions of the genome to develop and commercialize data-driven healthcare solutions. The complexity and sheer size of genomics data requires software talent to write and validate predictive algorithms that help run these diagnostic applications. The nearly 22,000 software developers in the region are twice as likely to work in scientific research and development as developers elsewhere in California. This makes software developers a crucial component of the genomics talent pool. In 2015, local institutions graduated more than 2,150 students from software-related degree programs that can complement and collaborate with the region's genomic-specialized talent.<sup>32</sup>

## COMPETING FOR TALENT

An analysis of professional online profiles shows that, since 2010, about half of the region's alumni who go into these key occupations now reside outside of the region.<sup>33</sup> Approximately 9 percent moved to San Francisco and another 3 percent are in Boston. Although some of these alumni likely returned to their hometown. In order to remain competitive in the future, devising strategies to retain locally-produced talent is essential.

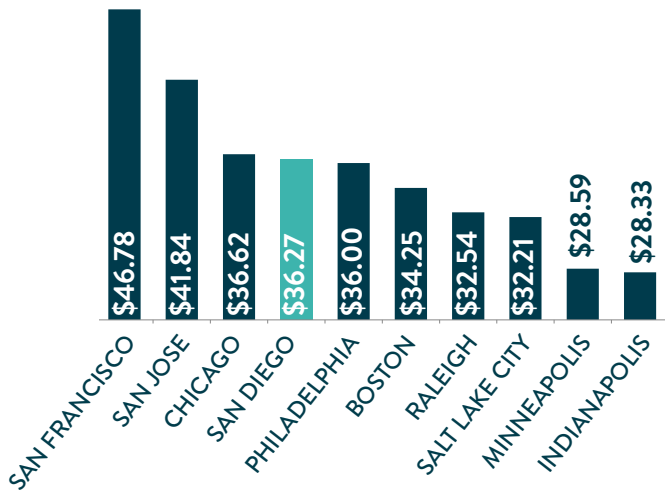
## RECRUITING TALENT

In an effort to attract new talent into the region, the San Diego Venture Group led a recruitment event, Tacos and Tech, in the Bay Area. It was accompanied by genomics giants Illumina, Thermo Fisher Scientific and Human Longevity Inc. to showcase San Diego's opportunities for new graduates.

## WAGES IN GENOMICS

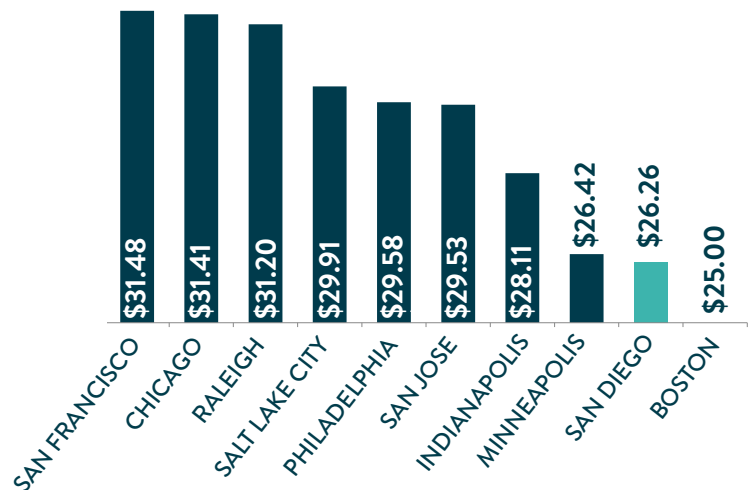
Although these are all well-paying jobs, wages vary across the ten metros. While San Diego fares better than most, with a median hourly wage of \$36.27, the same job can pay the equivalent of \$10 more per hour in San Francisco. Furthermore, once cost of living differences are taken into account, San Diego wages become far less competitive. The adjusted median hourly earnings drop to \$26.26; this is only slightly better than Boston's \$25.00, which is the lowest adjusted wages among the ten metros.

**FIGURE 5.9: MEDIAN HOURLY EARNINGS BY METRO, 2016**



Source: San Diego Regional EDC; EMSI

**FIGURE 5.10: COST OF LIVING MEDIAN HOURLY EARNINGS BY METRO, 2016**



Source: San Diego Regional EDC; EMSI

## SPOTLIGHT: PREPARING THE NEXT-GEN WORKFORCE

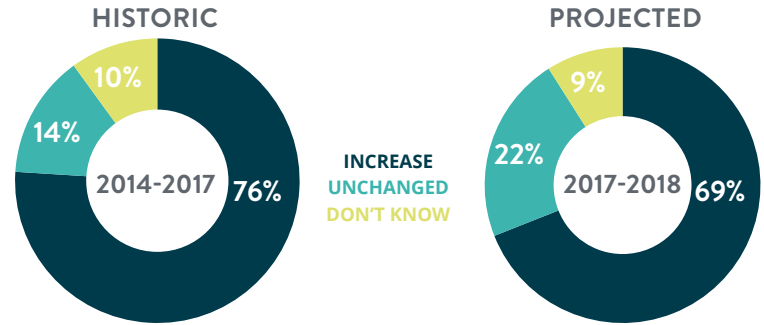
UC San Diego's Center for Epigenomics is led by Dr. Bing Ren, who has been with the lab more than 15 years researching the functional annotation of the human genome. The lab employs 20 people, including a core of 15 researchers. The lab also offers UCSD students internship and lab assistant opportunities. This provides students with valuable training and preparation for entering a highly-technical job market. Many of the Dr. Ren's students and lab trainees go on to work for local genomics companies such as Illumina.<sup>34</sup>

## A THRIVING INDUSTRY

In a relatively short period of time, San Diego's genomics industry has flourished. Once limited to a handful of key players, the industry has grown to include more than 115 companies and continues to expand at an impressive rate.

Over the past three years, more than three quarters of local genomics firms expanded their workforce, growing by an average of 68 percent. The outlook for growth in the near-term future is also positive, with 69 percent of firms indicating they intend to hire over the next 12 months.<sup>35</sup>

FIGURE 5.11: EMPLOYER REPORTED GROWTH



Source: San Diego Regional EDC; Survey by BW Research (n = 32)



SAN DIEGO RANKS 4<sup>TH</sup> IN TALENT

## A GROWING TALENT POOL

From 2011 to 2016, San Diego's genomics talent pool grew by 11 percent, far outpacing the national growth rate of 5 percent. It is projected that the local talent pool for key occupations will grow by an additional 10 percent by 2021. By comparison, key occupations are expected to grow by 6 percent nationally during the same time frame. Compared to its peer metros, San Diego's historic growth rate in key occupations lags, ranking seven out of ten. Moving forward, however, San Diego is one of a few markets where a double-digit rate of growth is projected.<sup>36</sup>

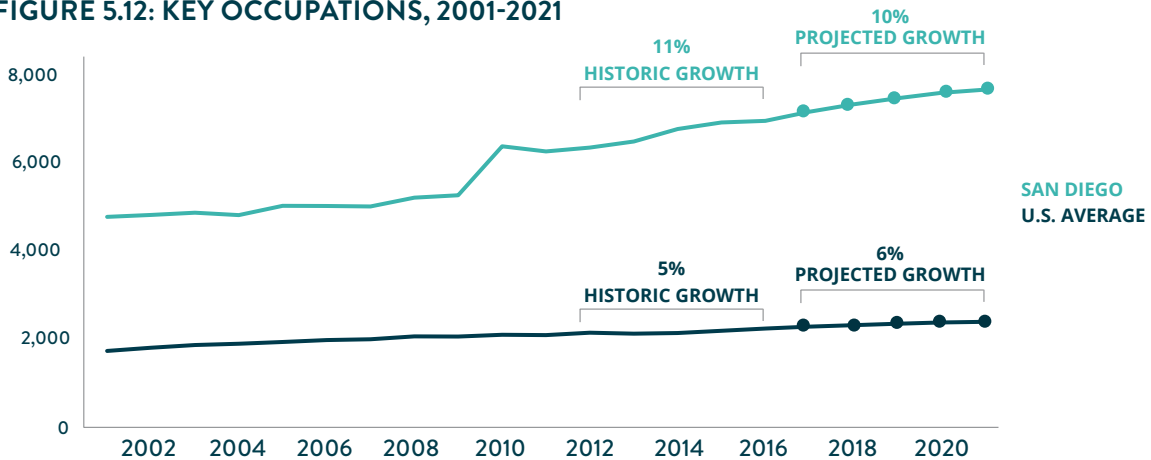


SAN DIEGO RANKS 3<sup>RD</sup> FOR PROJECTED GROWTH IN GENOMICS OCCUPATIONS



SAN DIEGO RANKS 7<sup>TH</sup> FOR HISTORIC GROWTH IN GENOMICS OCCUPATIONS

FIGURE 5.12: KEY OCCUPATIONS, 2001-2021



Source: San Diego Regional EDC; EMSI



## GENOMICS: HELP WANTED!

Demand for talent is indicative of industry growth. In just three short years, annual genomics-related job postings grew by more than 120 percent.<sup>37</sup>

In 2016, there were 2,940 unique genomics job postings regionwide. Each of these jobs was posted an average of six times. This is lower than the average posting intensity for all occupations in the region (7-to-1), indicating that key occupations in genomics may be filled more quickly.

FIGURE 5.13: GENOMICS JOB POSTINGS, 2016



Source: San Diego Regional EDC; EMSI

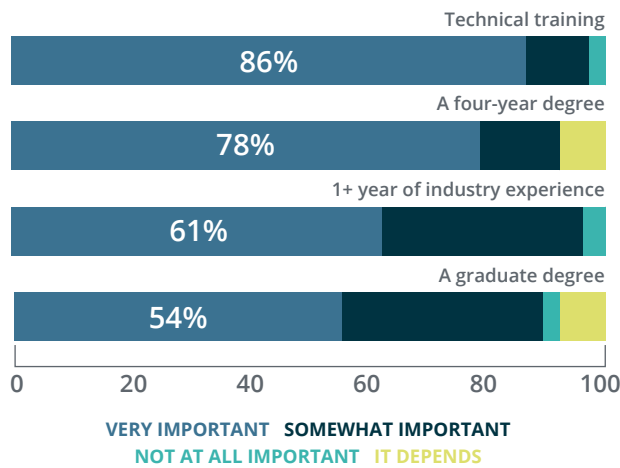


**SAN DIEGO RANKS 3<sup>RD</sup> FOR  
UNIQUE GENOMICS JOB POSTINGS**

**120%**

**GROWTH IN GENOMICS-RELATED  
JOB POSTINGS 2013-2016**

FIGURE 5.14: EDUCATION & EXPERIENCE MATTER



Source: San Diego Regional EDC; Survey by BW Research (n = 32)

## SPECIALIZED SKILLS & TRAINING

More than half of local genomics firms surveyed say it is very important for job candidates to have laboratory skills, such as running experiments using instruments and reagents relevant to genomics.

Firms were just as likely to want candidates to possess software skills, such as programming and data analytics.<sup>38</sup> Yet, companies want more than technical training and work experience. More so than in other innovation industries, genomics firms want college educated employees; and more often than not, they want people with graduate degrees.

## EVOLUTION OF EMPLOYER NEEDS

Human Longevity, Inc., a genomics-based company founded in 2013 by Craig Venter, is combining big data with the power of machine learning to transform the practice of medicine and improve personal health outcomes. With the growing appeal in understanding the connection between personal genetic data and overall health, many companies like HLI are growing quickly to meet the demands of consumers. In just three short years, HLI has grown from a small startup of 30 to a team of roughly 300 employees. While genomics research is at the core of its operations, the company now offers a suite of products, including its [Health Nucleus platform](#), to consumers, necessitating additional skillsets beyond traditional research and development, or programming. In the case of HLI, adding genetic counselors to its occupational roster was a must in order to properly serve their customer base.<sup>39</sup>



## THE RISE OF PRECISION MEDICINE

The sequencing of the human genome represents one of the single most influential advancements in modern science. Today, genome sequencing has become commonplace in research laboratories, and the continued proliferation of sequencing in clinical applications and precision medicine is inevitable.

Looking ahead, the opportunities and promises for the field of genomics are abundant. The ultimate promise of the future is figuring out how to use personal genetic data to enhance peoples' lives through preventing, diagnosing and treating chronic illnesses and delivering personalized medical solutions. Its potential for use in medical applications is limitless, from the treatment of cancer and other chronic illnesses to diagnosing infectious and rare diseases. Innovation in genome sequencing technologies is showing no signs of slowing and it is possible that in the near future, the cost of sequencing will drop below \$100. The path to precision medicine as the standard of care, however, is still beset with many challenges.

## BARRIERS TO INNOVATION

### INSURANCE REIMBURSEMENTS

While there is a strong, mounting body of evidence that genomic medicine provides clinically useful information and provides the ability to better predict, prevent and treat many diseases, widespread implementation of this medical science and technology hinges on the coverage and reimbursement standards of insurances companies. Currently, the need for more data and analysis on the economic utility of genomic testing is an impediment to reimbursement decisions.<sup>41</sup>

### REGULATORY ENVIRONMENT

Tasked with ensuring the validity and accuracy of medical devices and laboratory-developed tests (including some genomic tests), the Food and Drug Administration (FDA) wields tremendous power to regulate genomic testing. Some regulations limit what types of genetic information can be shared with consumers. The continuing debate within the scientific community is whether or not the FDA is well-equipped to effectively regulate the industry without hindering innovation or stifling new discoveries.<sup>42</sup>

### WIDESPREAD ADOPTION OF GENOME SEQUENCING

Genetically speaking, humans are more alike than they are different; each human possesses a 0.1 percent variation in genetic makeup – however, this minute variation can lead to substantial differences in biological processes and outcomes. Scientists must be able to compare genomes across tens of the thousands of people, healthy and sick, in order to truly understand the role of genetic variations and environmental factors on health outcomes.<sup>43</sup>

### SPOTLIGHT: SEQUENCING TO SAVE LIVES

At Rady Children's Institute for Genomic Medicine, Dr. Stephen Kingsmore and his team are working to make genomic medicine the standard of care in diagnosing and treating childhood genetic diseases. Dr. Kingsmore is credited with the world record for fastest sequencing of a genome. Using sequencing technology developed by Illumina, Dr. Kingsmore and his staff work daily to diagnose critically ill infants with unknown conditions. Rady is also investing in fundamental genomics research, leveraging San Diego's diverse population to develop a more comprehensive database of human genomes and disease, ultimately contributing to the broader body of genomics research and benefitting all of humanity.<sup>44</sup>

## SAN DIEGO IS THE FUTURE OF GENOMICS

Through the hard work and continued collaboration of a dedicated and diverse life sciences community, San Diego has established itself as a global leader in genomics. Every day, local research institutes, universities and firms work together to solve some of the most complex problems in science and medicine. It is these factors that have positioned the San Diego region to shape the future of genomics and precision medicine.

### KEY TAKEAWAYS

#### SAN DIEGO IS LEADING THE WAY IN GENOMICS, CREATING A PLATFORM FOR PRECISION MEDICINE

Intellectual property is the foundation for nearly every commercial technology and revolutionary therapy. In research facilities and laboratories around the region, groundbreaking discoveries fuel the production of intellectual property. From 2014 to 2016, the region generated 371 genomics-related patents, making it a leader and the most patent intensive genomics market in the nation.

#### SAN DIEGO IS END-TO-END GENOMICS

San Diego's genomics industry truly does it all. From the fundamental research at some of the world's leading academic institutions and research institutes, to the production of sequencing technology, to implementation of discoveries and therapies in a clinical setting, the region handles every aspect and stage of the industry - a complete ecosystem.

#### SAN DIEGO IS AN ATTRACTIVE MARKET FOR INVESTMENT IN GENOMICS

San Diego is home to one percent of the nation's population, yet collected nearly 22 percent, or \$292 million, of all genomics related venture capital in 2016. The region is rife with investment opportunity, as local incubators, accelerators, universities and research institutes churn out the next wave of trailblazing startups.

#### SAN DIEGO'S GOT TALENT

From medical scientists, to biologists, to laboratory technicians, software programmers and geneticists, a highly-skilled workforce is a pre-requisite for any successful genomics ecosystem. In 2016, San Diego's genomics talent pool was 3.1 times more concentrated than the national average, giving it a competitive advantage. Furthermore, San Diego's local universities conferred more than 2,000 degrees across 22 genomics-related degree programs, giving it the number one standing in the nation for the production of genomics talent.

### SPOTLIGHT: COLLABORATION IN ACTION

In 2016, Dr. Eric Topol, founder and director of the Scripps Translational Science Institute (STSI), was awarded a record \$120 million grant from the NIH to help recruit one million volunteers for President Obama's All of Us initiative. This ambitious study is designed to help scientists collect a wide variety of data on health with the goal of better understanding the influence of individual genetic makeup on wellness and chronic disease.

Dr. Topol and his team have found a creative way to garner participation. Taking its cues from a [successful partnership](#) between Illumina and the San Diego Blood Bank (SDBB) in 2015, STSI has teamed up with SDBB to recruit volunteers for their study. Blood donors can choose to provide an extra blood sample that will be used by Scripps for the study. By leveraging this existing channel through SDBB, Scripps is able to reach a large, genetically diverse population of people who are more likely and willing to share their personal health data for the sake of advancing science. It is partnerships such as these that highlight how strong alliances in San Diego are shaping the future.<sup>45</sup>



*“ It’s much more than genomics; San Diego is the ultimate place for research, sequencing technologies and the demonstration of human longevity, giving us a natural platform for precision medicine.”*

**Mark Stevenson**, Executive Vice President & President  
of Life Sciences, Thermo Fisher Scientific

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San Diego Regional EDC's mission is to maximize the region's economic prosperity and global competitiveness.

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**THIRTY-THREE**

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**Bioinformatics** is an interdisciplinary field that develops methods and software tools for understanding biological data. Can be an umbrella tool for the body of biological studies that use computer programming as part of their methodology as well as specific analysis pipelines repeatedly used, particularly in the fields of genetics and genomics.

**Biomarkers** is a word derived from “biological marker,” which indicates a substance or physical event that can be measured and correlated with health, disease or drug treatment. One practical example of a macroscopic biomarker for cardiovascular disease is the measurement of blood pressure. At the molecular level, the expression of certain genes is used as biomarker to determine the appropriate therapy for cancer patients. Biomarkers are thus a key component of Personalized Healthcare approaches. Appropriate biomarkers are also essential to design clinical studies and to define their intended or expected outcome. Diagnostic methods aim at identifying and quantifying disease-relevant biomarkers.

**DNA**, or deoxyribonucleic acid, is a self-replicating material which is present in nearly all living organisms as the main constituent of chromosomes. It is the carrier of genetic information.

**DNA polymerases** are enzymes that create DNA molecules by assembling nucleotides, the building blocks of DNA.

**DNA sequencing** is the process of determining the precise order of nucleotides within a DNA molecule. It includes any method or technology that is used to determine the order of the four bases - adenine, guanine, cytosine and thymine - in a strand of DNA.

**Epigenome** consists of a record of the chemical changes to the DNA and histone proteins of an organism; these changes can be passed down to an organism’s offspring.

**Genomics** is a discipline in genetics that applies recombinant DNA. DNA sequencing methods and bioinformatics to sequence, assemble and analyze the function and structure of.

**Gene therapy** is the therapeutic delivery of nucleic acid polymers into a patient’s cells as a drug to treat disease. The polymers are either expressed as proteins, interfere with protein expression, or possibly correct genetic mutations.

**Next Generation Sequencing** (NGS) applies to genome sequencing, genome resequencing, transcriptome profiling (RNA-Seq), DNA-protein interactions (ChIP-sequencing) and epigenome characterization.

**Nucleotides** are organic molecules that serve as the monomers, or subunits, of nucleic acids like DNA and RNA.

**Pharmacogenomics** is the study of how the genome can influence an individual’s response to drugs. Still a nascent application, pharmacogenomics will radically alter the precision medicine landscape through the development of tailored drugs to treat a variety of chronic diseases including cancer, Alzheimer disease and cardiovascular disease.

**Precision Medicine**, or personalized medicine, is medical care designed to optimize efficiency or therapeutic benefit for particular groups of patients, especially by using genetic or molecular profiling.

**RNA**, or ribonucleic acid, helps carry out this blueprint’s guidelines. Of the two, RNA is more versatile than DNA, capable of performing numerous, diverse tasks in an organism, but DNA is more stable and holds more complex information for longer periods of time.

TABLE B.1: SAN DIEGO INCUBATORS, ACCELERATORS &amp; OTHER RESOURCES

NAME	DESCRIPTION	WEBSITE	CATEGORY
Accelerate-IT Advisors	Match your increased momentum with increased power. Our Startup Acceleration Program means that your business will be ready to rise to the next level and our Lifecycle Growth Management approach means we can help you through every phase of a startup's maturation, from inception to liquidity.	<a href="http://accelerateit.com/">http://accelerateit.com/</a>	Accelerator
Analytics Ventures	A bi-national Accelerator that brings to entrepreneurs its strong understanding of technology, marketing, sales, capital and early stage growth. Actively help companies with financing strategy, business development, customer introductions and team development.	<a href="http://www.analytics-ventures.com/">http://www.analytics-ventures.com/</a>	Incubator
Ansir Innovation Center	An incubator for emerging startups. The Ansir Innovation Center provides startups with a variety of services, including co-working spaces and weekly networking events.	<a href="http://ansirsd.com/">http://ansirsd.com/</a>	Incubator
Bio, Tech and Beyond (BTNB)	A non-profit open innovation laboratory dedicated to life science research. BTNB provides access to many of the molecular tools of modern medicine. Researchers can develop disease bio-markers in cell cultures, clone new genes and develop diagnostic markers, side by side with engineers using 3D printing and the latest automation technology to create the next generation of life science tools.	<a href="http://biotechnbeyond.com">http://biotechnbeyond.com</a>	Incubator
Biotech Incubator of San Diego	The North County Biotech Incubator is managed by CJ Lopek Associates LLC. It has fully furnished biotech labs available on short term leases in a convenient North County location.	<a href="http://www.biotechincubatorofsandiego.org/">http://www.biotechincubatorofsandiego.org/</a>	Incubator
Collective 1939	A coworking accelerator for a collective of neoteric entrepreneurs, innovators and creatives bringing ideas to life based in El Cajon.	<a href="http://sdtechscene.org/venues/collective-1939/">http://sdtechscene.org/venues/collective-1939/</a>	Accelerator
CONNECT Springboard Program	Springboard is CONNECT's flagship program. It is designed to assist science and technology companies with marketing, financial and strategic business advice.	<a href="http://www.connect.org/entrepreneur-experience">http://www.connect.org/entrepreneur-experience</a>	Entrepreneurship Mentoring
Cyber Hives	Non-profit incubator program that delivers business and technical support to early stage companies providing cyber security and high tech related products and services.	<a href="http://cybertechnetwork.org/cyberhive/">http://cybertechnetwork.org/cyberhive/</a>	Incubator
EvoNexus	Non-profit high-tech trade organization. Only community-supported, fully pro-bono technology incubator that provide full services to startups. Such as furnished office space, domain experts and mentors and the opportunity to leverage wide network of business and VC contacts.	<a href="http://evonexus.org/">http://evonexus.org/</a>	Incubator
Fab Lab San Diego	Connects people with technology through education, both for youth and adults, developing partnerships locally in order to create site-specific learning programs. Lab users and students have receive no-cost staff attention, training, machine use and even the materials needed to create their ideas.	<a href="http://www.fablabbsd.org/">http://www.fablabbsd.org/</a>	Training
Founder Institute	The world's largest startup accelerator. The Founder Institute is an early-stage startup accelerator that provides a four month program to help entrepreneurs launch their dream company.	<a href="http://fi.co/">http://fi.co/</a>	Accelerator
Hera Labs	Hera LABS is a unique business accelerator for aspiring entrepreneurial women. The program provides female startups, in all industries, a safe place to test ideas and grow their business.	<a href="http://www.heralabs.com/">http://www.heralabs.com/</a>	Accelerator
Impact Without Borders	An accelerator for companies, nonprofits, cooperatives, activists, artists and entrepreneurs committed to positive, sustainable change.	<a href="http://www.impactwithoutborders.com/">http://www.impactwithoutborders.com/</a>	Accelerator
JLABS	JLABS is part of Johnson & Johnson's external research and development department. Independent emerging companies can progress their research with access to core research labs hosting specialized capital equipment and shared administrative areas.	<a href="http://jllabs.jnjinnovation.com/locations/san-diego">http://jllabs.jnjinnovation.com/locations/san-diego</a>	Incubator

TABLE B.1: SAN DIEGO INCUBATORS, ACCELERATORS & OTHER RESOURCES (CONTINUED)

NAME	DESCRIPTION	WEBSITE	CATEGORY
Lab Fellows	San Diego co-lab and equipment sharing network making infrastructure accessible to academic, entrepreneur and industry scientists.	<a href="https://www.labfellows.com/">https://www.labfellows.com/</a>	Incubator
MakerPlace	MakerPlace is a San Diego based accelerator that provides workspace for entrepreneur inventors including metal, wood and electronics shop equipment.	<a href="http://makerplace.com/">http://makerplace.com/</a>	Incubator
Plug and Play San Diego	Co-invest in early high-tech companies in the city, to accelerate their growth. Provides access to the resources and infrastructure essential to building rapidly growing and profitable enterprises.	<a href="http://sandiego.plugandplaytechcenter.com/">http://sandiego.plugandplaytechcenter.com/</a>	Accelerator
ScaleMatrix	The ScaleMatrix Launch Center is a unique Life Science & Technology accelerator and coworking space designed to help early stage businesses develop, grow and reach their goals sooner. The Launch Center offers a low cost of entry for traditional office and business services while providing access to industry-leading Life Science and Technology resources which are critical to the success of every business today.	<a href="https://www.scalematrix.com/">https://www.scalematrix.com/</a>	Accelerator
The Startup Leadership Program	A highly selective, 80-hour, 6-month global program which trains the next generation of startup leaders, helping them build a local community of entrepreneurs with international reach.	<a href="http://www.startupleadership.com/chapters/9/">http://www.startupleadership.com/chapters/9/</a>	Entrepreneurship Mentoring
The Wireless Health Hub	Run by SoCal EED, creating seed accelerators and business incubators which are industry focused. Wireless Health Hub offers focused programs, combining industry-specific Seed Accelerators with Business Incubators.	<a href="http://wirelesshealthhub.org">http://wirelesshealthhub.org</a>	Incubator
The Zahn Innovation Center	The Zahn Innovation Center is a commercial and social incubator that supports San Diego State University innovators and aspiring entrepreneurs, students, faculty and staff from any major or department on campus as they transform their ideas into companies.	<a href="http://newscenter.sdsu.edu/gratzahncenter/home.aspx">http://newscenter.sdsu.edu/gratzahncenter/home.aspx</a>	Incubator
UCSD Institute for the Global Entrepreneur	The Institute for the Global Entrepreneur encompasses education and training programs, mentoring and strategic partnerships, all working toward a common goal: preparing engineers and MBA students to become change makers, technical leaders and entrepreneurs who drive innovation within organizations both large and small. The Institute is a collaboration between the UC San Diego Jacobs School of Engineering and Rady School of Management. It is dedicated to training global technology leaders and translating university discoveries to the marketplace.	<a href="http://jacobs.school.ucsd.edu/ige/index.sfsf">http://jacobs.school.ucsd.edu/ige/index.sfsf</a>	Entrepreneurship Mentoring
UCSD The Basement	The Basement is a campus-wide resource that all university students – regardless of college or department affiliation can access. Any student with an idea for a business or product concept can apply to join The Basement. Students accepted to the program are provided space and mentorship to develop their business and product concepts. The Basement also hosts open workshops and programs accessible to all students and the community.	<a href="http://www.ucsdbasement.com/">http://www.ucsdbasement.com/</a>	Entrepreneurship Mentoring

## EMPLOYMENT METHODOLOGY

### KNOWN UNIVERSE

Similar to many emerging industries, genomics is not yet captured exclusively by any one North American Industrial Classification System (NAICS) code. In fact, the majority of genomics firms identified fall primarily within Scientific Research & Development Services (5417), with many also falling within various manufacturing NAICS codes. As an interdisciplinary field spanning research and development in biotechnology, manufacturing, software as well as data analysis and processing, identifying firms in the genomics industry is challenging. An initial list procured from [genomicscapital.com](http://genomicscapital.com), which includes roughly 80 firms, was used as the starting point from which to build a known universe of genomics firms in the San Diego region. The list was supplemented with records obtained through a targeted search on ReferenceUSA by InfoGroup, as well as information from California Employment Development Department, and for some records, aided in determining firm size and year established. Additional details and validation came from the quantitative survey executed by BW Research. The Genomics Advisory Committee was consulted throughout the process, providing feedback and recommendations to enhance the database. Ultimately, roughly 115 core genomics firms were found to currently exist.

### EMPLOYMENT ESTIMATES

For purposes of this study, MIG IMPLAN, a widely accepted tool for economic impact assessment, was used to assess the indirect and induced impacts on employment, value added (gross regional product), labor income (wages) and taxes. Indirect impacts are the effects of local industries buying goods and services from other industries. For instance, management consultants, law firms, market research and other establishments generate local impacts through their buying and selling activities with software development firms. Induced impacts are a result of employees at these firms spending their wages in the local economy, usually on food services, medical services, housing and leisure. The inputs for the model came from the results of defining the Known Universe. Total employment for each NAICS code was converted to IMPLAN codes using the built-in code bridge in the IMPLAN software.

**TABLE C.1: EMPLOYMENT BREAKDOWN BY IMPLAN CODE**

IMPLAN Code	Description	Employment Input
174	Pharmaceutical preparation manufacturing	1,650
175	In-vitro diagnostic substance manufacturing	110
314	Electromedical and electrotherapeutic apparatus manufacturing	110
320	Analytical laboratory instrument manufacturing	120
379	Surgical and medical instrument manufacturing	1,030
395	Wholesale trade	110
422	Software publishers	500
430	Data processing, hosting, and related services	20
449	Architectural, engineering, and related services	115
451	Custom computer programming services	120
453	Other computer related services, including facilities management	20
455	Environmental and other technical consulting services	10
456	Scientific research and development services	4,880
478	Outpatient care centers	30
479	Medical and diagnostic laboratories	1,230

## SCORECARD METHODOLOGY

### CONCEPT

In order to more accurately and clearly compare metros, this study used an indexing approach to measure the relative contribution of key factors for a thriving genomics industry. The goal of this approach was to take complex metrics (e.g. genomics-related occupation concentration) and translate them into an easily understandable scale, with a max score of 100. The study used a common “classroom-style” indexing methodology based on standardized values, and weighted metrics, mostly evenly, based on the judgment of the research team. The result is nine total metrics across three categories of innovation, talent and growth. For a detailed description of each measure, see the table on the following page.

### METRO SELECTION METHODOLOGY

Given the volume and complexity of the data, the research team narrowed the field of markets for review to the top ten life science metros. The ten markets were determined by first limiting the list of metros to those with populations greater than 1 million, resulting in 53 metros). The research team then took the ten markets with the highest concentration of their employment in life sciences. The employment concentration was determined using the North American Industry Classification System’s (NAICS) codes: 325412, 325413, 339112 and 541711.

### WEIGHTING

Each of the three categories (Talent, Innovation and Growth) is weighted equally as one-third of the final score. For each category there are three metrics; these metrics are weighted equally, with the exception of the talent category. The talent category is unbalanced in order to lessen the impact of talent specialization (reduced to 20% weight) and increase the weight of the other two categories. This is done because the talent pool metric already reflects an element of the talent specialization metric and, along with the talent pipeline metric, is considered to be more important. This was a judgment made by the research team and did not impact the final rank or significantly change the talent rank. Weighting decisions were made before standardization and tallying. Each category score was then re-weighted equally as one-third of the final score.

### STANDARDIZATION

In order to index around an average, the research team had to first standardize the values before weighting. Standardization is a simple formula based on the mean and standard deviation of a data set:

Standard Value = (Base Value - Mean)/Standard Deviation.

This makes every value in the data set a reflection of how many standard deviations it is from the mean, with the new mean set to zero. Standard values are typically very small numbers, generally ranging from -2.5 to +2.5. The size of these values make it challenging to draw meaningful comparisons. Therefore, in order to make a more intelligible comparison, the team multiplied standard values by ten and scaled the max value to 100. The relative distance of each metro from the max value became the other metro scores. For example, if Metro1 has the highest score and is +2.0 standard deviations from the mean, Metro1 would have a score of 20. Since 20 is the max, we would add 80 to make it 100, which would mean every score below 20 would also get 80 added to it.

Indexed Score = (100-(10\*MAX('MSA1:MSA10')))+('MSAx'\*10)

where MSA1:MSA10 is the pool of MSAs studied, and MSAx is each individual MSA’s standard value.

## QUANTITATIVE SURVEY

BW Research developed and administered a telephone and online survey to assist with meeting the research objectives of the study. In developing the survey instrument, BW Research utilized techniques to overcome known biases in survey research and minimize potential sources of measurement error within the survey.

Prior to beginning data collection, BW Research conducted interviewer training and pre-tested the survey instrument to ensure that all words and questions were easily understood by the respondents. The data collection period spanned four weeks from April 11 through May 9, 2017. The survey took approximately 9 minutes to complete, and was completed by 32 genomics firms in the San Diego Metropolitan area. The table below provides an overview of the survey methodology utilized for the project.

### OVERVIEW OF SURVEY METHODOLOGY

Method	Telephone (Mobile & Land Line) and Online Survey
Universe	Businesses engaged in genomics in the San Diego Metro area
Number of Respondents	32 genomics firms
Average Length	9 minutes per survey
Collection Period	April 11 through May 9, 2017

Based on the findings of the quantitative survey, BW Research developed a discussion guide to conduct executive interviews with leaders in the San Diego genomics industry. Executive interviews were completed by EDC Staff with decision makers and hiring managers at different genomics firms and research institutes. The main goals of the executive interviews were to provide explanations for quantitative findings and explore issues driving specific trends. As challenges, trends and outcomes were identified through the secondary data analysis and quantitative survey, interviews allowed for greater context behind these quantitative factors.

## SECONDARY DATA ANALYSIS

Secondary data analysis was performed by EDC staff using data from EMSI and ReferenceUSA.com that was pulled in Q2 2017. EMSI was used for economic and labor market analysis in order to understand and quantify the genomics industry in San Diego. Industry and employment concentrations, as well as trends in occupations, sales and educational attainment were all analyzed. EMSI data is sourced from the Bureau of Economic Analysis, U.S. Census Bureau, Bureau of Labor Statistics, U.S. Department of Education and a number of private sources including Infogroup and professional online profiles.

TABLE D.1: SCORECARD METHODOLOGY SUMMARY TABLE

Category	Metric	Description	WEIGHT (WITHIN CATEGORY)	SOURCES	SEARCH PARAMETERS	NOTES
Innovation	Federal Funding	Avg. Annual Federal Funding for Genomics 2014-2016, per \$mil GDP	0.33	USASpending.gov; Bureau of Economic Analysis	Keywords: Genome, Genomic, Nucleic Acid, Sequencing (for grants only)	Federal funding consists of grant and contract data from the Department of Health and Human Services. Grant Data used keywords to identify genomics-specific dollars. Contracts do not have fields in which a keyword search is useful; therefore, the research team limited the data to contracts from the National Human Genome Research Initiative (NHGRI). Dollars are shown as a share of GDP to account for relative concentration, not overall size.
	Venture Capital	Avg. Annual VC Dollars Received for Genomics Technologies 2014-2016, per \$mil GDP	0.33	Pitchbook; Bureau of Economic Analysis	Keywords: Genome, Genomic, Nucleic Acid, Sequencing	VC dollars were identified using a Pitchbook keyword search. Dollars are shown as a share of GDP to account for relative concentration, not overall size.
	Patent Intensity	Patents in Genomic Technologies, per 100k workers	0.33	USPTO; EMSI	Keywords: Genome, Genomic, Nucleic Acid, Sequencing	Patents were identified using a keyword search on the USPTO's PatentsView tool. The value is shown as a share of the workforce to account for relative concentration, not overall size. This is a common method for showing patent intensity.
Talent	Talent Pipeline	Degree Completions in Genomics-Related Fields, per 10k workers	0.40	EMSI 2017.2	See CIP code list	EMSI uses data from the Integrated Postsecondary Education Database (IPEDS) to measure degree completions. Genomics-related fields were chosen based on their likelihood to result in a profession on the list of key Genomics occupations. Completions are weighted to the size of the overall workforce to account for relative concentration, not overall size.
	Talent Pool	Location Quotient of Genomics Occupations	0.40	EMSI 2017.2	See Genomics SOC codes	This measure uses EMSI's occupation figures to measure the concentration of key occupations related to genomics. Location quotient is a way to measure intensity of a region relative to the U.S. average. Formula: $(\text{GenomicsJobsMSA} / \text{TotalJobsMSA}) / (\text{GenomicsJobsUSA} / \text{TotalJobsUSA})$ where GenomicsJobs are those on the SOC list.
	Talent Specialization	Proportion of Key Occupations in Genomics	0.20	EMSI 2017.2	See Genomics SOC codes and Life Science NAICS Codes	While the list of genomics occupations is heavily associated with the field, many who work in those occupations work in fields outside of the life sciences. This measures the specialization or concentration of the talent pool who work in life science sectors.
Growth	Unique Job Postings	Unique Genomics Job Postings in 2016, per 10k workers	0.33	EMSI 2017.2	Keyword: genomics; See Genomics SOC codes	Unique Job Postings denotes the number of de-duplicated job advertisements listed by different companies on career sites and job boards, in order to best approximate demand for certain jobs.
	Projected Growth	Projected Genomics Occupation Growth 2016-2021 (%)	0.33	EMSI 2017.2	See Genomics SOC codes	This measure uses EMSI's occupation projections to estimate the percentage change in key occupations related to genomics.
	Historic Growth	Historic Genomics Occupation Growth 2011-2016 (%)	0.33	EMSI 2017.2	See Genomics SOC codes	This measure uses EMSI's occupation figures to measure the percentage change in key occupations related to genomics.



**TABLE D.2: STANDARD OCCUPATION CLASSIFICATION (SOC) TABLE**

SOC	Description
19-1029.01	Bioinformatics Scientists
19-1029.02	Molecular and Cellular Biologists
19-1029.03	Geneticist
19-1042.00	Medical Scientists, Except Epidemiologists
19-4021.00	Biological Technicians

Source: ONetonline.gov

**TABLE D.3: CLASSIFICATION OF INSTRUCTIONAL PROGRAM (CIP) CODES USED FOR GENOMICS-RELATED DEGREES**

CIP CODE	Program
26.0101	Biology/Biological Sciences, General
26.0102	Biomedical Sciences, General
26.0202	Biochemistry
26.0204	Molecular Biology
26.0499	Cell/Cellular Biology and Anatomical Sciences, Other
26.0503	Medical Microbiology and Bacteriology
26.0801	Genetics, General
26.0802	Molecular Genetics
26.0806	Human/Medical Genetics
26.0807	Genome Sciences/Genomics
26.0899	Genetics, Other
26.091	Pathology/Experimental Pathology
26.1103	Bioinformatics
26.1104	Computational Biology
26.1199	Biomathematics, Bioinformatics, and Computational Biology, Other
26.1201	Biotechnology
26.1309	Epidemiology
26.1501	Neuroscience
26.1503	Neurobiology and Anatomy
30.2501	Cognitive Science
41.0101	Biology Technician/Biotechnology Laboratory Technician
51.1401	Medical Scientist

Source: EMSI, NCES, IPEDS

**TABLE D.4: GENOMICS SCORECARD SUMMARY**

Overall Rank	MSA	Overall Score	Innovation		Talent		Growth	
			Score	Rank	Score	Rank	Score	Rank
1	Boston	91.3	92.1	1	98.2	1	83.7	5
<b>2</b>	<b>San Diego</b>	<b>90.1</b>	<b>90.4</b>	<b>2</b>	<b>94.7</b>	<b>2</b>	<b>85.4</b>	<b>4</b>
3	San Francisco	87.7	83.0	4	89.5	3	90.7	2
4	San Jose	82.2	83.6	3	75.6	7	87.3	3
5	Salt Lake City	77.1	64.4	7	74.6	8	92.3	1
6	Philadelphia	75.9	71.9	5	86.4	4	69.4	10
7	Raleigh	75.4	62.4	10	81.6	5	82.3	6
8	Indianapolis	73.5	62.4	9	79.9	6	78.2	7
9	Minneapolis	72.0	69.3	6	73.6	9	73.2	8
10	Chicago	68.6	62.4	8	73.2	10	70.3	9

**TABLE D.5: GENOMICS SCORECARD FULL DETAIL**

MSA	Innovation			Talent			Growth		
	Federal Funding	Venture Capital	Patent Intensity	Talent Pipeline	Talent Pool	Talent Specialization	Projected Growth	Historical Growth	Unique Job Postings
Boston	100.0	100.0	76.3	97.1	98.5	100.0	70.9	85.8	94.4
Chicago	69.4	50.0	67.8	76.2	70.5	72.7	72.5	65.8	72.6
Indianapolis	66.4	50.0	70.7	71.7	82.7	90.9	72.5	88.2	73.9
Minneapolis	67.6	72.1	68.1	77.0	73.4	67.3	69.2	79.9	70.5
Philadelphia	70.7	72.2	73.0	87.9	81.4	93.2	59.5	71.7	76.9
Raleigh	66.8	50.0	70.3	87.8	77.4	77.7	79.0	90.6	77.3
Salt Lake City	73.5	50.0	69.7	69.3	74.8	84.9	100.0	100.0	76.8
San Diego	81.1	89.9	100.0	100.0	93.5	86.5	79.0	84.7	92.6
San Francisco	73.6	90.5	84.7	82.0	100.0	83.8	75.7	96.5	100.0
San Jose	84.4	79.8	86.6	74.6	79.1	70.9	82.2	90.6	89.2

**TABLE D.6: REFERENCE DATA**

Metro	Population	GRP, millions	Total Employment	Number of People in Key Occupations
Boston	4,774,321	\$396,549	2,589,715	14,897
Chicago	9,550,108	\$640,656	4,438,163	3,171
Indianapolis	1,988,152	\$134,081	981,891	2,840
Minneapolis	3,524,583	\$248,779	1,857,138	2,306
Philadelphia	6,069,875	\$411,161	2,709,156	7,256
Raleigh	1,273,568	\$75,756	584,017	1,144
Salt Lake City	1,170,266	\$78,950	679,158	995
San Diego	3,299,521	\$220,573	1,398,492	6,957
San Francisco	4,656,132	\$431,704	2,304,858	14,310
San Jose	1,976,836	\$235,222	1,056,744	2,408

Source: San Diego Regional EDC, 2017. For individual data points refer to table D.1.

TABLE D.7: GENOMICS SCORECARD INNOVATION METRICS

Metro	Federal Funding			Venture Capital			Patent Intensity		
	Avg. Annual Federal Funding, 2014-2016	Avg. Annual Federal Funding (2014-2016) relative to GRP (2015, millions)	Standard Value	Avg. Annual Venture Investment, 2014-2016, millions	Avg. Annual Venture Capital Investment (2014-2016)* relative to GRP (2015, millions)	Standard Value	Patents, 2014-2016	Patents Intensity (per 100,000 jobs)	Standard Value
Boston	\$154,937,025	\$390.7	2.5	\$491.7	\$1,239.9	2.1	199	7.68	0.0
Chicago	\$23,055,633	\$36.0	-0.6	\$0.0	\$0.0	-0.7	41	0.92	-0.9
Indianapolis	\$209,346	\$1.6	-0.9	\$0.0	\$0.0	-0.7	32	3.26	-0.6
Minneapolis	\$3,690,206	\$14.8	-0.8	\$4.7	\$18.8	-0.7	22	1.18	-0.9
Philadelphia	\$20,832,920	\$50.7	-0.5	\$8.7	\$21.1	-0.7	137	5.06	-0.4
Raleigh	\$461,788	\$6.1	-0.9	\$0.0	\$0.0	-0.7	17	2.91	-0.6
Salt Lake City	\$6,577,882	\$83.3	-0.2	\$0.0	\$0.0	-0.7	17	2.50	-0.7
San Diego	\$37,994,243	\$172.3	0.6	\$176.0	\$797.9	1.1	371	26.53	2.3
San Francisco	\$36,679,400	\$85.0	-0.2	\$355.7	\$823.9	1.1	332	14.40	0.8
San Jose	\$49,294,570	\$209.6	0.9	\$84.0	\$357.1	0.1	168	15.90	1.0

Source: San Diego Regional EDC, 2017. For individual data points refer to table D.1.

TABLE D.8: GENOMICS SCORECARD TALENT METRICS

Metro	Talent Pipeline			Talent Pool			Talent Specialization		
	Genomics-Related Degrees Conferred	Genomics-Related Degrees Conferred per 10,000 Jobs	Standard Value	Occupation Concentration (Location Quotient)	Standard Value	Key Occupations in Genomics	Proportion of Key Occupations in Genomics	Standard Value	Standard Value
Boston	3,381	13.1	1.5	3.72	1.5	5,974	40.1%	1.7	0.0
Chicago	2,828	6.4	-0.6	0.47	-1.3	453	14.3%	-1.0	-0.9
Indianapolis	484	4.9	-1.1	1.89	0.0	893	31.4%	0.8	-0.6
Minneapolis	1,231	6.6	-0.5	0.81	-1.0	210	9.1%	-1.6	-0.9
Philadelphia	2,736	10.1	0.6	1.74	-0.2	2,446	33.7%	1.0	-0.4
Raleigh	589	10.1	0.5	1.27	-0.6	217	19.0%	-0.5	-0.6
Salt Lake City	282	4.2	-1.3	0.97	-0.8	257	25.8%	0.2	-0.7
San Diego	1,956	14.0	1.8	3.14	1.0	1,898	27.3%	0.4	2.3
San Francisco	1,893	8.2	0.0	3.90	1.7	3,539	24.7%	0.1	0.8
San Jose	617	5.8	-0.8	1.47	-0.4	302	12.5%	-1.2	1.0

Source: San Diego Regional EDC, 2017. For individual data points refer to table D.1.

TABLE D.9: GENOMICS SCORECARD GROWTH METRICS

Metro	Unique Job Postings		Projected Growth		Historical Growth		
	Unique Job Postings	Unique Job Postings per 10,000 Jobs	Standard Value	Projected Growth in Key Occupations, 2016-2021 (%)	Standard Value	Historical Growth in Key Occupations, 2011-2016 (%)	Standard Value
Boston	5,845	22.6	1.2	5%	-0.5	12%	0.0
Chicago	1,642	3.7	-1.0	6%	-0.4	(5%)	-2.0
Indianapolis	474	4.8	-0.9	6%	-0.4	14%	0.3
Minneapolis	349	1.9	-1.2	4%	-0.7	7%	-0.5
Philadelphia	2,023	7.5	-0.5	(2%)	-1.7	0%	-1.4
Raleigh	456	7.8	-0.5	10%	0.3	16%	0.5
Salt Lake City	501	7.4	-0.6	23%	2.4	24%	1.5
San Diego	2,939	21.0	1.0	10%	0.3	11%	-0.1
San Francisco	6,325	27.4	1.8	8%	0.0	21%	1.1
San Jose	1,910	18.1	0.7	12%	0.6	16%	0.5
							1.7
							-1.0
							0.8
							-1.6
							1.0
							-0.5
							0.2
							0.4
							0.1
							-1.2
							1.0

Source: San Diego Regional EDC, 2017. For individual data points refer to table D.1.

# San Diego Regional EDC

San Diego Region Genomics: Survey Research



## TOPLINE RESULTS (N=32)

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### Screener Questions

A. Are you involved or leading the hiring, planning, or budgeting at your organization?

- 100% Yes [CONTINUE]
- 0% No [TERMINATE]
- 0% Not sure [TERMINATE]

B. How many business locations does your company or organization have in San Diego County?

- 84% One business location
- 16% Two business locations
- 0% No business locations [TERMINATE]
- 0% Not sure [TERMINATE]

### [PART 1 – BUSINESS PROFILE AND CUSTOMER AND SUPPLIER CONNECTIONS]

1. How many years have you had at least one business location in San Diego County?

- 19% 0 to 2 years
- 41% More than 2 up to 5 years
- 22% More than 5 up to 10 years
- 19% More than 10 years up to 20 years
- 0% More than 20 years
- 0% (DON'T READ) DK/NA

Next I would like to ask about the industries that are most important to your firm.

2. What industry or industries best describes the work that your firm is involved in and connected to? (DO NOT READ, ALLOW MORE THAN ONE RESPONSE)

*Verbatim responses to be provided*

3. Which of the following categories does your firm fall into? (ALLOW MULTIPLE RESPONSES)

- 88% Our firm does research and development activities
- 69% Our firm designs and/or produces products to sell to customers

- 66% Our firm provides services to sell to customers**
- 3% (DON'T READ) Other**
- 0% (DON'T READ) Don't know**

4. Are your customers primarily local - within San Diego County, regional - within Southern California, Statewide – within California, national – within the Country, or international - outside the Country? [ALLOW MULTIPLE RESPONSES] *Multiple responses permitted, percentages may sum to more than 100%.*

- 63% Local – San Diego County**
- 53% Regional – Within Southern California**
- 50% Statewide – Within California**
- 88% National – Within the United States**
- 78% International – Outside the United States**
- 0% (DON'T READ) Don't know**

5. Next, I would like to ask if your firm is primarily focused on serving customers in other businesses, a b2b focus, or primarily focused on serving consumers directly or a combination of both b2b and consumers?

- 59% Primarily businesses or B2B**
- 13% Primarily consumers directly**
- 28% A combination of both businesses and consumers**
- 0% (DON'T READ) Don't know**

6. What industry or industries are your customers primarily found in? (DO NOT READ, ALLOW MORE THAN ONE RESPONSE)

***Verbatim responses to be provided***

7. As a firm do you sell any products or services related to genomics or the mapping of genomes? [ALLOW MORE THAN ONE RESPONSE] *Multiple responses permitted, percentages may sum to more than 100%.*

- 34% We sell genomics related products**
- 47% We sell genomics related services**
- 19% No, we do not sell genomics related products or services**
- 0% (DON'T READ) Don't know**

**[PART 2 – GENOMICS PROFILE AND FUNDING]**

For this survey, we will just be asking about the employees that work from or directly report to your San Diego County location(s). [CONFIRM ZIP CODE OF THE CURRENT LOCATION/S]

8. Including all full-time and part-time employees, including permanent, contract and contingent workers, how many work at or from your San Diego County location(s)?

16% Less than 5 employees  
 13% 5 to 9 employees  
 13% 10 to 19 employees  
 16% 20 to 49 employees  
 19% 50 to 99 employees  
 16% 100 or more employees  
 9% (DON'T READ) DK/NA

9. If you currently have [TAKE Q1 #] full-time and part-time employees, including permanent, contract and contingent workers, how many more or less employees do you expect to have at your San Diego County location(s) 12 months from now?

84% More  
 0% Fewer  
 9% Same number  
 6% Don't know/ Refused

**Expected Employment in 12 months**  
 (Calculated by only examining businesses with both current and projected data)

	<u>Current</u>	<u>12 months</u>
n	29	29
Mean	148.79	177.07
Median	20.00	36.00
Total Employees	4,315	5,135
Change		820
% Growth		19.0%

[If amount differs by 10% or more in either direction, ask: ]  
 Just to confirm, you currently have \_\_\_\_ employees and you expect to have \_\_\_\_ (more/less) employees, for a total of \_\_\_\_ employees 12 months from now.

**[IF Q1>'0 to 2 years" THEN ASK Q10, OTHERWISE SKIP]**



10. Over the last three years, has your company grown, declined or stayed about the same in terms of permanent, contract and contingent employment at your San Diego County location(s)? [If it has grown or declined, ask] By about how many people? (n=29)

- 76% Grown
- 14% Stayed the same
- 0% Declined
- 10% Don't know/ Refused

**Growth in Employment over last Three Years**  
(Calculated by only examining businesses with both current and past data)

	<u>3 years ago</u>	<u>Current</u>
n	26	26
Mean	98.54	165.58
Median	10.00	37.50
Total Employees	2,562	4,305
Change		1,743
% Growth		68.0%

Next I want you to think about the people at your work that are directly involved in genomics or mapping genomes and related applications, **this could include researchers, managers and/or technicians**. [REMIND AND REPEAT GENOMICS EMPLOYMENT DEFINITION AS NEEDED].  
– CONFIRM DEFINITION

11. If you currently have [TAKE Q8 #] full-time and part-time **permanent, contract & contingent** employees at your San Diego County location(s), how many of these employees are directly engaged in genomics, mapping genomes or related applications? [IF NEEDED: THIS INCLUDES ]

- 34% Less than 5 employees
- 19% 5 to 9 employees
- 9% 10 to 19 employees
- 9% 20 to 49 employees
- 3% 50 to 99 employees
- 13% 100 or more employees
- 13% (DON'T READ) DK/NA

12. If you currently have [TAKE Q11 #] full-time and part-time **permanent, contract & contingent** employees at your San Diego County location(s) who are directly engaged in genomics, mapping genomes or related applications, how many more or less genomics employees do you expect to have at your location 12 months from now?

- 69% More
- 0% Fewer

- 22% Same number
- 9% Don't know/ Refused

**Expected Employment in 12 months**  
(Calculated by only examining businesses with both current and projected data)

	<u>Current</u>	<u>12 months</u>
n	28	28
Mean	95.82	115.43
Median	6.50	10.00
Total Employees	2,683	3,232
Change		549
% Growth		20.5%

**PART 3 - Location and Overall Rating for Economic Development**

Next I want to ask about San Diego County as a place to do business for firms engaged in genomics related work.

13. How would you rate San Diego County as a place to do business for firms that are engaged in genomics?

- 66% Excellent
- 22% Good
- 6% Fair
- 0% Poor
- 0% Very poor
- 6% (DON'T READ) DK/NA

14. Please tell me how satisfied your company is with the following issues and attributes regarding the business climate in San Diego County.

Is your company satisfied, dissatisfied, or neither satisfied nor dissatisfied with San Diego County's: (GET ANSWER AND THEN ASK:) Would that be very (satisfied/dissatisfied) or somewhat (satisfied/dissatisfied)? (n=31)

RANDOMIZE

	Very <u>satisfied</u>	Somewhat <u>satisfied</u>	Neither satisfied nor <u>dissatisfied</u>	Somewhat <u>dissatisfied</u>	Very <u>dissatisfied</u>
A. Access to capital	10%	26%	13%	16%	23%

<b>B. Access to clients and customers</b>	<b>35%</b>	<b>39%</b>	<b>13%</b>	<b>3%</b>	<b>3%</b>
<b>C. Ability to recruit experienced, high-level genomics specialists and researchers</b>	<b>29%</b>	<b>39%</b>	<b>10%</b>	<b>10%</b>	<b>3%</b>
<b>D. Ability to find qualified entry to mid-level genomics technicians</b>	<b>35%</b>	<b>29%</b>	<b>13%</b>	<b>6%</b>	<b>3%</b>
<b>E. Access to relevant vendors and suppliers</b>	<b>58%</b>	<b>26%</b>	<b>10%</b>	<b>3%</b>	<b>3%</b>
<b>F. Ability to retain valued employees over time</b>	<b>45%</b>	<b>39%</b>	<b>10%</b>	<b>0%</b>	<b>6%</b>
<b>G. Access to other firms that working on products or services that you can partner with</b>	<b>61%</b>	<b>19%</b>	<b>6%</b>	<b>6%</b>	<b>6%</b>
<b>H. Education and training institutions that help develop genomics talent</b>	<b>65%</b>	<b>19%</b>	<b>6%</b>	<b>3%</b>	<b>3%</b>
<b>I. Access to research institutions that are doing innovative research related to genomics</b>	<b>55%</b>	<b>23%</b>	<b>10%</b>	<b>6%</b>	<b>3%</b>

Next, I would like to ask you about financing or funding that your firm may have considered or sought after.

15. Has your firm tried to get financing or funding in [IF NEEDED THIS COULD INCLUDE TRADITIONAL BANK LOANS, VENTURE CAPITAL INVESTING AND/OR CROWDFUNDING] the last five years [IF NEEDED FROM 2012 THROUGH 2016]? (n=31)

**77% Yes**  
**19% No**  
**3% (DON'T READ) DK/NA**

[IF Q15="No" OR "DK/NA" SKIP TO Q19 – ASK Q16 IF Q15 ="Yes"]

16. Over that 5 year time period, did your firm receive financing or funding? [IF NEEDED FROM 2012 THROUGH 2016]? (n=24)

**92% Yes**  
**0% No**  
**8% Currently or still in the process of trying to get funding**  
**0% (DON'T READ) DK/NA**

[ASK Q17 IF Q16="Yes", "No" OR "Currently or still in the process of trying to get funding"]

17. What type of financing or funding did your firm receive or try to get? [MULTIPLE RESPONSES PERMITTED] (n=24) *Multiple responses permitted, percentages may sum to more than 100%.*

- 58% Grant funding, such as SBIR or STTR
- 54% Angel investment
- 54% Venture capital investment
- 29% Traditional bank loan or small business loan
- 4% Crowdfunding
- 38% Other
- 0% (DON'T READ) Not sure

[ASK Q18 IF Q16="Yes"]

18. How much difficulty has (did) your firm had (have) getting financing? (n=22)

- 23% Little to no difficulty
- 45% Some difficulty
- 27% Great difficulty
- 5% (DON'T READ) DK/NA

#### PART 4 – Workforce Development & Skills Assessment

Now I would like to ask about your organization's need for new employees.

19. Thinking about the **positions related to genomics and the mapping of genomes** you hire at your San Diego County location(s), how much difficulty does your company have finding qualified applicants who meet the organization's hiring standards? (n=30)

- 20% Little to no difficulty
- 60% Some difficulty
- 10% Great difficulty
- 10% (DON'T READ) DK/NA

20. Please tell me if you employ individuals in your genomics team that generally meet the following position titles. (n=30)

RANDOMIZE

	<u>Yes</u>	<u>No</u>	(DON'T READ) <u>DK/NA</u>
<b>A. Product or marketing manager</b>	53%	43%	3%
<b>B. Director, department head or principal investigator</b>	67%	30%	3%
<b>C. Scientist or associate scientist</b>	87%	10%	3%

<b>D. Molecular biologist or clinical scientist</b>	<b>70%</b>	<b>27%</b>	<b>3%</b>
<b>E. Bioinformatics or data analyst</b>	<b>73%</b>	<b>20%</b>	<b>7%</b>
<b>F. Laboratory or genomics technician</b>	<b>63%</b>	<b>30%</b>	<b>7%</b>
<b>G. Medical doctor or clinician</b>	<b>33%</b>	<b>63%</b>	<b>3%</b>
<b>H. Geneticist, genetics counselor or genetics nurse</b>	<b>30%</b>	<b>67%</b>	<b>3%</b>

21. Please tell me how important the following items are when considering candidates for available genomics positions at your firm: very important, somewhat important, or not at all important. (n=30)

RANDOMIZE

	Very <u>import</u> <u>ant</u>	Somewhat <u>impor</u> <u>tant</u>	Not at all <u>import</u> <u>ant</u>	(DON'T READ) It <u>depends</u>	(DON'T READ) <u>DK/</u> <u>NA</u>
<b>A. A graduate degree</b>	<b>50%</b>	<b>33%</b>	<b>3%</b>	<b>7%</b>	<b>7%</b>
<b>B. At least one year of industry related work experience</b>	<b>57%</b>	<b>33%</b>	<b>3%</b>	<b>0%</b>	<b>7%</b>
<b>C. A four-year college degree</b>	<b>73%</b>	<b>13%</b>	<b>0%</b>	<b>7%</b>	<b>7%</b>
<b>D. Technical training and expertise specific to the position they are applying for</b>	<b>80%</b>	<b>10%</b>	<b>3%</b>	<b>0%</b>	<b>7%</b>

22. Please tell me how important the following skills are when considering candidates for available genomics positions at your firm: very important, somewhat important, or not at all important. (n=30)

RANDOMIZE

	Very <u>import</u> <u>ant</u>	Somewhat <u>impor</u> <u>tant</u>	Not at all <u>import</u> <u>ant</u>	(DON'T READ) It <u>depends</u>	(DON'T READ) <u>DK/</u> <u>NA</u>
<b>A. Basic epidemiologic skills</b>	<b>13%</b>	<b>27%</b>	<b>30%</b>	<b>13%</b>	<b>17%</b>
<b>B. Proficiency in identifying ethical and medical limitations to genetic testing</b>	<b>13%</b>	<b>33%</b>	<b>30%</b>	<b>10%</b>	<b>13%</b>
<b>C. Ability to assess program effectiveness including cost-benefit analyses</b>	<b>23%</b>	<b>33%</b>	<b>23%</b>	<b>10%</b>	<b>10%</b>
<b>D. Ability to use software for genomics research or applications</b>	<b>53%</b>	<b>37%</b>	<b>0%</b>	<b>3%</b>	<b>7%</b>
<b>E. Ability to run experiments using instruments and reagents relevant to</b>	<b>57%</b>	<b>20%</b>	<b>10%</b>	<b>7%</b>	<b>7%</b>

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**F. Knowledge or regulatory compliance relevant to genomics and/or reimbursement for genomic tests or therapies**

17%                      37%                      27%                      10%                      10%

23. Are there any specific skills or areas of expertise that we have not discussed that are important for any genomics related employees that you would hire?

*Verbatim responses to be provided*

24. What city is your firm headquartered in?

*Verbatim responses to be provided*

25. Would you be willing to be contacted by researchers and/or educators who are developing new strategies and regional plans to support the San Diego County Genomics community?

60% Yes  
30% No  
10% (DON'T READ) DK/NA

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For a copy of the complete study, visit  
[sandiegobusiness.org/research](http://sandiegobusiness.org/research)

For an expanded, interactive version of the timeline,  
visit [GenomicsSD.org](http://GenomicsSD.org)

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