Southern California Region

Bioscience Profile

A Look at Regional Assets and Market Opportunities

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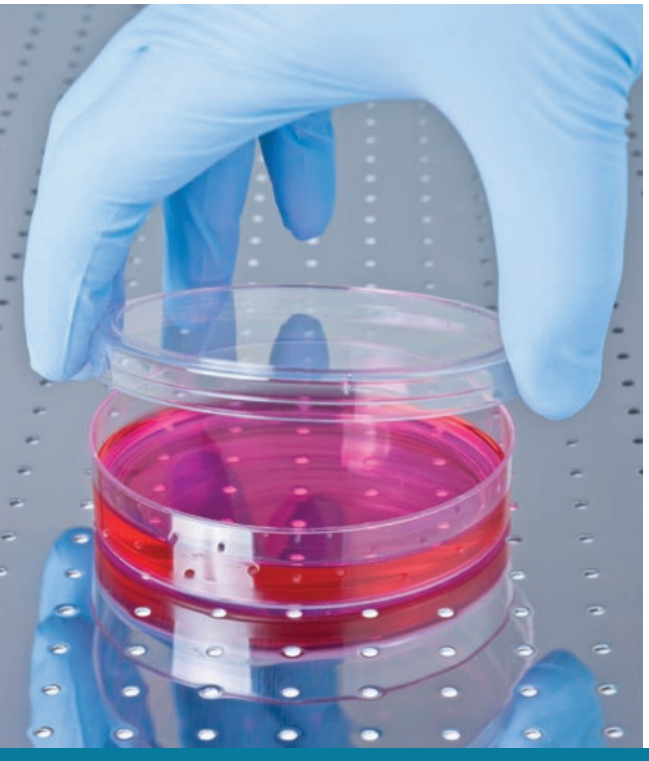
Table of Contents



Introduction

Within Southern California, the bioscience industry comprises research and development-intensive companies active in pharmaceuticals, diagnostics, and medical devices. The industry is a central driver of growth within the knowledge-economy.

Pharmaceutical companies have created new classes of drugs, many of which have cured previously untreatable diseases. Medical diagnostics firms are active in creating instruments and medical tests that can more accurately diagnose disease, often at an earlier stage of development, when treatments are simpler and more cost-efficient. Medical device companies harness advances in bioengineering to create a wide range of medical tools. Device companies have created important, life-saving technologies in cardiovascular medicine, such as synthetic heart valves, drug-eluding stents, and pacemakers. They are active in a wide range of related fields associated with orthopedics, imaging, and surgical procedures.

The bioscience industry is high growth, profitable, and export-oriented. It is populated by hundreds of entrepreneurial companies, many of which were initially "spun off" from universities and hospitals. Entrepreneurial technology companies invest heavily in people and equipment. Start-up bioscience companies, including many firms located in Southern California, have commercialized radical new therapies generating billions in revenues as a result. Larger, often international firms, active in pharmaceuticals, diagnostic equipment, and medical products, co-exist with smaller, research-oriented start-ups. Large bioscience companies have the resources needed to invest in expensive processes of clinical development, regulatory approval, manufacturing, and marketing of new medical technologies. Larger firms often partner with or acquire successful start-ups.

Governments around the world have targeted biosciences as a key industry for investment and growth. Regions that have developed successful bioscience clusters employ tens of thousands of highly-skilled scientists, engineers, and medical professionals involved in medical research, as well as large numbers of additional individuals involved in administrative activities, marketing, and manufacturing. Successful regional bioscience industries also attract investment by firms in related or supporting industries, such as law firms focusing on intellectual property, consultancies and contract research and manufacturing organizations. Moreover, most clusters of bioscience firms develop strong linkages to nearby universities, enriching the vibrancy of local scientific communities. In addition to the tax benefits accrued by local governments, regions fortunate enough to build successful bioscience industries are likely to attract a highly educated, diverse, and civic-minded population associated with the emergence of a "creative class."

Southern California is home to a thriving bioscience industry. Two hundred and forty research-intensive bioscience companies are currently headquartered in Southern California, employing 26,826 individuals. In addition, 29 subsidiaries of large companies are located in the region, employing an additional 15,920 people. Total bioscience industry employment is 42,756. Highly inventive, these companies have obtained thousands of patents and have commercialized dozens of new products. Southern California-based bioscience firms have prospered in part because they can draw upon an outstanding ecology of universities, medical research institutes, and support organizations. The local ecology includes several world-class universities, medical schools, and research hospitals, an active investor community, and strong local industry associations. Southern California has also developed a large and flexible labor market of researchers, clinical experts, and industry professionals to staff local companies.

The first section of this profile explores the landscape of companies active within the Southern California bioscience scene. It surveys companies active within each of the three main biomedical-related industry segments, demonstrating that the region is fertile ground for entrepreneurial start-ups, mature companies, and subsidiaries of global-bioscience companies.

The second section focuses on the broader ecology of institutions and resources that local bioscience companies draw upon for support. The ecosystem includes a large labor market of scientists and bioscience professionals, a community of large universities, hospitals and medical research institutes actively linked to the bioscience industry, and a robust community of venture capitalists and angel investors with a proven track record of investing in local companies.

The Company Landscape

The Southern California bioscience industry is large and diverse.

Other U.S. cities have developed successful bioscience clusters that are heavily specialized in one segment of the industry, such as biotechnology-related drug discovery or medical devices. The six-county Southern California region, made up of Los Angeles, Orange, Ventura, Santa Barbara, San Bernardino and Riverside counties, is fortunate to have one or more leading firms in drug discovery related biotechnology, diagnostics, and medical devices, as well as small and large R&D-intensive companies in each of these segments. This section showcases the vibrancy of the regional bioscience industry through profiling the activities of companies in each of the three major bioscience market areas.[1]

Drug Discovery and Pharmaceuticals

Companies active within the pharmaceutical industry participate in the complex value chain surrounding the discovery, development, manufacture, and sale of medicines. The Southern California region currently has 88 companies active within different areas of the pharmaceutical industry. Of these firms, 66 are headquartered in Southern California, and 22 are subsidiaries. Combined, these companies employ 14,699 individuals in a variety of highly-skilled local jobs.

A broad spectrum of companies is active in the Southern California biopharmaceuticals industry, including development-stage biotechnology companies, contract research organizations, pharmaceutical companies focused on selling off-patent generic drugs, subsidiaries of large pharmaceutical companies, and firms focused on neutraceuticals and supplements. Table 1 presents a snapshot of the number of companies and local employment across each of these categories.

Fully Integrated Pharmaceutical Companies
Bioscience firms in this category have the capability to discover new drugs, push them through the clinical development and regulatory process, and, once approved by the FDA, manufacture, distribute, and market them as medicines. As the process of drug development and approval now typically costs several hundred million dollars, fully integrated pharmaceutical firms are typically large, well-financed, and sophisticated organizations staffed by scientists and industry professionals.

Table 1: Snapshot of Southern California Firms Active in Pharmaceutical-Related Activities

	Locally-Owned Companies		*Subsidiaries*			
Industry Segment	**Number of Firms**	**Employment**	**Number of Firms**	**Employment**	**Total Firms**	**Total Employment**
Fully Integrated pharmaceutical	4	9,510	2	801	6	10,311
Development stage biotechnology	37	448	0	0	37	448
Contract research	22	348	3	225	25	573
Pharmaceutical company subsidiary	0	0	9	322	9	322
Generics pharmaceutical company	2	543	2	900	4	1,443
Neutraceuticals and supplements	1	10	6	1,592	7	1,602
Total	**66**	**10,859**	**22**	**3,840**	**88**	**14,699**

[1] A database of 269 companies active within the six-county Southern California region was developed for this profile. Only bioscience industry-focused companies with a research and development capability were included in the database. The primary source of information on companies was Rich's California Bioscience Database and the list of companies available on the Southern California Biomedical Council website *(www.socalbio.org)*. Employment information, when not available from the Rich's Database, was located through searches of company websites and several online directories of companies, including *jigsaw.com, manta.com,* and *Hoovers.com*. Rankings of companies by size throughout the profile are based on employment.

Figure 1: Southern California Pharmaceutical Companies by Segment

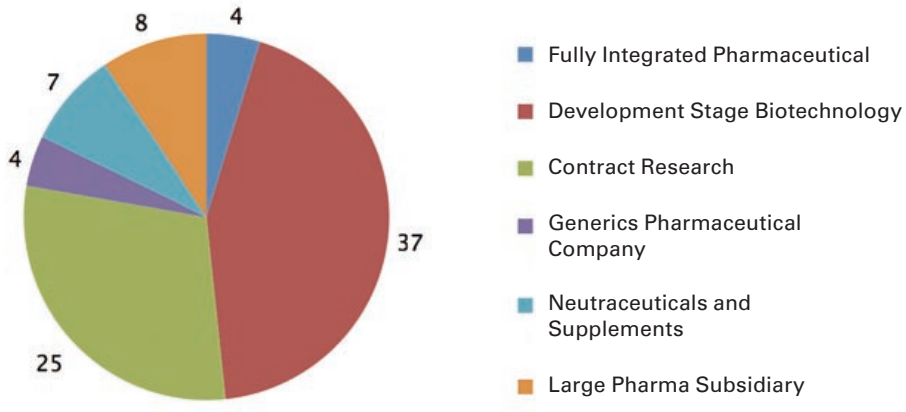


Table 2: Ten Largest Pharmaceuticals-Related Companies in Southern California by Employment

Company	Focus	Location	Employment
Amgen	Biopharmaceuticals	Thousand Oaks	8,200
Allergan	Biopharmaceuticals	Irvine	1,300
Pharmavite	Neutraceuticals and Supplements	Northridge	850
Teva	Generics	Irvine	800
Herbalife	Neutraceuticals and Supplements	Inglewood	600
Watson Pharmaceuticals	Generics	Corona	441
Gilead Sciences	Biopharmaceuticals (manufacturing plant)	San Dimas	231
Ingenium LLC	Contract research	Tustin	151
Ampahstar Pharmaceutical	Generics	Rancho Cucamonga	140
Irvine Scientific	Contract research	Irvine	103
Abnaxis Biosciences	Biotechnology	Los Angeles	100

The Southern California region currently has six fully integrated pharmaceutical companies. The two largest firms are Amgen and Allergan. Amgen has long been the most profitable biotechnology focused pharmaceutical company in the world. The firm markets several successful protein therapeutics, including Enbrel, the leading treatment for rheumatoid arthritis, and Epogen, a genetically engineered form of the erythropoietin protein that is commonly used to treat anemia in patients facing kidney failure. These and other Amgen products generate over $14 billion in annual revenue, allowing the company to invest over $3 billion annually in R&D and employs close to 18,000 individuals, 8,200 of which work at the firm's corporate headquarters in Thousand Oaks. Allergan, located in Irvine, is best known for developing the cosmetic agent Botox, but also has successfully developed a range of treatments targeting obesity, central nervous system disorders, and eye care. Allergan employs 1,300 individuals within its Irvine headquarters and generates over $4.2 billion in annual sales.

The Company Landscape *continued*

Southern California is also home to several subsidiaries of global bioscience companies. These include the major pharmaceutical companies Novartis, Pfizer, Wyeth, and Eli Lilly. These subsidiaries are primarily active in coordinating commercial and marketing operations within the Southland. Another major company with a substantial presence in the region is Gilead Sciences. Gilead is the third-largest biotechnology company worldwide behind Genentech and Amgen and operates a sophisticated manufacturing facility in San Dimas, employing 231 people.

Development-Stage Biotechnology Companies
Companies in this segment are most commonly associated with biotechnology: small, entrepreneurial and research-intensive companies focused on discovering new cures for disease. Such companies are commonly referred to as "development-stage" because they have no revenues. They are financed primarily by venture capitalists in the hope that the firm develops a promising new treatment against disease. Most biotechnology firms are closely linked to local universities.

The Southern California region currently has 37 development-stage biotechnology companies employing 450 people. These firms are small, averaging about 12 employees each. The founding science behind most regional biotech start-ups was developed within local university labs and represents a range of promising approaches to developing new drugs. Examples of technologies embraced by local companies include stem cells and regenerative medicine, protein and related biologics-based therapies, genomics and proteomics, cell therapy, and gene therapy. Local firms have targeted a variety of disease areas. At least eleven local biotech start-ups are creating therapies against cancer, while firms are also working on new drugs against cardiovascular disease, obesity, a variety of central nervous system diseases such as Parkinsons and Alzheimer's Disease, blood-related diseases, anti-infectives, and allergies.

Contract Research
Firms in this category have developed technologies that may be able to increase the productivity of drug discovery research and development conducted by biotechnology start-ups and biopharmaceutical companies. R&D-oriented contract research firms offer a range of services. Many contract research companies create customized chemical and biological products for use as intermediary ingredients within drug discovery research. Other companies offer consulting services designed to speed up the drug development process or increase the probability that a client firm's discovery activities will produce biologically active products. Contract research companies that offer unique technologies of value to drug discovery companies can be highly profitable and are frequently able to demand downstream royalties on new drugs discovered using the firm's research technologies.

Southern California has 25 contract research companies, employing 573 personnel. The two largest local contract research companies, both employing about 100 people, are Irvine Pharmaceutical Services and Irvine Scientific. Irvine Pharmaceutical Services offers a range of analytical chemistry, preclinical trials, and chemical formulation activities that allow drug discovery firms to outsource drug development activities. Irvine Scientific is a company focused on creating cell cultures and other consumable products in the area of reproductive health.

Other smaller contract research companies in the region specialize in stem cell research, genomics, developing animal models for use in preclinical trials, and a range of chemistry and biology-based services.

Generics
Companies in this segment market and sell drugs for which patent protection has expired. Generics-based pharmaceutical companies do not need to incur either the R&D expenses of creating new drugs or the costs of taking a new drug through clinical trials. Rather, they usually reverse-engineer existing drugs for which patents covering the active ingredient have expired, creating a new formulation that the firm then manufacturers and markets. Because competition within the generics drug category is intense, prices often fall to between 10 to 20% of the original price of the patented drug. The two largest generics firms active in Southern California are Corona-based Watson Pharmaceuticals with 441 employees, and Teva, an Israeli subsidiary, employing 800 individuals at its Irvine facility.

Neutraceuticals and Supplements
While traditionally unregulated, this segment is growing due to the general public's increased interest in living healthy lifestyles. This has promoted sales of a range of neutraceuticals, supplements, and vitamins linked to perceived health benefits. While typically less R&D-intense than the regulated biopharmaceutical industry, companies working within this industry do commonly conduct research activities focused on validating potential health benefits from the consumption of naturally occurring products and supplements. Firms within this segment also commonly employ teams of chemists and food-technology experts to work on extraction and formulation processes and often develop sophisticated manufacturing and marketing capabilities. The largest local firm within this category is Pharmavite, which is headquartered in Northridge with additional facilities in San Bernardino and Valencia and employs 850.

Medical Diagnostics

Accompanying the growth of the biotechnology industry has been the creation of a number of new technologies that can help physicians more accurately diagnose and treat disease. Moreover, new molecular-based diagnostic tools often allow diseases to be identified at a much earlier stage of development when they can be more easily treated, often at lower cost. Companies located in Southern California are major players in the diagnostic industry. The region currently has 27 R&D-focused diagnostic companies, employing 6,834 individuals.

There are three major segments of the diagnostics industry: molecular diagnostics research, diagnostic equipment and instrumentation, and reagents and test kits. Table 3 (see next page) summarizes the number of companies and employment in each segment. Table 4 (see next page) lists the top 10 diagnostic companies operating in Southern California based on employment.

Molecular Diagnostic Research Companies
Diagnostic tests used today increasingly rely on molecular research methods. Southern California currently has six specialized research companies oriented towards the discovery of new diagnostic tests. The largest organization focused on molecular diagnostic research in Southern California is the Nichols Institute, the research arm of Quest Diagnostics, which operates diagnostic reference laboratories. Southern California is also home to five smaller, R&D-focused companies. The largest of these companies, Osmetech Molecular Diagnostics in Pasadena, is developing new molecular screens to detect cystic fibrosis.

An important trend in molecular diagnostics is the development of genetic screens that can be used to predict one's susceptibility to disease, including some cancers. Genetic markers can also make medical treatment more effective through predicting whether particular medicines are likely to be effective or well-tolerated by individuals. Three genomics-based diagnostics firms are located in the region. Medomics, located in Azuza, has developed tests that use mitochondrial DNA to examine the tolerance of an individual to particular treatments, such as Warfarin. The other two companies, Manhattan Beach-based DxTerity and Pasadena-based Genome Diagnostic Incorporated, are both working to create new genetic tools that can increase the speed and lower the costs of conducting personalized screening.

Diagnostic Equipment and Instrumentation
Companies in this segment develop and manufacture a variety of instruments used to run diagnostic tests. This equipment can range from low-cost devices used to screen for an individual disease, often at the point-of-care, to high-throughput instruments that can run a battery of tests on hundreds of samples in parallel. Southern California has six companies

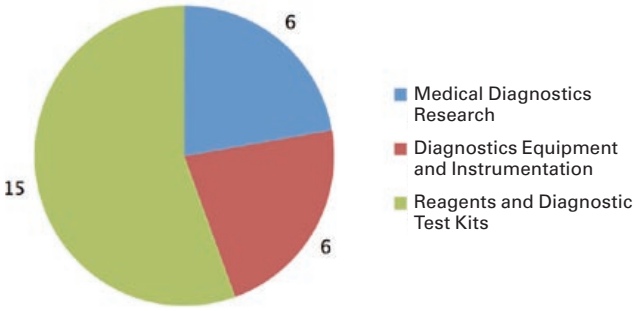
Table 3: Snapshot of Southern California Firms Active in Diagnostics-Related Activities

	Locally-Owned Companies		*Subsidiaries*			
Industry Segment	**Number of Firms**	**Employment**	**Number of Firms**	**Employment**	**Total Firms**	**Total Employment**
Molecular Diagnostics Research	6	1,467	0	0	6	1,467
Diagnostics Equipment and Instrumentation	5	2,090	1	450	6	2,540
Reagents and Diagnostic Test Kits	11	117	4	2,800	15	2,917
Total	**22**	**3,584**	**5**	**3,250**	**27**	**6,834**

Table 4: Top Ten Diagnostics Companies in Southern California by Employment

Company	Focus	Location	Employment
Beckman Coulter	Diversified manufacturer of diagnostics equipment	Fullerton	2,000
Siemens Diagnostics	In vitro diagnostics kits	Los Angeles	2,000
Quest Diagnostics – Nichols Institute	Molecular diagnostics research	San Juan Capistrano	1,400
Grifols Biologics, Inc.	Devices and test kits for hematology	Los Angeles	450
Qiagen	Diversified manufacturer of diagnostic test kits	Valencia	250
Hycor	Test kits related to allergies and the immune system	Garden Grove	100
Osmetech Molecular Diagnostics	Molecular diagnostics research	Pasadena	60
DxTerity Diagnostics	Molecular diagnostics – personalized medicine	Manhattan Beach	25
Epinex Diagnostic Inc	Point of care test kits focused on diabetes	Irvine	25
Molecular Biologicals International Inc	Molecular diagnostics/assay technology	Irvine	25

Figure 2: Southern California Diagnostics Companies by Industry Segment



active in diagnostics equipment. The largest of these firms is Beckman Coulter, a leading global manufacturer of high-throughput diagnostic equipment sold to hospitals and reference labs. In 2008, Beckman Coulter had sales of over $2.1 billion and employed over 2,000 in Southern California within its global headquarters in Fullerton and nearby R&D center in Brea. Southern California is also home to several companies producing smaller scale equipment, often focused on a particular diagnostic test.

Manufacturers of Diagnostic Kits and Reagents
Large markets have developed for more specialized diagnostic tests, which are often sold as individual kits, as well as for reagents and other consumables needed to run more general-purpose diagnostic equipment. The largest company in the area is Los Angeles-based Siemens Diagnostics, which, until a 2006 acquisition, was the independently owned Diagnostic Products Corporation. Siemens Diagnostics markets over 1,200 in-vitro diagnostic kits that are produced locally and employs over 2,000. Qiagen, another global leader in the development of diagnostic kits, is the second-largest employer in this category in the region with 250 people located in its North American headquarters in Valencia. Orange County is home to the three largest independent kit manufacturers. Hycor Biomedical, located in Garden Grove, develops kits to diagnose rheumatoid arthritis. Epinex and Cervilenz, both based in Irvine, produce point-of-care diabetes monitoring devices and kits to help predict the premature birth of babies, respectively.

Medical Devices

The device field is extremely broad, ranging from relatively mundane hospital supply companies to a variety of high-tech firms focusing on the commercialization of new surgical procedures and other devices that can be used to prolong or save lives. Southern California is especially strong in the medical device field. There are at least 165 firms, employing 21,242 individuals within the region's device industry. However, this figure is conservative, as many entrepreneurial companies in the device field are established to commercialize a new device or surgical procedure quickly and then are acquired by established companies. Orange County in particular is well-known as a hot-spot for entrepreneurial device companies.

Numerous market segments exist in the medical device field. Table 5 (see next page) provides a snapshot of the region's device industry. Southern California device companies are present in most of the major segments, including cardiovascular-related devices and technologies, orthopedics, scientific measurement companies, and surgical devices. The "Other" category is very diverse, ranging from firms focused on respiratory devices (3), neuroscience (3), cancer therapy devices (2), and a range of other tools, such as implantable diabetes pumps. While independently-owned companies dominate the local scene, several international medical products companies have device-related subsidiaries in the region, the largest of which

Insulin Pump

are Abott, Baxter, and Bioscience Webster. The largest Southern California device companies, ranked by employment, are listed in Table 6.

To provide more insight on the diversity of the Southern California medical device industry, the cardiovascular, ophthalmic, and surgical devices segments are profiled in more detail.

Cardiovascular

The high incidence of cardiovascular disease, including stroke and heart attacks, has sparked the formation of a large industry of companies active in creating new surgical procedures and devices. Southern California has 15 companies active in this segment, employing 9,884 individuals. The region is home to three world-wide leaders in the creation of cardiovascular-related devices, including the area's largest and most successful medical device company, Edwards Lifesciences. Located in Irvine, Edwards Lifesciences pioneered the market for artificial heart valves, and has since diversified into a range of other heart-care related products. The firm generated about $1.2 billion in revenue in 2008. Also active in heart valves is a subsidiary of Minneapolis-based Medtronics, which employs 500 people in its Santa Ana facility. The third-largest cardiovascular-oriented device company is Sylmar-based Pacesetter, a division of St. Jude Medical. Pacesetter, a company founded by medical device innovator Alfred Mann, was the first company to develop pacemakers to regulate the beating of the heart.

Ophthalmic Devices

Southern California also has a strong presence in vision and eye-care-related markets. This segment is anchored by Abbott Medical Optics in Santa Ana, which employs 4,100 people regionally and produces a wide range of products oriented towards ophthalmic surgery, laser vision correction, and consumables used in contact lens care. The second-largest local vision-related device company is Staar Surgical Equipment, which makes sophisticated lenses and other equipment used for eye surgeries. In addition to these large companies, the region has over a dozen smaller companies active in creating a range of related ophthalmic devices, particularly in the highly specialized eye-surgery market.

Table 5: Snapshot of Southern California Firms Active in Device-Related Activities

	Locally-Owned Companies		*Subsidiaries*			
Industry Segment	**Number of Firms**	**Employment**	**Number of Firms**	**Employment**	**Total Firms**	**Total Employment**
Cardiovascular	9	7,000	6	2,864	15	9,884
Dental	25	939	0	0	25	939
Hospital Supply	10	431	0	0	10	431
Imaging	8	161	0	0	8	161
Measurement	10	594	0	0	10	594
Ophthalmic	16	720	1	4,100	17	4,820
Orthopedic	22	350	2	61	24	411
Prosthetics and Braces	18	180	0	0	18	180
Surgical	14	792	0	0	14	792
Other	21	1,726	3	1,304	24	3,030
Total	**152**	**12,893**	**12**	**8,330**	**165**	**21,242**

Surgical

Large markets exist for companies that can create more effective tools and devices aimed at the general surgery market. Fourteen local companies, employing 792 people, are active in surgical device innovation. The region has one company, San Clemente-based USGI Medical, active within the fast-growing minimally-invasive surgery market. Local companies have also been founded to reduce the incidence of tearing and abrasion during surgeries. The three companies active in this area are Irvine-based Innovamed, Ventura-based Injectimed, and Goleta-based Sienta. Other companies in the area have focused on introducing innovations to more common surgical devices, such as blades and other instruments.

Figure 3: Southern California Medical Device Companies by Segment

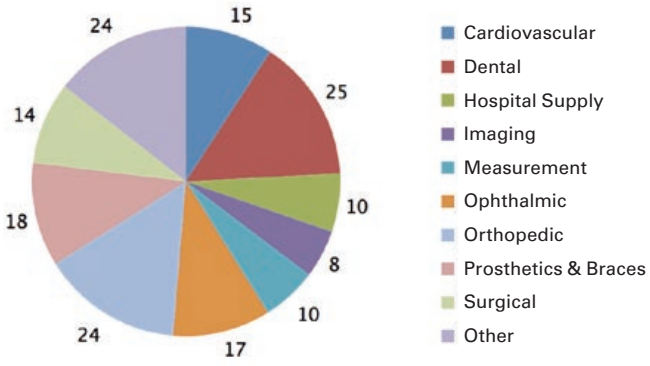
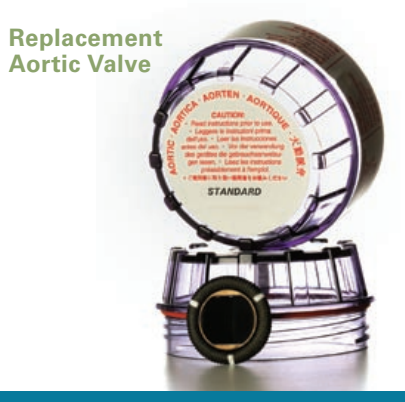
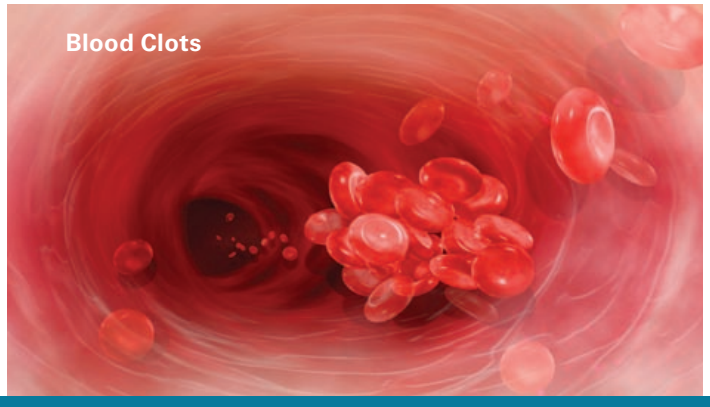


Table 6: Top Ten Medical Device Companies in Southern California by Employment

Company	Focus	Location	Employment
Edwards Lifesciences	Heart valves	Irvine	6,200
Abbott Medical Optics, Inc.	Ophthalmic surgery, laser vision correction, and contact lens care	Santa Ana	4,100
Pacesetter, Inc.	Pacemakers and other implantable devices	Sylmar	2,100
Medtronic MiniMed, Inc.	Insulin pumps and related devices for diabetes patient care	Northridge	1,800
International Medication Systems Ltd.	Specialized syringes and related devices for drug delivery	South El Monte	720
Biosense Webster Inc.	Cardiology-related devices	Diamond Bar	525
Medtronic	Heart valves	Santa Ana	500
Baxter	Diversified medical products	Newbury Park	500
Staar Surgical Company	Eye surgery equipment and lenses	Monrovia	408
Discus Dental	Diversified manufacturer of dental products	Culver City	400





The External Ecosystem

The six-county Southern California region is succeeding in the biosciences due to the region's ability to attract and nurture a diversified pool of successful companies.

Companies are drawn to the region's strong infrastructure of related and supporting institutions. Bioscience companies, especially smaller entrepreneurial firms, depend on the quality of their local environment for success. Firms rely on the expertise and capital of local and national investors and often draw on university technologies for their founding science. They also benefit from the establishment of specialized industry associations and infrastructure, such as incubators, which create a support network for early stage companies. Southern California is fortunate to be home to a world-class collection of universities and medical schools that are active in research and committed to commercializing technology. The region also has a strong financing community and a thriving labor market of well-trained scientists and industry professionals.

Universities, Medical Schools, and Research Institutes

Southern California's ability to nurture hundreds of bioscience companies is directly tied to the region's strength in university science. Universities and medical schools shape the success of regional bioscience clusters through commercializing science, forging collaborative links between faculty and industry scientists, and educating scientists and professionals that are a primary source of human capital for firms. The region is home to six major research universities, which include four branches of the University of California, the California Institute of Technology, and the University of Southern California. Table 7 provides a general snapshot of the scientific capacity of these universities. On an aggregate level, the six core campuses in the region employ close to 10,000 faculty, attract $2 billion annually in funded research, and have over four hundred members of the prestigious National Academies and 45 Nobel Prize winners. The region is also home to four branches of the California State University system and numerous liberal arts schools, including the nationally ranked Claremont Colleges. In terms of raw academic talent and educational and research capacity, Southern California is competitive with the best university centers in the world, including San Francisco, Boston, and Cambridge, United Kingdom.

Focusing more specifically on the biosciences, Southern California universities are highly competitive. Local universities each have large academic departments specializing in biology,

Table 7: Snapshot of Major Southern California Research Universities

	Size of Faculty	Nobel Prizes	Members of National Academies*	Total Sponsored Research Funding 2008 ($ million)
University of California, Los Angeles	2,654	5	119	750
University of Southern California	3,200	1	57	484
University of California, Irvine	1,685	3	40	218
University of California, Santa Barbara	1,084	5	70	194
University of California, Riverside	549	0	7	110
California Institute of Technology	416	31	109	260
Total	**9,589**	**45**	**402**	**2,016**

Source: University websites.
*National Academies = National Academy of Sciences, National Institute of Medicine, and National Academy of Engineering

chemistry, and other bioscience-related fields. Four local campuses, UCLA, UCI, USC, and Loma Linda University operate medical schools, and UC Riverside is currently constructing a fifth. The region is also home to three specialized hospitals with extensive research capacity: the City of Hope, which focuses on cancer, and the Children's Hospitals of Los Angeles and Orange Counties. Dozens of specialized research centers and institutes exist across these universities and hospitals. A good example is stem cells and regenerative medicine, a highly-promising research area that has benefitted from a $3 billion dollar stimulus funded by the State of California. Large centers and institutes focused on stem cells have developed within most of the large university campuses and research hospitals in the region. These include the Broad Stem Cell Center at UCLA, the Sue and Bill Gross Stem Cell Center at UCI, the Stem Cell Center at UC Riverside, and the Stem Cell Project within the Saban Research Institute at the Children's Hospital Los Angeles. Combined, these centers helped capture 77 of the initial California State research grants in stem cell research valued at over $167 million.[2]

Biomedical research centers have also proven successful at winning highly-competitive funding from the federal National Institutes of Health (NIH). In 2006, the last year for which comprehensive data is available, organizations in Southern California were awarded 2,441 NIH grants, totaling slightly over $2 billion in total funding.[3] Table 8 lists the top ten organizations according to grants received. UCLA, UCI, and USC dominate local NIH funding with about 60% of the total, in part because they operate medical schools. However, many other local research institutes receive tens of millions of dollars in NIH funding on an annual basis, fueling Southern California's biomedical research capacity. To put these figures in context, organizations in Southern California received about one-third of total funding for the State of California. Given the extremely strong life science research centers in the San Francisco Bay area and San Diego, this confirms the region's research strength in the biomedical sciences.

Table 8: Top 10 Southern California Based Organizations Receiving National Institutes of Health Awards, by Number of Awards (2006)

	Number of Awards	Total Funded (Million $)
University of California, Los Angeles	950	388
University of California, Irvine	362	126
USC	248	167
California Institute of Technology	101	51
City of Hope	75	33
Cedars-Sinai	72	21
RAND Corporation	69	30
University of California, Santa Barbara	69	21
Children's Hospital Los Angeles	65	25
University of California, Riverside	53	14
All other	377	200
Total	**2,441**	**1,076**

Source: National Institutes of Health

[2] Data from the California Institute of Regenerative Medicine.
[3] Data from the National Institutes of Health.

Southern California is also home to an outstanding collection of research-oriented hospitals. Several of these hospitals, such as Cedars-Sinai, LA County, LA Biomed, and the newly opened UCI-Douglas Hospital, are integrated within medical schools. Other hospitals, such as the City of Hope and Children's Hospital of Los Angeles and Orange Counties, have large research enterprises and, in the case of the City of Hope, run graduate-training programs. Local hospitals are the source of many entrepreneurial technologies. A large number of new medical devices, for example, originate with surgeons and other hospital personnel, who spot new market opportunities as part of their daily hospital practice and research. The strength of the region's medical device industry is strongly linked to the large number of research-oriented hospitals.

Hospitals also serve a crucial role in clinical trials, most importantly for new medicines, but also for most medical devices and some diagnostic products. Local access to clinical investigators provide a competitive advantage for companies both in terms of access and collaborations on the design and implementation of trials. Southern California is a major center for clinical trials. Table 9 lists the number of trials conducted during the 2005-2009 period, showing that over 1,700 trials have taken place in the region's large research hospitals.

Table 9: Number of Clinical Trials Sponsored at Major Southern California Medical Schools and Research Hospitals (2005-2009)

University of California Los Angeles (including Cedars-Sinai and LA Biomed)	640
University of Southern California (including LA County Hospital-USC Medical)	281
University of California, Irvine (including UC Irvine Health Science Hospitals)	205
City of Hope	292
Children's Hospital Los Angeles	184
Children's Hospital Orange County	153
Total	**1,755**

Source: www.clinicaltrials.gov

Technology Transfer

Each of the major universities in Southern California has developed sophisticated technology transfer offices. Personnel working within these offices work with faculty to patent inventions which then become available for license to companies. University commercialization efforts influence both established companies and start-ups. Established companies frequently license new technology, which then can be used to establish new products and services or improve the productivity of company R&D processes. Local universities are active in working with faculty that are interested in launching new entrepreneurial ventures. Licensing offices often serve as matchmakers, linking professors with venture capitalists interested in developing new companies. In such cases, universities often license technology in return for equity in the new company.

Table 10 summarizes technology transfer outputs within the four local University of California campuses. UCLA alone holds over 500 patents, has active licensing agreements with 204 companies, and earned over $37 million from these licenses in 2008. While these figures include all industries, bioscience inventions constitute a large share of this activity. Across the entire UC system, for example, bioscience inventions constitute 23 of the 25 top licenses in terms of revenue earned. Table 11 lists several of the top-earning biomedical patents that have been licensed out of UCLA and UC Irvine; these six inventions alone earn close to $21 million annually.

Table 10: Aggregate Invention and Technology Transfer Activity, Southern California Based University of California Campuses (2008)

UC Campus	Total Patents in Portfolio	Invention Disclosures	Active Licenses	Licensing Revenue ($ thousands)
Los Angeles	536	314	204	37,716
Irvine	250	159	80	6,418
Santa Barbara	316	200	46	5,987
Riverside	79	53	25	2,237
Total	**1,181**	**725**	**325**	**52,358**

Source: University of California Office of Technology Transfer Annual Report, 2008

Table 11: Leading Biomedical-Related Inventions by Licensing Revenue, Southern California Based University of California Campuses

UC Campus	Invention	Licensing Revenue, 2008 ($ thousands)
Los Angeles	Treatment of Intracranial Aneurysm	11,736
Los Angeles	Biodegradable Impact Coils	3,373
Irvine	Dynamic Skin Cooling Device	2,845
Los Angeles	Nicotine Patch	1,634
Irvine	Detection of Mycoplasma	757
Los Angeles	Connective Tissue Stem Cell	574

Source: University of California Office of Technology Transfer Annual Report, 2008

USC and Caltech are also very active in technology transfer. USC holds 862 patents in its aggregate patent portfolio and has several dozen biomedical-related technologies currently available for license.[4] Caltech, since establishing a technology transfer office in 1995, has become one of the region's most aggressive universities in commercializing technology. Caltech has 428 active patents in bioscience-related technologies. In addition to third-party licensing, Caltech is particularly active in establishing entrepreneurial start-up companies.[4] Science and technology from the university has been used to help launch over 80 companies since 1995, the majority of which are in the biosciences.[5]

The Investment Community

Bioscience companies, particularly in their formative stages of development, rely on several sources of finance. The most prevalent form of financing for early-stage entrepreneurial companies is venture capital (VC), in which firms trade equity in their firm for funding. VC is commonly used to fund the early development of bioscience companies including, in some cases, expensive clinical trials. In addition to VC, other forms of capital are available for companies in their early development. These include funding from the U.S. Government through the Small Business Innovation Research (SBIR) program and private funding from so-called "angel investors." Southern California is fortunate to have a deep pool of venture capitalists who have invested across all segments of the local bioscience industry. Local start-up companies have also been extremely active in tapping into SBIR funding and have also become increasingly linked to angel investor groups in the region.

[4] Source: Free Patents Online and the USC Stevens Institute of Innovation website
[5] Source: Caltech Office of Technology Transfer website

The External Ecosystem *continued*

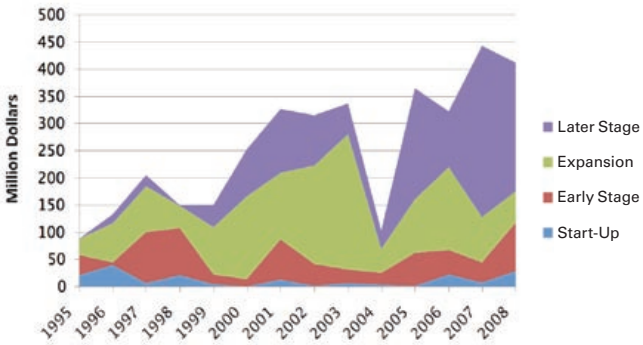
Funding through the SBIR program is channeled through most federal funding agencies and awarded through a competitive peer review process. In the bioscience area, most grants are awarded through the NIH. In 2006, companies in California, as a whole, were awarded over $105 million in SBIR funds.[6] While regional data on SBIR funding is not available, broader NIH funding data is available on a regional basis. This data shows that companies in Southern California were awarded 139 grants totally $53 million in 2006. While many of these grants may have been normal NIH research grants in which companies were collaborators, it is likely that a majority were SBIR grants. Bioscience businesses in Southern California have shown a prowess in successfully applying for highly-competitive federal funds, monies that can be used to invest in R&D at a very low cost of capital.

Bioscience companies in Southern California can also turn to "angel investors," which specialize in making small investments, typically less than $2 million, to early-stage companies. There are three primary angel investor groups in the region: the Pasadena Angels, the Thousand Oaks-based Maverick Angels, and the TechCoast Angels. Each organization holds frequent meetings in which entrepreneurs can present business plans for new start-ups, a small number of which receive investments from members. Investors from each group welcome solicitations from bioscience companies, though the TechCoast Angels and Maverick Angels have historically invested more frequently in the life sciences.

The Southern California bioscience cluster has also developed a sophisticated venture capital industry. At least 34 locally managed VC firms are active in Southern California. However, to diversify their investment portfolios, most VCs syndicate their investments, often bringing in investors from outside the region. An additional 286 VC companies have invested in Southern California bioscience firms between 1999 and 2008. During the 10-year period between 1999 and 2008, $5.2 billion was invested in Southern California bioscience companies.[7] The lion's share of this funding, $4.1 billion, was invested in the medical devices sector. However, $1.1 billion was invested in biotechnology-related applications which includes both pharmaceutical and diagnostic applications.

Entrepreneurial bioscience companies have several stages of development. A strength of the Southern California VC sector is its willingness to invest in local companies along all stages of their growth cycle, from initial start-up to expansion and later stage growth. Figure 4 displays the amount invested in each of the four growth stages. With the exception of a major short-term funding decline in 2004, a robust market for venture funding has expanded over the last decade. Local companies have attracted high-risk but generally smaller investments to fund initial start-up activities and also much larger later stage investments, which are frequently used to fund clinical trials and other commercialization activities.

Figure 4: Total Venture Capitalist Investments in Southern California by Investment Stage, 1995-2008



[6] Source: All data in this paragraph is from the National Institutes of Health.
[7] Data in this section is derived from two VC investment resources, Thompsons Research and PriceWaterHouseCoopers.

Human Capital and Workforce Skills

Because of Southern California's large population, local bioscience companies can draw from a dynamic labor pool. Labor turnover within the bioscience industry is typically about 10%. Given the large size of local employment in the bioscience industry, at over 40,000, this implies that a few thousand individuals with industry experience are searching for jobs at any given time. However, Southern California has an extremely large labor market of professionals working within related industries, such as healthcare. Data from the California Employment Development Department reveals that 106,000 individuals are employed in the hospital sector alone in Los Angeles county. This broader labor market pool serves as a source of trained technicians and professionals that can move into industry.

The large imprint of research-focused universities in the region also has an enormous impact on the quality of the local job market for scientists and professionals. Combined, the four local University of California campuses, USC, and Caltech enroll 26,057 graduate students, a large percentage of whom are in science and engineering programs oriented towards the life sciences. This creates a steady supply of PhD-level scientists who can staff the region's R&D-intensive bioscience firms. Southern California also has two well-established Schools of Pharmacy, located at USC and the Western University of Health Sciences in Pomona. Many graduates of PharmD programs eventually work in formulation-related jobs within the pharmaceutical industry.

Southern California also has the capacity to train hundreds of MBA-level managers each year. The region has large, internationally-ranked business schools at UCLA, UC Irvine, and USC and smaller, more regionally-based management programs at the California State Universities in Fullerton, Los Angeles, Long Beach, and Northridge, as well as the University of Redlands, Azusa Pacific University, and Pepperdine. In recent years, the U.S. National Science Foundation and the Sloan Foundation have supported the creation of Professional Masters Programs (PSMs), which integrate industry-oriented science and technology training with management education. The Keck Graduate Institute of Applied Life Sciences, one of the Claremont Colleges, is the only independent institution in the United States fully dedicated to offering PSM degrees oriented toward the bioscience industries. Over the past decade, the Keck Graduate Institute of Applied Life Sciences has graduated several hundred students within its "Masters of Bioscience" program, almost all of whom have moved to careers in industry. PSM programs oriented toward biotechnology have also been recently launched at Cal State Fullerton and Long Beach.

Conclusion

Southern California's Diversified and Innovative Bioscience Industry

Southern California has developed a unique demography of firms, universities, and support organizations. Many regional bioscience clusters are also concentrated geographically and focused primarily on one industry segment. The Southern California region is more dispersed geographically and has developed a balanced portfolio of well-established large companies and entrepreneurial start-ups and diversified across the industry's three major segments: pharmaceuticals, diagnostics, and medical devices.

While bioscience companies can be found in almost all cities across the region, Southern California, in recent years, has begun to develop clusters of companies or "hot spots" in a few areas of the region. Major hotspots for bioscience include:

- **Central and Coastal Orange County**

Anchored by UC Irvine and its large medical school, the region centered around Irvine has developed one of the country's most dynamic biomedical hot-spots, focused on medical devices and increasingly biotechnology-related drug discovery firms. This region is also home to a majority of the region's venture capitalists.

- **Pasadena**

Companies in this area can leverage into Caltech's enormous research expertise and its active commercialization programs. Pasadena has emerged as one of California's leading locations for the incubation of entrepreneurial technology firms, a large percentage of which have been spun off from Caltech.

- **The 101 Corridor**

Anchored by Amgen, recent years have seen numerous bioscience firms locate in this corridor linking northwest Los Angeles and Santa Barbara. Firms can draw on the rich pool of local bioscience expertise established by Amgen over the years, in addition to UC Santa Barbara to the north.

- **Santa Monica**

Numerous small start-ups in the biotechnology and diagnostics fields, often with strong links to nearby UCLA and USC, have been founded in and near Santa Monica.

The development of hot spots within the broader Southern California landscape presents a "best of both worlds" scenario for the local industry. Bioscience firms located within hotspots can benefit from being able to collaborate with key faculty at nearby universities and with neighboring companies. Yet, at the same time, such firms can also participate within the broader marketplace, especially for highly specialized human resources, that has developed in the large and growing Southern California bioscience industry.

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Dr. Casper, PhD, is a Henry E. Riggs Professor of Management and Director of the Masters of Bioscience Program at the Keck Graduate Institute of Applied Life Sciences, a member of the Claremont Colleges. Dr. Casper teaches courses on bioscience business strategies and successful entrepreneurship.

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www.sce.com/economicdevelopment,
click Key Industry Profiles

Resources

Industry Associations and Support Groups

Southern California Biomedical Council (SoCalBio): *http://www.socalbio.org/*

Orange County Technology Action Network (OCTANe): *http://www.octaneoc.org/*

Larta Institute: *http://www.larta.org/*

Biocom: *http://www.biocom.org/*

Angel Investor Groups

Maverick Angels: *http://www.maverickangels.com/*

Pasadena Angels: *http://www.pasadenaangels.com/*

Tech Coast Angels: *http://www.techcoastangels.com/*

Major University and Research Hospital Technology Licensing Offices

UCLA: *http://oip.ucla.edu/*

UCI: *http://www.ota.uci.edu/*

UCR: *http://www.ora.ucr.edu/ip/index.aspx*

UCSB: *http://research.ucsb.edu/tech_transfer/*

USC – Stevens Institute for Innovation: *http://stevens.usc.edu/*

Children's Hospital Los Angeles: *http://www.childrenshospitalla.org/*

Children's Hospital Orange County: *http://www.choc.org/*

City of Hope: *http://www.cityofhope.org/research/support/center-for-applied-technology-development/Pages/default.aspx*

LA Biomed: *http://www.labiomed.org/index.php?name=Tech%20Transfer%20Main%20Page*

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