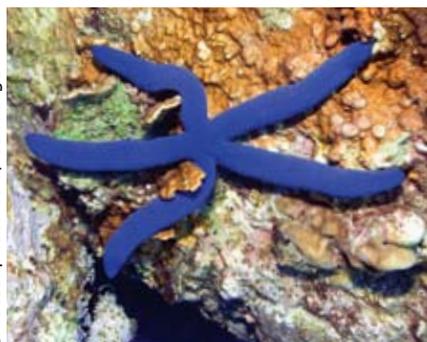


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CAREER DEVELOPMENT : ARTICLES

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"If you are a scientist, working everyday as diligently as you can to meet a compelling unmet need—that's incredibly motivating."

SPROUTING A CAREER IN REGENERATIVE MEDICINE

Emma Hitt
United States
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Over the course of a few months, the brilliant blue *Linckia laevigata* starfish can regrow its entire body from a solitary half-inch piece of its arm. Humans are not as gifted in this area of course, but the young field of regenerative medicine promises to solve a plethora of medical problems, making it a compelling career choice for any scientist who seeks to really "make a difference." In fact, recent breakthroughs in the creation of human induced pluripotent stem cells (IPS) and the engineering of biodegradable scaffolds to create tissues may ultimately be applicable to most health conditions known to humankind. Some applications are closer to the clinic than others, but regenerative medicine is beginning to show utility in treating spinal cord injuries, cardiovascular disease, juvenile diabetes, Parkinson's disease, wound repair, bladder dysfunction, liver and kidney disease, and joint/cartilage damage, among other conditions. And with funding levels around the world relatively bountiful, the future looks bright. **By Emma Hitt**

A Sizzling Growth Area

Several approaches are used in regenerative medicine—the process of creating living, functional tissues to replace diseased and/or dysfunctional tissues within the body—including stimulating adult stem cells to grow so that organs and tissues can heal themselves, and creating transplantable tissues and organs to eliminate the need for donor organs. Stem cell models, derived from healthy or diseased cells, are also being developed for use in drug efficacy and toxicity testing.

Part of the growth of the field is fueled by the aging of the world's population. "I've been in research for 30 years, and nothing has created more excitement than stem cell research," notes **Richard Boyd**, an immunologist and director of the Monash immunology and stem cell laboratories in Australia. "The excitement is due in part to the aging of society and the potential for treating chronic diseases associated with aging," he says. According to United Nations data, by 2050, nearly one in every six people is expected to be at least 65 years old (compared to only one in 20 in 1950), and the rate of growth in that age group is triple that of the overall population, triggering an unprecedented need for treatment of age-related morbidities.

"At this stage of its development, the regenerative medicine industry is comparable to the personal computer industry of the 1980s," says **Steven Nichtberger**, president and CEO of Tengion in Winston Salem, North Carolina. "We don't know exactly where it's going to go, but we know it is going to be really big," he says. Tengion develops human "neotissues and neorgans" using their Autologous Organ Regeneration Platform, and currently has several ongoing preclinical and clinical trials in the area of bladder and kidney augmentation and blood vessel replacement. "We have the opportunity to change the world for patients who need an organ or a tissue transplant or augment," says Nichtberger. "If you are a scientist, working every day as diligently as you can to meet a compelling unmet need—that's incredibly motivating."

“Not only is regenerative medicine a fast-growing market,” notes **Joydeep Goswami**, vice president of primary and stem cell systems at Invitrogen in Carlsbad, California, “but the possibilities are really endless in terms of what scientists can achieve and what they can do with their work. Invitrogen now has a team of about 30 scientists in the stem cell research division and is seeking to hire more.



Courtesy: Invitrogen Corporation

Wanted: Specific Expertise

While most types of life scientists can find a niche in the field, what’s really needed, says Nichtberger with Tengion, are individuals with highly specific technical and functional expertise. “People hoping to enter the field would be better off developing specific skills that they can bring to bear on a research question,” says Nichtberger. “Although ours is an integrated and multidisciplinary company, we seek to hire the best capabilities that we can find rather than someone who knows about the field of regenerative medicine in a broader sense.”

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— Joydeep Goswami

Goswami at Invitrogen agrees that functional expertise is extremely important. “If someone is not a stem cell expert but a molecular or cell biologist who wants to expand their horizons we’re definitely open to having them on board,” he says.

Notably, people who work in regenerative medicine or stem cell research may not in fact consider themselves regenerative medicine specialists. They may instead be bioengineers, developmental biologists, imaging specialists, transplant surgeons, orthopedists, or immunologists. “We’re a very broad church, requiring many different areas of expertise,” says **Fiona Watt**, with the Cancer Research UK Cambridge Research Institute and the 2008-2009 president of the International Society for Stem Cell Research (ISSCR). “Postdocs and students who are currently working in stem cell labs are finding themselves very highly marketable, but they should also think about how the field will transform in five or 10 years, about the bigger picture, and how to ask questions and develop expertise that will be relevant over the long term,” says Watt.

An overarching research question is how to grow stem cells on a large enough scale to ethically treat thousands or even millions of individuals. “Developing the tools required to do that I think is going to become very important,” says **Stephen Minger**, a senior lecturer in stem cell biology at King’s College London in the UK. In late 2007, the development of IPS cells from human somatic cells prompted great excitement in the field providing the potential for researchers to obtain pluripotent stem cells without the controversial use of embryos and also to produce them on a much larger scale than would be feasible using embryos. More recently, researchers have induced stem cells from diseased human somatic cells, which may serve as new model systems for various illnesses.

Imaging skills, bioinformatics, and an understanding of systems biology will also be important in regenerative medicine, notes **Timm Schroeder**, head of the hematopoiesis group at the Helmholtz Zentrum München Institute of Stem Cell Research in Germany. “People who have an understanding of good manufacturing practices (GMP) and standard operating procedures (SOP), who have the know-how to conduct cellular work and other work under GMP conditions, will be very marketable in this field,” he adds.



Tengion

Steven Nichtberger

Another area that is becoming increasingly important is the translation of basic science research findings into clinical applications, and there is a growing need for physician scientists, says **Alan Trounson**, president of the California Institute for Regenerative Medicine (CIRM). “We see an entire pipeline of basic science research through translation and eventually to the clinic. Some of our efforts are focused on attracting people that have a medical degree as well as a research degree (e.g., MD-PhD) and can help take a discovery and then format it appropriately for registration and ready for clinical applications.”

Funding and Regulatory Climate

In August 2001, US President Bush restricted federal funding of research only to those projects using human embryonic stem cells already in existence (currently not more than about 21 lines). This set the stage for a relatively restrictive environment for embryonic (although not adult) stem cell research in the United States relative to some other countries the National Institutes of Health currently funds between about \$600 million to \$700 million a year in stem cell research. However, at the state level, local funding measures have largely circumvented the federal restrictions. States paving the way in this area include California, Connecticut, Illinois, Maryland, Massachusetts, New Jersey, and Wisconsin. In late 2004, California voters approved Proposition 71, allocating \$3 billion over 10 years, making California the largest single funder of embryonic and pluripotent stem cell research in the world and consequently one of the strongest job markets for regenerative research. In a recent survey, nearly 90 percent of stem cell scientists ranked California as one of the top three states for their field compared with about half of the nonstem-cell scientists.

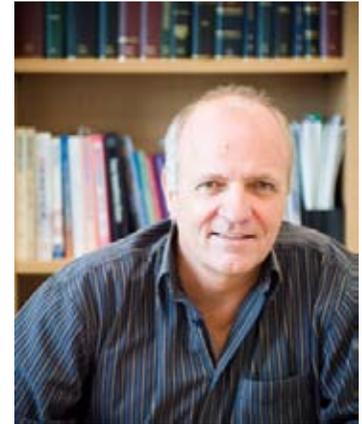


Photo courtesy of Monash University

Richard Boyd

"We have just allocated \$271 million in funds, which leveraged over \$500 million from donors and the institutions' own reserves to build 12 stem cell institutes in California; these are really large institutes that will accommodate a very large number of scientists," says Trounson, an Australian native who pioneered in vitro fertilization in the 1980s and relocated to California to head up the CIRM in December 2007. "One can expect that positions in this field are going to be much more available here than anywhere else in the world," he adds.

Massachusetts is also a major hub for stem cell research in the United States. "Massachusetts has a very vibrant community with the proximity of Harvard and MIT," says **Leonard Zon**, with the stem cell program and division of hematology/oncology, Children's Hospital. According to Zon, the Harvard Stem Cell Institute has a number of young investigators who collaborate freely, and group meetings that share results can include as many as 200 scientists. "Recently, the governor of Massachusetts and the legislature have passed the Life Sciences Bill, and this should really accelerate the research," Zon says.

Philanthropy in the United States is also done on a larger scale than perhaps anywhere else in the world. "I routinely see where individual stem cell centers in the United States receive donations from some high-net-worth individuals in the range of \$50 million you don't see that happening routinely here in the UK," says KCL's Minger, an American who moved to the UK about 13 years ago. Well-known US celebrity efforts include the Michael J. Fox Foundation, which has funded more than \$115 million in research directly or through partnerships focusing on Parkinson's disease, and the Dana and Christopher Reeve Foundation, which has granted more than \$40 million toward spinal cord repair since its initiation.

Opportunities Spanning the Globe

More permissive environments than in the United States, however, are dotted around the globe and include Australia, Israel, Japan, the United Kingdom, and Singapore. The latter, for example, boasts a permissive and well-funded research environment without some of the regulatory restrictions present in the United States and elsewhere. "Singapore has rapidly built up an excellent and compact research infrastructure over the last four years, most notably the Biopolis campus, a concentration of academic institutes under the Agency for Science, Technology and Research (A*STAR) and commercial biomedical research organizations," notes **Alan Colman**, executive director of the Singapore Stem Cell Consortium (SSCC) A*STAR, noted for his role in the cloning of the sheep Dolly.

Canada also has a long tradition of involvement in stem cell research dating back to the early 1960s when J.E. Till and E.A. McCollough became the first researchers to demonstrate the existence of stem cells. "Right now we have many Americans applying for jobs in Canada," says



Photo courtesy of Monash University

Immune Regeneration Laboratory

Michael Rudnicki, scientific director of the Canadian Stem Cell Network. He notes that it's very "un-Canadian" to "blow our own horn," but "we're incredibly productive in this area. The funding situation in Canada remains very good our pay line for grants is around 24 percent on average. New investigators can get grants, and are able to renew them it's a very different funding environment from that facing my colleagues in the United States," Rudnicki says.

The UK also offers a favorable funding and regulatory climate, says Minger, whose lab works on the therapeutic and clinical applications of stem cell research. "We can work with any embryonic stem cell line from any source and are not restricted to working with the very small number of federally approved lines as is the case for researchers in the United States," says Minger. "We also aren't required to distinguish between federal and private funding for stem cell research, which makes conducting research logistically much easier," he adds.

Australia also has a permissive regulatory environment. "We are a small country of only 20 million people, and the funding levels and private philanthropy in Australia aren't as robust as in the United States," says Boyd, "but we have demonstrated the capacity to generate excellent results on less funding. We can also conduct clinical trials more economically and we have an efficient transit mechanism through the multiple regulatory hurdles, which collectively makes us a more preferred environment than the United States," he says. He adds that Australia is one of China's strongest trading partners. China recently announced that stem cell research will be one of the top technologies slated for development in that country, says Boyd, who together with professor Lingsong Li of the Peking University Stem Cell Research Centre, directs the recently formed Australia-China Centre for Excellence in Stem Cells.

Israel is another hotspot for stem cell research, and according to Trounson, is second only to the United States in terms of its research paper output on human embryonic stem cell research. The leading institutions in Israel include the Hadassah University Medical Center in Jerusalem, the Technion-Israel Institute of Technology in Haifa, and the Rambam Medical Center, also in Haifa.

Managing Expectations

On a global scale, therefore, the young, ripe field of regenerative medicine seems poised for some rapid advances that may transform treatment approaches. However, in the wake of fatalities from gene therapy and other technologies, as well as the potential for cancers associated with stem cell transplants, governments are understandably nervous about safety issues not to mention the ethical maze of tinkering with fledgling life. According to Watt, a key concern of the International Society for Stem Cell Research is to manage expectations of all involved parties, including scientists, patients, and commercial enterprises, to ensure that the field overall progresses in a responsible way. "Nonetheless," says Boyd, "it's exciting to think that, if we can overcome the issues of immune rejection, the millions of people whose quality of life if not life itself is being compromised because of chronic diseases may all be treatable with the help of this technology. Feasible stem cell-based therapies are now on the horizon."

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CAREER WEBPAGES AT SELECT COMPANIES INVOLVED IN REGENERATIVE MEDICINE

Aastrom Biosciences - www.aastrom.com/corporate/Careers.cfm

Advanced Cell Technology - www.advancedcell.com/careers

AllCells, LLC - www.allcells.com/jobs.asp

Arthro Kinetics - www.arthro-kinetics.com/index.php?article_id=351

AstraZeneca - www.astrazeneca-us.com/careers

Bioheart - www.bioheartinc.com/career.php

Cambrex - www.cambrex.com/content/careers/careersgeneral.asp

Celgene - www.celgene.com/careers/pharmaceutical-careers-home.aspx

Cord Blood Registry - www.cordblood.com/aboutus_cord_blood_registry/careers.asp

Cellular Dynamics International - www.cellular-dynamics.com/careers.htm
Cytori Therapeutics - www.cytoritx.com/us/careers
Fraunhofer Institute - www.izi.fraunhofer.de/izi_stellenmarkt.html
GenVec, Inc. - www.genvec.com/go.cfm?do=Page.View&pid=24
Geron - www.geron.com/careers
GlaxoSmithKline - www.gsk.com/careers/index.htm
Intercytex - www.intercytexas.com/icx/about/careers/
International Society for Stem Cell Research - jobbank.isscr.org/home/index.cfm?site_id=319
Invitrogen - www.invitrogen.com/site/us/en/home/corporate/Careers.reg.us.html
Isolagen - www.isolagen.com/corporate/careers.htm
Lexicon Genetics - www.lexicon-genetics.com/careers/index.html
MaxCyte - www.maxcyte.com/employment.shtml
Miltenyi Biotec - www.miltenyibiotec.com/en/NN_424_Job_openings.aspx
NeuroNova - www.neuronova.com/index.php?option=com_content&task=view&id=21&Itemid=52
Osiris Therapeutics - www.osiristx.com/careers.php
Pfizer - www.pfizer.com/careers
Progenitor Cell Therapy, LLC - www.progenitorcelltherapy.com/careers
ReNeuron - www.reneuron.com/company_info/job_opportunities
StemCells, Inc. - www.stemcellinc.com/opportunities.html
Stem Cell Innovations - www.stemcellinnovations.com/about/careers.php
StemCell Technologies - www.stemcell.com/about/careers.aspx
Tengion - www.tengion.com/careers/openings.cfm
Thermogenesis - www.thermogenesis.com/contact-careers.aspx
TiGenix - www.tigenix.com
ViaCell - www.viacellinc.com/career_opportunities.htm
VistaGen Therapeutics - www.vistagen.com/htm_pages/career_page.htm

FEATURED PARTICIPANTS

California Institute of Regenerative Medicine - www.cirm.ca.gov
Cambridge Research Institute - www.cambridgecancerresearchinstitute.org
Canadian Stem Cell Network - www.stemcellnetwork.ca
Children's Hospital Boston - www.childrenshospital.org
Helmholtz Zentrum München Institute - www.helmholtz-muenchen.de
Invitrogen - www.invitrogen.com
Kings College London - www.kcl.ac.uk
Monash University - www.monash.edu.au
Singapore Stem Cell Consortium - www.sccc.a-star.edu.sg
Tengion - www.tengion.com

UPCOMING FEATURES

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Postdoc 1—February 20
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