Forbes/Wolfe Emerging Tech REPORT
Volume 10/ Number 5/ May 2011 www.forbesnanotech.com

The Insider

JOSH WOLFE, EDITOR

Robotic warfare, regrowing organs, rapidly making new vaccines: The future is here, it's just unevenly distributed. And our three exclusive interviews this month reveal three more clues to who your couriers of the future are.

We start with Tony Atala, the director of the Institute for Regenerative Medicine at Wake Forest. His lab focuses on growing organs from blood vessels to bladders and beyond. Consider the impact and implications of his breakthrough work on patients who wait today on distressing donor lists for critical organs they need—and imagine the ability to print

Continued on page 2

Tony Atala: Building Better Body Parts

TONY ATALA

Dr. Anthony Atala is director of the Wake Forest Institute for Regenerative Medicine, where his work focuses on growing and regenerating tissues and organs. He is also chair of the department of urology at the Wake Forest University School of Medicine in North Carolina. His team engineered the first lab-grown organ to be implanted into a human–a bladder–and is developing experimental fabrication technology that can print human tissue on demand. In 2007, Atala and a team of Harvard University researchers showed that stem cells can be harvested from the amniotic fluid of pregnant women. This and other breakthroughs in the development of smart biomaterials and tissue fabrication technology promises to revolutionize the practice of medicine. Atala was born in Peru in 1958 and grew up in Boca Raton, Florida. He obtained his undergraduate degree in psychology from the University of Miami, and his medical degree from the University of Louisville where he also completed his residency in urology. From 1990-1992, he trained under world-renowned pediatric urologic surgeons Alan Retik and Hardy Hendren as a fellow at the Harvard Medical School affiliated Children's Hospital Boston.

Continued on page 2

PW SINGER

PW Singer: Waging War With Robots

Peter Warren Singer is an author and senior fellow and director of the 21st Century Defense Initiative at the Brookings Institution. He is the youngest scholar named senior fellow in Brookings's 90-year history. Dr. Singer's most recent book, *Wired for War* (Penguin, 2009), looks at the implications of robotics and other new

Continued on page 4

CHIP CLARK

Chip Clark: Vaccines To Vanquish Disease

Chip Clark is the chief executive officer of Genocea Biosciences, a vaccine development company based on a revolutionary platform for the rapid discovery of antigens that induce T-cell immunity (*Full disclosure: my venture firm Lux Capital is an equity investor*). Clark joins Genocea with more than 20

Continued on page 6

Continued from page 1

Tony Atala: Building Better Body Parts

Continued from page 1

and grow organs, like we print paper or prototypes on 3D printers today.

It is this steady march of technology and its healing potential that attracts talent and attention. But technology's power also attracts talent and attention, to both protect and destroy. We speak with military and technology expert PW Singer in an exclusive and wide-ranging interview on the complicated and quickly changing nature of technology in combat and the rapidly evolving way we wage war. PW is the author of *Wired for War* (a double entendre suggesting both our machines and ourselves) and discusses 21st century warfare and how robots are becoming as significant as gunpowder. As one friend says: it's our Silicon versus their sons.

We also sit with Chip Clark, CEO of Genocea (full disclosure: my venture firm, Lux Capital is a founding investor) who is fighting another kind of warfare: biological. Chip shares stories at the front lines of the fight against infectious disease and the quest to protect mankind from some of the worst offenders by rapidly discovering and developing new vaccines.

As always, here's to thinking big about thinking small and to the emerging inventors and investors who seek to profit from the unexpected and the unseen.

Broadly, how would you describe the work that you do?

What we're working on is really the field of regenerative medicine–trying to get cells and tissues to regenerate, so that we can help accelerate the delivery of these technologies to patients.

What is regenerative medicine?

A science that involves many multi-disciplinary areas with a common goal of achieving the regeneration of diseased or injured tissues and organs.

How old of a field is this?

The field really dates back to the early 1900s, when people started thinking about the replacement of organs and creating tissues. Through the years it has taken on many different names, including cell transplantation and tissue engineering. It's finally come together as a common area we now call regenerative medicine.

What were some of the early successes in the space?

One of the very first applications of cells for regeneration of tissue dates back to 1981, when a patient with a burn had a very small piece of normal skin taken, then grown outside the body and subsequently placed over the burn area. It did not regenerate the skin, but it did help the wound to heal faster, and that's the very first time that cells were used to help to regenerate tissue. Since that time we've had to face many challenges in the field, which involve how to get cells to effectively grow outside the body, how to make sure these tissues function properly, and how to safely turn these cells into effective therapies for patients.

Where are the researchers who are pioneering this space coming from?

It's interesting to see that every single major university has some activity in the area of stem cell biology or regenerative medicine at this point. So it is definitely a growing field, and one that is benefiting from more investigators joining the area. It's not just the U.S.–there are many countries where these efforts are being conducted. The U.S. benefits from the interactions that we have with our international colleagues.

When was the first time you got introduced to the concept of regenerative medicine?

I'm a pediatric surgeon; I was looking at alternatives to the standard approaches for doing surgery on children with congenital defects. I realized that probably the best option would be to replace their diseased tissue with their own tissues that could be created outside the body. The first thing we started working on was bladder tissue, and we also worked with cartilage and skin tissues.

Could you walk through the process of how you grow a bladder outside the body?

We take a very small piece of tissue from the specific organ of interest within a patient–less than half the size of a postage stamp. Then we grow and extend these cells outside the body in large quantities. We are then able to create a biomaterial that replicates the structural properties of the tissue or organ being replaced, and we coat or layer the cells onto this biomaterial, one layer at a time. Then, we are able to place these cells and this material in a bioreactor, which has the same conditions as the human body. Finally, we are able to place that functional tissue or organ back into the patient. In some ways, it's very much like baking a cake.

So if you were to write a cookbook on growing an organ, what are the basic ingredients required?

First you need a cell source. Then you need some adequate biomaterial to create a structural scaffold. Finally, you need sufficient vascularity for blood flow.

Are you effectively trying to recreate the ecosystem of the body externally for cells to grow?

Absolutely. We try to replicate the normal conditions of the human body outside of the body. At the end of the day, as long as the cells are in the right environment, they know what to do.

Over the last 30 years, what has been the biggest change in the field of regenerative medicine?

At a high level, we've transitioned from concept to practicality. We've come to prove that engineering of complex tissues is indeed possible. We faced many challenges along the way; the first was just the ability to grow cells outside of the body in large quantities–something very hard to do several decades ago. The second was vascularity–the ability to have cells be fed with blood vessels so that they could survive a long time. The third was biomaterials–finding the right materials to use so we could actually engineer tissues that would be biocompatible, and more importantly, function as they are supposed to.

Continued from page 2

"We've come to prove that engineering of complex tissues is indeed possible. We faced many challenges along the way; the first was just the ability to grow cells outside of the body in large quantities."

How far have we come? What's possible and what remains fantasy?

The most common misconception about this field is that we're close to replacing whole solid organs, but that is still years away. There are four levels of complexity of tissues. The most basic are flat structures, such as skin. Next are tubular structures, such as blood vessels, windpipes or urethras. Hollow organs, such as bladders, are more complex still. Solid organs are the most complex. We've been able to implant those first three levels of complexity in patients.

What are some of the different approaches used to create complex scaffolds for replacement organs?

One method is called decellularization, where you remove cells from a tissue or organ leaving behind just the scaffold. We've been decellularizing tissues for more than 20 years, and we've used decellularized tissues to actually replace some organs. Our first application was in 1996–we would use the scaffold on its own inside the body to help the body regenerate its own tissue. In the early 1990s, we also started looking at solid organs and how to decellularize those. We've recently been able to show that the technology is feasible in experimental models–we can decellularize organs, re-seed them with tissues outside the body, and then implant them where they're able to function long-term. Last year, we published a paper in *PNAS* demonstrating this technique for penile tissue–the most vascular organ in the body.

What did you prove with this paper?

We were able to replace the entire penile structure in a rabbit model, and we were able to show that it functioned quite fully, to the point where these rabbits could give rise to offspring. So the technology is indeed possible. The question is, for solid organs, will this be the best option? There are challenges with using decellularized organs–every patient is unique, and requires an organ of a different size or shape. So we are exploring many different options. Perhaps we can design the organs from scratch, by printing them in a more controlled manner.

Printing organs as in using a 3D printer?

Correct, using a 3D printer, yes.

Is this a new concept?

No, this is actually a concept that's been around for a while, but is just getting to the point now where we're able to print three-dimensional structures with a fairly sophisticated level of detail.

Besides 3D printing, what other advances are leading to potentially exciting developments for regenerative medicine?

Stem cell biology is another. A lot of new cells have been discovered and proposed. Also, better techniques in terms of cell and tissue preservation, and the ability to actually have the organs regenerate.

What's the distinction between what we've seen is possible and what is actually in use today?

Because these technologies are still fairly new, they still need a lot of work before they can be expanded to large quantities in patients. The typical timeline for just a regular drug to go from Phase I to Phase III clinical trials is about 14 years in the FDA regulatory process. These are much more complex technologies than just a drug, so they do take a lot of time and effort to get them through the regulatory process to ensure that they can be safely placed in patients for the long-term.

What's currently underway in clinical trials that you're excited about?

We're generally excited about the fact that we are seeing more technologies get to patients, and that we have the ability now to try to expand the implications for these technologies and the number of patients that can be treated. For example, for the replacement of cartilage, skin, muscle tissue, and the replacement of other types of organs like bladders, urethras and blood vessels. The number of tissues that are currently being studied and that are being successfully transferred to patients keeps increasing.

If you could whisper in the ear of the President or the head of the NIH to try to advance these technologies more quickly, what would you ask for?

The main obstacle right now is simply more resources. Think about an organ like the kidney–you realize that this is going to cost our health care system more than $1 trillion in the next decade just to manage patients with kidney disease. It would be of huge benefit to make a $1 billion investment to make sure that you could prevent that kind of disease.

So you think a billion dollars could get us to a point where we could produce personalized kidneys?

I don't know what the exact numbers would be, but I think dedicated resources to these technologies pursuing some of these challenges would be very beneficial, because regenerative therapies, as opposed to other treatments, have the potential not just to manage disease, but also to cure it.

From an economic perspective, is there some price point where growing an organ is a viable substitute for a transplant?

The economics are actually very powerful. I'll use the kidney example I mentioned. The average cost of keeping one patient on dialysis for a year is approximately $250,000. So you can see how the numbers stack up fairly quickly. So for something that's costing our system that much, you should be willing to spend at least $100,000 as a one-time cost to create such an organ. Of course, it's not just about the cost savings, but also the benefits for the patient.

In the future, what do you envision we'll be able to accomplish?

I think you will see applications of these technologies for diabetes, cardiovascular disease and liver disease–these are certainly a lot of the current targets that are being explored. I'm convinced it's possible; it's just a question of the timeline. Even though some of these technologies are currently in patients, many applications are not just around the corner, but may take decades to get there. ET

Continued from page 1

technologies for war, politics, ethics and law in the 21st century. The book made the *New York Times* non-fiction bestseller list and was named a non-fiction Book of the Year by *The Financial Times*. It has also been made an official reading with organizations that range from National Defense University, U.S. Air Force and U.S. Navy, to the Royal Australian Navy. Prior to his current position, Dr. Singer was the founding director of the Project on U.S. Policy Towards the Islamic World in the Saban Center at Brookings. He has also worked for the Belfer Center for Science and International Affairs at Harvard University, the Balkans Task Force in the U.S. Department of Defense and the International Peace Academy. In his personal capacity, Singer also served as coordinator of the Obama-08 campaign's defense policy task force. In 2005, CNN named him to their "New Guard" List of the Next Generation of Newsmakers. In 2009, Singer was named by Foreign Policy Magazine to the Top 100 Global Thinkers List, of the people whose ideas most influenced the world that year. Singer received his Ph.D. in Government from Harvard University and a BA from the Woodrow Wilson School of Public and International Affairs at Princeton University.

What catalyzed your interest in the technology of warfare?

The spark that really started me out happened in a Sharper Image store, where I saw a robotic system for sale. Soon I was talking with friends in the Air Force who were operating unmanned aerial systems–robotic planes–and I was struck by the disconnect between their reality and the talking points of military experts. At a major defense conference, where many key civilian and military leaders were analyzing current revolutionary trends, I never once heard the words "robot" or "unmanned" spoken. My friends in the military were carrying out battlefield action thousands of miles away and using robots to diffuse bombs, yet no one was talking about this incredibly momentous change that was starting to play out! So, from 2005 to 2008, I traveled the world interviewing anyone and everyone connected to the realm of war and robotics to research my latest book.

What types of questions did you set out to answer in your research?

I asked what it's like for the young pilots flying planes 7,000 miles away over Afghanistan. And what's it like to be their squadron commander or their general? I asked about working for a company that designs robotic weapon systems, and what civilian politicians think about it all. I talked to science fiction authors who, it turns out, are also quietly consulting with the Pentagon. On the opposite side, what do insurgents in places like Iraq think about our robots being sent out to fight them? How are news journalists covering it around the world? What do human rights activists and humanitarian organizations think about it?

"The steam engine ended the age of sails and eventually the internal combustion engine mechanized war with tanks and airplanes. Then came the atomic bomb, the computer…I believe robotics stands to have that same game-changing effect."

Let's step back for a moment and look at the broader trends in the evolution of technology and warfare. What have you observed?

Technology clearly does evolve, from the story of fire to the story of the Internet. Every so often in history, technological revolutions come along and change the rules of the game–they disrupt the norm. In business terms, we describe these as killer applications. But "killer app" takes on a whole new meaning when we're referring to an armed robotic system. Technological advances in war have ranged from weapons like the longbow to inventions like gunpowder. Consider the world before and after gunpowder: when suddenly a peasant could carry a small weapon and be more effective than a knight who had spent his entire life training to fight. The steam engine ended the age of sails and eventually the internal combustion engine mechanized war with tanks and airplanes. Then came the atomic bomb, the computer…I believe robotics stands to have that same game-changing effect.

When were the first robotic warfare systems deployed?

The interest in using robots or robotic-like technologies in war spans the 20th century. During World War I, the Germans deployed remote-controlled motorboats that were loaded with explosives, and the Army Air Corp in the U.S. worked on a biplane that could fly itself over 70 miles to hit a target. In World War II, an accident with a remotely controlled B-24 killed John F. Kennedy's older brother, Joseph Kennedy, Jr. (who was the eldest of the family and originally considered the presidential candidate). These early systems, however, didn't possess the capability to gather or use information about the world around them. Different levels of autonomy exist—a robotic system doesn't have to be like the Terminator, thinking on its own, to be considered a robotic system.

Was there a pivotal turning point in the capabilities of unmanned systems that truly began to unleash their potential?

One Air Force officer I talked to described the integration of GPS as the "magic moment" because GPS allows us to know where the robot is in the world, and the robot knows its own location as well. Without GPS technology, a Predator drone could send video footage of what it was seeing, but we didn't know where it was on the map. Prior to 9/11, the military had just a handful of unmanned aerial systems; we now have more than 7,000. On a similar note, the first invasion force of Iraq utilized no unmanned ground vehicles. We now have over 12,000 systems such as the PackBot, made by **iRobot** [IRBT], in the U.S. military inventory. The only part of the defense budget that's growing right now is for unmanned systems and cyber warfare. Like any other industry, once the technology is proven, a global market is born. Forty-four other nations are now building, buying, and using military robots.

The best research and technology once came from the military institutions, but now it seems to be sourced from commercial manufacturers and systems. Is this the case with unmanned systems?

This trend is certainly true at the meta-level. The amount of R&D spending pouring out from the military can't compete with the broader marketplace, so the military can't steer or shift the marketplace the way it used to a

Continued from page 4

few decades ago. A funny illustration of this is that there are a large number of Army generals who use iPhones. Recently, a four-star General talked about his plan to give every soldier an iPhone. The problem is that **Apple** [AAPL] has a proprietary mode of business that won't change, even for the U.S. Army, and so the likelihood of using iPhones in the Army is unlikely. The military relies on an absolutely terrible acquisitions process, and it simply cannot deliver IT as rapidly as in the civilian markets.

With that in mind, how does open-source technology impact military options?

As related to robotics, I see huge possibilities in open source, off-the-shelf technology. But we want to keep our eyes on a couple of dangerous points. This technology is not like an aircraft carrier or an atomic bomb, which need huge industrial systems. It's not limited to large, well-funded militaries. Any non-state actors can access this technology, and we've seen groups like Hezbollah fly their own drones in Iraq; we've seen jerry-rigged IEDs that are crossed with robotic systems so they're not buried along the side of the road—they're mobile and they can drive themselves. The worry here is that one person's hobby may be another person's terrorist plot. As technology spreads, the set of users gets wider. Most people use it for good, but there's always that slender minority that wants to use it for some form of bad. We've seen that happen with the Internet, which has revolutionized our world while simultaneously creating issues in cyber-security and cyber-warfare. New technology is going to be used in lots of unexpected ways, and we'll always be trying to catch up. The pace of technology is starting to outstrip our human institutional responses, including our legal rules and restrictions.

What other countries are working to acquire a decisive advantage in robotics technology and talent?

Internationally, distinct planning is going on in some very surprising places. UAE, particularly Abu Dhabi, has just signed an amazing set of consortium and partnership agreements with some of the top robotics companies. Some wouldn't think of them as having a technological leading edge, but a lot of really interesting things are starting to happen there. Globally, states driven to acquire an edge in robotics tend to be smaller, with troubled relationships with their neighbors. Israel and Singapore are both in that situation, so it's not surprising that they both have got a lot of neat things going on in robotics. Japan has a very strong civilian robotics industry, but not much on the military side, because of the restrictions of the post-WWII constitution. In Korea, the government has created a robotics park that took billions of dollars worth of planning; it has similarities to the biomedical research triangle in North Carolina. China originally worked in copycat mode, but they are starting to turn out new systems of their own. At a trade show last year, Chinese companies displayed 25 different unmanned aerial systems. We can argue whether their products are as capable as ours, but the point is, their industry is growing rapidly. In a broader context, we need to think in overall terms about our manufacturing, and about the science, mathematics, and engineering training in our schools. I believe this is an actual security crisis and a national economic crisis as well. As one U.S. Air Force Officer that I interviewed put it, "The Chinese are kicking our butts, and we're sitting on our stumps."

Can the U.S. stay competitive in military robotics?

In any field of technology, but particularly in robotic technology, the ability to innovate and be creative, not just at an individual level but at an organizational level, are strong determinates of success. We still do pretty well at both of these in the U.S., although not as well as we used to. On a broader level, our massive national debt and our weakening American education system are hollowing out our national power. We've been aware of these problems for more than a generation and basically the baby boomers just kicked the can down the road and left the problem to the next generation. I'm still optimistic, because I see that generation starting to get serious about it. We're finally starting to argue about the solutions, rather than continuing to live in blissful ignorance.

You once told about a young individual who had little aptitude as a traditional soldier, but was encouraged to become an unmanned systems operator. Could you relay that story?

That story is in the book. This young man was a high school dropout, and his dad was angry with him. To make his dad proud, he volunteered to join the U.S. Army as a helicopter mechanic. But due to his poor grades he couldn't qualify. The recruiter asked whether he'd consider being an unmanned aerial systems operator–a drone pilot. The young man turned out to be a natural at this job because he had spent much of his life unintentionally training for it via video games–which may be why he failed in high school. He turned out to be so good that the Army promoted him to a specialist, and then they made him an instructor at the Pilot Training Academy–the equivalent of a professor, and a job that had once been limited to officers. He's taken out more enemy targets and arguably has saved more American lives than all the F22 fighter pilots combined. Some look at him with the same mix of disdain and fear that the knights experienced when the peasants were given gunpowder. Soldiers using robots are put in roles that are fundamentally different than anyone at their rank or training have done before–that is one part of the game-changing effect of this technology.

The young drone pilot you speak of sounds eerily similar to a character in the science fiction novel *Ender's Game*, by Orson Scott Card. What does science fiction have to say about where we're headed?

The essence of *Ender's Game* was the notion that wars could be fought without involving the public. In fact, some of the people doing the fighting think they are playing a game. We're seeing some interesting echoes of this idea today. We're integrating video game technology into war; military controllers are literally modeled after the Xbox and the PlayStation controllers. Yet soldiers don't treat their missions, including using the unmanned systems, as just a video game–they take it quite seriously. Those who fight from afar still deal with the very same issues of combat stress and fatigue as traditional soldiers. War, whether it's up close or at a distance, is still challenging and traumatic. The broader issue, I think, is not the idea of soldiers treating it as a game, but rather that the public does not connect to the war. We've dropped over 200 munitions on targets in Pakistan; that's actually greater than the number of targets hit with manned bombers in the opening round of the Kosovo War. But unlike the Kosovo War, we just don't view the Pakistan operation as a war. The public just doesn't see it that way, the public doesn't even think about it, and the media doesn't report it that way. ET

Continued from page 1

years of industry experience, most recently as co-founder and chief business officer of **Vanda Pharmaceuticals** [VNDA]. Prior to Vanda, Chip was a principal at Care Capital, a venture capital firm investing in biopharmaceutical companies, and served in a variety of commercial roles at SmithKline Beecham (now part of **GlaxoSmithKline** [GSK]). Clark holds a B.A. from Harvard University and an M.B.A. from The Wharton School at the University of Pennsylvania.

Having spent time as a venture capitalist, what lessons-learned are you applying to your current role as startup CEO?

I learned two things especially well: First, how to be cost effective, and second, that the only way to be cost effective is to have a terrific team. At my previous company, Vanda, I was fortunate to work with a very cohesive team. I feel lucky to have found an opportunity that builds on my previous work here at Genocea, and I'm hopeful that the atmosphere here will be similar. Our team has a lot of fun, but we're also quite productive, and ruthless in managing costs. We are careful to allocate resources to projects most likely to yield value.

What were the biggest challenges you faced at Vanda?

The biggest challenge is easy to identify: the FDA turned down our lead product, and that decision resulted in our stock price dropping by 95%. As a result, we needed to reduce staff by 75%, and our staff was like family. To look people in the eyes and explain that we needed to downsize, and then to forge a path to rebound–that was a significant challenge, and I'm very proud of the work that was done to keep the company together during those times. We eventually convinced the FDA they were wrong in their decision, and ultimately emerged at the end of the day with an approved product on the market.

Another challenge was building and maintaining a good corporate culture. Small companies can't succeed unless they work smart, because they compete against big companies with much greater resources. The only way to succeed is to be nimble, smart and ruthless with cash. I believe I made a significant contribution along those lines for Vanda, and as I think about my overarching goals for Genocea, that's number one.

What specifically about Genocea made you want to join the company?

"After basic sanitation and clean water, vaccines are the only technology that's been proven to extend life. In fact, those three factors alone are the greatest contributors to the nearly doubled lifespans in the developed world between 1900 and 2000. Genocea creates new types of vaccines where challenging diseases await new cures."

Both the rational and the emotional perspectives played a part. Rationally, in order to successfully compete for scarce dollars, a company needs to have a valuable and provable proposition. After basic sanitation and clean water, vaccines are the only technology that's been proven to extend life. In fact, those three factors alone are the greatest contributors to the nearly doubled lifespans in the developed world between 1900 and 2000. Genocea creates new types of vaccines, both for the Western world and developing economies, where challenging diseases await new cures. We have the chance to significantly reduce diseases that kill millions of people annually around the globe. If we are successful, the ability to look back and know that our company had that kind of impact–it's incredibly motivating.

Vaccines are also unique in that more grant money is available than for many other disease areas. Genocea has already raised more than $6 million from grant sources, including PATH and the U.S. military. We expect such grant monies will continue to be available and we're going to pursue them aggressively.

How does Genocea's approach to vaccine development differ from what others have tried in the past?

Broadly speaking, the human immune system has two arms, and most vaccines today speak to only one–the B-cell. When a body is exposed to a pathogen, these cells develop a memory that enables the body to recognize that pathogen in the future, and mount an immune response. There are dozens of diseases, however, where the mechanics of the immune system response have been mysterious. The list of diseases includes malaria, tuberculosis, HIV, HSV, herpes and chlamydia. We've learned that the immune response to these diseases often involves T-cells, so to prevent or treat those diseases, both B and T-cell immune responses are needed. Genocea is using a terrific platform technology developed at Harvard that can identify the pieces of a pathogen that elicit a T-cell response. The fact that we can do this rapidly, and cheaply, enables us to quickly develop vaccines for these more challenging diseases. I'm sure that if **Merck** [MRK], or Sanofi Pasteur or GlaxoSmithKline could have developed vaccines for any of these diseases, they would have done it a long time ago–but they haven't yet. We think our technology cracks the problem, and that's incredibly exciting.

What has the company proven to-date?

We've proven that we can essentially create a window into a person's immune system. We've collected blood from hundreds of people, and have been able to see exactly how their bodies generate B-cell and T-cell responses. Our platform relies on finding antigens, and we have found antigens in four of our five primary targets already. The fact that we have successfully identified antigens is proof of our technology. We've also run these antigens through a battery of animal tests to confirm our results. Overall, we've seen tremendous progress in all four programs in just a few years.

Looking ahead, what are you hoping to accomplish over the next several years?

Our next element of proof will come when we focus on our lead program: developing a therapeutic herpes vaccine. A tremendous need exists to treat herpes, both in fighting the infection itself and in reducing transmission. Herpes is an epidemic in the U.S., with 15% to 20% of the population carrying HSV2. If we can effectively both fight the virus and reduce its transmission, we can have a significant effect on the epidemic. So over the next few years we will advance our therapeutic HSV2

Continued from page 6

"We've proven that we can essentially create a window into a person's immune system...and have been able to see exactly how their bodies generate B-cell and T-cell responses."

vaccine through the first two phases of FDA trials. Our goal is to demonstrate that the vaccine is safe and has the potential to be efficacious. We expect that successful trials would constitute significant new validation in the eyes of potential partners or potential acquirers of the company.

Most people may be familiar with herpes, but not one of your other vaccine programs: pneumococcus. What is pneumococcus?

Pneumococcus is another name for a pathogen called *Streptococcus pneumoniae*; we know it as a major cause of pneumonia and other infections. This is not just a sickness we occasionally get in the winter–this pathogen is the number two or three killer of children in the developing world, where infants and toddlers are especially vulnerable to the bug. Pneumococcus vaccines are becoming part of the arsenal to fight disease. In fact, the top selling vaccine in the world is a pneumococcus vaccine called Prevnar, marketed by Wyeth. That vaccine was developed by George Siber, our executive chairman, so we know quite a bit about the pathogen. More than 90 strains of this bug have been identified, and Prevnar works by addressing as many of those strains as possible. The initial vaccine covered seven strains, and a newer one addresses 13. Our vaccine program purports to work differently. We've isolated proteins that are conserved across all strains of pneumococcus, so this should allow us to create either a unique standalone vaccine, or one that works in combination with existing vaccines. Other pneumococcus vaccines protect the lungs, while ours aims to prevent the bug from taking hold in the nose, throat and ears. If we can do that, we can radically improve protection against this disease.

There are many regulatory changes taking place that could impact the health care sector. How do you see Genocea being affected?

To some extent, we have to ignore these broader conditions, and focus on the fact that our technologies can radically improve the treatment or the prevention of the diseases we're targeting. If we can do that, the rest will take care of itself. We don't ignore the market, but we stay focused on executing our plan. As much as we can, we look around the corner to anticipate how the failures of our science, or the missteps we make, or exogenous factors might affect our options; if we do those things, we'll be fine.

Genocea has several corporate investors. What do they bring to the table?

A few years ago, we were fortunate to get SR One, the venture arm of GlaxoSmithKline, as an investor in Genocea. Not only are they terrific investors, but their name also provides corporate validation. More recently, we were pleased to attract both **Johnson & Johnson** [JNJ] and Mitsubishi Healthcare Ventures, both because they are terrific collaborators and because working with several investors removes the possibility that we seem beholden to one company. With our corporate investors, we have the best of both worlds. They provide a stamp of approval, validating our strategic importance, and bring a tremendous amount of experience and perspective to the table. And while these groups have privileged access to Genocea, they don't have preferential rights to our technology, so we're not giving anything away in exchange for their investments. Our hope is that these corporations will be at the front of the line when Genocea is ready for strategic transactions. But since big pharma has significant interest in vaccines, and we're going after diseases for which effective vaccines don't yet exist, we hope there will be others in that line too.

"Vaccines are also unique in that more grant money is available than for many other disease areas."

How do you think the outside world of big pharma views Genocea at the moment?

They may view us with a mix of interest, anticipation and a little bit of skepticism, because we're proposing to do something radical–we're changing mindsets about how to prevent or treat infectious diseases. The anticipation comes from the fact that they know we're generating new data rapidly, and that it's going to be released soon. There is also excitement because we're going after diseases that no one else has solved. They're starving for new vaccine ideas, and we are poised to capitalize on that hunger.

Outside of infectious diseases, where else could Genocea's technology be applied?

One of the amazing things about this technology is the potential to exploit it beyond our current projects to any areas where T-cells play a significant role, such as oncology or auto-immune diseases. These areas have not been priorities for us to-date, but the potential applications are very broad, for both treatment and diagnosis. We absolutely expect to target these areas in the future.

As CEO, how do you think about building a positive culture in your organization?

A CEO can be effective by setting the tone for the company in several ways: in the way that the company socializes, and the way that the company asks and answers questions. In the asking and answering of questions, my job is to be as data-driven as possible, to ensure we base decisions on as many facts–and not emotions–as we possibly can, but also to recognize when too many facts just lead down blind alleys. It's also important to socialize. You've got to have fun with your team. This company didn't need me to tell them to have fun, but we make sure that we take time to step back and appreciate that we're doing something really cool, and that we're working with great people. Life is not just work.

Any great books you've read recently?

I'm reading a great book about Magellan. He was an incredibly persistent guy who was doggedly determined to do something radical–to sail around the world at a time when people weren't even sure the world was round. The title is *Over the Edge of the World.* ET

The Emerging Tech Portfolio

Company[symbol]	Coverage Initiated	Current Price	52-week range	Mkt Cap ($mil)	Buy/Sell/Hold
INTELLECTUAL PROPERTY INCUMBENTS *Leading researchers in the physical sciences, with big potential for spin-offs and revolutionary breakthroughs*					
GE [GE]	8/07	$19.62	$13.75-$21.65	$208,080.00	Buy
Hewlett-Packard [HPQ]	3/02	35.98	35.91-49.39	77,860.00	Buy
IBM [IBM]	3/02	170.16	120.61-173.54	206,100.00	Buy
MATERIALS *Companies producing materials with novel properties that have applications for a wide range of industries*					
ShengdaTech [SDTH]	8/08	3.55	3.27-6.45	192.47	Hold
LIFE SCIENCES *Companies that are working at the cutting edge of medical technology*					
Life Technologies [LIFE]	11/05	53.98	41.10-57.25	9,650.00	Buy
Nanosphere [NSPH]	11/07	2.39	2.10-5.95	66.34	Buy
ELECTRONICS *Companies that have corralled the key intellectual property that will be the foundation for next generation electronics*					
Nanosys [private]	3/02	n/a	n/a	n/a	n/a
NVE Corporation [NVEC]	7/03	61.66	38.00-63.49	294.49	Hold
ENERGY *Companies that are developing high-efficiency, low-cost alternative energy technologies*					
First Solar [FSLR]	8/07	126.38	100.19-175.45	10,890.00	Hold
A123 Systems [AONE]	9/09	5.66	5.21-11.53	712.93	Buy
ENABLING TECHNOLOGIES *Tools and instrumentation that enable critical science and technology discoveries*					
Veeco [VECO]	3/02	54.79	29.54-56.05	2,230.00	Buy
FEI Company [FEIC]	1/03	39.43	16.51-40.24	1,530.00	Buy
Accelrys [ACCL]	3/02	7.06	5.96-8.95	391.04	Buy
INVESTMENT VEHICLES *Funds that have investments in promising emerging technology companies*					
Harris & Harris Group [TINY]	5/02	5.40	3.70-6.30	167.40	Buy
PowerShares Lux Nanotech Portfolio [PXN]	8/07	9.09	7.74-10.62	38.39	Buy
PowerShares WilderHill Clean Energy [PBW]	8/07	9.40	7.98-11.42	541.48	Buy

Word on the Street

Stock prices as of May 26, 2011

GE: Shares fell 2.4% despite plans to buy back $12B worth of shares over the next few years. GE has already repurchased $2.3B in shares since last Summer, and wants to redeem Warren Buffet's $3.3B in preferred shares. GE also said it plans on increasing its dividend ratio. Fairholme Capital sold its entire $290M GE position.

HPQ: HP declined 11.6% to a new 52-week low after issuing a pessimistic 2011 outlook. Net income of $2.3B ($1.05 per share) is up from $2.2B ($0.91 per share) in Q1 2010. Revenue grew 3% to $31.63B. The results beat expectations but HP lowered its guidance for the current quarter and full year. It now expects adjusted Q3 EPS of $1.08 and $31.1-$31.3B in revenue. Wall Street had expected adjusted EPS of $1.23 and revenue of $31.84 billion—the stock was downgraded by 10 analysts.

IBM: Big Blue hit a new 52-week high. IBM's market cap surpassed Microsoft's for the first time in 15 years.

SDTH: ShengdaTech remains halted pending an appeal to the Nasdaq over potential delisting. The Nasdaq sent SDTH a letter saying its failure to timely file its 10-Q for the period ending March 31, 2011 is in violation of Nasdaq listing rules and serves as an additional basis for delisting. The delisting has been stayed pending the outcome of a hearing on May 26.

LIFE: Life Technologies ended slightly lower. Diagnostic test maker Gen-Probe [GPRO] hired Morgan Stanley to seek a buyer for the company and Life is reportedly among the potential bidders. LIFE is hedge fund Glenview Capital's second largest health care holding ($493M position)

NSPH: Nanosphere plummeted 20.3%, hitting a new 52-week low. It raised $32.1M in a secondary offering, pricing shares at $2.20. The cash infusion should allow it to progress through 2012.

NVEC: NVE was up 6.1% after completing a record FY 2011. It reported Q4 revenue of $8.183M, up from $8.179M in Q4 2010. Quarterly net income increased 2% to $3.67M ($0.75 per share), compared with $3.60M ($0.74 per share) for the prior-year period.

FSLR: First Solar lost 7.4% on continued subsidy fears. Q1 earnings fell 32% to $116M ($1.33 per share), from $172.3M ($2 per share) in the prior year period. Wall Street had been expecting EPS of $1.16. FSLR reiterated FY 2011 profit forecasts of $9.25-$9.75 per share. FSLR said much of its 2011 sales and earnings would be pushed into the second half due to delays in closing a DOE loan guarantee for a large Arizona project and European subsidy changes. Italy, which makes up nearly 13% of FSLR's sales, is cutting back its incentives.

AONE: A123 dropped nearly 6% after reporting a wider Q1 net loss of $53.6M ($0.51 per share) during the quarter, compared to a loss of $29M ($0.28 per share) in Q1 2010. Total revenue fell 26% to $18.1M. Analysts expected A123 to lose $0.46 per share. A123 expects sales to ramp in coming quarters as it starts volume production of battery systems for EV maker Fisker. A123 said other customers including BMW and Daimler would bolster 2H 2011 sales.

VECO: Veeco shares hit a new 52-week high and ended up 9.5%. Veeco is benefiting from China's aggressive move into LED production. According to IMS Research, shipments of MOCVD tools (used to make LEDs) to China rose from 64% to 74% in Q1. For Veeco, China represented 90% of its Q1 shipments.

FEIC: FEI Co. surged 20.8% to a fresh 52-week high. The nanotools leader reported a record Q1 earnings report. FEI earned $22.3M ($0.54 per share), compared with $21.3M ($0.52 per share), in the prior year period. Revenue rose to $197M, from $186.1M in Q1 2010. Wall Street had expected earnings of $0.46 per share on revenue of $185.8M. Q1 gross margin was 43.6%, compared with 39.7% in the prior year period. FEIC said it expects Q2 EPS of $0.55-$0.61 on revenue of $195-$210M. Analysts were expecting $0.45 in EPS on revenue of $185.1M.

ACCL: Accelrys fell 7.7% after reporting Q1 results. Q1 GAAP revenue increased 67% YoY to $34.6M (from $20.8M). It reported a GAAP net loss of $5.7M ($0.10 per share), compared to a net loss of $2.4M ($0.09 per share) for the prior year period. Quarterly results were impacted by the merger with Symyx completed on July 1, 2010. For FY 2011, ACCL expects non-GAAP revenue to fall between $152-$156M, and non-GAAP EPS to be $0.33- $0.35.

TINY: Harris & Harris Group gained nearly 6% in advance of the IPO for biofuels company Solazyme, its largest holding. TINY reported a Q1 Net Asset Value (NAV) of $4.73, down from Q4 2010's $4.76. Solazyme accounts for 24% of the carrying value of TINY's $97M equity portfolio. A successful IPO should boost the company's NAV—and its stock price.

PXN: The PowerShares Lux Nanotech portfolio dropped 5.1%.

PBW: The PowerShares WilderHill Clean Energy portfolio lost 7.3%.

Forbes/Wolfe Emerging Tech Report
is published monthly by Forbes Inc. and Angstrom Publishing LLC, 60 Fifth Avenue, New York, NY 10011
Editor: Josh Wolfe Contributing Editors: Zack Schildhorn, Suzanne Johnson

Forbes, Inc.
Vice President/Editor, Newsletters: Matthew Schifrin
Senior Editors: John Dobosz, Tina Russo
Subscription Director: Tyler McKee

To subscribe call 1-877-733-7876 from within the U.S. or 952-646-5381 from outside the U.S.; or visit Forbes.com Investment Newsletters (www.forbesnewsletters.com) on the Web.

For editorial information, e-mail: nanotech@forbes.com

