A city built on science

Bay Area science

Techs and the city

Lab by lab in and around San Francisco

Jul 31st 2009

Monday

SAN FRANCISCO conjures up images of hippies and of free love, the psychedelic 60s and leftist politics. A member of Jefferson Airplane, a rock band, described it as "49 square miles surrounded by reality". It has always had that air. In a letter written in 1889, Rudyard Kipling wrote of "a mad city, inhabited for the most part by perfectly insane people."

But as someone who writes about science (and in the interests of full disclosure, practices it for a living), I see a different side of San Francisco and the broader Bay Area around it. I don't see a region full of people looking to escape reality; I see scientists and engineers at universities, companies, and national labs probing and investigating that reality on a daily basis. Instead of mind-altering drugs, I see the world-altering technology that flows out of Silicon Valley.

Plutonium was first discovered in a Berkeley lab (as were the aptly-named berkelium and californium). The Bay Area is the birthplace of "big science" and of the atom smashers that have told us so much about the fundamental building blocks of matter. Quarks were first discovered just down the peninsula at the Stanford linear accelerator.

In the 1970s, two professors from Stanford and the University of California, San Francisco (UCSF) figured out how to use bacteria to clone segments of DNA. In the process, they gave birth to genetic engineering and the modern biotechnology industry. South of the city, Silicon Valley gave us the personal computer, the mouse, and the verbs "to google" and "to tweet". Sit down in any local coffeeshop and you're just as likely to end up next to someone nursing a startup as you are someone nursing a cappuccino. Now, the Valley's venture capitalists are hoping that their magic will work just as well on the clean-technology industry.

The Bay Area hosts the world's biggest laser (at the National Ignition Facility in Livermore), the world's most intense X-ray source (at the LCLS at Stanford's national lab) and an institute devoted exclusively to the scientific search for extraterrestrial intelligence (the SETI Institute in Mountain View). NASA's outpost here just launched a probe that will slam into the lunar surface in search of water.

Between them, Stanford, Berkeley, and UCSF employ some 50 Nobel laureates spanning the full range of scientific disciplines. True, a handful of these are for economics, but we'll cut the dismal science some slack.

Science and technology are to the Bay Area what finance is to New York and what cars are (or were) to Detroit. They underpin the region's economy, influence its culture and shape the very character of this region as much as its notoriously active seismic geography does.

Over the next four days, I intend to explore a few of the different faces that science
and technology present to residents here. From the stem cell research that promises to revolutionise medicine, to the science of growing and making the best wine, to the science-fiction sounding search for extraterrestrials, we’ll be taking a scientific road trip around the San Francisco Bay Area. Think Thelma and Louise meets Watson and Crick.

Tuesday

I WAKE up slightly disoriented at 5:45am. Waking in darkness makes me feel more like a farmer than a scientist, but perhaps that’s appropriate for the task at hand today. I’m on my way to the University of California, Davis for their annual RAVE conference, a gathering of scientists, winegrowers and winemakers meant to share the most recent advances in the disciplines of viticulture and oenology.

Gulping down a large coffee, I head east on I-80 across the Bay Bridge and through the sprawl of the East Bay. I pass the exit for Highway 37, which winds its way north and west to Napa and Sonoma, the heart of California’s wine country. In Napa alone, over 40,000 acres of vines produce an annual crop of grapes worth $400m. I manage to resist the pull of the wineries and instead follow I-80 east into the brightening dawn.

You may not realise it when you pop the cork on a nice bottle of cabernet sauvignon, but many scientists spend their lives studying every facet of wine, from the best pruning and watering techniques for growing the tastiest grapes to the genetics of the bacteria used in their fermentation. And UC-Davis is one of the world’s great centres for wine science.

Its Robert Mondavi Institute for Wine and Food Science, founded with a donation of $25m from the father of California’s wine industry, boasts 75,000 square feet of state-of-the art labs, kitchens, and sensory-testing equipment. Inside, the halls literally smell of wine and the researchers seem to be having a lot more fun than the typical science PhDs.

Studying wine seems like a far cry from curing cancer or weaning the world off of fossil fuels, but the scientists who do so are no slouches. They make use of the latest techniques in biochemistry and biotechnology. Their analyses are sprinkled with complex mathematics and multivariate statistics.

As I learn later in the morning, “whole genome shotgun sequencing”, originally developed for the Human Genome Project, was put to work on pinot noir in 2007. Besides shedding light on fundamental issues of plant evolution, wine scientists hope the grapevine genome will reveal some of the pathways that control wine flavour and resistance to various pests.

The packed program includes lectures on viticultural practices, techniques for drying grapes into raisins, the perils of something called “berry shrivel” and how microbes contribute to flavour during fermentation. We hear about genomics, proteomics, and the “wired vine”, where all aspects of growing are monitored and controlled by sensors. Terpenes, norisoprenoids, oak lactones—the biochemical jargon comes thick and fast and eventually overwhelms me.

But what comes through is a sense, as one speaker puts it, that wine is truly “chemistry in a glass”. Wine contains hundreds of complex chemical compounds, some of which are active in startlingly small amounts. Methoxypyrazine, which gives sauvignon blanc a slight bell-pepper odour, can be detected by the nose at less than two billionths of a gram in an entire bottle.

To the purist, all of this measuring and quantifying might destroy the beauty of a perfectly balanced bottle paired with a delicious meal. But I think of the child who looks up at the night sky and grows up to become an astronaut. Science begins with and returns to beauty and wonder.

As I hit the road back to the city, I think about the theory that it’s better to give grapes slightly less water than they want in order to stress them and to concentrate their intense flavours. Out of great struggle comes great wine—and great science.

Wednesday

TONIGHT I’ve got two of the hottest tickets in town. As the bouncer checks my ID, I
Anthony Gordon can hear the low bass emanating from the DJ’s turntables inside the glass doors. The crowd is dressed in slinky skirts, tight jeans, and sport coats. This is not the hippest new club in the city, but the normally staid halls of the California Academy of Sciences. My girlfriend and I head off for a stiff gin and tonic at one of the many bars (though not the one sitting beneath the watchful eye of Tyrannosaurus rex).

To most people, the words “science” and “nightlife” don’t usually go together. This spring, however, the Academy opened its doors for a series of boozy evenings intended to give the residents of this young, tech-savvy city another view of the science museum. “NightLife”, as the event is called, has been selling out, with more than 3,000 people attending each week.

It was only last September that the Academy returned to its home in Golden Gate Park. After the 1989 Loma Prieta earthquake damaged the aquarium here, the Academy undertook a complete rebuilding project that took $488m and the better part of a decade. Designed by Renzo Piano, the museum is now the largest public building in the world to have a LEED Platinum rating. Its design, which melds modern glass and steel with the classical architecture of the original building, reminds me of science itself—a combination of the new and modern with the solid, tested principles of the past.

Inside, an exhibit demonstrates some of the building’s environmentally friendly features. Recycled blue jeans are stuffed into the walls to serve as insulation (which seems fitting, as San Francisco is home to both Levi's and The Gap). Half of the building’s cement was made with recycled waste products from coal combustion and steel production, and the glass canopy outside houses 60,000 photovoltaic cells. Instead of using treated freshwater for the aquariums, water is pumped in directly from the Pacific at the other end of the park.

We continue our stroll past the 90-foot diameter glass dome that houses a living rainforest. Next to the DJ, people are gaping through a glass window at scientists in white coats working on specimens—perhaps a nod to the traditional view of scientists in a museum.

Downstairs, the Steinhart Aquarium is packed and people are noticeably tipsier. An alligator drifts towards the thick glass, having recently sent its albino tankmate Claude to the hospital with a nasty bite on the toe. A scantily clad girl sticks her tongue out at a lizard in its tank. It responds in kind and then lazily drops off its branch.

We head back upstairs and onto the museum’s “living roof”, which is planted with native Californian grasses and flowers. They help reduce runoff and, from a distance, cause the building to mirror the hilly landscape of the city around it. A line is patiently snaking its way to a docent with a telescope trained on Saturn’s rings and the moon Titan.

After we’ve had our fill of stargazing, we spill out into the beautiful evening and stroll out of the park. I’m left with the inescapable feeling that this taste of the nightlife has been high on style but a little light on the scientific substance. But that’s no terrible thing. Science will survive and grow, as this museum has.
passed Proposition 71, a ballot measure allowing the state to fund research into human embryonic stem cells. Overnight, California became one of the largest backers of stem-cell research in the world. At a time when the federal government was unwilling to invest in regenerative medicine, the message from the state’s voters was clear: the incredible therapeutic promise of stem cells outweighs the moral objections to using them.

That therapeutic promise, the meeting’s three panellists explain to us, comes from stem cells’ chameleon-like ability to turn into any of the cells that make up the body’s tissues and organs. Most cells are tailored to perform a particular function. Heart cells are good at beating, neurons transmit electrical signals and pancreatic islet cells produce insulin. While they all contain the full set of instructions of the human genome, each uses only the small subset that directs its particular task.

A stem cell, on the other hand, is a cellular jack-of-all-trades. Given the right signals, it can become a brand new heart cell or neuron or insulin-producing cell. Bruce Conklin, a professor at the University of California, San Francisco and the second speaker of the evening, plays us a dramatic video of 2,000 human heart cells that had been derived from embryonic stem cells. Sitting in their Petri dish, they wriggle and beat, just like a human heart.

Embryonic stem cells were first isolated in 1998, and since then the pace of progress has been furious. Much work has gone into figuring out how to reliably and efficiently generate the different cell types that doctors would like to use in patients. In addition, as the speakers emphasise, understanding exactly when and how implanted stem cells can go awry and cause tumours remains an essential research task that confronts all potential therapies.

Such therapies are slowly, but surely, making their way towards the clinic. In January, Geron, a biotechnology giant, got FDA approval to conduct the first clinical trial testing the safety of an embryonic stem cell therapy. It will work with patients with severe spinal cord injuries. For its part, CIRM is hoping to get ten to 12 human stem cell trials going in the next four years. In December, it will award $20m to researchers and their corporate partners with that goal in mind.

After the speakers finish their presentations, the moderator opens the floor to questions from the audience. From the front row, a young girl raises her hand. In a high-pitched, slightly faltering voice, she asks a deeply personal question: “I was burned very badly in August 2008. How might this help me, and how can I help in your research?”

After the dry PowerPoints and data-filled charts, the scientists seem slightly taken aback by the raw emotion. They stammer through some answers, but none seems satisfying. Despite stem cells’ promise, the science just isn’t quite there yet. This moment brings home both the deep hopes and the urgent desperation that surround what are undoubtedly the early days of regenerative medicine.

Friday

ONCE again I’m braving the early morning traffic on I-80, heading out of the city past Oakland and Berkeley. But just before I reach Davis, I veer north onto Interstate 5. It’s not the earthly delights of carefully cultivated varietals and nuanced terroir that concern me today. I’m heading into the mountains to get a tour of the Allen Telescope Array (ATA), a collection of 42 large telescopes that have just begun scanning the heavens for radio transmissions from intelligent extraterrestrials. Yes, you read that right—aliens.

Three hours later, my small Toyota begins the climb into the mountains of Lassen National Park. Eureka, Whiskeytown, Old Oregon Trail—the road signs here recall the miners and pioneers who trudged through during California’s mid-19th century gold rush. The two-lane road I’m driving on used to be a trail for rattling stagecoaches.

The San Francisco radio stations faded hours ago, and now only a few talk stations break through the static. Maybe I’ve lived in Haight-Ashbury for too long, but as I make a right turn into the observatory, Timothy Leary is in my head: “Turn on, tune in, drop out.” Here in Hat Creek, which is nearly devoid of manmade sounds, the ATA just turned on for science operations in May. For many years to come, it will tune into the radio sky to study the evolution of galaxies, the properties of black holes, and one of the most
profound questions of all—whether we're alone in the universe.

My tour guide this afternoon is Garrett Keating, a former cop turned astronomer. We walk out towards one of the 42 telescopes, a gleaming aluminium dish six metres in diameter. Mr Keating opens a trap door and we poke our heads inside. The main dish reflects incoming radio waves onto a smaller dish off to our left. That in turn bounces them onto the telescope's main receiver, a long pyramid with different sized antennas poking off of it.

The antennas pick up an extremely wide range of frequencies, from those used for broadcast television on the low end up through the ones that transmit satellite television. In between is the emission frequency of hydrogen gas—the most common element in the universe and the raw material for the formation of stars and galaxies.

Off in the distance, we hear the rumbles of an approaching storm, and several lightning bolts streak across the sky. Mr Keating insists we return to the lab. The antennae, he reassures me, are well grounded. I don’t tell him that it wasn’t the antennae I was worried about.

Inside, fibre-optic cables carry the signals from the dishes to enormous racks of computers. By using the computers to combine data from each individual dish, the ATA is able to mimic a much larger telescope for a fraction of the cost. An initial donation of $25m from Paul Allen, the co-founder of Microsoft, and $25m from other sources financed these first 42 dishes. Eventually, the team hopes to collect enough funding to get up to 350.

Operating together, the telescopes are quite sensitive. And they need to be, since a single mobile phone located on the moon would give off a much stronger signal than almost every astronomical object in the radio sky. In addition to its sensitivity, the ATA also views a large patch of the sky all at once. Most other radio telescopes are like telephoto lenses, zooming into a tiny region of space. The ATA, however, is the first that can take snapshots with a wide-angle lens.

Just outside the sliding glass door to the control room, I notice a doormat with a bug-eyed alien and the caption “welcome all species”, a reminder of the ATA’s second mission. This telescope array represents a great leap forward for the enterprise known as SETI, the search for extraterrestrial intelligence.

In the past, SETI has had to squeeze precious observation time out of existing telescopes around the world. With the ATA, the search for signals from intelligent life elsewhere in the universe will be carried out constantly, right alongside the astrophysics.

So what exactly is SETI looking for? Essentially, something that seems not to belong—an odd man out in the cosmic radio haze. One possibility is a very powerful signal confined to a tiny frequency band, like the manmade transmissions that are continually leaking off of earth. As Mr Keating explains, “nature doesn’t produce pure tones”. In addition, if the signal really is extraterrestrial, its broadcast frequency should drift, as the alien planet orbits its own star.

Over its lifetime, the ATA hopes to survey 1m promising candidate stars within a thousand light years of earth, and ten billion more in the central region of our own Milky Way galaxy. And as computers and algorithms improve, so will SETI’s ability to look for more complex alien transmissions in this mountain of data.

Black holes, exploding stars, clouds of swirling hydrogen gas light-years across the galaxy—this is hallucinatory stuff. Yet if the little green men finally arrive, San Francisco—built as it is on science, tolerance and the counterculture—would seem like a natural first port-of-call.

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