INVESTING THEMES FROM TECHNOLOGY & BIOLOGY

A Lux Capital White Paper
December 2014
Investing Themes From Technology & Biology

“Yes” is the answer to the question of whether innovation thrives more amidst abundance or scarcity of capital. When money flows, more ideas (and yes, even more bad ideas) reach fruition from the fuel of funding. When the spigot drips dry, it is necessity—that maternity of modernity—that births inventions.

Whatever may come, we are thrilled. We’re at once indifferent to uncertainties pervasive in headlines and plaguing so many investors, unsure of what to do as they are pushed out further on the risk curve (if you were a saver you were pushed into Treasuries, where you were nudged into corporate bonds, structured credits, high yield, equities, high risk equities, and on and on). We are thrilled by the progress of our existing portfolio companies and we are thrilled with the new opportunity set before us. Rational optimism (or optimistic caution) has us extra selective as we see growing signs of pockets of excess. We have defensive and offensive strategies to take advantage.

Apt for biological analogies, it is the slime mold where we turn for a clue. When the environment is resource rich, this multicellular superorganism spreads out, spores off, takes risks and searches more widely than it would when food supply is scarce. And when the food supply gets scarce, chemical stress signals sound an alarm telling the individual cells to congeal, return and rejoin into one. The economy follows this undulating pattern of dispersion in good times and consolidation in bad. Today we observe signs, each an individual point of light, each part of a faint constellation growing brighter. In public markets, mergers are called off and spinoffs are called on with increasing frequency. We see individual investors, once part of larger VC fund partnerships, spawning off and raising single GP funds. Many bankers and management consultants are following suit, leaving behind their suits and trying their hand as venture investors. Family offices and LPs, happily allocated to Fund-of-Funds, are going directly to GPs and increasingly directly to companies. Real estate landlords are also benefiting from the current rising demand. Sparse spaces once vacant are revamped as incubator and co-working spaces and, comforted by ascendant valuations, landlords are accepting equity in lieu of cash rent. Until, of course, they begin demanding six months cash up front.

The fittest investment strategy we can deploy – against an ever-shifting and ever-evolving landscape of structural shifts and fickle sentiments (themselves as likely to accelerate as to reverse course without warning) – is to deploy all the arrows in our investment strategy quiver: thesis-driven contrarian newcos, people-driven audaciously-bold high-growth ventures, and special-situations affording late stage assets at early-stage prices. Perceptions and expectations of others matter (though we can only control our own). The more stable the environment is thought to be, the further out people will look. And the more unstable the environment, the more steeply others will discount the future and have less forward-looking behavior. This seems to be universal, whether across the behavior of bond market participants, populations of differing socioeconomic demographics and animals in ecosystems facing abundance and calm, or scarcity and stress.

In a loose-money rising valuation environment, our best offense is to emphasize starting new companies from scratch, where we control valuations and terms from the very start, immunizing ourselves from excess and positioning ourselves to take advantage of it. We call this “ball control,” and it historically accounts for one-quarter of our portfolio construction.
In an environment where capital – whether generally, in specific sub-sectors or specific companies – gets scarce, then we emphasize special-situations where we can own later stage assets at early stage prices, whether through recapitalizations, divestitures or spin-offs. Here we have the chance to earn returns and get paid on the money, time invested and risks borne by others (who stumbled).

This healthy positioning makes us indifferent to whether we may have a rising or ebbing tide. It’s an offensive stance making us neither dependent on donning rosy spectacles nor speculating on less-rosy times. It’s especially useful (and intellectually honest) because in the overlapping magisteria of what matters and what we can control, the (mis)behavior of markets (and others) serves us.

The Vast Un

While we seek to be agnostic to macro forces, we’re true believers about one thing: the invariable march of progress driven by the exponentially expanding cornucopia of new technologies, innovations and investable companies commercializing them.

Nobody can predict the future, but there are undeniable directional forces in both biology and technology. We know that whatever just happened is about to be eclipsed by whatever is about to happen. Whether (as in biology) there is a Cambrian explosion or a Permian extinction, technology, like life itself, progresses in a clear direction. To understand where technology is going, it helps to study from where it came. Technology has much in common with biology: it trends from simple to complex; from few species or technologies to many specialized ones; from isolated organisms or ideas or objects to highly networked combinations; from disorder to high-order, information and energy density and energy efficiency. And while life and technology follow these parallel paths, they’re now co-evolving and influencing each other.

Inspiringly staggering is the number of technologies not yet invented that can be. We can call this the vast “Un”. All the things yet to come. The things that don’t yet exist but can and will. All the books as yet unwritten and unread. The stories as yet untold. The people as yet unborn, technologies as yet uninvented, companies as yet unformed.

Consider this arresting passage from Oxford professor Richard Dawkins. Easily mistaken as macabre, it’s optimistic, hopeful, inspiring, and motivating:

“We are going to die, and that makes us the lucky ones. Most people are never going to die because they are never going to be born. The potential people who could have been here…but who will in fact never see the light of day outnumber the sand grains of Arabia. Certainly those unborn ghosts include greater poets than Keats, scientists greater than Newton. We know this because the set of possible people allowed by our DNA so massively exceeds the set of actual people. In the teeth of these stupefying odds it is you and I, in our ordinariness, that are here. We privileged few, who won the lottery of birth against all odds…”

So too, for technology. But here is one place where technology and biology are very different. 99.9% of all species that have emerged since life’s origins are extinct today. Life has big exogenous shocks; meteors can wipe out entire populations of dinosaurs and life. Unlike life, technology doesn’t go extinct. Technology embodies ideas, and those ideas can be rediscovered or resurrected.
Future (as yet uninvented) technologies are combinations of past and present technologies. Even the bad ideas and technologies that may die are more often the detritus that form fragments fomenting some future combination to yield a better idea and more useful technology.

Some of the principles have fancy names but are really simple phenomena that lead to complex outcomes. First there’s the toolkit of evolution, consisting of three basic things: variation, selection and amplification. Lots of combinatorial experiments get tried. Lots of keys get produced against a backdrop of ever-changing locks to open. Most keys don’t work, but some do. More of the ones that work get made.

The Adjacent Possible

Then there is the extraordinarily powerful, pessimism-evading idea of the adjacent possible. The easiest way to describe this is the inventory of all existing stuff that can be combined to make new stuff. The more stuff there is, the more possible combinations and the more possible new stuff. And the new stuff that forms from the old then becomes the next generation of inventory to do the same in the future. And on and on…

If you had a circle spotlight that represented everything that existed, all around the edge in the shadow would be the adjacent possible: an as yet unrealized future that is within reach by combining existing things from the present and past. And the boundaries keep expanding. You start in a room with four doors; you open one and enter a new room with three more rooms. And a palace of the possible builds.

In biology we can call all the first-order combinations, “the adjacent possible”. From the primordial soup, combinations could make building blocks of life like cell walls and sugar molecules that could build DNA. Basic fatty acids self-organize into a double layer of molecules just like a membrane. Once they do this, you have a new possible: a cell with a boundary of inside and outside. And you can put stuff inside like organelles and genetic code and food. Small molecules can get in and combine but are too big to get back out. And eventually we get mitochondria and chloroplasts, the engines of animals and plants.

But importantly, from out of the primordial soup you couldn’t directly build a bird or a flower or brain. Because a flower needs chloroplasts to capture sun, vascular tissue to carry water and those things wouldn't be invented or possible for billions of years. The phrase, “he was before his time” is how we describe someone with the right idea but too early. The same thing holds in both biology and technology.

Happy Accidents

The parts list might not be ready yet. One of the best ways to expand the parts list is by accidentally stumbling on new parts. In fact, thousands of great inventions, from Penicillin to vulcanized rubber to Viagra, were preceded almost universally by the same phrase: “Hmm. That’s funny.”

Modern photography grew out of a happy accident. In the 1830s, Louis Daguerre kept trying to create images out of silver plates. Nearly giving up, he put the plates in a cabinet that happened to be filled
with chemicals. The next day, to his surprise, the fumes from a spilled jar of mercury made an image on the plate—and the daguerreotype was invented.

Ham radio enthusiast and Cornell alumnus Wilson Greatbatch stumbled on the pacemaker in the 1950s when he was trying to help a friend make a device to record signals of heartbeats. He accidentally picked up a wrong resistor and when he plugged it into the measuring device, it pulsed and produced the familiar thump of a human heart instead of recording it. He then remembered a random lunch conversation from years earlier with surgeons who were talking about heart problems from irregular rhythms and connected the two things and thought, “What if you could send a regular signal back?” Millions of people have since been saved and billions of dollars have been made.

When Lux first started Kurion, we pitched a Nobel Prize winner turned venture capitalist (who, in a longer story for another time, was animatedly disturbed by a vitrified sample of non-radioactive waste, demanding we get it out of the room immediately no matter how much we insisted it was safe!). This Nobel laureate made a much more important mistake that led to one of history’s greatest scientific breakthroughs. Hearing what he thought was meaningless static, it wasn’t until a colleague suggested it might be ancient signs of the birth of the universe that he realized he mistook hearing evidence of the Big Bang for thinking his telescope equipment was busted.

Combinations are critical. Witness human culture: the same 26 letters (plus a few punctuation marks) can be reshuffled to produce Great Expectations or The Great Gatsby. But so are errors and mutations. The more mutations you get, and the more that evolves out of the adjacent possible, the more combinations are possible of taking old things are recombining them into new things. Contrary to experts that would seek efficiency, we actually need errors, mutations and noise. Without them, there’d be no change or adaptation: no new additions to the adjacent possible.

Benjamin Franklin once said, “Perhaps the history of the errors of mankind, all things considered, is more valuable and interesting than that of their discoveries. Truth is uniform and narrow; it constantly exists, and does not seem to require so much an active energy, as a passive aptitude of soul in order to encounter it. But error is endlessly diversified.”

**Convergent Evolution & Simultaneous Invention**

So now we have lots of ideas on the boundaries, they are combining and that’s so often the precondition when you hear people describe something as “an idea whose time has come” – it’s usually because an idea or discovery forms from combining a few prior ones, spare parts, inventory that existed. A Hungarian mathematician in the 19th century, Farkas Bolyai, said that, “When the time is ripe for certain things, they appear at different places in the manner of violets coming to light in early spring.”

The way you know that an idea’s time has come is an amazing phenomenon in both biology and technology of simultaneous invention. In biology they call it “Convergent Evolution”: photosynthesis evolved independently in multiple places for unrelated plants, the eye was invented 30 different times across unrelated species, winged flight was invented at least four times (birds, bats, insects, reptiles), hovering at least twice (dragonflies and hummingbirds), bioluminescence multiple times, venomous stings about 20 different times and echolocation at least twice (in bats and dolphins).

Amazingly, so too for technology. The light bulb was discovered 23 independent times with Edison really being the last to grab the flag of fame. Both Isaac Newton and Gottfried Leibniz developed
calculus separately at the same time. Platinum was simultaneously discovered in the 1740s, oxygen in the 1770s, as was steelmaking in the 1850s, the theory of evolution in the 1860s, discovery of radioactivity in the 1890s, the telephone and sound film in the 1920s, color photography, the atom bomb, the jet engine, the polio vaccine, packet switching, conductive polymers, and on and on. The thermometer was invented at least six different times and the telescope at least nine. This was our own experience with the simultaneous work done by scientists in metamaterials, leading to our Lux Ventures III investments in Kymeta and Evolv.

Exaptations

Related to the idea of the “adjacent possible” are “exaptations”. A trait or a technology develops for one use and gets hijacked for another. Bird feathers were for temperature regulation and led to flight. A French weaver made the first punch cards for complex silk patterns with mechanical looms, and then Charles Babbage used them to make one of the first calculators and computers. And punch cards defined our computers until the 1970s. The screw press used for wine in Gutenberg’s hands became fodder for the printing press, which in turn begot demand for lenses to read, which further led to innovations in optics that would create telescopes to see to outer-space and microscopes to see inner-space. As Darwin said, “From so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.”

Lux is investing in Computational Photography. Consider one of the great recent successes like GoPro, which seems at once obvious to so many in hindsight and still trivial to so many more. You can only understand its success in the context of the adjacent possible. GoPro needed YouTube. But if YouTube itself launched 10 years earlier, it would have failed. Video wasn’t possible on slow-dial-up connections. It would’ve taken over an hour to download your average two-minute video clip. YouTube also benefited from Adobe’s Flash platform (which didn’t exist until 1996 and didn’t support video until 2002) instead of having to pour millions into its own video standard.

Peter Weijmarshausen, in birthing Shapeways, needed the 3D printer, as well as the marketplace models of eBay and Amazon. Kegan Schouwenberg, in birthing SOLS, needed not only Shapeways, but also the invention of the 4-inch heel to realize how miserably uncomfortable she was running around Shapeways’ Factory of the Future. And she also needed the pre-existence of the iPhone or iPad and its integrated and abundant cameras, as well humans’ own imperfectly evolved feet laboring on modern city streets.

Orbital Insight wouldn’t be possible without the likes of Planet Labs, which wouldn’t be possible without the march of microelectronics, memory chips, optical components, cameras, processors, and plastic casing that adjacent possible.

Innovation in Scarcity and Abundance

All of this innovation of technology happens with the same powerful thrust of progress that biology and the forces of evolution show, regardless if the macro-economy or markets are thriving or struggling, or if investor sentiment is optimistic or pessimistic. Abundance yields lots of experiments and produces many
more technologies and companies than can ultimately survive. But though their corpus may go bust, their assets may live on as surely as their ideas will – new parts to be re-assembled into more fit configurations to solve more urgent problems. Constraint too yields experimentation and variation.

Consider a passion of some members of the Lux team: coral reefs. They make up less than 0.1% of the earth’s ocean surface and are often in nutrient poor water, but provide a home to 25% of all known marine life. Reefs are networked and resilient, even against violent forces of water that can crack fragments that end up on beaches. As Darwin said, “Let the hurricane tear up its thousand huge fragments; yet what will that tell against the accumulated labour of myriads of architects at work night and day, month after month?” Darwin’s myriad architects were the life of the coral, the tiny organisms that build it. Similarly the engineers, entrepreneurs, tinkerers and inventors who we at Lux are inspired by and partner with are the ever-creative inventive architects of our present and our future.

Sincerely,

Josh Wolfe