Systematic Innovation

e-zine

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In this month's issue:

The Systematic Innovation e-zine is a monthly, subscription only, publication. Each month will feature articles and features aimed at advancing the state of the art in TRIZ and related problem solving methodologies.

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Readers' comments and inputs are always welcome.
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A Sense Of Progress

There aren't too many certainties in business, but one that seems clear is that motivated employees perform best. But what, then, is the key driver of motivation? Making consistent, daily progress in the work itself, say Teresa Amabile and Steven Kramer, whose research sheds light on the processes that underlie motivation, revealing the most effective principles and behaviors for combating employee disengagement. The gap between observable work life and what goes on below the surface is the focus of a comprehensive research project led by Drs. Teresa Amabile and Steven Kramer and reported in Reference 1. Their study of the hidden emotions, perceptions, and motivations that underlie observable work life seems to prove that positive thoughts and feelings measurably improve performance results, and that the most effective way to foster such positivity in staff is by supporting their ability to make progress in their work. Their key findings in summary:

Nothing motivates better than progress
What keeps videogame players focused hour after hour? Progress bars that are constantly visible onscreen as players engage in the game. Likewise, the recent transformation of the dieting industry in the UK has largely been realized through delivery of easy and reliable means by which dieters are able to rapidly see and plot their progress. The authors identify the "three key" drivers of employee satisfaction at work: progress as an instance of moving forward in the work itself; direct support of the work; and emotional support such as recognition or encouragement. By comparing the satisfaction of employees with their performance (assessed by their peers), they also show that a positive state of mind is associated with enhanced performance results.
What prevents managers from supporting progress?
"In light of the study results, managers who say—or secretly believe—that employees work better under pressure, uncertainty, unhappiness, or fear are just plain wrong," say Amabile and Kramer. When managers adhere to certain blocking beliefs, they are prone to obstructing rather than facilitating progress. The main two blocking beliefs are :
Blocking belief n°1: "Progress is an individual responsibility."
Blocking belief n°2: "One reward compensates for a thousand frustrations."

Although focused on the business world, as the video-game and dieting examples serve to illustrate, the fact is that there is something perhaps universal about the idea of 'a sense of progress' as a primary intangible driver. Given the response of managers to the Amabile findings, however, it would appear that not too many people have recognized the importance of the driver as a significant untapped resource. For this reason alone, we might consider the research finding to be sufficient in its own right to justify our replication of the findings here, uncovering untapped resources being one of the central pillars of the Systematic Innovation methodology.

There is, however, we think a problem that need to be addressed in order to sensibly be able to claim 'a sense of progress' as any kind of universal anything. Actually two problems:

1) Establishing 'progress' is relatively easy when we have a clear road ahead of us. If I determine that I wish to lose 10kg in the next 6 months and am able to track my calorie intake and expenditure hour by hour, the road ahead is very clear. Ditto for any kind of optimization task. The problem comes, however, when the road takes me beyond the limits of my current system. Or, put another way, as soon as a (climb the s-curve) optimization challenge shifts to one of a (jump to a new s-curve)

innovation challenge, where, while my destination might be clear, the road to it no longer exists. In s-curve terms, measuring 'progress' in the uncomfortable limbo that exists in the transition from one curve to another is very difficult indeed. Usually to the extent that, even if in reality we are making progress, emotionally it very often feels like we're not… which is why, of course, so many innovation projects end in failure.

2) Perhaps even worse than the 'special world' limbo that comes with the innovation territory, is the fact that often – indeed almost inevitably when we are working with any kind of complex system – in order to move forwards it is first necessary to move backwards. And 'moving backwards', psychologically speaking is about as far away from 'a sense of progress' as it is possible to get.

This article, then, is not so much about 'a sense of progress' as a largely untapped intangible driver, as it is about addressing these two problems in order to see just how universal the driver might be in the real world we live in. The first of the two problems feels like the easier one to address, so let's start there:

When we talk about 'progress' it ought to immediately beg the question, 'relative to what?' There is an awful lot that can't be said about the limbo world that exists once we decide to leave our system and determine that we will go and find the new one, and so measuring progress relative to anything is going to be difficult. What we know from the previously much discussed 'Hero's Journey' work of Joseph Campbell (Reference 2), however, is that while we not be able to identify any specific milestones on the trek through the special world, there are some very clear generic ones. We reproduce them in Figure 1 below:

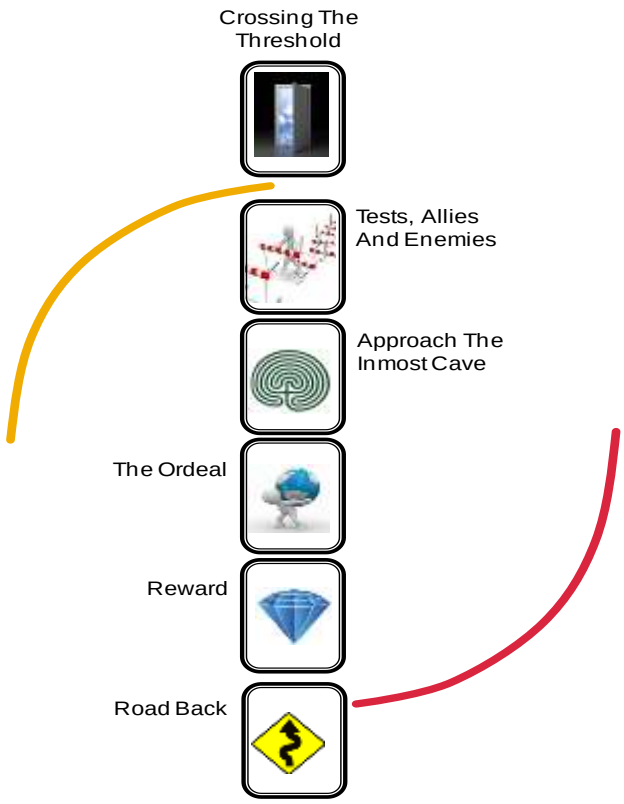


Figure 1: Principal Stages Of The 'Special World' Limbo Between S-Curves

Although we can't place any specific timings on each of the steps, what Campbell teaches us is that they all inevitably need to occur at some point. Many of the milestones are also quite negative (the 'ordeal' inherently so), but knowing that they exist as milestones along

the way, and making people aware of them before the crossing of the threshold, should at least give some coherent way of allowing your fellow innovation travelers to know if and when progress is actually being made even if it feels like it's not… which is why, of course, the Hero's Journey finds its way into the Innovation Capability Maturity Model journeys (Reference 3).

So much for charting 'progress' through the space between s-curves, what about the situation where we fundamentally have to go backwards in order to later make the progress that we desire? At first sight, this appears to be a far less tractable problem – largely because there don't appear to be any clear signposts at all to indicate when a negative-progress backwards step is called for. Our reluctance to contemplate, never mind actually take apparently backward steps is perhaps best seen in the so called 'Sunk Cost' or Concorde Fallacy: When one makes a hopeless investment, one sometimes reasons: I can't stop now, otherwise what I've invested so far will be lost. This is true, of course, but irrelevant to whether one should continue to invest in the project. Everything one has invested is lost regardless. If there is no hope for success in the future from the investment, then the fact that one has already lost a bundle should lead one to the conclusion that the rational thing to do is to withdraw from the project, to go back, and start again somewhere else. To continue to invest in a hopeless project is irrational. Such behaviour may be a pathetic attempt to delay having to face the consequences of one's poor judgment. The irrationality is a way to save face, to appear to be knowledgeable, when in fact one is, in objective reality, acting like an idiot. For example, it is now known that Lyndon Johnson kept committing thousands and thousands of U.S. soldiers to Vietnam after he had determined that the cause was hopeless and that the U.S. would not win the war (Reference 4). George W. Bush continued to argue that thousands more soldiers and billions more dollars needed to be committed to the war on Iraq, despite the fact that the preponderance of the evidence indicates not only that the war can't be won but that the U.S. has no definite idea of what winning even meant.

This time, what we have seems to bear all the hallmarks of a genuine contradiction – there are times when we need to move both forwards *and* backwards. Again, there can only be specific answer to such a problem when we know the specific situation, but knowing we have a contradiction at least means we can identify some generic solutions. Figure 2 illustrates how we might best map the problem:

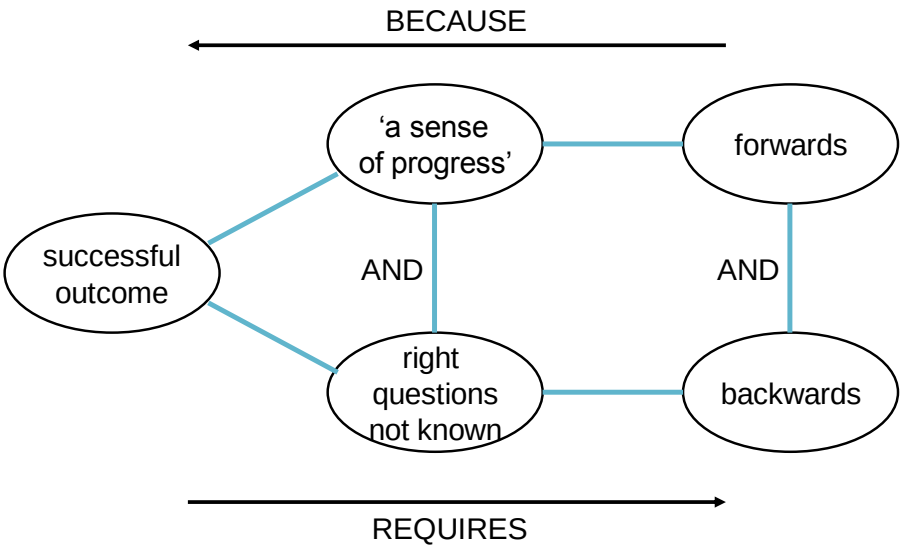


Figure 2: The Backwards/Forward Progress Contradiction

And once we can map it, we can also examine the Inventive Strategies adopted by others in similar situations. Figure 3 illustrates the ranked list of Principles obtained when we map the central 'sense of progress' ('Positive Intangibles' parameter in the 2010 matrix) versus 'right questions not known (amount of information) conflict onto the Matrix:

Figure 3: How Others Have Tackled Similar Backwards/Forwards Contradictions

Perhaps not so surprisingly, Inventive Principle 23 finds its way to the head of the list of recommendations. Not a surprise given that providing people with timely feedback was central to the Amabile findings that started this article. The problem with feedback in the backwards/forwards problem is knowing what feedback is needed and when it is needed by. Intriguing clues suggesting possible answers to these two questions come from the other Principle recommendations:

What can we merge our system with to provide a positive feeling of progress when we find the need to go back?

How can we use an enriched atmosphere during the backwards moments?

How can we make going backwards into a clear sign of 'progress' (clue: several R&D teams these days are financially rewarded for killing dud programmes early – rather than completing them anyway – in this way creating new reward resources to devote to other more promising avenues of exploration)

How can we build a virtual copy/simulation of the journey to define scenarios that allow teams to anticipate where and when new questions will arise that may serve to re-define the initial question?

The specifics, of course, are up to you. The point is, 'a sense of progress' is a universal resource when we're dealing with the human mind. We just have to know what the exceptions to the rule are, and what the new rules for dealing with these exceptions will be. Hopefully, something we've at least pointed you in the right direction towards here. Expect this topic to run forward for quite some time yet.

References

1) Amabile, T., Kramer, S., 'The Progress Principle', Harvard Business Review Press, August 2011
2) Campbell, J., 'The Hero With A Thousand Faces', New World Library, 3rd Edition, 2008.
3) Mann, D.L., 'Innovation Capability Maturity Model – An Introduction', IFR Press, June 2012
4) McMaster, H. R., 'Dereliction of Duty: Johnson, McNamara, the Joint Chiefs of Staff, and the Lies That Led to Vietnam', Harper Perennial, 1998.

Trilemmas Part 2: Yin-Yang-Yuan

A long time ago now, we wrote the first part of what was always intended to be a trilogy of connected articles on the subject of 'trilemmas' (Issue 92, November 2009). Now, finally, we get a chance to pick up the story. By way of a recap for those readers with a short (!) memory, the main idea behind the trilemma concept is that when we are solving a contradiction (a conflict between a pair of parameters – i.e. a dilemma) we are very often 'merely' solving one problem at the expense of another, third, parameter. On the one hand, in the words of a famous Baby Boomer song, 'two out of three ain't bad', but from an innovation perspective, We had the hypothesis that far stronger solutions emerge when we attempt to work on problems in such a way that we don't allow this two-out-of-three compromise to occur. Not to say that this will deliver anything like a 'perfect' solution – there will always be the 'next' problem – but that it will take innovators to a higher level of answer. An answer that may be said to truly transcend the problem.

The example used in Part 1 was the classic TRIZ contradiction case study involving the Boeing 737 engine nacelle design change necessitated by the adoption on a new generation of high bypass ratio engines:

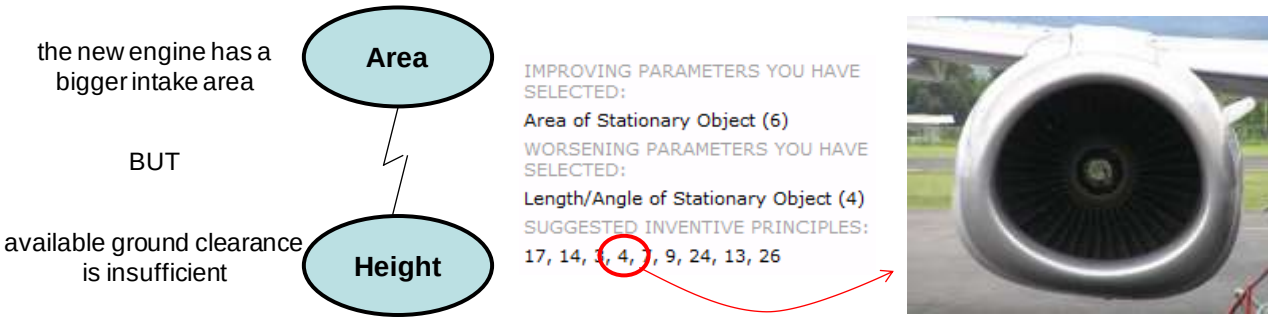


Figure 1: Boeing 737 Engine Nacelle And The Dilemma It Resolves

The 'solution' of this dilemma resulted in a significant compromise to a third parameter, pressure loss. At the time of the design decision point, the increased loss was deemed an acceptable penalty to pay in light of the overall increased efficiency delivered by the new engine, but the transcending solution would not just have solved the dilemma, it would have also delivered a solution in which pressure losses were not made worse at all.

The Boeing 737 re-engine case highlights a typical trilemma problem, in this case between the three parameters length, area and pressure-loss. Interestingly, when looking at all three parameters together, it is possible to construct three inter-related versions of the

contradiction mapping template we often bring to bear on dilemma problems. Figure 2 illustrates how we can take one of the three parameters as the source of a physical contradiction that then maps to the conflict between the other two parameters:

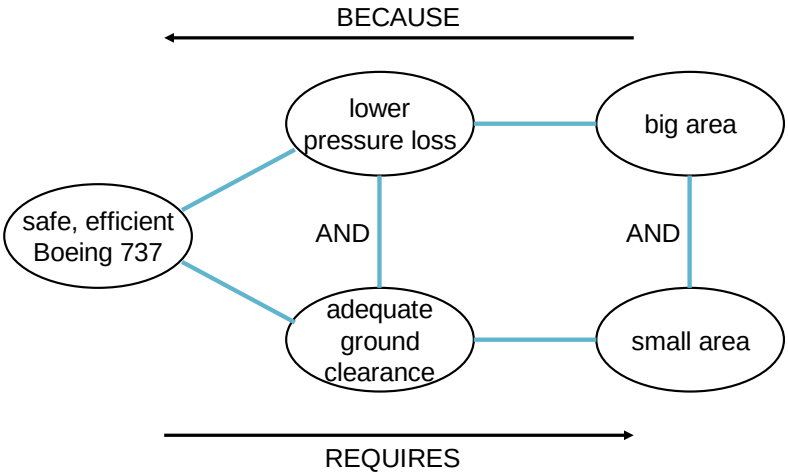


Figure 2: Mapping The Trilemma Problem Onto The Contradiction Template

(Dedicated readers looking for some template construction experience might at this point wish to construct the other two possible models that we could create for the trilemma – putting length and then pressure-loss as the A/-A physical contradictions.)

In all three cases, what the template shows is the intimate relationship between the three trilemma parameters. We propose that this phenomenon – the ability to construct three models with each of the three parameters becoming the source of the physical contradiction – is a universal trait of any trilemma. Let's call it a trilemma Axiom:

Any of the three parameters contained within a trilemma can be mapped as a physical contradiction, which in turn connects to a conflict between the other two parameters.

Figure 3 represents a first attempt to plot the three templates onto one figure – not coincidentally using the Chinese yin-yang-yuan symbol as the focus:

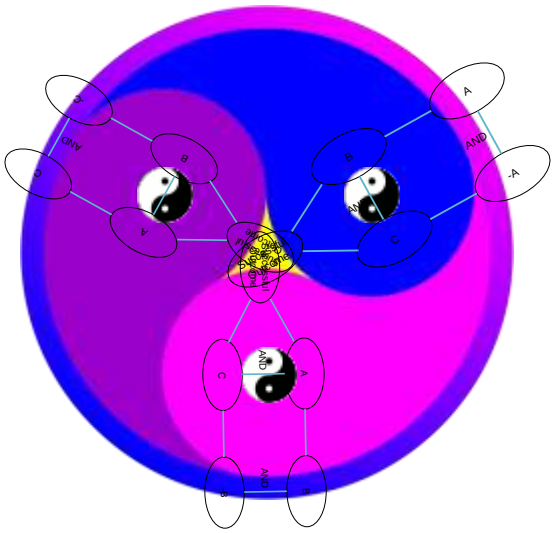


Figure 3: Three Trilemma Contradiction Templates And Yin-Yang-Yuan Model

The barely visible yellow region in the centre of the picture very conveniently acts as the centrepoint around which the three templates can be rotated, with, each time, the 'successful outcome' left-hand point of the template acting as the focus. Although not traditionally viewed that way in the Chinese model, it feels to us that we achieve this central goal when we successfully transcend the trilemma problem.

Knowing what we do about physical contradictions, we can then further stipulate what might be too soon to call an Axiom per se, but we suspect it is already close enough to merit describing it here:

Transcending a trilemma situation will necessarily involve alteration of a variable that is not one of the three parameters that make up the trilemma.

On one level this is quite profound (we think). On another, while it gives some clues about where not to look for solutions, it hardly counts as anything we might consider to be an answer. In order to reach that stage – or something like it – we need to dig a little deeper.

Here's another nearly-Axiom emerging from our ongoing patent research programme:

Transcending a trilemma requires a combination of at least two Inventive Principle solution directions.

And here's what we've further uncovered in relation to the long held view that 'some Inventive Principles are more important than others':

Of the two or more Inventive Principles required to transcend the trilemma, at least one should be present in this list:

7, 10, 13, 18, 19, 21, 22, 25, 28, 33, 35, 36

(i.e. these Inventive Principles are inherently 'stronger' than the others – noting particularly with Inventive Principle 35, we mean in the true step change role of the Principle rather than the 'optimization' role we often hear described by others in the TRIZ community – see ezine Issue 58 from January 2007 if you're not sure what this means)

At this stage, we're happy enough with the research – it has taken us over eighteen months since we wrote the first part of this trilemma trilogy! – to present it here as a hypothesis for readers to explore and develop, In Part 3 we present one or two examples of our own. Hopefully in something less than eighteen months time from now.

Humour – Perfect Timing

Not sure if it's about Inventive Principle 5 or 16 or 27 or even 36, but some photographers seem to develop a terrific knack for capturing the just-right image at just the right moment. Like the jet-powered heron above. Or how about, sticking with the nature theme for a moment, this very elegant pigeon modification sculpture from Germany:

We also quite like the idea of photographing very important people at precisely the right, ego-pricking, moment. I bet this guy has prints of this one all over his office. Or at least his staff do:

Personally, being a patriot and all, I have a print of this next one on my office wall. God save my future monarch. And all who sail in him.

If that feels a little bit un-supportive (if you'll pardon the pun), try this one instead:

With London 2012 coming up soon, I'd have to say that feels a bit like cheating to me. A sure sign that team-Australia is prepared to go to whatever lengths necessary to make sure they end up with more medals than GB this time around. Sometimes, it's possible to just take that competitive edge a shade too far.

Best calm things down with – guaranteed to never fail – a few pictures of cute cats:

Ah, that's better.
Spend a happy couple of hours finding more examples at: http://perfectlytimedphotos.com/

Patent of the Month – Pulsed Extraction

Patent of the month this month takes us on a rare visit to Canada, and specifically to a group of inventors at McGill University in Montreal. Their 'Pulsed electric field enhanced method of extraction' solution was granted as US patent number 8,147,879 on April 3.

Here's what the invention disclosure has to say about the problem being addressed by the invention:

One of the most challenging problems facing the biorefinery industry is the difficulty of handling and transporting bulk plant based biomass. Typically, these materials must be size reduced before they can be conveniently processed into other valuable products. Pelleting is one of the most common techniques used to convert the ground or loosed materials into more compact, higher density units that are amenable to handling. Pellets can be used as animal feed or they can be used directly in combustion for energy generation. Since the handling properties of pellets are similar to those for grains, existing, well-developed, conventional bulk handling equipment can be used to handle pelleted biomass.

Pelleting normally involves mixing the plant biomass and forcing them through a die to form pellets. More recently, most processors inject steam and binders in order to improve pellet quality and reduce spring back of the biomass as well as reduce wear on the pelleting die cavity. The binder chemical may present problems if the pellet is to be used as animal feed or as an energy source. The chemical binders must receive FDA or CFIA approval before they can be used in feeds. There is currently no effective means of achieving adequate conditioning of the biomass in order to produce high quality pellets. Pellets must be durable and able to withstand the handling operations without breaking.

One chemical component of plant biomass is phytochemicals. Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties (Nishino et al., 2005, Oncology, 69: 38-40). There are more than one thousand known phytochemicals. It is well-known that plant produces these chemicals to protect itself but recent research demonstrated that many phytochemicals can protect humans against diseases…

…Due to their anti-allergic, anti-inflammatory, anti-microbial and anti-cancer activity and potential use in treatment and/or prevention of cardiovascular diseases, there is a great interest in increasing phytochemicals concentration in fruits or vegetables and improving extraction techniques.

It would thus be highly desirable to be provided with effective means of achieving adequate conditioning of the biomass in order to produce high quality pellets and extracting maximum amount of phytochemicals from plant materials.

It is not immediately obvious here what the 'yes, but' is in the invention. We know we're trying to improve the extraction of the phytochemicals, but we don't yet know why the extraction is difficult, other than, perhaps, the use of pellet forms isn't helping. Digging deeper into the disclosure detail eventually reveals what seems to be the core stopper: 'insufficienct membrane permeability of the plant material'. Now the problem can be mapped as a contradiction as follows:

IMPROVING PARAMETERS YOU HAVE SELECTED:

Loss of Substance (25)

WORSENING PARAMETERS YOU HAVE SELECTED:

Area of Stationary Object (6)

SUGGESTED INVENTIVE PRINCIPLES:

18, 10, 5, 30, 4, 13, 17, 34, 24

('Area' being chosen as the worsening parameter here since 'permeability' is all about things being able to or not able to get through holes in other things.)

Probably not a great surprise – given the title of the invention – the solution discovered by the inventors involves the use of pulsing. A very clear illustration, then, of the suggested Inventive Principle 18, 'Vibration' at the top of the list of Matrix suggestions. Here's what the inventors have to say in a little more detail:

In accordance with the present invention, there is provided a process enhancing the extraction of phytochemicals from plant materials using pulsed electric field (PEF).

The technique discloses herein allows preparation of stable pellets without the need for chemical binders and conditioners. Such stable pellet means a densified pellet that do not easily come apart during handling or that do not "spring back" during storage. The major advantages of the new technique include ability to work at cold or reduced temperature to preserve heat sensitive ingredients in the biomass (or value if the biomass is to be used as animal feed), reduced dust and fines due to improved pellet durability, and reduced energy requirements by eliminating steam conditioning.

The possibility of using high pulsed electric field to permeabilize cell membrane of plant was discovered between the 1960's and 1970's (Coster, 1965, Biophys J., 5: 669-686; Williams and Bradley, 1967, Biophys J., 8: 145-147).

Since then it has been used in pasteurizing juice and liquid food products. The technology has been found effective in enhancing juice extraction from apple, sugar beet and carrot. In these studies, pulsed electric field was used as a pretreatment of the products. When a plant is treated with high pulsed electric field, the cell membranes are ruptured leading to increase in permeability of the cell walls and subsequently increase in juice yield. However, it has never been used for extracting phytochemicals. Extracting phytochemicals and extracting juice are two distinct art or process, and a method for extracting juice may not necessarily extract phytochemicals.

As such, the disclosure also provides us with a clear reminder of the idea of nothing new under the sun, and the importance of looking in other analogous domains to identify and uncover good solutions.

Best of the Month – The Wide Lens

A nice easy choice this month. Ron Adner has pulled off the not inconsiderable coup of getting two of today's most revered management authors to write words like 'profound' and 'path-breaking' on the book's cover, which should immediately raise an eyebrow or two. While ultimately, this left me thinking that both Jim Collins and Clay Christensen weren't quite as smart as I previously thought – for anyone aware of TRIZ/SI or even just the 9-windows or 'where to innovate' templates, none of Adner's findings should come as such a great surprise – the book is nevertheless a useful addition to the canon. The essential thesis of the text is answering the question, 'how can great companies do everything right - identify real customer needs, deliver excellent innovations, beat their competitors to market - and still fail?'

Given that the 'great' companies in question include famous names like Michelin, Nokia, Pfizer, Sony and Philips, it's tempting to answer with phrases like 'myopic hubris'. Which wouldn't be totally fair, since the sad truth is that many companies fail because they focus too intensely on their own innovations, and then neglect the innovation ecosystems on which their success depends. A strategy that all of the named companies have won with in the past, but, in our increasingly interdependent world, one that now demands a different perspective on the world.

In *The Wide Lens*, innovation expert Ron Adner draws on over a decade of research and field testing to take you on far ranging journeys from Kenya to California, from transport to telecommunications, to reveal the hidden structure of success in a world of innovation ecosystems and interdependence.

While one might argue with the tools and templates Adner ultimately proposes to resolve the eco-system problem (rule one of complex systems: templates don't work), there can be little doubt that the case study write-ups are amongst the best ever published in the management literature. Adner is both a consummate story-teller and someone capable of stepping far enough back from a situation to see what is really going on. Admittedly, this reviewer had the added advantage of knowing one of the case studies (the failure of non-injected insulin) from an insider's perspective to know that Adner has been able to get beyond the high-level story known in the public domain to get to the real story, so Adner

immediately passes some kind of credibility test. In addition to being a real page turner in the true sense of the phrase, The Wide Lens presents a riveting study that offers genuinely new perspectives on triumphs like Amazon's e-book strategy and Apple's path to market dominance and, more rare in the management literature, the chutzpah to speculate on some still unresolved innovation eco-system issues like electric cars and electronic health records.

These reasons alone should justify the price of acquiring a copy of the book. All in all, Adner pulls off a quite rare trick: in many ways the book, being about interdependence and seeing beyond traditional perspective, is only of direct use to organizations that have achieved Level 4 status on our Innovation Capability Maturity Model. Which, of course, ought to immediately limit the audience to a pretty small proportion of the world's organizations. The reason the book successfully gets to be relevant to everyone is that the stories Adner conveys should provide convincing evidence to the Level 1, 2 and (especially) 3 organisations that there are certain types of innovation project they have no ability – or therefore, chance – to succeed with:

- Nokia failed with their first-to-market 3G capability because they were a Level 3 organisation trying to do a Level 4 project
- Sony failed with their e-reader because they were a Level 3 organisation trying to take on a Level 4 project (and Amazon succeeded because they were Level 4)
- Pfizer failed with their inhalable insulin activities because they were a Level 3 organisation trying to do a Level 4 project (spot the pattern yet?)
- Probably no-one on the planet right now can win the hospital Electronic Health Record challenge (something that has defeated every one of a small armada of greedy, hubristic names that have attempted to crack this toughest of nuts) because it is a Level 5 project

A book that tells you (and your manager) what they *shouldn't* be doing (and why they shouldn't be doing it) and does it in an entertaining and insightful way might not make you the most popular person inside your organization in the short term, but, we think, it's something a lot of people will come to thank you for in the next couple of years. You can also expect to hear more from us on Wide Lens' in the coming months, as we try to turn Adner's weak attempts at tools and strategies into something that might actually be deployable, meaningful ways to make complex innovation eco-systems work for you. Better to get on the ride early we say – go buy the book now.

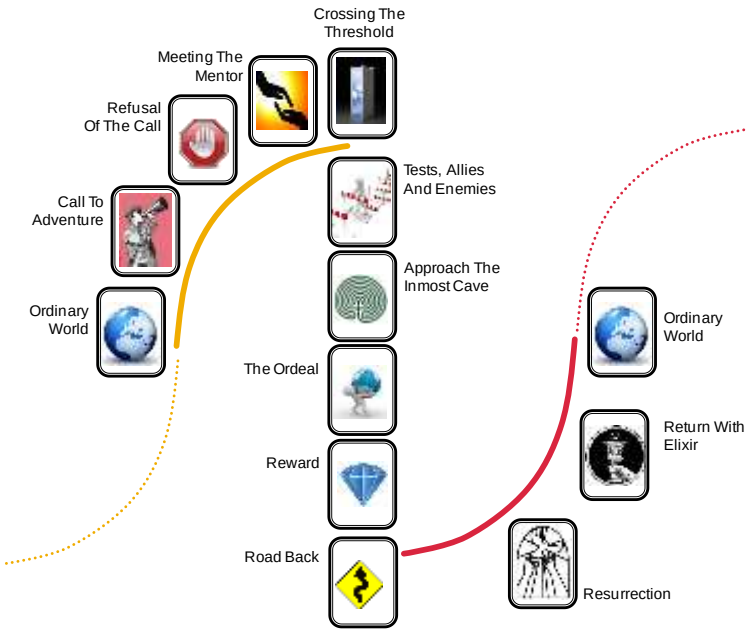
Film – Moneyball

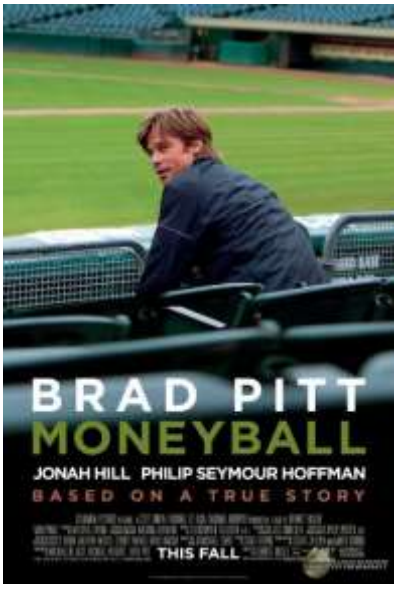
No conference to go to this month, so we decided to go to the movies instead. Almost true. More like we were flying home from Shanghai and failing to get to sleep so decided to try and find a watchable movie on the Etihad inflight entertainment system. Enter 'Moneyball', an admittedly rather random choice, especially given the fact that, being British, I have no idea about or interest in American baseball… subconsciously I imagine I selected the film expecting that it might well help me to find the missing sleep I was looking for.

As it turns out, five minutes into the movie and sleep was the last thing on my mind. Rather it felt like we were at the beginning of what was going to be a classic innovation journey. For those that might not have heard about the film, it relays a true story starting from 2001 when General Manager Billy Beane's Oakland A's lose to the Yankees in the end of season playoffs then lose three stars to free agency.

It's an opening describing a classic call for innovation. And also a good first nod to what is almost becoming an innovation truism: real innovation happens when there are insufficient resources. In Beane's case, how can he field a competitive team when the A's player salaries total less than a third of the rich teams?

If the film quickly sets itself up as a terrific innovation metaphor, it does an even better job of following the patterns defined by Joseph Campbell's 'Hero's Journey':





Without giving too much of the plot away, and also to allow potential viewers to watch the film looking for the various stages of this archetypal Hero's Journey (all of the steps are present by the way), the next two hours takes us through an emotional innovation rollercoaster. To the consternation of his scouts, Beane hires and listens to ('meeting the Mentor') Peter Brand, a recent Yale grad who evaluates players using Bill James' statistical approach. Using, Brand, Beane (crossing the threshold) assembles a team of no names who, on paper, can get on base and score runs. In classic innovation project fashion, Beane meets a whole series of obstacles along the road of, in effect, rethinking the way baseball is played and managed: the incumbent scouts want to stick to the way they currently do things; they don't understand the new system and don't get to see any

proof that it works. Then, in what turns out to be ‘The Ordeal’ Beane's manager, Art Howe, won't use the players as Beane wants. How Beane circumvents Howe, win games, make it to the 2002 Series, and stand baseball's hidebound conventions on their heads, I won’t reveal here. Needless to say, in true Hero’s Journey fashion, things end with the ‘innovation’ coming to re-define the way the whole world of baseball operates.

Not that any innovation project group I know of these days is willing to take a couple of hours to sit down and think about what they should be doing, never mind take the afternoon off to go to the movies, but it’s an activity that I would heartily recommend in this case: cancel that next brainstorming session, and go sit the team down in front of a Moneyball DVD. It might just be the best couple of hours you spend all year.

The Life Of The Innovator

Investments – 'Buckliball'

The buckliball (left) and the toy that inspired its creation

We love auxetics. And this month's investment feature is auxetic structures on steroids! Taking inspiration from a toy (great start point for almost any innovation), a team of researchers at MIT have developed a new engineering structure that is mechanically unstable, yet collapses in a way that is predictable and reversible. The structure, formed out of a single piece of rubber-like material, is fabricated so that it collapses in harmony to form a smaller structure that can then be expanded into the original shape. This structure opens up new potentials in everything from architecture to micro-medical applications.

When we think of structures, we tend to think of them as things that don't fall down. If you had to come up with one common criterion for bridges, buildings, houses, stadiums, sheds and dog houses, it's that once built, they should tend to stay upright and not come crashing down around people's ears. If they do so, that is generally regarded as a failure, so engineers put a great deal of effort into keeping that from happening.

Nonetheless, a team at the Massachusetts Institute of Technology led by Katia Bertoldi, an assistant professor in applied mechanics at Harvard, and Pedro Reis, the Esther and Harold E. Edgerton Assistant Professor of Civil and Environmental Engineering and Mechanical Engineering at MIT, were looking for a engineering structure that was intended to collapse. Its function was to fall down.

No, this wasn't meant as some sort of practical joke. The idea was to have the structure collapse in a controllable, predictable fashion that could then be reversed, with the structure going back to the way it was. Think of it as being a bit like those old-fashioned cups made out of nesting rings that you could pull out to form a drinking vessel, or paper origami that folds down or pops up when you pull on it the right way. The origami analogy is very close because, according to the MIT team, what they were looking for was a "buckling-induced origami" they call "buckligami."

The idea was simple in theory, but frustrating in practice. It didn't just need to be a shape that could be folded or unfolded. It had to be a shape that would collapse completely from one form to another. The answer kept eluding them until one of the team noticed a toy ball made up of t-shapes, pivots and linkages that, when pressed, did exactly what the MIT

team was looking for - it fell in on itself in a state of complete collapse until it formed a smaller ball. Pulling on it made it expand, evenly reforming itself into the original, larger ball. It was the model they were looking for.

From toy to breakthrough

In a way, this isn't too surprising. Toys are big business and a lot of cutting-edge or, at least, very clever science and technology goes into their development. Many of modern history's most popular toys started out a laboratory curiosities or were the product of incredible research and development efforts. Sometimes, toys return the favor.

Go into any modern development lab and there's a good chance that there will be some equipment cobbled together out of parts from a toy construction set, or using bits cannibalized from some plaything that can't be found by its seven-year old owner. In this case, what this particular toy ball contributed was the very idea behind its construction. The bits of the ball were put together in such a way that all the pieces that held the ball together in its spherical shape could be made, with a slight pressure, to lose all structural integrity simultaneously and fold in on themselves.

It's like a building where every single girder fails at the same time or, to use a more realistic example, whenever I try to put up a tent. The only difference is that here you end up with a pile of rubble or a heap of nylon and poles while the toy ball collapses into another ball.

This example allowed the MIT team to create the simplest three-dimensional structure that could take advantage of mechanical instability to reversibly collapse. Using 3D printing techniques, they made a hollow sphere out of a rubber-like material. It had no moving parts. Instead, it was fashioned with 24 carefully spaced dimples. They called this a "buckliball" because of its resemblance to the buckyball carbon nanostructures, plus it's a play on the phrase "bucklely ball." This is why scientists don't write advertising copy.

These buckliballs hold their shape quite nicely when inflated, but take the air out and they fold in on themselves quite dramatically. The thin ligaments between the dimples collapse and all the bits (or the structure) start to move in a remarkably orderly fashion. They just sort of slide past one another in a rubbery dance. Some bits go clockwise, others go anticlockwise and it all folds into a nice little "rhombicuboctahedron" – that's an irregular geometric solid with eight triangular and 18 square faces, if your Euclid is a bit rusty. It's also the first morphable structure to incorporate buckling as a engineering element. That's pretty impressive for a bit of plastic without any moving parts.

Applications

"In civil engineering, buckling is commonly associated with failure that must be avoided," said Dr Reis. "For example, one typically wants to calculate the buckling criterion for columns and apply an additional safety factor, to ensure that a building stands. We are trying to change this paradigm by turning failure into functionality in soft mechanical structures. For us, the buckliball is the first such object, but there will be many others." What that means is that a material that can collapse predictably on order and return to its original shape could be very useful.

One area of application could be in engineering. Buildings could be made with collapsible roofs and walls. Remodelling could be a matter of giving the wall a good shove and

watching it tuck itself away. You could have real folding chairs - maybe one where the couch folds into a love seat. Robots could be built with buckliballs where the hinges go to provide a robot arm with more strength for less weight. You could even make robot skin that takes the place of a motor, making it even lighter and more compact.

Then there are medical applications. Something like a buckliball already exists in nature. Some viruses inject their DNA into host cells by means of buckliball-like structures that they use as a sort of nano squeezy bottle. Reis believes that by imitating this, doctors could design drug delivery systems with an incredible degree of precision. The implications in treating cancer, for example, by applying drugs just to the cancerous cells in chemotherapy could save a lot of suffering.

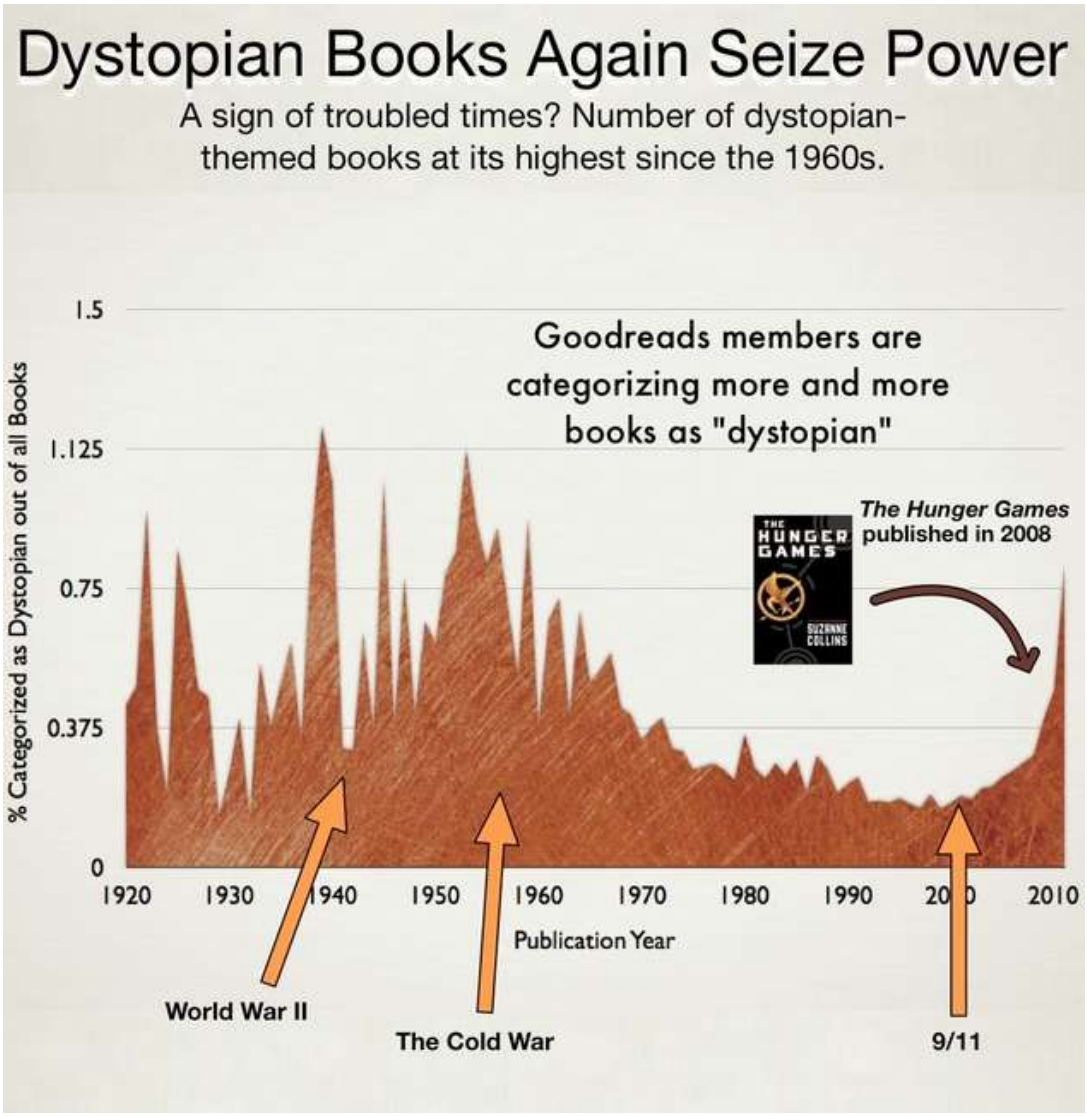
Ironically, one other application that the MIT team see is in toys. They say that materials derived from the buckliball could be used to design transformers that make current morphing toys look unbelievably lame by comparison.

It can be seen in action in the video at:

http://web.mit.edu/press/2012/buckliball-collapsible-structure.html

Generational Cycles – Dystopia

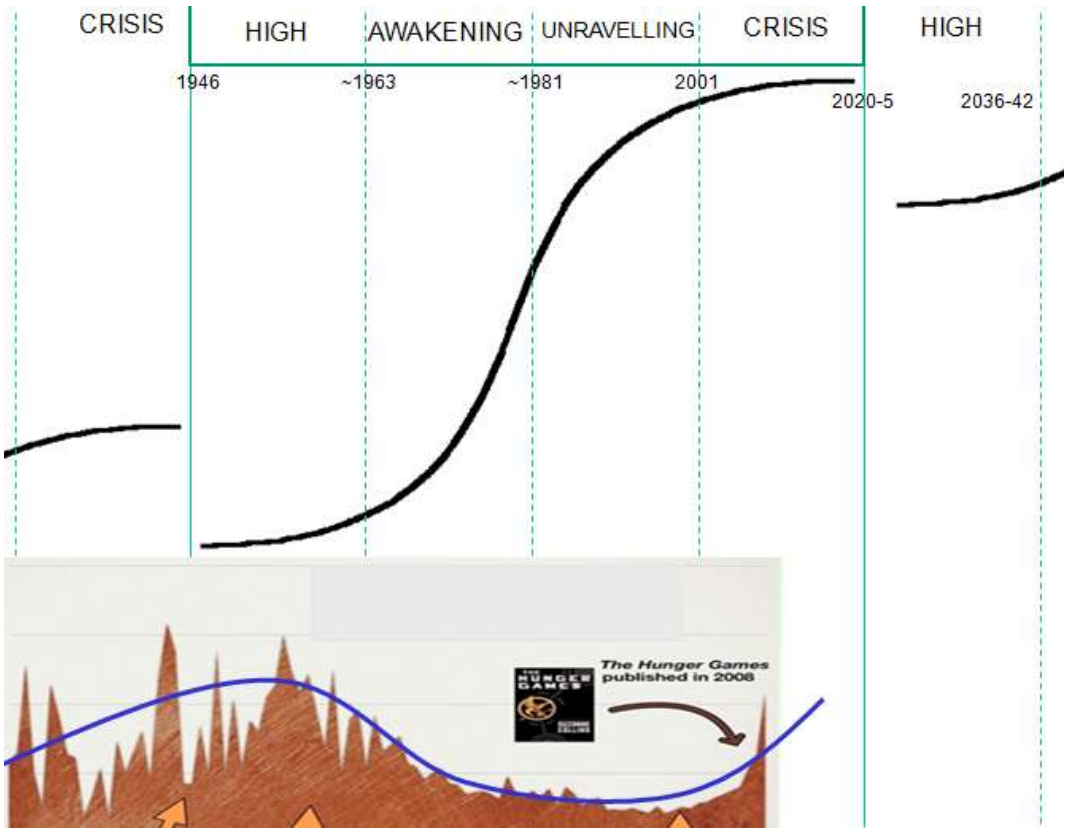
According to a recent edition of online literature journal, Staple News, Dystopian fiction is more popular than it has been in more than 50 years. Whether it's the result of political turmoil, global financial crises, or other anxieties, readers are craving books about ruthless governments and terrifying worlds. The new breed of dystopian novels combines classic dystopian themes of cruel governments and violent, restrictive worlds with a few new twists—badass heroines and romance. To mark the movie release of the most popular of this new wave of books, The Hunger Games, we examined the history of the dystopian genre to see how it has evolved and why it's so popular today. Here's the Staple News picture:



Closer inspection reveals an interesting series of shifts in the focus of the dystopian situations during the different periods. During the dystopian peak during the 1930s, inspiration largely came from a fear of the state no doubt inspired by the competing communism/fascism political ideals and, later, the Second World War. The theme was typically about controlling governments and loss of personal freedom. Here are some of the most popular books of the period:

The more recent rise in the dystopian form has shifted somewhat from the state to romance, forbidden love, tough heroines and anti-conformism:

More interesting of all perhaps is how the focus has shifted to younger readers (the 'young adult' genre – something that didn't exist during the 1930s, 40s and 50s). Most interesting of all is what happens when we plot the rise-fall-rise profile of dystopian literature on a version of the generation cycles map showing the passage of time in terms of societal s-curve cycles:



It is, of course, difficult to say too much about the universality of this pattern, but what seems clear is that there is at the very least a correlation between the crisis periods in history and the preponderance and popularity of dystopian fiction. Which in theory makes a lot of sense – fewer people can empathize with stories about bad times during good times. Whereas when times are tougher, it's perhaps comforting to know you're not alone, that someone's in a worse position than yourself (?), or even as a warning (a la George Orwell and Aldous Huxley) that unless we do something about it, the dystopian prophecy could become reality.

Whether the link is correlation or causation, our hypothesis is that the rise of dystopian literature will continue to rise beyond The Hunger Games and not peak until sometime after the end of the forthcoming crisis reaches its own peak. Thanks for that. Stay happy!

Biology – ***Streptococcus pyogenes***

A strong and highly selective instant adhesive inspired by the bacterium *Streptococcus pyogenes* has been developed by Oxford University researchers. *S. pyogenes* is a common resident of human throats that is normally kept in check by the body's defenses, but when it gets out of control it can cause diseases ranging from strep throat to toxic shock syndrome or flesh-eating disease. By engineering a protein that is central to *S. pyogenes*' infectious arsenal, the researchers have developed a new superglue that can't be matched for sticking molecules together and not letting go.

S. pyogenes have thin protein hairs which extend from the bacterium to form strong attachments to human cells. The 3D structure of a protein, wherein the long chains of amino acid polymers are folded and looped up into three-dimensional structures, are usually the result of relatively weak hydrophobic interactions and hydrogen bonding.

However, a special protein called FbaB found in *S. pyogenes* has a 3D structure that is stabilized by formation of an extremely strong intramolecular isopeptide bond. This isopeptide bond is not broken by boiling in detergent or strong acids. In fact, using an atomic force microscope (AFM), the isopeptide bond was found to survive a force along the protein chain of one nanoNewton, roughly corresponding to the tensile strength of a carbon nanotube. The AFM study did not reveal the strength of the isopeptide bond, as the rest of the protein broke before the isopeptide bond.

The Oxford team formed a new protein, which shares the isopeptide bond, but is much smaller and simpler in structure than FbaB. They found a way to split the protein at the isopeptide bond, giving a protein and a peptide each of which possesses one of the spontaneously active groups of this enormously strong bond. The protein and peptide are separated and incorporated into a two-part adhesive carrier.

With this new approach the protein and peptide partners are easy to produce and react irreversibly through formation of an amide bond, simply upon mixing. The two parts are permanently locked together, just as the original FbaB protein was locked permanently into a particular 3D structure. This lock is stable over time, high temperatures, high forces and with harsh chemical treatment.

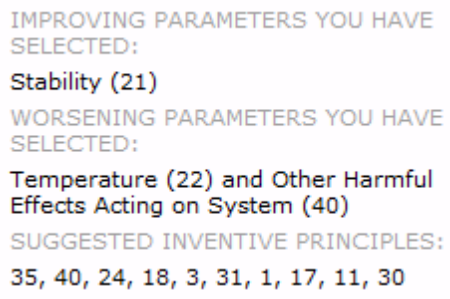
The team have given the bonding fragments the moniker "SpyCatcher" and "SpyTag" for the larger and smaller fragments respectively. In biochemical research *S. pyogenes* is unimaginatively abbreviated "Spy," and a tag is a peptide sequence genetically attached to a recombinant protein. SpyCatcher was named because once SpyCatcher gets hold of the shorter protein segment, SpyTag, it never lets go.

When SpyCatcher and SpyTag are brought together, they bond in minutes with high yield (over 80 percent). It doesn't matter whether it is in acidic or neutral conditions, or whether it is 4°C (39°F) or 37°C (99°F). An important attribute for one of the world's strongest adhesives is that SpyCatcher and SpyTag won't bond to fingers - they will *only* stick to each other. Being the basis of an adhesive, however, the adhesive carriers will have to bond to other materials, as SpyTag and SpyCatcher cannot.

Further development of the new class of adhesives is ongoing through the auspices of Isis Innovation, Oxford University's technology transfer arm.

What attracted the biochemists' interest was a specific protein which the bacteria use to bind and invade human cells. 'The protein is special because it naturally reacts with itself and forms a lock,' says Mark. All proteins consist of amino acids linked together into long chains by strong covalent bonds. The long chains are folded and looped up into three-dimensional structures held together by weaker links and associations.
The protein FbaB from *S. pyogenes* has a 3D structure that is stabilised by another covalent bond. This strong chemical bond forms in an instant and binds the loops of the amino acid chain together with exceptional strength.
Mark and his colleagues reckoned with a bit of engineering they could split the protein around this extra covalent bond. Then, when the two parts were brought together again, they might dock and form this strong bond once more.

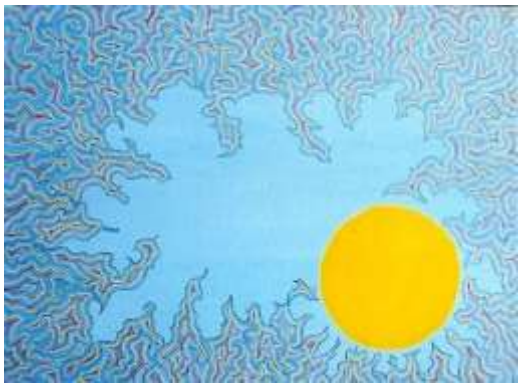
Nice as the human-engineered evolution of the bacterium might be, the solution evolved by *S. pyogenes* also makes for a rather elegant illustration of contradiction solving down at the molecular level. Here's what the core conflict looks like:



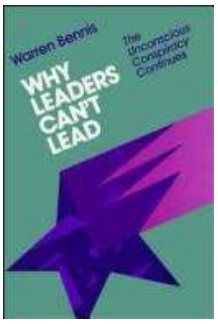
And one only needs to take the scantest interest in the *S. pyogenes* image at the head of the article to see an elegant illustration of Principle 17, Another Dimension in action.

Find out more about *S. pyogenes* and its emerging biomimeticised offspring at:
http://www.ox.ac.uk/media/science_blog/120221.html

Short Thort



"It is difficult sometimes to tell the difference between the innovators and the crazies. Eccentricities and idiosyncrasies in change agents are often useful and valuable. Neurosis isn't."
Warren Bennis



News

Korea TRIZ Conference

Further to last month's announcement of our keynote address at the Korean TRIZ Conference in July, we're now also able to confirm that the 2-day 'Business TRIZ' workshop will take place on the 12th and 13th. The venue is yet to be agreed, but we do know that the workshop will be open to the public. Just in case any of our readers are planning to be at the conference.

University of Warwick

We couldn't be happier to announce that Darrell has just been offered a Visiting Professorship in the Engineering faculty at the University of Warwick. The appointment will commence in September with a duration of two years. Warwick is generally believed to be one of the top 5 universities in the UK overall, and top 3 from an engineering perspective.

UK TRIZ Forum

Well, it felt even more like a thankless game of herding cats than in previous years, but we finally achieved a critical mass of presenters and papers, so the Forum will take place again as planned on May 15 and 16. No doubt falling on deaf ears again, Hannah would appreciate it if people planning on attending the event would let her know before the end

of April. So she can do things like organize a venue and food with more than a week's notice. Your assistance is greatly appreciated.

Creativity and Innovation in Micro-Enterprises
Our involvement in the Wales-Ireland CIME project has been extended to also include participation in judging a 'Dragon's Den' event on June 28. The originally planned keynote address ('SME Growth – Overcoming the 'Can't Get There From Here' Paradox') will take place on the 27th. Both days of the event will be held at the rather splendid National Botanic Gardens. More details on the website as the complete programme is finalized by the organizers.

New Projects
This month's new projects from around the Network:

- Automotive – SI education programme
- FMCG – packaging innovation project
- FMCG – NPD 'fuzzy-front-end' clarity project
- Power – Infrastructure asset sweat project
- Mining – SI Certification programme
- Financial Services – Marketing strategy innovation workshops
- Industrial – B2B TrenDNA study