



Lead Indicators
shaping
Biotechnology
to 2017

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Introduction

This Lead Indicator document is not intended to be just another source of information.

Its purpose is to provide a 'big picture' view of some of the key global drivers that are reshaping countries, markets, and societies at the global and local levels.

We have therefore provided a highly simplified overview of the trends, discontinuities and uncertainties associated with these Lead Indicators so we can better understand how that 'big picture' view may evolve over the coming years.

There are a many things in play locally and globally that could tip the balance at any time – think of demographic change, changing work and lifestyles, the increasing skills shortage, political change, and the impacts of IT and technologies.

The space we operate in is going to change – probably to a greater degree and more rapidly than most of us expect.

Being more informed about what might change longer term enables us to better understand the strategic issues we need to focus on and address in the medium to short term.

These Lead Indicators are being shaped by continuous dynamic processes and ongoing monitoring is an important tool to ensure we understand over time what is happening at the leading edge.

NEXT continuously monitors a wide range of highly reputable global sources providing a comprehensive research-backed basis for the Lead Indicator reporting we present to clients.

Tomorrow's successful businesses and organisations will be so because they have adopted continuous Lead Indicator monitoring and response processes which constantly drive adaptive changes in strategic planning.

The Foresight Context

Foresight enables us to form a view of the future that helps us to develop more relevant and effective strategies and implementation plans. It requires taking a different approach to thinking and strategic planning than that which has traditionally been the case.

Developing a foresight context requires us to think within future-focussed frameworks, such as those described in the following sections.

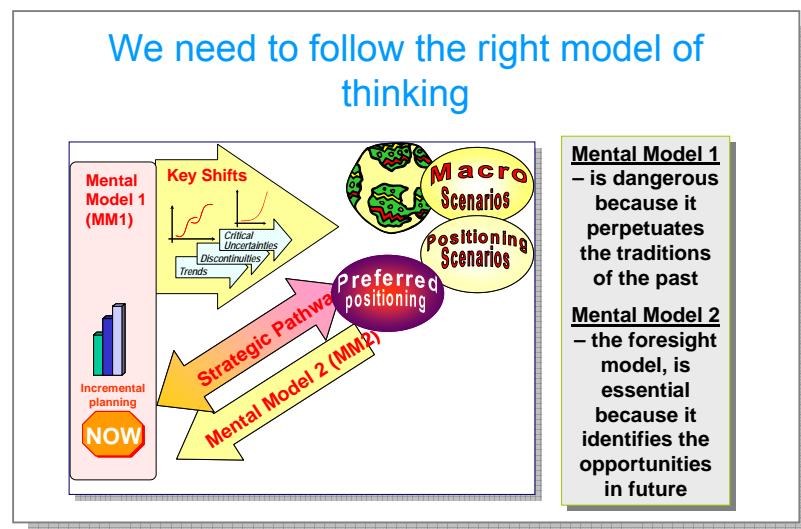
The Foresight Way of Thinking

We use the term 'Mental Models' to describe the way people think about the future.

'Mental Model 1' thinking is based on projecting forward from today and is based strongly on historical patterns. But that can be a dangerous way to plan for the future because there may be something looming over the horizon that is likely to change the whole playing field. A great example is how e-mail is currently destroying the traditional postal delivery model. Another example is how screw caps on wine bottles are threatening the traditional cork producing industry.

In contrast, **'Mental Model 2' thinking** is a knowledge based way of thinking that is built around developing sets of alternative scenarios that portray how things may have changed some years into the future. For example, how will the international energy market look once the world reaches 'peak oil' in 2010 – 2012? How is it likely to have changed by 2020? By developing a set of alternative scenarios that explain how things may look some years into the future we can make more informed decisions today when we develop our go-forward planning strategies and our annual or biennial implementation plans.

Figure 1: The foresight way of thinking



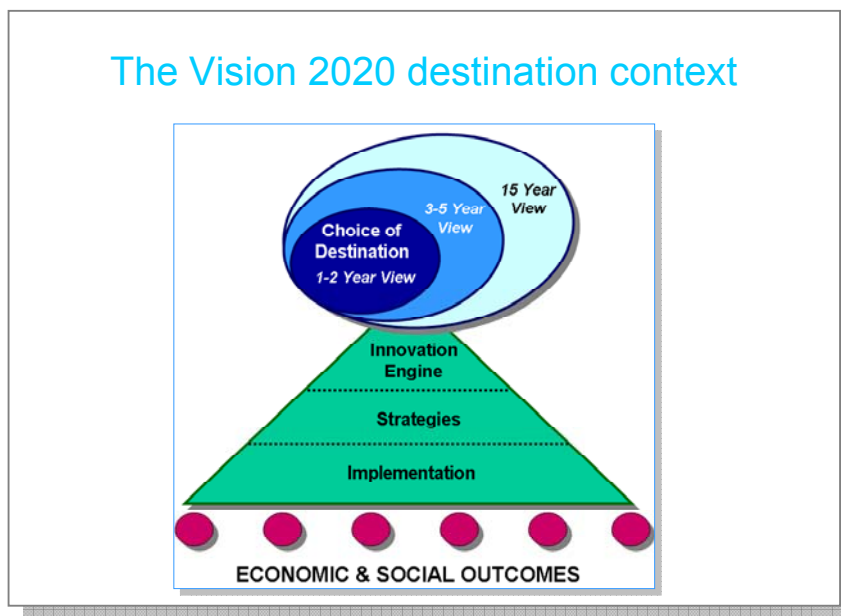
Knowing the Destination

No-one knows exactly how the future may play out. But we can develop views that portray several alternative futures that could happen. Some of those alternative futures may be negative, others may be positive, and still others could be a combination of both. A key component of the foresight process is developing a consensus view of 3 – 4 alternative futures (scenarios) and then selecting the preferred future amongst those alternatives that the majority wishes to head towards.

Once the preferred future has been agreed to, then every initiative and action in the political, environmental, R&D, social, and economic spheres can be aligned so that they are focussed in the same direction - to move a country or organisation in that preferred direction. This alignment reaches right down to our day-to-day activities at home and at work.

Such a preferred future is often called a vision – but it should be understood that a vision is more than a one-liner. It is actually something that has depth and breadth and needs to be visualised in a quite detailed way and developed on a consensus basis.

Figure 2: Understanding the ‘destination’ and how things are aligned



It should also be understood that any preferred future is based on a dynamic vision and that it will need re-visiting on a regular basis over time so that it can be re-shaped as new information and knowledge comes to hand.

In this way we avoid becoming ‘blindsided’ by changes that are likely to occur after the initial visioning exercises are completed. Such changes happen all the time, in some cases by the second (see Peter Russell’s ‘World Clock’ at <http://www.peterrussell.dreamhosters.com/Odds/WorldClock.php>).

The 3 Horizons

Once we know what our preferred destination some years into the future is, we then need to use a long-term context, which we call Horizon 3, as the guiding basis for all the decisions made regarding strategic planning at the Horizon 2 level, and short-term operational planning and day-by-day implementation at the Horizon 1 level.

This is what we call a ‘backcasting’ process – from Horizon 3 in the future back to Horizon 1 in today’s world. It is quite the opposite from forecasting. Being in Horizon 3 requires us to imagine standing in the future at a particular point in time and visualising the things that might surround us in both our work and personal lives in our preferred future and developing a consensus-based picture of how that preferred future may look using foresight tools such as PESTE (a tool that uses five visualisation parameters – political, economic, social, technology, and environment).

Figure 3: ‘Backcasting’ from Horizon 3



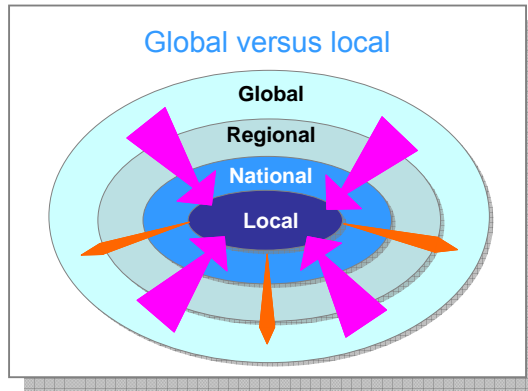
Global versus Local

The final piece of the foresight jigsaw puzzle is to develop an understanding of where we fit individually, as a community, or as a country within a global context. Globalisation today means we can no longer live and work in isolation – even though many would like that to be the case. Globalisation imposes things upon us in our local daily lives and workplaces that we can’t escape from. It can also draw the smart young people away from our country to benefit another – if we don’t create an environment that is attractive for them to stay.

At the same time it offers us a growing opportunity to participate in and influence the larger national, regional and global spheres from our own small local place on the planet.

Global communications networks and the Internet are driving this global – local connectedness – in both directions.

Figure 4: What happens globally impacts locally – and vice versa



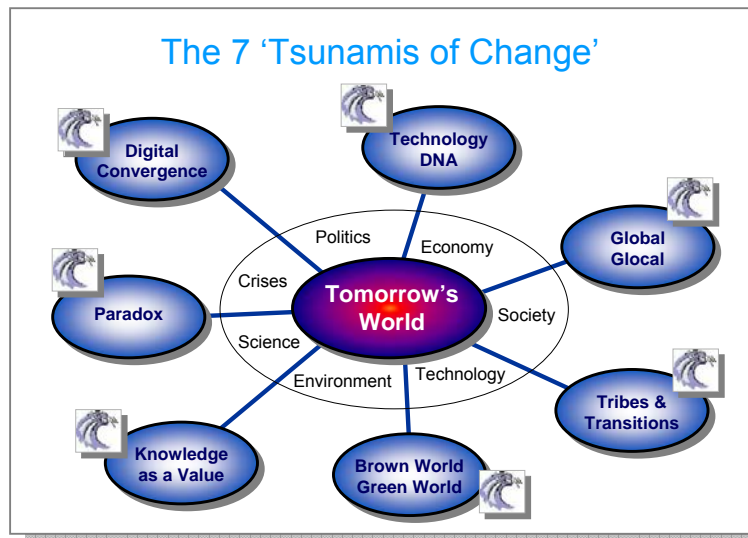
Key Global Trends, Discontinuities & Uncertainties

To understand what a future view may look like, we need to develop an understanding the key drivers of change that are likely to shape that view. We call them ‘The 7 Tsunamis of Change’.

The 7 Tsunamis of Change

We use the terminology ‘Tsunami’ because these major drivers of change have a similar impact to a large tidal wave. After the wave has vent its fury the landscape has changed. Some things remain as they were. Some have been changed. Others have disappeared forever.

Figure 5: Seven major global drivers of change



These 7 Tsunamis of Change are creating a similar effect at the global, regional, national and local levels.

Each Tsunami can be summarised as follows:

1. **Digital Convergence** – Chips in everything, total interconnectivity, virtuality.
2. **Technology DNA** – Biological and technological convergence, cumulative innovations, the re-shaping of life itself.
3. **Global Glocal** – The global village, cultural convergence, being the biggest or most unique.
4. **Tribes and Transitions** – The digital divide, tribalism, demographic change, changing global lifestyles/work styles.
5. **Brown World, Green World** – Climate change, resource productivity, water – air – energy.
6. **Knowledge as a Value** – The hierarchy of knowledge and value, knowledge management, consumer power.
7. **Paradox** – Unexpected outcomes, living with degrees of grey rather than black or white, solutions take opposites into consideration.

Trends, Discontinuities, and Uncertainties

Within each of these '7 Tsunamis' there are numerous trends, discontinuities, and uncertainties (TDUs) evolving at any one point in time.

- Trends are things that are changing along a relatively predictable pathway.
- Discontinuities are things that are likely to change the shape of the future in a way quite different to how things have been in the past.
- Uncertainties are areas where we can see that changes are likely to happen but we have no clear idea how and to what extent.

In the 2006 NIHERST Biotechnology Best Bets Sector Foresight project, we developed a comprehensive picture of global trends in biotechnology which we won't repeat here.

However, since that project was published there have been some interesting new TDUs emerging within these '7 Tsunamis of Change'. The following are examples that all have particular relevance to the Advanced Biotechnology 'Best Bets' Foresight Project. These include:

- According to a 2004 report from Norway, within a few decades biotechnology is expected to be 70% of the world's industrial economy and be associated with 40% of the world's total global economy ([Norwegian link](#)).
- However, in a recent interview international biotechnology researcher, Gary Pisano, said that the expectations for the sector have been over-optimistic and the lead times are a lot longer than for other technology sectors such as IT. There is a disconnect between the innovation pathways in business and science which is holding the sector's development back – particularly in terms of R&D investment ([Pisano interview link](#)).
- The close proximity of the world to 'peak oil' where global demand exceeds supply. The International Energy Agency recently reported ([Link to July 2007 report](#)) that this is likely to occur between 2010 and 2012 – far sooner than most have been expecting it might happen. This has huge ramifications for the

world's economies and societies and will accelerate the shift to more sustainable alternatives.

- Health care costs are soaring around the world. In the USA, unless things change, by 2015 (just 8 years from now) some 20% of that country's GDP is expected to be allocated towards health care ([Health spending link](#)). In Switzerland and Germany these costs are already close to 11% of GDP. Ageing populations, heightened consumer expectations, and unhealthy lifestyles are all contributing factors.
- Rapid growth in the bio-fuels sector has brought to light an interesting conundrum. The more farmers switch from growing crops for food to crops for bio-fuels, the greater the concerns about food supply and security are becoming. The prices for many basic food commodities, such as grains and sugar, have been soaring and the world reserves are at an all time low ([World food reserves link](#)).
- Bio-plastics are moving rapidly into the commercial production arena and the demand for such product, e.g. from Japan, appears to be strong ([Bio-plastics link](#)).
- Going back to nature to learn more about innovative and unique solutions to many of the world's challenges is an accelerating trend ([Example link - India](#)). Progress is also being made in identifying components beneficial for human health and wellness that consumers are prepared to pay a substantial premium for ([University of Dresden – link](#)).
- The first patent application in the world for an artificially designed organism was filed in June 2007 ([Link](#)). This has ignited the ongoing controversy about what can and can't be patented when it comes to genetic material and its manipulation.
- The convergence between biological and technological systems and processes is accelerating with humans perhaps soon powering their own 'personal infrastructure' ([Fraunhofer link](#)). A whole new opportunity in 'functional fashion' is opening up.

In this document we will look at a set of 'Lead Indicators' associated with such trends in more detail.

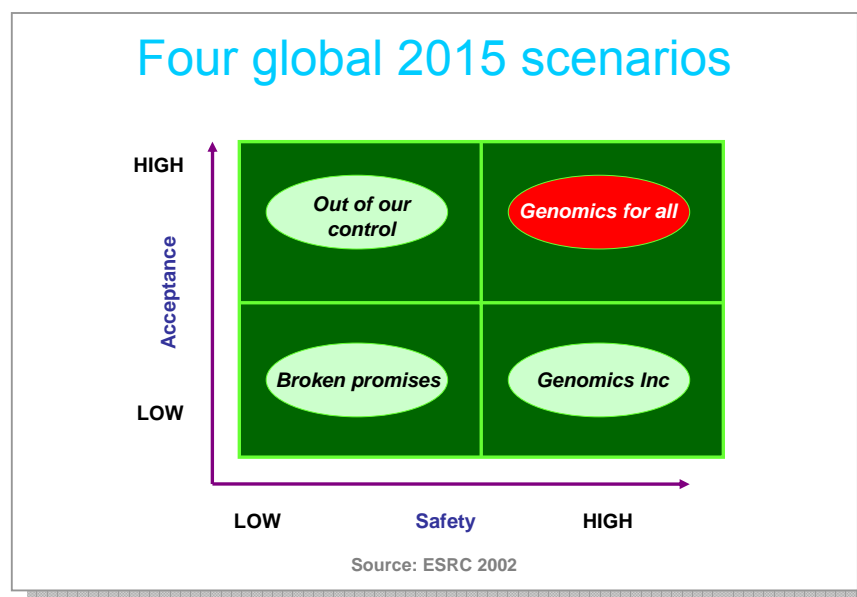
The World In 2020

Global Scenarios

There have been several sets of global scenarios developed in recent years that have focussed on biotechnology and genomics. However, in 2002 a joint UK and US working group produced a set of four global scenarios focusing on genomics and society. We think that the views associated with each of these scenarios are applicable to biotechnology in general terms of the potential alternative future outcomes ([ESRC Genomics Scenarios - Link](#)).

A simple overview of these scenarios is shown in the Figure 6.

Figure 6: A set of possible global genomic scenarios



These scenarios present four alternative futures for genomics in the world. The essence of each has been summarised by the ESRC group as follows:

Genomics for All – Genomics is successfully implemented, with wise and participatory management of the risks and side effects. A consensus emerges not only on how genomics should be implemented, but also on the type of society that genomics should serve. Genomics plays an important role in building a global society dedicated to improving equity and sustainability (*a highly positive scenario*).

Out of Control – Genomic breakthroughs accelerate and the costs of research decline. Throughout the developed world and in developing nations, the use unregulated field trials to rapidly advance and develop genomics applications is rife. Miracle products create widespread public acceptance, despite genomic accidents and uncertainties (*a high risk scenario driven by market demand*).

Genomics Inc – Genomics gains more public acceptance as better safety standards and new applications demonstrate the value of genomics. Mergers and alliances create a handful of 'Life-Science' conglomerates that operate on a global scale (*a scenario which sees a concentration of power in a few hands and perhaps a divide between who benefits and who doesn't*).

Broken Promises – Genomics applications prove to be more difficult to develop than expected. Several prominent genomics accidents turn public opinion against genomic technology. Activists mobilise for stronger measures against the industry and reduce further public demand. Liability lawsuits severely diminish the industry and force genomic patents into the public domain (*a negative scenario*).

What these four scenarios describe are four different potential future outcomes for genomics. The basic tenet within each of them can just as easily apply to the whole biotechnology sector.

For example, if a company develops a drug that causes negative outcomes (such as Vioxx) or it becomes proven cell-phones cause brain cancer, they could be triggers that lead us towards a negative ‘Broken Promises’ scenario.

On the other hand, if a genetic manipulation can be found that has no side effects and can eliminate the likelihood of more mature women giving birth to a child with Down’s Syndrome or we can prove that Trinitario Cocoa contains a specific measurable and quantifiable component that is positive and safe for human health and wellness, they could be triggers that lead us towards the positive ‘Genomics for All’ scenario.

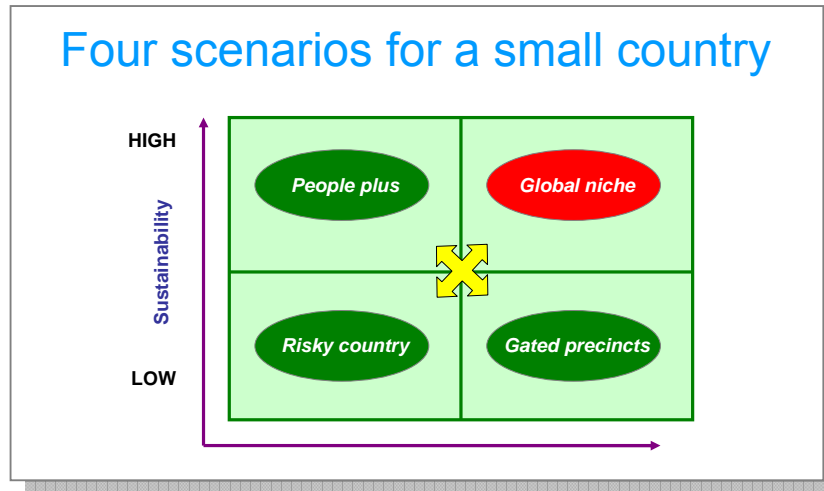
The ‘stealing’ of biological and genetic IP from developing nations by big corporations might be part of the ‘Genomics Inc’ scenario – creating a ‘biotech divide’ between the haves and have-nots.

If someone in China came up with a treatment for cancer derived using genetically-modified plants, and a high demand caused it to be released before any potential adverse ecological and environmental impacts had been checked, this could be a trigger leading us towards the ‘Out of Control’ scenario.

Small Country Scenarios

As shown in Figure 4, we have to think about regional, national, and local scenarios within a global context. Over the past several years we have developed a simple matrix, shown in Figure 7, which we believe provides a useful basis for developing a set of scenarios (alternative futures) for small countries like Trinidad and Tobago.

Figure 7: A set of possible scenarios for a small country like T&T



We can use this matrix as a basis for developing four alternative biotechnology futures for a small country such as T&T. In broad terms each scenario focus might be described in the following way:

- **Global Niche** – A positive scenario where the country has been able to develop a number of high value global niches built around the natural assets and specialised technical capabilities that the country possesses. In 2015 they contribute 20% towards the country's GDP and this is expected to rise to 30% by 2020.
- **People Plus** – A middle of the road scenario that foresees a largely cottage industry based biotechnology industry which supplies key raw material components but most of the value adding is done overseas. The basis is sustainable but the value is low and biotechnology only contributes a few percent to GDP by 2015.
- **Gated Precincts** – A partial solution where there has been a significant improvement in the country's economic position but the wealth generated from biotechnology developments (15% of GDP by 2015) remains largely in the hands of an elite few and there is a large and growing gap between the 'haves' and the 'have-nots'.
- **Risky country** – A negative scenario where the country has failed to develop the potential of its biotechnology sector. It contributes less than 2% to the country's GDP in 2015. The country overall is making little or no progress economically or socially. The result is a flight of talent – including the people needed to drive the development of a biotechnology sector, an increase in crime and despair, and the country faces a dismal future.

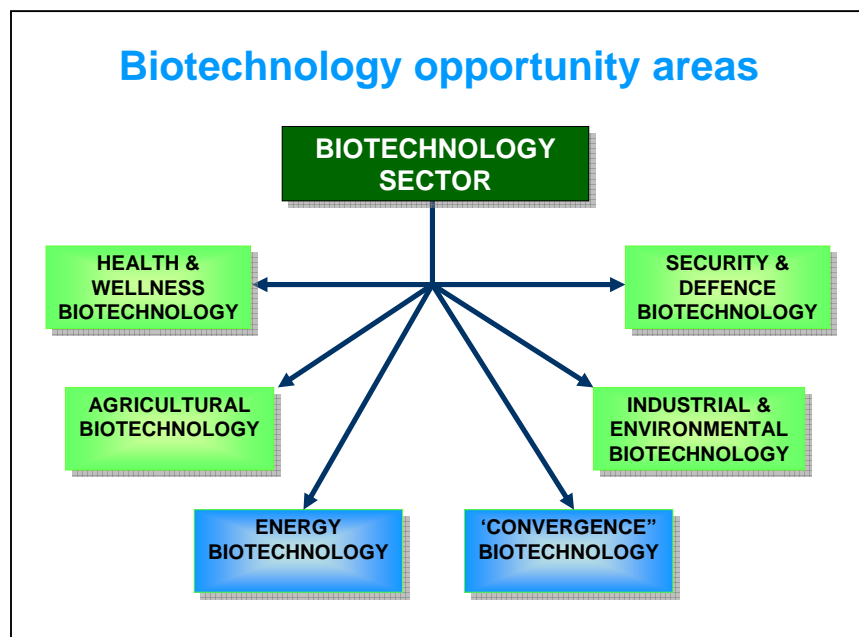
As in the case of the four global scenarios, as time progresses towards 2015 any one of the four scenarios may predominate but parts of the other three scenarios are also likely to come into play.

The direction the country takes in the biotechnology sector will depend upon decisions made by the country's leaders, key stakeholders, and individual citizens, right now.

Revisiting the Future Biotechnology Opportunity Areas

We have revised our original overview of major global opportunity areas, that we developed in 2006 for the biotechnology sector project, to include two new ones. Through our global trend research we have identified several emerging areas that offer some interesting and quite unique opportunities. These are the areas shown in the two blue boxes in Figure 8.

Figure 8: Future opportunity areas we have identified for biotechnology



Both these new areas offer a range of quite specific opportunities that have a great deal of potential for both niche and global players.

They can be described briefly as follows:

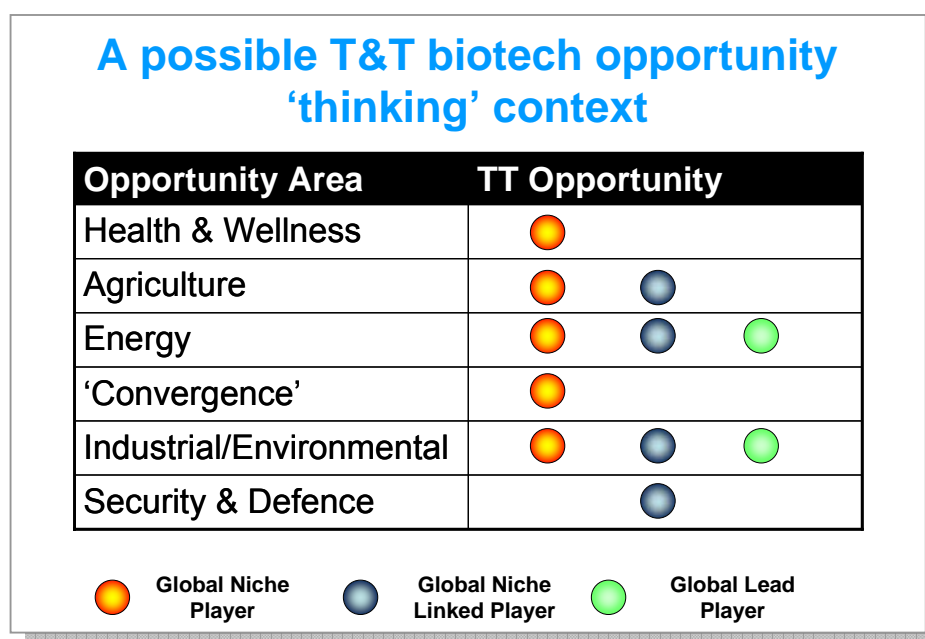
- **Energy Biotechnology** – A whole new set of thinking is emerging with regard to how the world is going to cope once 'peak oil' is reached. There is a huge focus on bio-fuel production, but only some options will be sustainable long-term. For this reason the opportunities will be quite specific (and potentially highly valuable), However, each will need to be carefully considered within a 'big picture' context.
- **'Convergence' Biotechnology** – This is a totally fascinating emerging field and overlaps a whole range of sectors including ICT, fashion design, bio-mechanics, and human biology. There are some huge opportunities emerging that will be built around 'solutions for one' – individually customised packages – which are perfect for a small country like T&T to become a player in. One example is clothing that generates electricity from body heat in quantities sufficient to power cell phones and small computers.

Putting the Opportunities in a Realistic Context

If we go back and look at Figure 4, we can see that we have to look at the local context within a global context, and vice versa. So when we use foresight to identify new and emerging opportunities for a sector such as biotechnology, we need to rationalise the areas we identify into ones in which we can realistically become a player – based upon the resources, capabilities, financial support, infrastructure and regulatory support available locally.

For this reason we suggest that perhaps the way we should be thinking about the types of opportunities available for the T&T biotechnology sector in future might be along the lines suggested in Figure 9 – but it's open for discussion!

Figure 9: Possible future biotechnology opportunity contexts for T&T



We can define the intent of the ratings depicted in Figure 9 as follows:

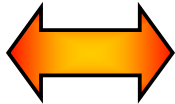
- **Global Niche Player** – This means the opportunities that T&T is likely to develop successfully are highly defined niche opportunities based upon a local resource and/or capability which already exists and can be leveraged. The resulting businesses would be T&T owned.
- **Global Niche Linked Player** – This means the opportunities that T&T is likely to develop successfully are as a niche player within a larger global alliance or partnership that is developing and marketing relatively complex but quite specific niche focussed products and services.
- **Global Lead Player** - This means the opportunities that T&T is likely to develop successfully are as being a significant global player that has developed key marketing and distribution arrangements in other parts of the world which can deliver internationally competitive large-scale innovative products and services.

Lead Indicators

The following Lead Indicators provide us with some interesting ideas and aim to stimulate our thinking about possible Horizon 3 'Best Bet' opportunity areas in the biotechnology sector.

Lead Indicator Trend Arrows

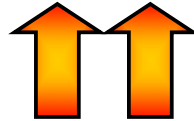
The indicator arrows used throughout this report have the following meanings:



Could go either way



Slight move



Moderate move



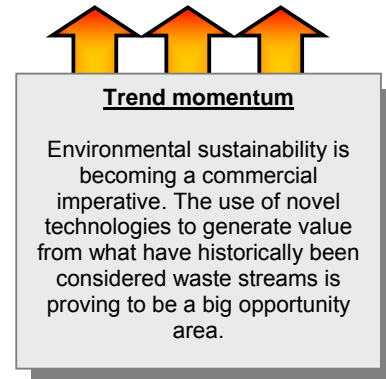
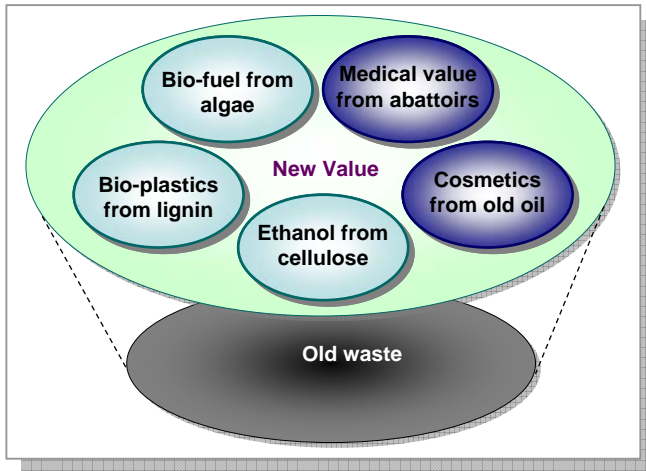
Strong move



***LEAD INDICATORS 1:
Value Adding Trends***

Lead Indicators 1 – Value Adding Trends

High value products from waste streams - The increasing cost of safe and environmentally friendly waste disposal is prompting companies to find value from effluent.



Supporting views

Smart entrepreneurs are converting waste problems into value added opportunities

- A prototype bioreactor has been developed that uses an enzyme harvested from genetically modified *E. coli* bacteria to turn CO₂ wastes into bicarbonate.
- Therapeutic cosmetics that regenerate damaged skin can be derived from waste cooking oil from restaurants.
- Bio-plastics are being made from lignin extracted from willow tree waste left over from bio-fuel production – Biojoule, New Zealand.
- Algae are being used to remove the CO₂ from coal-fired power station flue gas streams and converting it into bio-fuels.
- By 2010 bio-ethanol produced from cellulosic wastes is expected to become a viable commercial proposition.
- A New Zealand company is selling bovine tendon tissue components extracted from abattoir waste for up to US\$ 2000/kg for medical bio-assay use in the USA.

Key references

Examples of smart solutions

- [Prototype bioreactor](#) ; [Bio-plastics - Biojoule](#)
- [Therapeutic cosmetics](#) ; [Algae make bio-fuel from CO₂ waste](#)
- [Betting on biofuels](#)

What might this mean for T&T?

Opportunities to 'make money from muck' already exist in T&T

Research needs to focus on developing commercially attractive opportunities

- Are there opportunities for T&T to turn CO₂ waste streams associated with the energy sector into value-added businesses?
- Do we have agricultural or wood processing wastes from which we could derive valuable products?
- With all our energy sector expertise, should we not be looking more closely at bio-plastics as a future opportunity area?
- What else could we derive from our country's growing waste streams by using biotechnology?

Lead Indicators 1 – Value Adding Trends

‘Factor X’ - Marketing based around identifying a specific health and wellness factor and quantifying it are making ‘healthy foods’ a real high growth opportunity area.

The value of a ‘Factor X’

Commodity Honey



US\$ 5.00/KG

+

Active Manuka Honey



US\$ 120.00/KG

Factor X =

Trend momentum

Over the next decade the proportion of consumers following special diets will rise as the baby boomers age and young people face a battle with unhealthy lifestyles. Consumers are opting for natural products that offer a health benefit and are prepared to pay a significant premium.

Supporting views

There are many ‘Factor X’ components in food products that can be leveraged

- Bisdemethoxycurcumin, a chemical found in curry, has been shown to help the human immune system destroy a key Alzheimer’s brain plaque protein.
- Phenethyl isothiocyanate, a molecule found in broccoli and cauliflower, aids in the prevention of prostate cancer.
- The *Aspilia Africana* plant has properties that can stop bleeding, block infection, and speed wound healing.
- German researchers have recently identified the anti-bacterial chemical agent, methylglyoxal, that has driven a 25 times increase in price for high active New Zealand manuka honey.
- This same chemical agent is also found in cocoa and coffee.
- Research trials have proven that the consumption of pomegranates, and products derived from them, improves human health and wellness because of specific biochemical components.

Key references

From curry to pomegranates

- [Curry and Alzheimer’s disease](#) ; [Methylglyoxal in honey](#)
- [Broccoli - cancer benefits](#) ; [Pomegranate success story](#)
- [Aspilia’s properties](#)

What might this mean for T&T?

Ageing populations and obesity problems are opening up new opportunities

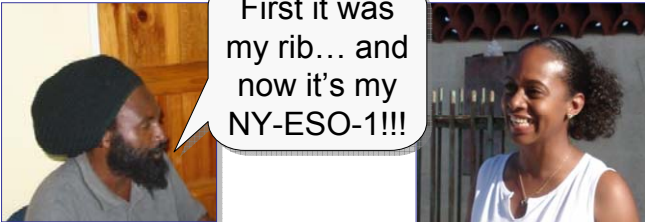
T&T has a lot of potential to leverage ‘Factor X’ as a value adding tool

- What would be our top 2 – 3 choices of T&T derived natural raw materials/products that could provide a valuable ‘Factor X’?
- Are our research focuses sufficiently commercially oriented?
- Do we need to look at a public-private sector consortium type approach for researching opportunities in this area so that we have a greater chance of achieving commercial success?
- Do we need to form alliances with external parties so that we can leverage the greatest value from these opportunities?


Lead Indicators 1 – Value Adding Trends

Health and wellness – Health and wellness is becoming the number one personal priority around the world – especially as populations age. This is driving a lot of science based innovation.

The ultimate transfer



First it was my rib... and now it's my NY-ESO-1!!!



Trend momentum

By around 2015 it is expected that a huge 20% of the US GDP will be spent on personal health and wellness. In other countries spending levels are also on the rise. People expect more and better solutions to fix the things that ail them.

Supporting views

<p><i>From nature to hi-tech - new solutions are being discovered all the time</i></p>	<ul style="list-style-type: none"> Scientists in Cuba have found a way of using chitin and chitosin derived from lobster shell waste to coat surgical threads and improve healing processes. An intense pulse of visible light kills viruses found in the human blood stream. This new technique may provide a way to target and destroy HIV and hepatitis C – two big global killers. The 'Exelon Patch' has been developed to treat mild to moderate Alzheimer's disease and Parkinson's disease. Initial results show a great deal of promise for an age-related disorder on the rise. A vaccine developed from a protein called NY-ESO-1, found in the male testes, stops the development of ovarian cancer. The Golden Triangle Partnership in India aims to move the country's large herbal medicine industry towards a more scientific proof-based future.
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Key references

<p><i>Interesting sources</i></p>	<ul style="list-style-type: none"> Light pulse kills viruses ; Lobster magic Exelon patch offers hope for Alzheimer's ; Herbs go scientific Male vaccine for females
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What might this mean for T&T?

<p><i>T&T has produced a number of icons in the health sector</i></p> <p><i>Health and wellness offers huge opportunities globally</i></p>	<ul style="list-style-type: none"> What areas in the health and wellness sector could T&T realistically focus on, bearing in mind the limitations of human and technical resources, to take advantage of the growing number of global health and wellness opportunities? What have we got that could be used as a basis for developing an innovative product or solution? Could we form an alliance or partnership with an offshore party to accelerate progress?
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***LEAD INDICATORS 2:
IP Trends***

Lead Indicators 2 – IP Trends

Global IP trends – In an age where ideas increasingly have a value that is far greater than physical assets, IP protection is becoming a high profile focus area.



Trend momentum

Intellectual property has the potential to yield billions in rewards to the owners of such IP. More IP is becoming ideas based rather than a physical item. The recent sale of the website, YouTube, to Google for US\$ 1.65 billion illustrates the value creation potential.

Supporting views

General trends shaping the IP sector

- A number of companies are beginning to release details of valuable patents and other IP material into the public domain to stimulate value adding collaboration.
- The UK Intellectual Property Office (UKIPO) plans to change its policy of denying applications on the basis of third party rights.
- The legal patenting process is an area being increasingly outsourced to India.
- A total of 196,436 patents were registered with the US patent office in 2006 – 52% of all global patent registrations. This total was up 24.5% on the 2005 year.
- There has been an increase in intellectual property litigation costs, exploding by 10 percent to 15 percent annually. Companies are more aggressively enforcing their rights to intellectual property.
- Comedians, chefs, fashion designers, and sports leagues are all pushing to get protection and recognition for their work.

Key references

Recent interesting reference sources

- [Release of IP material](#) ; [US patent registrations 2006](#)
- [Third party rights](#) ; [Outsourcing to India](#)
- [Increasing IP litigation](#) ; [Comedians etc. get protection](#)

What might this mean for T&T?

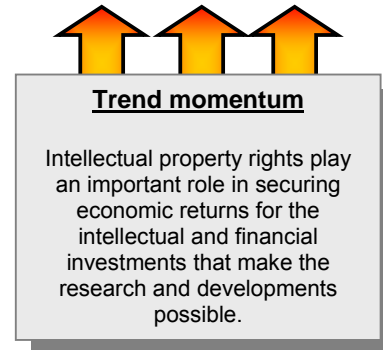
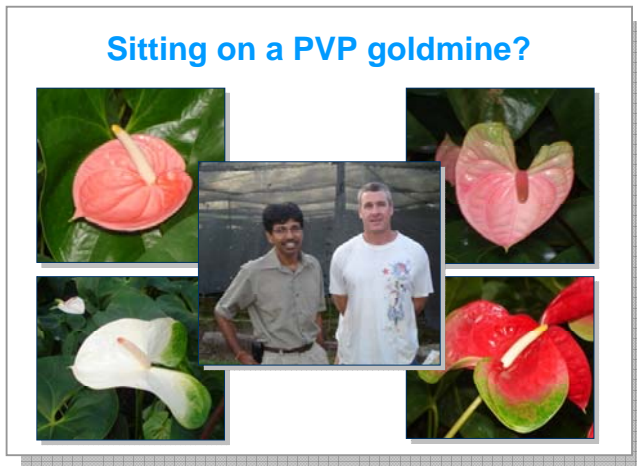
IP protection has the potential to yield billions in revenue streams for countries

T&T needs to become more proactive in leveraging value

- There are many great ideas, such as steel pan, that have been developed in T&T but how many of them have been leveraged through IP protection to benefit the country?
- Is there a need to instil in people's minds a greater consciousness about the potential value that could be leveraged?
- What do we have now in the private sector and within our institutions which could be leveraged by applying for IP protection and which would offer us the best prospects?

Lead Indicators 2 – IP Trends

Plant variety rights – Developing unique new cultivars and derivatives from plants is becoming a growing opportunity to leverage greater value from R&D efforts globally.



Supporting views

PVP is gradually gaining greater strength as an international value adding tool

- Soon all plant materials and plant-derived products will be covered by Plant Variety Protection (PVP). Currently products only have optional protection.
- PVP varieties cannot be used for breeding for a 10 year period, and thereafter permission from the owner must be obtained and royalties paid.
- Applications for PVPs will soon be on the basis of one international application that covers all those countries internationally that recognise PVP protection.
- In 2006 some 1149 PVP patents were granted in the USA alone.
- PVP security in non-signatory countries to international patent laws can still be largely assured by entering into local alliances with trusted partners and establishing a 'win-win' basis for both parties.

Key references

PVP trend references

- [Materials and Products](#) ; [PVP Trends](#)
- [No breeding for 10 years](#)
- [International applications for PVPs](#)

What might this mean for T&T?


T&T has undertaken a lot of research into plants and derivatives but little effort has been made to secure potential value


- How much potential 'gold' do we have in T&T that could be used to leverage value from plant based products (think of Trinitario cacao and Anthuriums as two examples)?
- How much potential value does this 'gold' have for the country?
- What needs to be done to extract this value?
- If you had to pick three areas with PVP potential that would yield benefits 5 – 10 years from now, what would they be?

Lead Indicators 2 – IP Trends

Genetic ‘capital’ patenting – There is a great deal of controversy emerging around the patenting of gene-related discoveries. How it will develop in future no-one is sure.

What’s OK and what’s not







Trend momentum

There is a huge amount of research being focussed towards the genetic modification of organisms. The big question now is where the line will be drawn between what is patentable and what is not.

Supporting views

The patent laws are being pushed to the limit in the genetic modification area

- Holders of individual patents are looking for ways to sell or license their IP that gives them more power over the fees they receive.
- Proposed US legislation seeks to ban gene patenting as the patenting of genes is considered to be analogous to patenting water, air and other resources.
- However, the development of gene screening technologies is an area that offers a great deal of potential for IP protection
- US biotechnology company, Proteus, recently gained a patent for a protein modification-based screening technology. It speeds up the search for new valuable protein-based compounds.
- Dr Craig Venter filed a patent in late 2006 for a synthetic bacterium he and his colleagues have developed over recent years. Whether this will be approved is still open to debate.
- This has stimulated a strong response from Canadian company, ETC who see Venter’s work and his patent application as being ‘competition for God’.

Key references

Interesting reference sources

- [Licensing of IP : ‘Synthia’ creates waves](#)
- [US ban on gene patenting](#)
- [Mechanised gene screening patent](#)

What might this mean for T&T?

T&T already has developed at least one genetic screening process for which patent protection has been applied

- Dr Pat Umaharan at UWI, St Augustine, has developed a unique process for screening Anthurium plants for bacterial resistant genes. What else has been developed in the R&D sector in T&T that could be patented?
- Where should we be looking for such opportunities?
- Do we have something now that could be developed into an internationally patentable proposition through investment in R&D?

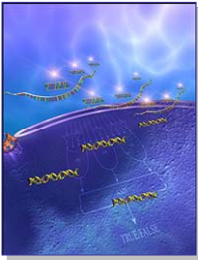


***LEAD INDICATORS 3:
Technology Trends***

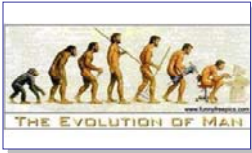
Lead Indicators 3 – Technology Trends

Bio-mechanics – The convergence of biological, mechanical and ICT technologies is opening up a whole new range of fascinating opportunities.


Blurring boundaries



A DNA based computing system
Image: Kirk Moldoff



The Bionic Hand
Image: National Geographic





Trend momentum

The idea of the 'cybermensch' – part human, part mechanical, and part computer - is beginning to be reflected in real life. The convergence of technologies is leading to a whole range of new innovative solutions to mankind's challenges.

Supporting views

The boundaries between biological and technological systems are blurring

- Researchers have developed a DNA computer which could lead to faster diagnosis of the West Nile Virus and bird flu.
- In the future, this type of DNA computer could be implanted in the body to detect and kill cancer cells and help control diabetes by dispensing insulin when needed.
- Researchers are developing a biological interface that could link a patient's nervous system to a thought-driven artificial limb. The interface connects living neurons to synthetic chips.
- Touch Bionics in the UK have developed a new bionic hand that can be controlled by the wearer's mind and muscles.
- A team of researchers in Korea claim to have identified two genes in rice which respond to sound waves. They say that the promoter of one of these genes could be attached to other genes to make them sound sensitive.

Key references

Convergence references

- [DNA computer diagnosis](#) ; [The bionic hand](#)
- [The bio-mechanical interface – neurons communicate with chips](#)
- [Plants and sound waves](#)

What might this mean for T&T?

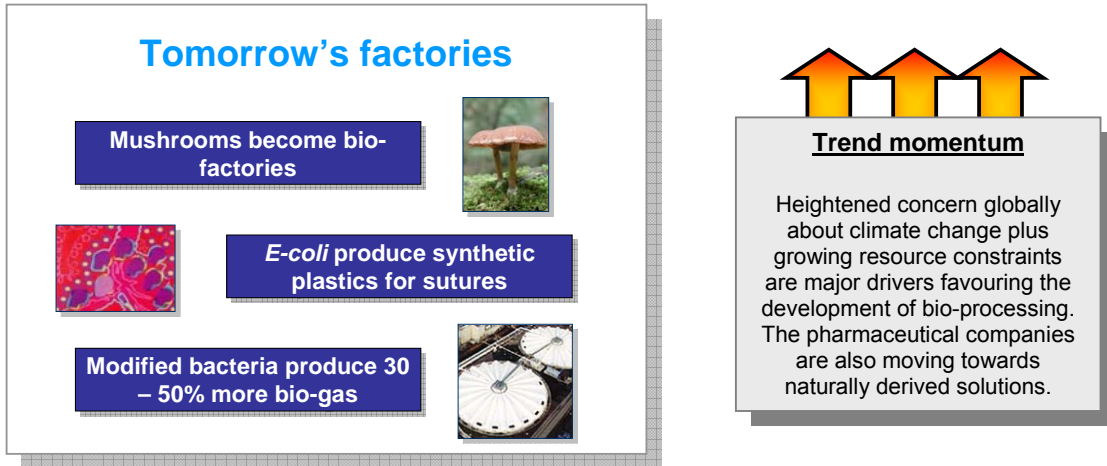
Bio-mechanics is a field that is growing rapidly

There may be specialised opportunities for T&T

- Is this a field that we could realistically contemplate becoming involved with in T&T?
- Are their opportunities associated with the T&T energy sector that could provide the basis for innovative bio-mechanical solutions?
- Are there opportunities in other fields that T&T could realistically focus on to develop?
- Do we have the necessary skills base to warrant pursuing opportunities in this field?

Lead Indicators 3 – Technology Trends

Bio-processing – As the world begins to wake up to the fact that it is using up many of its finite resources at a rapid rate, bio-processing is evolving as a more sustainable option.



Supporting views

The leading edge is moving fast and approvals for innovative processes are being granted

- Scientists have developed transgenic mushrooms that paves the way for them to serve as 'bio-factories' for the production of a variety of pharmaceutical products e.g. insulin.
- A new type of absorbable sutures (joint/bone) made from a polymer produced by genetically modified *E. coli* has been approved for use by the FDA in the US.
- Dutch researchers have developed a new sensor array that better measures conditions in industrial microfermenters making the process more efficient, less time-consuming, and less expensive.
- Scientists have developed a way to grow a new flu vaccine in insect cells that is faster and more cost efficient than using eggs – the traditional approach.
- US researchers are genetically modifying microbes, currently used to turn solid waste into biogas, so they will work at a 30-50% faster rate e.g. in wastewater treatment plants.

Key references

Some stimulating sources

- ['Magic mushrooms'](#) ; [Polymers from E.coli](#)
- [Smarter microfermenters](#) ; [Vaccines from insect cells](#)
- [Faster biogas production](#)

What might this mean for T&T?

There is no question that a lot more resources and products are going to be produced by biological 'factory' systems

- As T&T's oil and gas industry gets closer to its sunset phase, is bio-processing an area the country could exploit?
- Do we need to partner with offshore research partners to develop expertise in this field?
- What might be areas we could focus on as part of this global shift towards producing more sustainable renewable resource streams?
- What do we have already that we could build on?

Lead Indicators 3 – Technology Trends


Bio-engineering – This is making an enormous contribution to the advancement of health care sector – an area where people are less concerned about genetic manipulation.

Innovation doesn't have to be complex – just smart!

An innovative new way of injecting solid medications and removing the risks associated with syringe needles and liquid drugs



Source: Glide Pharma



Trend momentum

The one big driver that will favour bio-engineering is human health and wellness. People generally won't take risks with bio-engineered food – but when it comes to their health – well, that's a different story!

Supporting views

The leading edge is incredibly innovation driven

- The use of rodent epiblast stem cells, which closely resemble human stem cells, is likely to speed up research that could lead to cures for diseases such as Parkinson's and Alzheimer's.
- Researchers have developed a device that can be used to find proteins that interfere with normal cell processes and cause disease.
- Researchers at MIT and Boston University are engineering viruses so they can destroy bio-films that host harmful bacteria in the human body and on medical and industrial devices.
- Glide Pharma's Solid Dose Injector uses a spring mechanism which pushes a solid phase drug into underlying tissues where it then dissolves. This removes the need for liquids and syringes.
- *E. coli* bacteria can be engineered so that they can harvest light.
- Microbial fuel cells are being developed that turn organic fuels such as sugars and sewage waste into electricity.

Key references

Advances in bio-engineering

- [Epiblast stem cells](#) ; [Identifying 'bad' proteins](#)
- [Demolition viruses](#) ; [Needle free injections](#)
- [E.coli harvest light](#) ; [Microbial fuel cells \(and a lot more!\)](#)

What might this mean for T&T?

Not all the above areas are practical for T&T to pursue – but some might be worth looking at

- Can we use our combined medical and engineering skills capabilities to focus on specific areas where we have a capability in T&T to produce a potentially commercial result?
- If so, in what area could we actually make some progress?
- Once again, do we need to look at forming some key alliances with offshore stakeholders to make progress in the bio-engineering field?




***LEAD INDICATORS 4:
Emerging Fields***

Lead Indicators 4 – Emerging Fields


Invertebrates and insects - Venoms are exquisitely complex and composed of hundreds of different enzymes and proteins. They are opening up some exciting new opportunities.

To kill or cure – that’s the question!



At least it might help cure the heart attack I’m about to have!

Ruud Kleinpaste – International ‘Bug Man’



Trend momentum

Until recently there has been limited research into possible health and bio-pesticide applications for components of insect and invertebrate venoms. But now that interest is growing as researchers discover some fascinating highly specific treatments and applications.

Supporting views

There is a surge in interest in developing new products from insect and invertebrate venoms

- The venom of the Giant Yellow Israeli scorpion contains a protein which appears to target and kill brain cancer cells associated with malignant glioma tumours.
- An experimental drug derived from Malayan pit viper venom is showing promise for the treatment for strokes. It targets and thins blood clots for twice as long as today’s current t-PA treatment.
- A highly effective painkiller (a 1000 times more powerful than morphine) is being made from the venom of a small sea snail found off the coast of the Philippines.
- A new blood thinning drug developed from Indian cobra venom, known as Exanta, is expected to be marketed within 18 months.
- Components in venom of an Australian funnel-web spider have been found to be specific for insects such as cockroaches, crickets, fruit-flies and can be used as a bio-pesticide.
- A component of the Chilean Rose Tarantula can be used to help treat heart attack victims.

Key references

- [Scorpion’s can help as well as hurt](#) ; [Malayan pit viper](#)
- [Sea snail relieves pain](#) ; [Cobras help in health](#)
- [Applications for spider venoms](#)

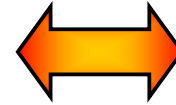
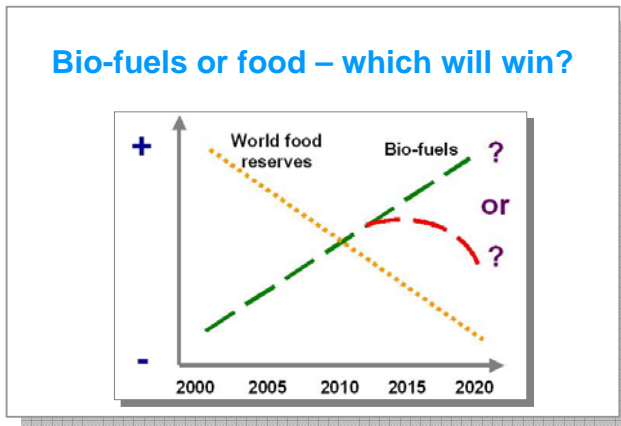
What might this mean for T&T?

Trinidad and Tobago is home to hundreds of species of invertebrates that may possess pharmaceutical properties.

- Are there potential health and bio-pesticide products that could be developed from the country’s diverse invertebrate and insect resources?
- What work has been done so far to identify potential opportunities and who has been doing it?
- Could we link with Chilean and other offshore research groups who already have expertise to fast-track the research process and deliver results within the next 5 – 10 years?

Lead Indicators 4 – Emerging Fields

Bio-energy – According to the conservative International Energy Association, the world will reach ‘peak oil’ in 3 – 5 years – so the rush is on to develop sustainable bio-fuels.



Trend momentum

The future prospects for bio-fuel are not 100% clear. The conflict is between food and fuel. Unless ‘big picture’ thinking comes into play, more crops will be grown to produce energy and the price of food will rise further. Bio-fuel may well turn out to be a niche transitional opportunity.

Supporting views

The need will be to focus on non-food bio-fuel production opportunities that do not tie up highly productive land

- World food prices are expected to rise by 20 – 50% over the next ten years. This is being driven by an ongoing increase in the global population, climate change, and the bio-fuel boom.
- There are a number of projects underway internationally which process algae to make ‘bio-crude’. Algae grow rapidly in non-productive areas, such as on sewage ponds, and produce oils.
- Bio-fuel produced from cellulosic plant material is the big future hope. Enzymes and yeasts are being tailored to break apart plant fibers and convert them into alcohol.
- Butanol is an alternative being researched and can be made from a wider range of biomass such as straw and corn stalks. It is more like petrol than ethanol and can use existing infrastructure.
- Researchers at the Fraunhofer Institute in Germany are developing hi-tech clothing that generates electricity from human body heat – the ultimate bio-fuel!

Key references

Non-food crop based bio-fuel references

- [World food prices sky-rocket](#) ; [Algae as a bio-fuel source](#)
- [Cellulosic fuel](#) ; [Butanol – more like petrol](#)
- [Human energy](#)

What might this mean for T&T?

T&T is a big player in the global energy field. But it will also reach ‘peak oil’ too before long


Time to play in a new space!

- The world is moving rapidly towards renewable and sustainable energy systems. How up with the play is T&T?
- With the wealth of energy sector expertise in the country, would it not be wise to be working hard now to develop a strong future role in the global renewable energy sector?
- The question then is where should the country focus?
- Should we not pick some high priority ‘best bets’ now before its too late?

Lead Indicators 4 – Emerging Fields

Unique opportunities – There are a whole range of highly innovative developments emerging in the biotechnology field. It's a whole new 'universe' out there.

One is real – one not!



Hint = the robot wears pink!

Source: The National Geographic



Trend momentum

The convergence of a whole range of scientific disciplines e.g. ICT, biotechnology, mechanical technology, design, and energy, is leading to some highly innovative 'outside the square' developments.

Supporting views

The potential applications appear to be almost endless

- MAYA-II is a computer developed by researchers at Columbia University and the University of New Mexico in the US which uses a system of DNA logic gates to calculate its moves in 'tic-tac-toe'.
- Researchers at the Weizmann Institute of Science have developed a combined biological-chemical switch that can switch a whole lot of proteins 'on' or 'off'.
- Researchers at the MIT in the US have used nanotechnology to develop a liquid that stops bleeding within any tissue in a matter of seconds.
- CTX imaging facilitates the production of 3 dimensional animations of bones in motion e.g. walking, running, jumping.
- Researchers in Japan have developed a robot that is startlingly human-like.
- 'Spintronics' are being used to develop a bio-sensor that is patterned in a similar way to a DNA chip.

Key references

Some 'outside the square' developments

- [DNA computers](#) ; [Protein switches](#)
- [Nano-liquid stops bleeding](#) ; [CTX imaging – bodies in motion](#)
- [The Japanese robot](#) ; [Spintronics](#)

What might this mean for T&T?

The leading edge of research is moving into a whole range of new spaces

What about our leading edge in T&T?

- How much of the research and development work we are currently doing is 'leading edge'?
- Are we really working in areas that will contribute towards T&T achieving fully developed nation status in the year 2020?
- How good are we at commercialising the research we do?
- Is now the time to take a really good look at our whole R&D strategy and national (and regional) priority setting?

What Comes Next?

- This Lead Indicator document raises a number of ‘So what?’ challenges for the T&T biotechnology sector.
- The next step is to develop a greater understanding of how these challenges are going to shape the potential business opportunities at the Horizon 3 level 5 -10 years into the future that Trinidad and Tobago could exploit.
- These are the types of opportunities that need to be converted into operational business entities within the next 5 years so that T&T is able to progress towards its goal of achieving fully developed nation status in 2020.
- They are also essential if the country is going to be in a position to provide higher quality employment opportunities and prospects for the increasing number of graduates the country is producing.