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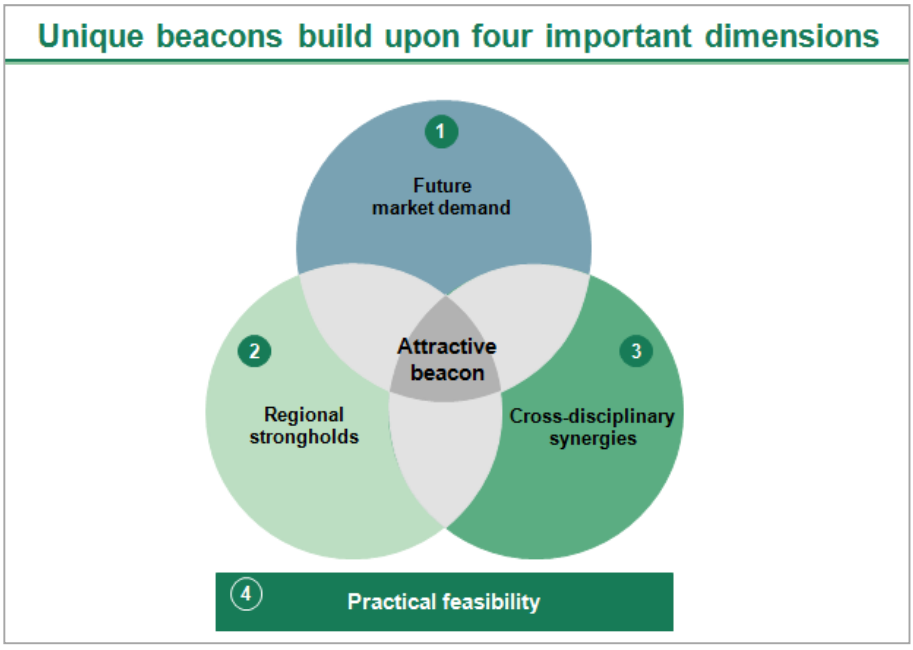
Evaluation of Future Opportunities in Medicon Valley

A report prepared by BCG on behalf of Medicon Valley Alliance



November 2012

medicon valley alliance
Creating Opportunities
THE EUROPEAN UNION
The European Regional Development Fund
Interreg IV A
ÖRESUND – KATTEGAT – SKAGERRAK
invest in skåne
part of business region skåne

Executive summary

The competitive position of Medicon Valley is under pressure

The risk of Medicon Valley falling behind in the highly competitive life science market calls for immediate attention. In recent years, Medicon Valley, the life science cluster in the Øresund region, has experienced multiple setbacks, including several companies downsizing operations in the region. The global competitive pressure of the life science industry in general continues to increase, e.g. due to the substantially decreasing return on R&D investments seen in recent years. Moreover, emerging clusters are improving their competitiveness in high-tech areas of the value chain, which is increasing the competition between life science clusters across the globe. Coordinated and collaborative efforts are required to maintain a strong position in this lucrative market.

Today, Medicon Valley is perceived as a fairly strong life science cluster, even on the global level, but the region is facing several challenges that can affect the future ability of maintaining this position. As a region Medicon Valley has been able to maintain a fairly strong position due to high historical innovation ability in terms of patent filings and new product development. The key challenge for Medicon Valley is, however, the productivity growth. This study shows that especially Denmark is lagging behind on productivity growth, while Sweden is above the average of comparable countries. Additionally, the region's ability to create growth from new businesses has been weak. Growth from the life science sector has mainly been driven by few large companies in the region, namely Novo Nordisk and Lundbeck. Growth from medium and in particular small sized companies in the region has, however, been marginal and far below that of other top life science clusters.

These regional challenges are driven by multiple factors that are impacting the so-called 'innovation eco-system'. This study particularly highlights the lack of role models: scientists and companies that encourage entrepreneurship by leading the way and providing beneficial exit options. Moreover, it is difficult to obtain funding for start-ups in the region. Compared to other top clusters like Boston and Silicon Valley, cultural and monetary incentives to go the entrepreneurial way therefore seems to be missing. Medicon Valley is fortunate to have very strong global life science players such as Novo Nordisk and Lundbeck, but to stay competitive in the future and ensure strong continuous growth in the region, it will be imperative to create a stronger foundation for start-ups to prosper.

The Beacon Initiative aims at repositioning MV as a world class cluster

Medicon Valley Alliance (MVA), the cluster organization of the Medicon Valley region, has initiated 'The Beacon Initiative' within the frame of the Interreg project “Medicon Valley - A world-class life science region” to address some of the regional challenges. The initiative is an ambitious attempt to proactively reposition Medicon Valley to stimulate innovation and economic growth. It is not the intention of this initiative to fix all the challenges of the innovation eco-system listed above through a bottom up approach. Instead it is the fundamental idea of the Beacon Initiative to identify a few focus areas where Medicon valley can become top of the class and

thereby indirectly boost the innovation eco-system and the underlying growth factors from a more strategic angle.

The Beacon Initiative specifically aims at identifying 3-5 areas, so-called 'beacons', in which Medicon Valley can become a world leader. Over time, these beacons are expected to become global sign-posts that will attract talent, business, and capital to the region. It is MVA's aspiration that the development of these priority areas will not only help Medicon Valley maintain a strong competitive position. Through dedicated focus on a few priority areas, Medicon Valley will also be able to bring the competitive advantage to a new level by creating centers of excellence that are truly unique.

The overarching idea of a beacon is to combine regional strongholds in a novel, innovative way by aligning forces between Sweden and Denmark, between the public and private sector, and through widespread cross-disciplinary collaboration across a range of life science fields. By physically gathering people in new environments, unique synergies and innovation will prosper.

Creating a unique position in selected areas is possible

BCG conducted a comprehensive study to identify potential opportunities for future beacons in Medicon Valley. This study entailed an in-depth analysis of current market conditions, global life science trends, as well as an identification of the regional strongholds that currently exist. BCG performed approximately 50 interviews with key stakeholders during this process to get their perspective on existing challenges and opportunities. This was combined with input from numerous regional stakeholder interactions held by MVA over a longer period of time.

Based on high level evaluations of approximately 30 opportunities identified during initial interviews with key stakeholders, the first phase of this study resulted in a long list of nine potential beacons. These nine beacons cover the areas with the greatest possibility to create unique synergies from enabling cross-disciplinary collaboration, building on one or more regional strongholds, and fulfilling an increasing market demand. The second phase of the study conducted by BCG included a more detailed evaluation of these nine potential beacons in terms of overall attractiveness and practical feasibility.

To evaluate the nine beacon candidates, BCG applied a framework using criteria similar to those applied for the high level evaluation of the initial ideas. The first three dimensions of the framework, I) building upon a market with future demand, II) unifying disciplines to create synergies, and III) leveraging regional strongholds, determine whether or not the beacon is considered attractive. The fourth and final dimension, practical feasibility, must also be fulfilled for the beacon to succeed in a highly competitive market.

The detailed evaluations of the nine potential beacons included in this study lead to the acknowledgment that several significant strongholds exist in the region, and that building something unique and competitive is indeed achievable. Specifically, four out of the nine evaluated beacons are, according to the BCG analysis, considered highly attractive and feasible, and certainly have the potential to create a sustainable competitive advantage. Not only can these four potential beacons: 'Bio-based

production of chemicals', 'Reproductive biology and technology', 'Systems biology', and 'Functional food', create highly competitive platforms through cross-disciplinary synergies. These areas also build upon scientific, industry, and society strongholds that are already present in the region and therefore require less investment to develop into world leading centers of excellence.

Additionally, these four potential beacons have the potential to create a unique integrated system of beacons, where new synergies can emerge and bring the competitive advantage to an even higher level. For instance, the Systems biology beacon can provide novel ways of structuring and analyzing large data sets that enable scientific advances across most life science fields, and can therefore have a positive impact on the research level of other selected beacons as well as boost the general level of research in the region.

Two other potential beacons, 'Healthy mental aging' and 'Immune regulation' would also be worthwhile taking a closer look at. The scientific strongholds in these areas are currently not as strong as the four above mentioned beacons, but significant activity is ongoing in the region to strengthen the areas through closer collaboration across research centers. With a dedicated focus the region might be able to create strong centers of excellence that are able to compete with the best.

To succeed wide-spread commitment is required

To succeed with this initiative, MVA will need to mobilize the large private and public foundations in Sweden and Denmark as well as public institutions. Only with their commitment and funding will MVA have the financial power that can give the region international, competitive superiority. Just as importantly, MVA must obtain acceptance from all key stakeholders in the region. MVA will need to institutionalize buy-in to the project and the selected priority areas in order to ensure the required level of collaboration and pre-competitive behavior.

The Beacon Initiative is highly ambitious and it will be a difficult task to mobilize all the organizations and stakeholders necessary for success. It will require a lot of human and capital resources, continuous focus and engagement from the project leadership and last but not least, commitment and close collaboration between all key stakeholders involved. But from the extensive analyses outlined in this study and from talking to numerous stakeholders in the region, it is clear that the skills, willingness, and support needed to succeed are present in Medicon Valley.

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1. Introduction

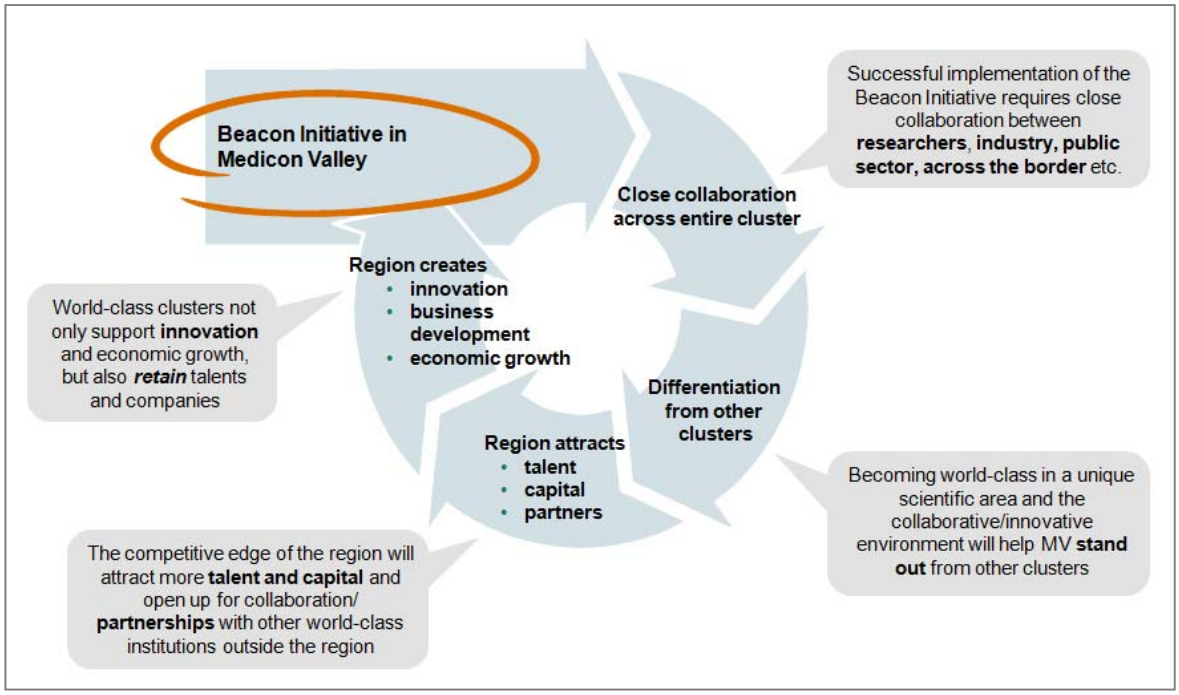
The life science sector contributes significantly to the economy of the Øresund region (Medicon Valley). But globally the life science sector is becoming increasingly competitive, thus putting significant pressure on Medicon Valley. Simultaneously, the area has experienced several challenges during the recent years; large companies are closing down sites, the productivity growth in the industry is marginal, and the number of new start-ups is limited. If Medicon Valley is to achieve the goal of becoming one of the leading life science clusters in the world, immediate action is needed. Medicon Valley will need to be more original, strategic, and coordinated than the rest.

One of the most important factors for success in this highly competitive sector is having a healthy innovation ecosystem, to which skilled employees are attracted and retained in the region. A wide-spread project could be initiated to clearly identify the root causes of the challenges the Medicon Valley region experience in terms of declining productivity and growth. Such an initiative would be a substantial effort and require involvement and mobilization of many organizations and institutions across the public and private sphere and would thus be far beyond the scope of MVA.

Instead it is MVA's belief, that these challenges can (at least in part) be addressed from a more strategic and visionary angle by identifying a few strategic focus areas where Medicon Valley can become world class. These focus areas will indirectly create a positive impact on the innovation ecosystem and the underlying growth drivers and hence, with time, turn the downturn spiral into a positive feedback loop.

To this end, the Medicon Valley Alliance has initiated the 'Beacon Initiative' within the framework of the Interreg project “Medicon Valley - A world-class life science region”. The aim of the initiative is to identify 3-5 areas (so-called "beacons") in which Medicon Valley can become world leading. By doing so, it is not only the intention to strengthen the selected research areas, but also to stimulate innovation, business development, and economic growth in the entire region.

The development and implementation of unique beacons requires close collaboration between academia and industry, across public and private sectors as well as across the Danish and Swedish border. By enabling a strong cross-disciplinary knowledge platform within specific scientific areas, Medicon Valley will obtain a competitive edge that helps to attract talent, encourage investments, and foster partnerships, all of which will boost the economic growth and innovation of the region. Over time, a positive feedback loop can be expected, where increased international recognition positively impacts the competency level in Medicon Valley, which will increase international recognition, and so on.



Medicon Valley Alliance – the local life science cluster organization

Medicon Valley Alliance (MVA) is a Danish-Swedish cluster organization representing life science organizations in Medicon Valley, one of Europe's strongest life science clusters. It spans the island of Zealand in the Eastern part of Denmark and the Skåne region of Southern Sweden, and its member base comprises biotech, medtech and pharma companies of all sizes, CROs and CMOs, as well as public organizations, universities, science parks, investors, and various business service providers.

As a non-profit member organization, MVA carries out initiatives on behalf of the life science community to create new research and business opportunities within the region – initiatives which members would not be able to implement individually, and which strengthen the development of Medicon Valley as a cluster.

The primary focus areas of the organization are:

- Building local and global networking platforms for academia and/or business
- Organizing events and seminars with the objective of improving knowledge and competencies in the region
- Providing overview of the ongoing development in Medicon Valley and an understanding of regional stakeholders' need in order to perform focused lobby activities with relevant decision makers
- Conducting analyses and leading strategic initiatives aimed at improving the region's life science environment

The Beacon Initiative is a long term investment

The Beacon Initiative was officially launched in November 2011 as part of the project "Medicon Valley – a world class life science cluster", which is funded by the EU Interreg IVA Programme, Invest in Skåne, and Medicon Valley Alliance.

As previously stated, the Beacon Initiative aims to identify strategic focus areas, i.e. beacons, on which Medicon Valley can build to sustain a world leading position. Through centers of excellence in specific scientific areas, Medicon Valley can create "sign-posts" that brand the region and attract skilled life science experts, as well as funding and business.

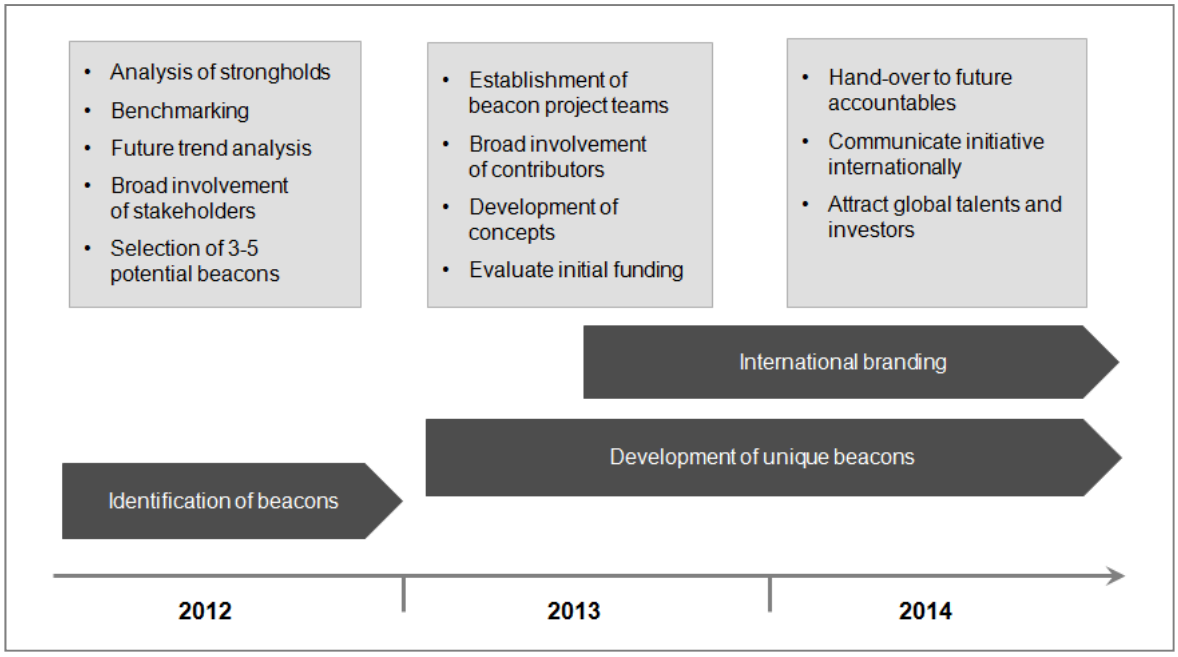
Mission of the Beacon Initiative

We commit to shape and implement a common strategy aimed to secure global attractivity, sustainable growth and position Medicon Valley as a world leading life science cluster

Given Medicon Valley's moderate size and resources, the Beacon Initiative is considered an efficient strategic approach to compete with more heavily resourced clusters. Overall, the objective of the Beacon Initiative will be achieved by

- Investing in and building on existing strongholds in smart and flexible ways to meet future challenges
- Building on cultural aspects in the region, such as capability of handling complexity and networking skills through a global and collaborative mindset
- Fostering an environment of open innovation by linking different disciplines and players

The Beacon Initiative is expected to run at least until 2014. At this point, the implementation of the strategic focus areas should be initiated and the international branding of the initiatives in place. The detailed process and project time line is illustrated below.



By 2013, the aim is to have concrete action plans in place along with project teams to move each of the prioritized beacons forward. This includes an objective analysis of the attractiveness and feasibility of each beacon as well as a description of the vision, organizational setup, potential funding opportunities, investment requirements, etc. Moreover, detailed business cases and implementation plans will be prepared, incl. project management, branding, communication, and funding setup.

Objective and methodology of this study

This study serves as a basis for the management team and board of MVA to prioritize the existing opportunities and agree on where MVA should focus their efforts going forward. The analysis included here is a perspective on potential opportunities, however, it is the intention that the most attractive beacon candidates should subsequently undergo an in-depth analysis to validate the potential benefits and challenges in detail.

The evaluation of beacons in this study is based on a combination of quantitative and qualitative research methods. The quantitative research methods include a comprehensive study of global life science trends and regional strongholds. These findings serve as input to identify potential beacon candidates. The qualitative input has been provided by key stakeholders in the region through interviews and workshops. These stakeholders represent life science experts from leading positions in academia, local industry, local government and other public organizations. During this study, BCG has conducted app. 50 interviews.

The figure below lists the key organizations that have either participated in interviews or the workshop. For more information, see appendix 1.

Chapter 4, "Identification of Future Beacons for Medicon Valley" provides a more detailed description of the methodology applied in this study.

Future role and involvement of Medicon Valley Alliance

MVA has initiated the Beacon Initiative and will continue to actively drive this forward, thus being the catalyst behind the actions needed to realize the opportunities. MVA will play a larger role in the initial phases of the project related to the identification and prioritization of future beacons and then gradually hand over to future stakeholders. Once the beacon candidates are prioritized, MVA will appoint a steering groups (similar to the steering group running the Drug Delivery Initiative[1]) which will be responsible for the actual detailing and planning of the most attractive initiatives.

MVA will continue to follow the traction of the program and provide assistance and guidance wherever needed to the steering groups. Moreover, MVA will track the success of the Beacon Initiative by measuring the performance of the region with specific attention to the scientific areas related to the beacons.

Concurrently, the project partner Invest in Skåne will play an important role in the International branding and marketing of the Beacons in order to attract talent and investors to the region.

[1] See the Medicon Valley Beacons Initiative, Concept paper, August 2012 for more details

2. The Current Performance of Medicon Valley

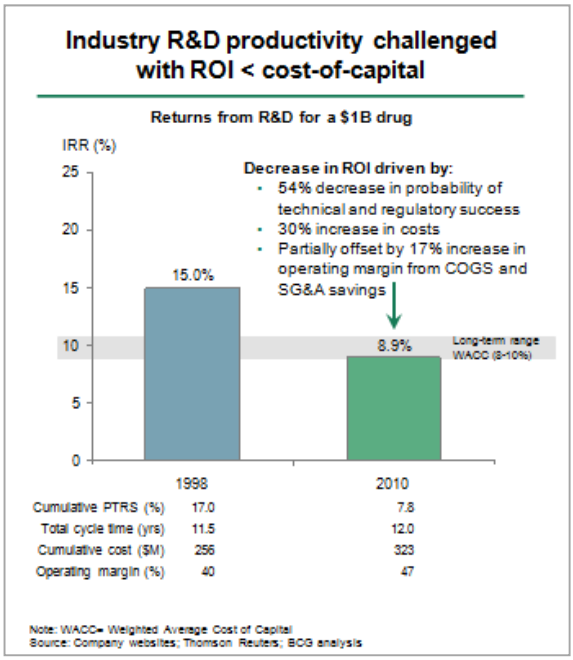
The life science sector in Medicon Valley contributes significantly to the region's development. The private life science industry alone employs 2.7 % of the workforce[2], and a high proportion of export goods – 5 % for Sweden, and 10 % for Denmark[3] – are generated by pharmaceuticals.

As a result, the Swedish and Danish governments have prioritized this sector significantly. This is exemplified by increasing public investments into the area. The Danish government has e.g. reserved DKK 6.5B for renewing research facilities at universities[4], whereas the Swedish government will invest SEK 11.5B from 2013-16 to strengthen life science competitiveness[5]. Other examples include the European Spallation Source research center currently under construction in Lund, the establishment of Medicon Village, DanStem, and the MAX IV laboratory.

Future profitability and growth under pressure

Looking ahead, the foundation for further profitability and growth seems challenged. The life science sector and associated clusters face a tough future due to three reasons.

First of all, profitability is under pressure due to lower R&D productivity. As illustrated below, the return on R&D investments has decreased substantially due to a combination of a decrease in the probability of technical and regulatory success, and an increase in costs, although partially offset by savings in costs of goods sold and selling, general, & administrative costs. The root causes behind these changes – e.g. the "easy" targets are gone, compound development is becoming more complex, larger clinical trials are required, safety thresholds are stricter – are not set to change.



Second, emerging clusters have increased their competitiveness in high-tech aspects of the value chain. Historically, emerging clusters have attracted life science players due to their cost advantageous manufacturing sites. These clusters are, however, also increasingly seen as attractive for R&D investments. With more than 250 life science clusters worldwide, global competition is already tough, and with emerging clusters increasing their competitiveness, this will only get tougher.

Third, demand for more and better services attracts new entrants, thus increasing competition further. The aging population e.g. increases demand for health care services, and combined with the fact that users demand more efficient and accurate treatment, opportunities for new entrants are created.

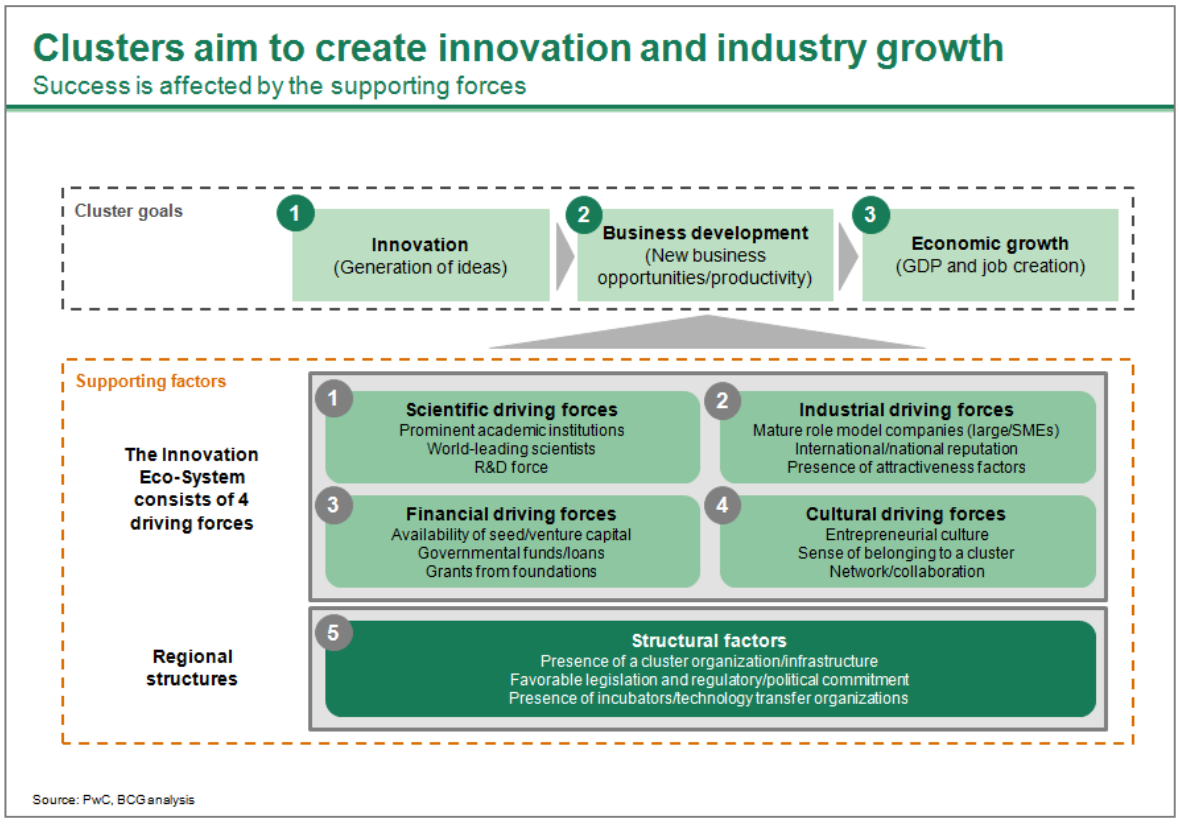
[2]http://www.mediconvalley.com
[3]SE data: Statistiska centralbyrån, DK data: Ministry of Foreign Affairs of Denmark
[4]Ingeniøren, *Regeringen afsætter 6,5 milliarder kroner til nybyggeri til forskning* (2012)
[5]Invest Stockholm, *Life science funding boost in Budget Bill* (2012)

Clusters aim to create innovation and economic growth

For a cluster to prosper in this increasingly competitive sector is it imperative to create knowledge milieus, where companies can innovate and collaborate. To analyze how Medicon Valley has performed in this regard, two dimensions are studied, namely I) performance on cluster goals, and II) presence of supporting forces.

For the first dimension, clusters generally have three interconnected goals as illustrated below. First and foremost, clusters aim to create innovation. Innovation will in turn lead to either new business opportunities or productivity increases, which subsequently create economic growth, measured by e.g. GDP and job growth.

The foundation for innovation is laid by the supporting factors – the second dimension. These consist of I) the so-called 'Innovation eco-system', and II) the regional structures. The innovation eco-system consists of four driving forces; 1) Scientific forces, 2) Industrial driving forces, 3) Financial driving forces, and 4) Cultural driving forces, whereas regional structures include things such as the presence of a cluster organization, and legislation. The presence of these is of utmost importance if a cluster is to create innovation.



The following section will outline how Medicon Valley performs on these dimensions.

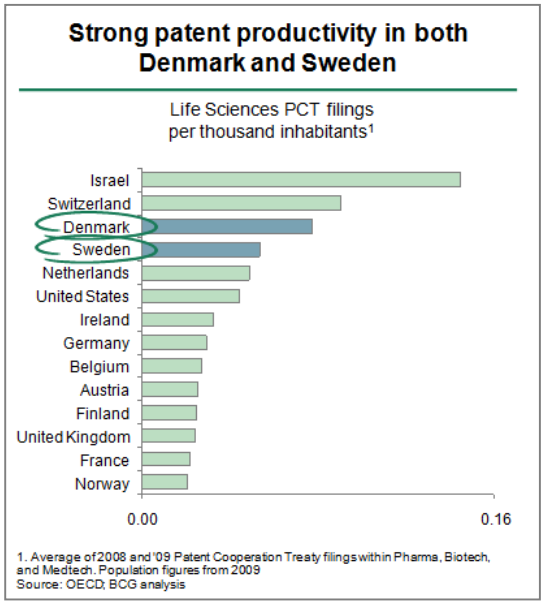
Medicon Valley is lagging behind on cluster performance

1. High *historic* innovation ability

Number of patent filings and product candidates are good indicators for innovation ability. Both indicators are historically oriented but still valid proxies, as the outcome of innovation (e.g. patents) is what generates business development and economic growth. Quality of

researchers (measured by e.g. the H-index) is to a larger extent an indication of *future* innovation ability, and will thus be discussed as a part of the scientific driving forces.

Denmark and Sweden score high when analyzing historic innovation ability within life sciences. As shown to the right, only Israel and Switzerland score higher than Denmark and Sweden, when benchmarking a selection of countries on the average yearly number of life science patent filings per thousand inhabitants in 2008 and 2009.[6] The picture is similarly positive when benchmarking the number of product candidates per inhabitant within phase I, II, and III. Here, Denmark scores highest, whereas Sweden comes in 4th after Switzerland and Israel.[7]



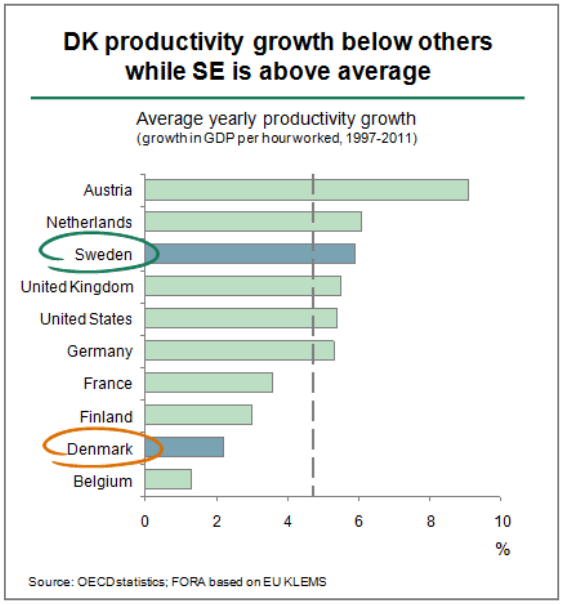
Although the whole of Sweden is not a true proxy for Skåne, the high rankings provide evidence that the region has indeed generated many patents and a large product pipeline relative to its size. The question is, naturally, whether this reflects the future outlook. This will depend on both the supporting forces and the success of the Beacon Initiative.

2. Limited business development

Innovation can give rise to new business opportunities, and new and improved production methods. These improvements typically lead to productivity growth.

Ideally, this dimension would be measured through growth in the number of companies and productivity growth in Medicon Valley. However, as there is no data available on the development of the number of companies in the cluster, only productivity growth is discussed here.

An often cited future challenge for Denmark is to reverse the trend of low productivity growth compared to other countries. Productivity growth is typically measured by growth in GDP per hour worked, and as illustrated to the right, Denmark is indeed performing poorly on this dimension, whereas Sweden performs above average. The picture looks similar when analyzing pharmaceutical productivity growth in isolation[8].



[6] An even better measure would be correcting the data for public and private R&D spend within life sciences. This data is, however, not readily available

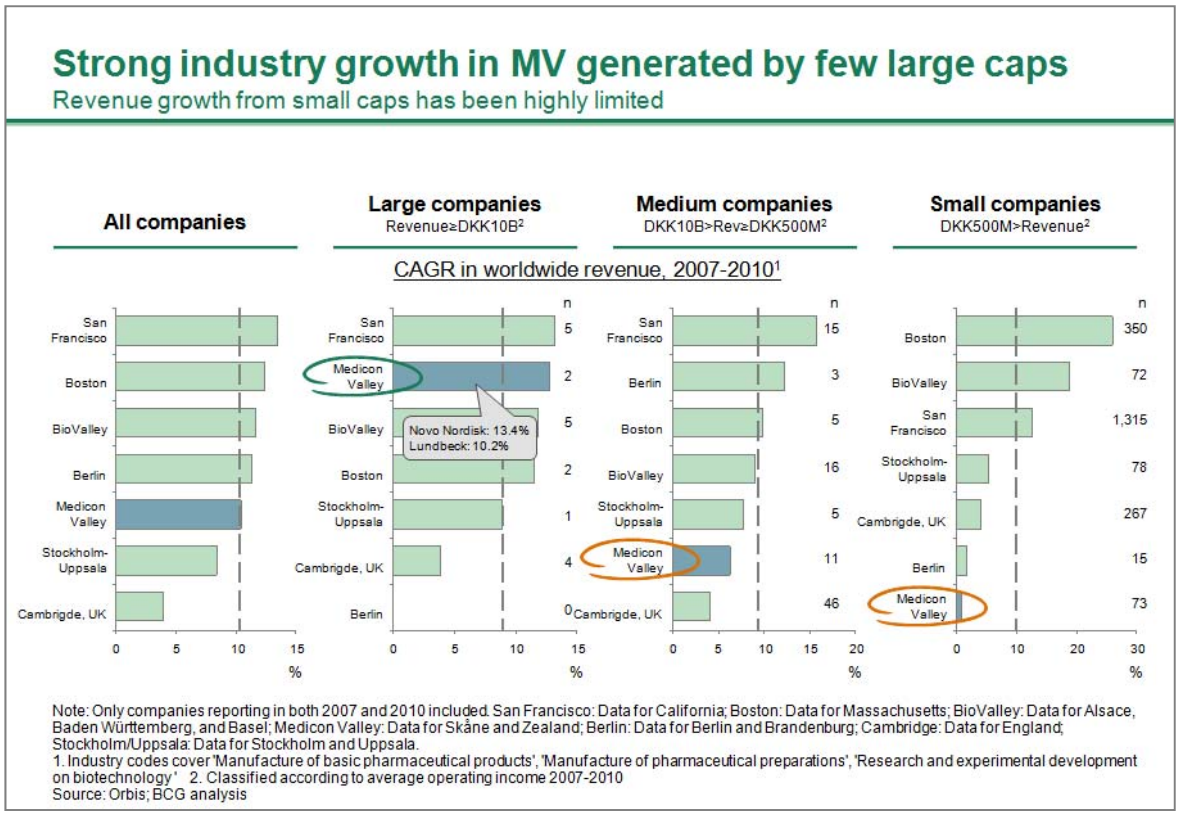
[7] Ernst & Young, Beyond Borders, 2012, and OECD data

[8] Fora, *Produktivitetsudviklingen i Danmark* (2011)

3. Economic growth creation driven primarily by large companies

Ideally, economic growth is measured by GDP or employment growth. However, due to data availability, the measure used here is worldwide revenue growth generated by Medicon Valley companies. This gives an indication of whether companies located in Medicon Valley have been able to generate growth through their products, production methods, etc.

When comparing Medicon Valley to a selection of world class clusters on the yearly revenue growth generated from 2007 to 2010, Medicon Valley scores close to average (average indicated by the dotted line in the graphs below). When distilling the data further, it becomes evident that the revenue growth is generated mainly by the very large companies in Medicon Valley, i.e. Novo Nordisk, Lundbeck, and Novozymes. SMEs (small and medium sized companies) in Medicon Valley on the other hand have not been able to grow their revenues as much as in other clusters.



It is interesting to note how companies of all sizes in the US clusters, San Francisco (Silicon Valley) and Boston, consistently generate above average growth. This could very well be an indication of stronger supporting factors in the United States.

Medicon Valley must overcome several challenges

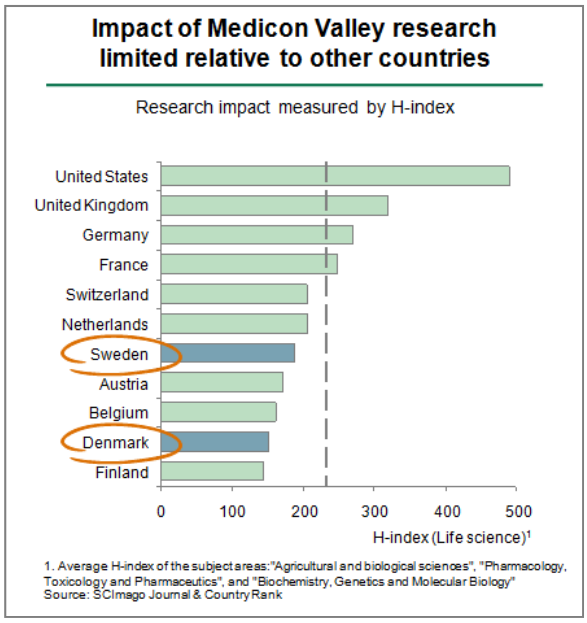
As previously stated, the supporting factors in a region lay the foundation for high cluster performance. Although the Beacon Initiative does not aim to change these directly, the initiative *is* expected to enable a positive feedback loop, which will improve these.

1. Potential to strengthen scientific competencies remains

A cluster is characterized by strong scientific forces if it has prominent academic institutions, world-leading scientists, a highly-skilled R&D force, etc.

Several universities such as Lund University (LU), Danish Technical University (DTU), and University of Copenhagen (KU) are present in Medicon Valley. These do, however, not rank among the top universities in global university rankings, which complicates the process of attracting world class scientists and talents. For instance, in the 2012 Shanghai ranking of World Universities in Life and Agriculture Sciences, several US and UK universities get top rankings, whereas Medicon Valley universities are all placed after top 50.

University rankings are based on several factors, one of which is typically the quality of research, e.g. measured by the H-index. The impact of Medicon Valley research is, however, somewhat limited relative to other countries. As evident to the right, both Denmark and Sweden score below average within life sciences.



2. Imperfect industry incentives discourage entrepreneurship

Industrial driving forces cover elements such as the presence of mature role model companies and industry attractiveness factors for e.g. employees.

Role model companies are important as they inspire other companies, but also tend to create and diffuse knowledge. This is the case for successful companies of all sizes, but especially large companies create a critical mass of experienced managers and workers that small firms can hire, provide incubation space to employees and inspire start-ups, create funding opportunities and work as a natural exit option for start-ups. Medicon Valley holds only a few really large players, namely Novo Nordisk, Lundbeck, and Novozymes, and according to interviews, these large companies have recently tended to invest mainly outside of Denmark. Furthermore, AstraZeneca recently closed down its R&D site in Lund. Large companies do not arise overnight, thus instead, there is a need to attract the attention of international players to the area.

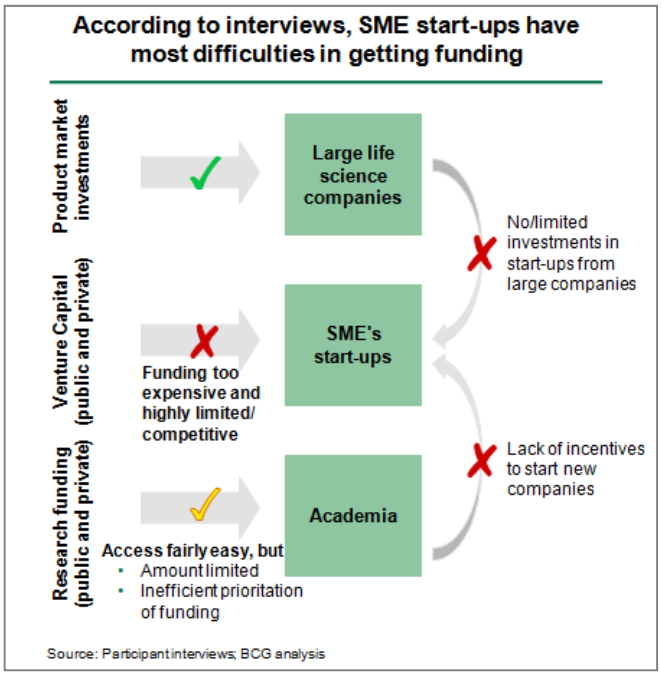
Attractiveness factors, such as cluster reputation, job security, wages, and training, are important to attract not only companies, but also a highly skilled workforce. Interviews have highlighted that the main challenge for Medicon Valley in this regard is the misalignment of incentives. Interviewees have e.g. stated that *"There are no monetary or acknowledgment incentives for innovation"*. This e.g. leads to a lack of entrepreneurial spirit, which will be discussed under cultural driving forces, the fourth dimension.

3. Competitive funding environment for start-ups

Three types of funding are used in the life science industry, namely product market investments, venture capital, and research funding (public or private).

According to interviewees, large life science companies and academia have fairly good access to funding in the region, as illustrated to the right.

Instead, the challenge lies in getting funding for SME start-ups. In particular, start-ups in Medicon Valley compete against start-ups from other cluster for funding, and worldwide competition for venture capital is therefore extremely tough.



4. Collaborative & entrepreneurial mindset could be strengthened

Collaboration among academia is relatively strong as evidenced by high co-authorship in research. For example, University of Copenhagen collaborated with ~4,000 different institutes from 2000-2012, whereas Harvard University for comparison collaborated with ~7,000 institutes, but also published four times that of University of Copenhagen. Co-authorship is, however, not enough.

The Nordics are according to interviewees characterized by a high degree of trust, which enables pre-competitive behavior (collaboration instead of competition). This is highly important both within and between academia and the industry, and across the Danish and Swedish border. In this regard, interviewees have, however, highlighted that *"It is difficult to create knowledge sharing in knowledge based industries, because your competitive advantage lies in that knowledge"* and *"Competition across the DK/SE border makes it difficult to find a common platform"*.

Furthermore, a lack of entrepreneurial role models creates a bias towards "the safe bet". Interview respondents e.g. state that role models are needed to motivate the entrepreneurial spirit in the region.

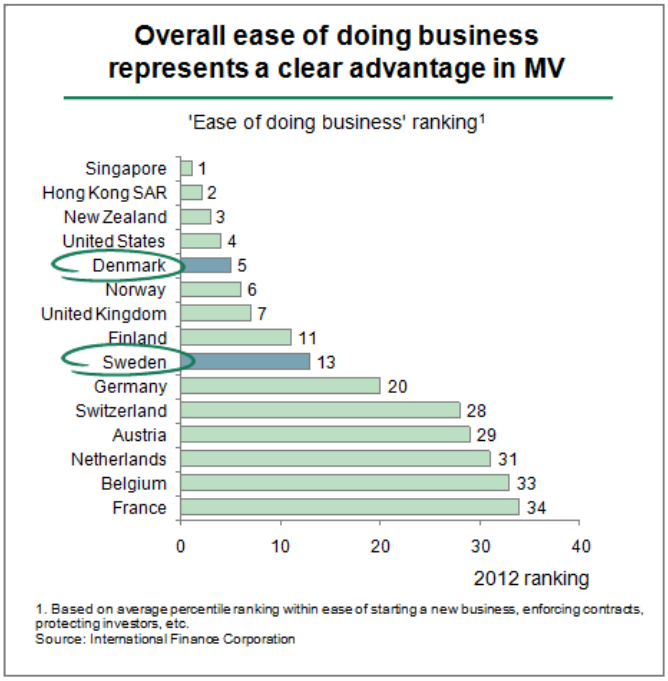
5. Favorable structural support, but a focused effort is needed

Denmark and Sweden are generally recognized for a favorable business environment, as e.g. evidenced by a global 5th and 13th place, respectively, in the 'Ease of doing business' ranking by the International Finance Cooperation. Both countries have legislation favorable to the business community, political stability, and strong and supportive industry associations, which benefits academia and the industry.

Medicon Valley is also supported through the presence of a cluster organization, and science parks and incubators, such as Ideon, DTU Symbion Innovation, Medicon Village, Cobis, and Medeon.

Requests are, however, made for more focused efforts from MVA's side. This is the case both on a high level, as interviewees e.g. request a shared vision for the cluster, and on a more concrete level through better support for facilitation of alignment between academics and industry.

The Beacon Initiative is a big step towards creating exactly this common vision for the region and prioritizing efforts.



Case study: Boston offers state-of-the-art conditions

As evident in the preceding chapter, the United States comes out ahead of Denmark and Sweden, or at least above average, on most dimensions. One cluster in particular, namely Boston, is known for its excellence within life sciences. The question is of course: What makes Boston special, and importantly, what can Medicon Valley learn from this?

Boston was ranked the best of 16 US clusters by Jones Lang LaSalle in 2011 in their Life Sciences Cluster Report. The cluster covers Massachusetts, and include >800 companies involved in life sciences, and ~75,000 private life sciences employees. The cluster has created impressive results. For instance, the top 30 companies in the cluster produced 1520 patents from 2007-10 (460 in 2010 alone).

Boston has created a flourishing life science cluster by focusing on all five supporting factors:

- **Scientific driving forces:** Boston is known for its scientific environment through e.g. high impact factors and several Nobel Prize winners. This is partly due to the presence of the two highest ranked life science universities in the world, Harvard and MIT, which attract leading scientists and talents. Furthermore, R&D is highly prioritized in the region with R&D spend as % of GDP being the highest among all US clusters
- **Industrial driving forces:** Boston has an international reputation as a top life sciences cluster, which e.g. lightens the process of attracting talent. In addition, there is a strong and growing base of role model companies comprised of e.g. Genzyme, Biogen Idec, Cubist Pharmaceuticals, Novartis, Pfizer, and AstraZeneca. The environment for start-ups is flourishing, and there are many success stories to draw upon
- **Financial driving forces:** The region has attracted a lot of venture capital in the past years. In 2010, $1,142m were invested in Boston life sciences according to PWC Money Tree, which placed Boston 2nd among the US clusters in terms of venture capital funding. The availability of government funds is also high. The region is the highest recipient of funding from the National Institutes of Health, federal agencies provide Small Business Innovation Research grants to engage small companies in R&D and help new start-ups, and the Massachusetts Life Science Center gives Small Business Matching Grants to commercialization ready companies. Compared to Medicon Valley, focus on helping small companies is immense
- **Cultural driving force:** Several formal and informal networks exist in Boston. One example is the Venture Café, where entrepreneurs can meet potential partners and investors every Thursday in an informal setting. Barry Greene, president of Alnylam Pharmaceuticals states in the Life Sciences Intellectual Property Review 2012, that the *"Main advantage of being at the hub's center is the partnership opportunities that arise"*

  Supporting factors: The United States – just like Denmark and Sweden – ranks high in terms of ease of doing business. Additionally, the government has established incentives for companies to locate and expand in Massachusetts, and companies are supported, e.g. by state funding of interns working at life science companies. The life science cluster organization, the Massachusetts Life Sciences Center, is also a very active player e.g. through the small business grants previously mentioned.

This case study is based on interviews, www.masslifesciences.com, www.massbio.org, www.massmedic.com, Jones Lang LaSalle, and the Life Sciences Intellectual Property Review 2012

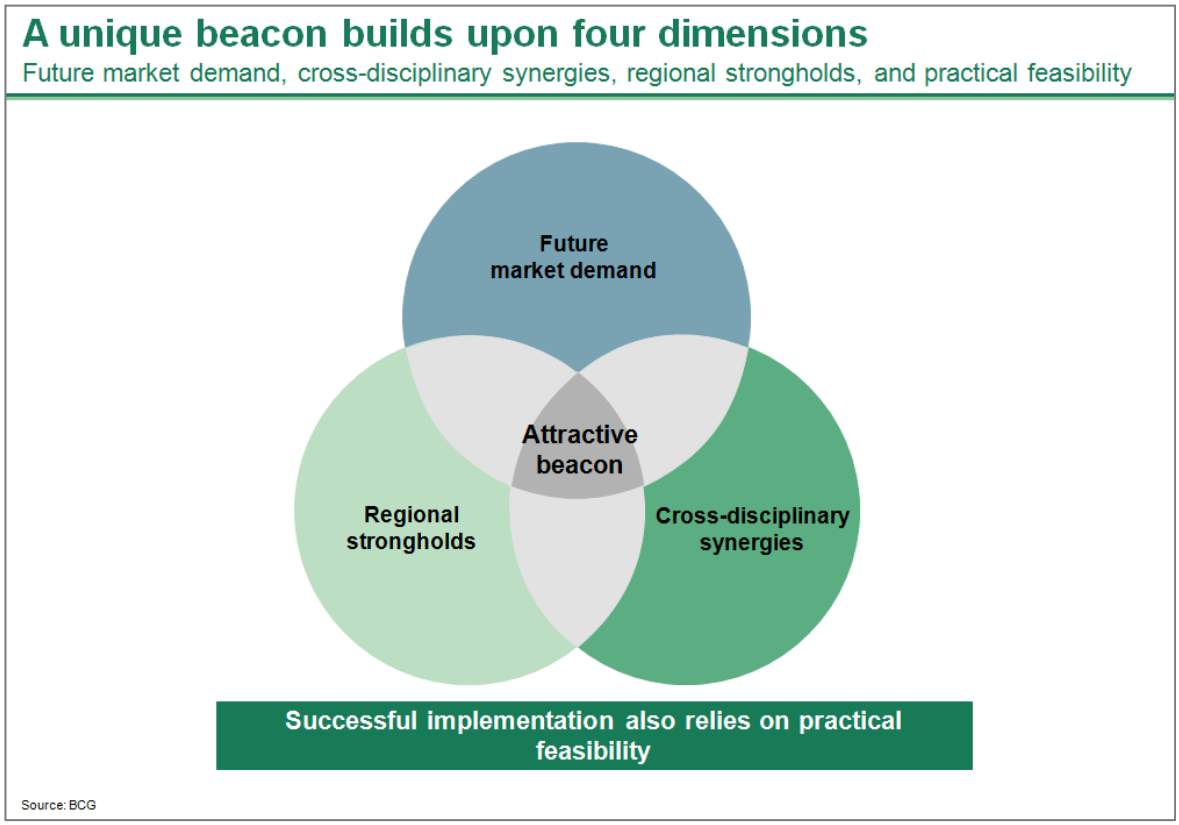
3. The Beacon Identification and Evaluation Framework

As pointed out in the introduction, the identification of beacons is a means to improve competitiveness in Medicon Valley. Medicon Valley Alliance defines a beacon as follows:

> *A Beacon is a signpost that attracts attention and says "we are here, on strong ground." It will serve as a navigation point for talents and investors. It can be seen from far away and it will lead the way. Finally, it is also a priority area.*

As evident, a beacon can include many things. But which beacons fulfill all the desired dimensions, and how do we identify unique and attractive, but also feasible beacons?

To identify these, we propose a four dimensional framework. If the beacon fulfills the first three, namely I) building upon a market with future demand, II) unifying disciplines to create synergies, and III) leveraging regional strongholds, the beacon is indeed attractive. This is not enough, however. The fourth and final dimension, practical feasibility, must also be fulfilled for the beacon to succeed in a highly competitive market.



This chapter discusses each of these dimensions in detail, including the suggested evaluation criteria of the various dimensions. Note that no explicit thresholds have been defined for these criteria, meaning that the criteria should be applied as part of a larger, combined evaluation.

I. Building upon an area with future market demand

If a beacon should succeed at attracting talent, capital, and partners to the region, it must be related to an area where it can create impact. Creating impact is possible to the extent that the beacon a) satisfies a medical need not covered otherwise, b) addresses a growing market, or c) reinvents demand patterns with groundbreaking, innovative solutions. Two important measures in this regard are total expected market size and expected market growth. Market growth can arise due to e.g. new treatment methods, new technologies, changing consumer demand patterns, demographics, or regulation. Additional criteria that can be taken into account are e.g. the severity of the medical needs uncovered, the current stage of development within the research area, as well as the competitive threat from other existing players in the field.

II. Unifying disciplines to create synergies

Competitive advantage in a cluster arises when other companies or regions cannot easily imitate that cluster's knowledge within a certain field of expertise. Competitive advantage typically arises in complex environments, where stakeholders share knowledge and collaborate closely across scientific fields and backgrounds, thereby lifting the level of excellence to a higher level. A beacon can give rise to competitive advantage if it enables collaboration within and across scientific disciplines, where Medicon Valley has a strong foothold to begin with. To succeed, however, this requires novel ways of collaborating as well as pre-competitive behavior from all stakeholders involved.

Again, a range of criteria can be taken into consideration. For the beacon to create competitive advantage, it must engage players across e.g., a) life science industries (pharmaceutical, medical technology, and biotechnology), b) therapeutic areas, c) technological areas, d) other natural sciences – potentially including non-traditional life science research areas, e) the private and public sphere, f) the Danish and Swedish border, and last, but not least, g) across clusters through partnerships. To evaluate the potential from such cross-disciplinary collaboration, it is important to think creatively about the potential disciplines relevant to the area as well as the current level of collaboration.

III. Leveraging regional strongholds

A beacon must build upon current regional strongholds to leverage the skills and knowledge that already exist and avoid overly investment requirements or time to impact. In order to build world class competences in an area, it is essential to identify these strongholds to a) understand where to focus, and b) understand how to fill potential knowledge gaps.

Both academic and industry strongholds must be present. A solid research platform is a pre-requisite, as this is where new insights are typically created. However, commercialization of ideas is equally important, and here, financially strong existing companies or new start ups play an important role, as they pull new products to the market. In addition to academic and industry strongholds, unique society traits, such as a society open towards tests, well-developed communication infrastructure, or registries can also be regional strongholds. Finally, it is important to keep in mind that the beacon initiative is a *cluster* initiative, meaning that the strongholds must represent the entire cluster, i.e. both Zealand and Skåne.

In order to evaluate the degree of academic strongholds, researchers must be committed to and leading in terms of e.g. quality of research (measured by e.g. the H-index), patent registrations, a well-connected network, and/or strong commitment to drive development within the area. Strong companies must also be present, highly active and committed, which

can be measured through e.g. patent registrations, and product pipeline/portfolio. Although difficult to measure, unique society traits must also be taken in to account.

IV. Ensuring practical feasibility

As already mentioned, a beacon is attractive to the extent that it fulfills the three dimensions above. In order for the beacon to be successfully implemented, however, it also needs to be practically feasible.

Practical feasibility can be affected by several things, and similar to the other dimensions, the relevant components to evaluate will depend highly on the beacon in question. Different beacons pose different implementation challenges. Examples of relevant, although generic, factors to take into account are:

- **Potential role or impact of Medical Valley Alliance:** MVA's core competences must be relevant for the implementation of the beacon, meaning that the cluster organization is the right forum to facilitate the initial phases of the beacon development. If this is not the case, the beacon could likely be better developed by another institution (public organizations, private foundations, companies, etc.), and MVA's resources could be spent more efficiently elsewhere
- **Realistic scope:** The beacon must be realistic in scope, meaning that the beacon should not aim for a setup that would never be practically possible. An example of this would be aiming for a physical test center with more than 1,000 patients in house. In spite of potentially finding the sufficient funding for this, this would most likely never be practically possible
- **Time to impact and measurability:** Each beacon must lead to actual outcomes that can be evaluated. Therefore, the expected output of the beacons must be measurable and possible to achieve within a reasonable time frame. The definition of a reasonable time frame will vary from beacon to beacon, depending on e.g. the expected impact. However, as new scientific breakthroughs are not created over night, a reasonable time frame will often be at least 5 years
- **Regulatory requirements:** Some research areas are constrained by regulation, whereas others have higher degrees of freedom. In order for the beacon to succeed, no or only few future regulatory constraints must be expected
- **Funding opportunities:** No beacon will succeed unless sufficient funding is obtained. Obtaining this is easier insofar regional funding organizations have an interest in the area. In addition, the investments needed to succeed should be reasonable. Reasonable in this regards will again depend on e.g. the expected outcome of the beacon

Before using the above framework to identify potential beacons for Medicon Valley, it will be exemplified through a case study on the 'Drug Delivery Research Centre'.

Beacon example: Drug Delivery Research Centre

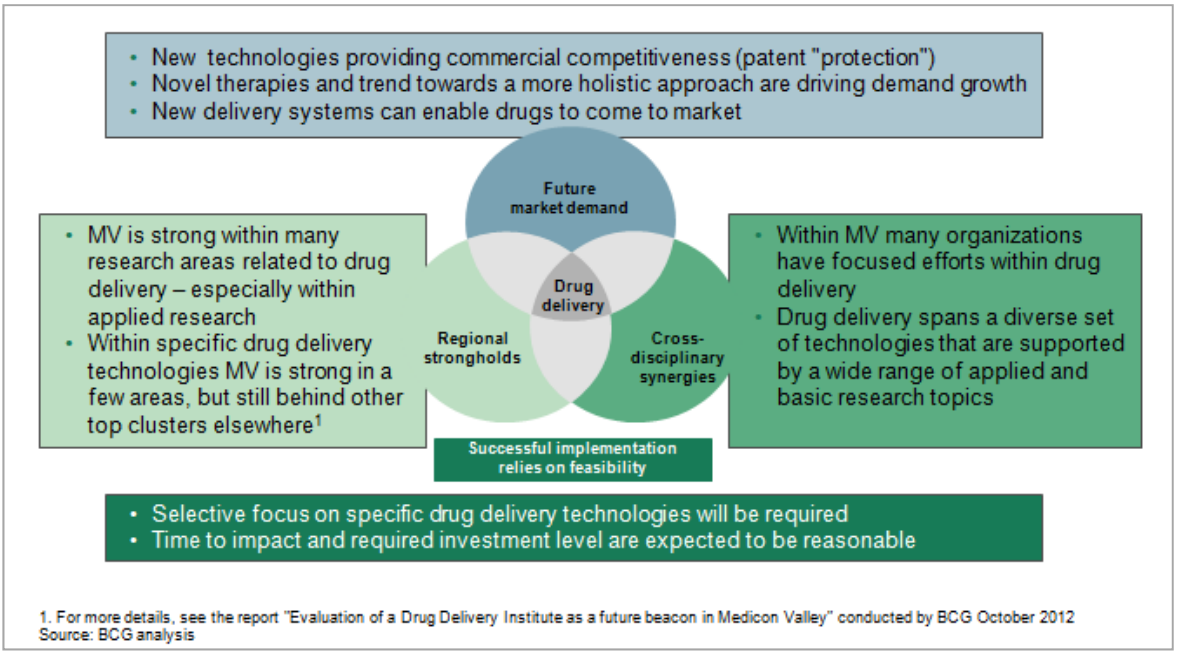
When initiating the Beacon Initiative in 2011, MVA decided to fast track one beacon candidate, namely the so-called Drug Delivery Research Centre. In relation to this, BCG has evaluated the attractiveness of a Drug Delivery Research Centre as a future beacon in Medicon Valley. The analysis validates that a Drug Delivery Research Centre in Medicon Valley has a solid value proposition and carries significant future potential for the cluster.

First, the drug delivery market is highly attractive and pharmaceutical companies are increasingly investing in new drug delivery systems. Despite significant progress within targeted drug delivery research, the commercial breakthroughs have been limited. Hence, a vast number of opportunity areas exist to improve the future success of drug delivery.

Second, based on the interdisciplinary nature of drug delivery research and the presence of many institutions in the region focusing on this topic, a Medicon Valley Drug Delivery Research Centre has significant potential for creating synergies.

Third, Medicon Valley has a solid scientific foundation across academia and industry to build unique competencies upon. E.g. across several drug delivery related research areas, Medicon Valley performs strongly compared to other top clusters, particularly in applied research areas (performance measure based on the H-index).

Fourth, a Drug Delivery Research Centre appears practically feasible. Much of the technological/scientific expertise and organizational support necessary for focused drug delivery research is already in place. This enables significant progress and commercialization within a reasonable time period and with reasonable investment needs.



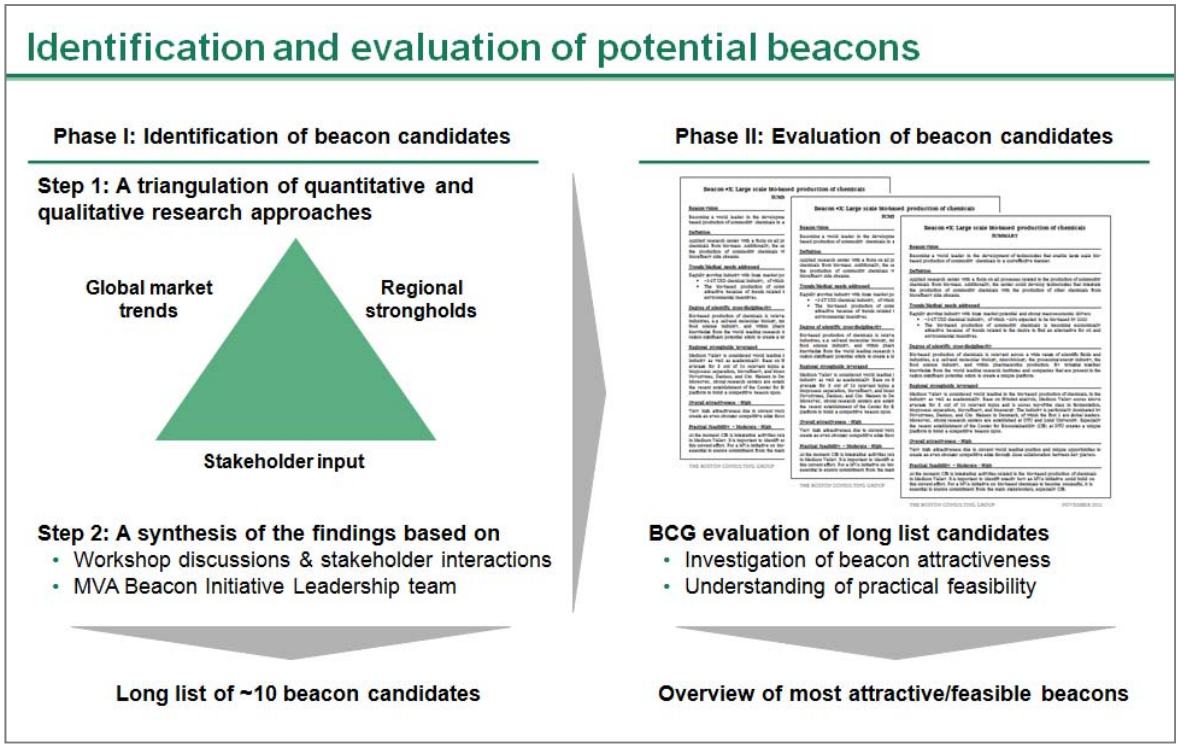
1. For more details, see the report "Evaluation of a Drug Delivery Institute as a future beacon in Medicon Valley" conducted by BCG October 2012
Source: BCG analysis

4. Identifying Potential Beacons for Medicon Valley

The framework outlined in the previous chapter is considered a solid tool to identify and evaluate potential future beacons for Medicon Valley. As already stated, this report serves as input to the MVA management team and board of directors to assist them in prioritizing which opportunities to pursue going forward. Before actually evaluating the various beacons that have been identified throughout this study, this chapter will provide important background information on *how* the framework has been applied and thus the methodology for *how* BCG has conducted the evaluation.

BCG's involvement in the Beacon Initiative includes two phases, as illustrated below. The beacon evaluation framework is applied in both of these phases to ensure that the beacons are both unique and difficult to copy:

- **Phase I:** Identification of potential beacon candidates by combining knowledge on market trends and strongholds with stakeholder input, and synthesizing findings
- **Phase II:** Evaluation of potential beacons by analyzing each beacon's attractiveness and feasibility



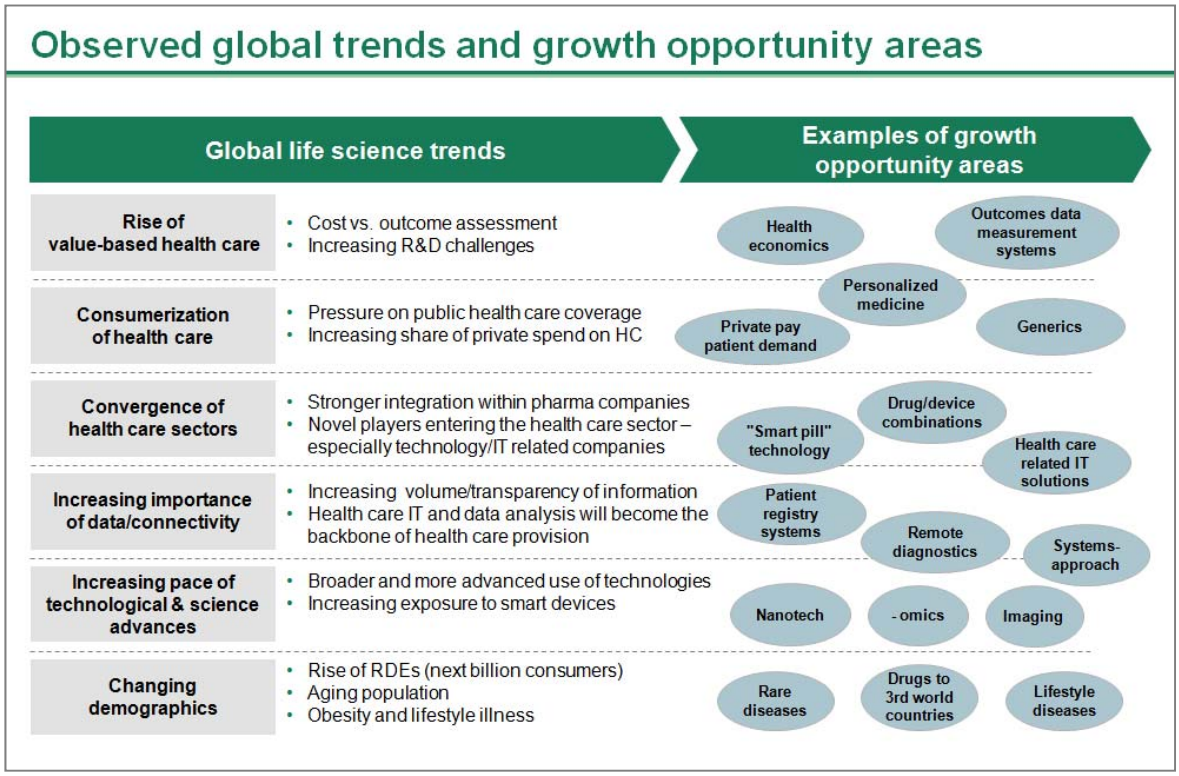
Phase I: Identification of beacon candidates

The identification of the potential beacon candidates is based on a two-step approach; 1) comprehensive quantitative and qualitative research, and 2) a synthesis of the key findings to reduce the long list of beacons to only the most attractive and feasible candidates.

Step 1: Triangulation of research methods

Step 1 was completed using both qualitative and quantitative analyses of global life science trends, a quantitative study of the scientific strongholds in the region, and qualitative input from key stakeholders through interviews and workshops. All these methods served as key input for the identification of potential future beacons.

Global market trends were identified by leveraging publicly available data as well as BCG's proprietary industry knowledge. BCG has extensive experience with the life science industry, and closely follows global mega- and life science specific trends due to BCG's ongoing support of clients within the sector. This knowledge served as valuable input to validate the attractiveness of the suggested beacons in terms of how the ideas support specific medical needs, meet changing demand patterns, utilize new technologies, etc. The relevant key trends identified are listed and briefly explained in the overview below.

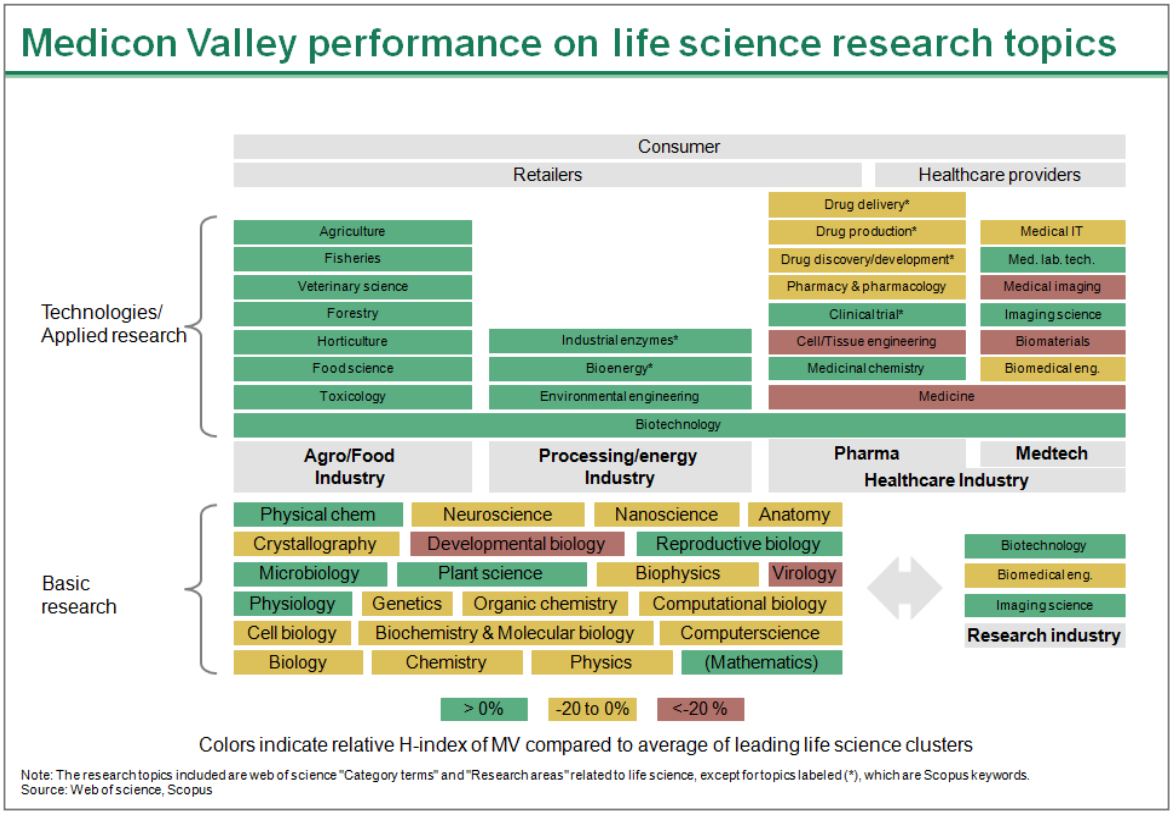


Related to each global trend, BCG identified a number of so-called growth opportunity areas that exemplify how each of these trends can be translated into potential future growth areas. Selected examples of these are listed on the right in the figure above, and these indicate that a vast number of future growth opportunity areas exist in the life science industry – all of which Medicon Valley potentially could take part of. It is important to note, however, that market trends and potential growth areas are constantly moving targets, especially in industries like life sciences that are characterized by rapid technological change and scientific advances.

An attractive beacon should build on at least one but ideally several of these growth areas to ensure a high future market potential and relevance. The drug delivery beacon e.g. builds on the drug/device combination trend, the increasing potential within nanotechnology, and the growing potential from personalized medicine.

The regional strongholds in Medicon Valley were identified through a comprehensive study of Medicon Valley and other top life science clusters. The analysis was based partly on a benchmark exercise of the top life science clusters in the world, including Medicon Valley, which is described in more detail below. The other part of the study was based on key findings from other recent studies of life science clusters conducted by BCG

The figure below shows the result of the benchmark study. The key industries and related life science topics of life sciences are organized in a so-called "Stack". A Stack is a structural framework that portrays the horizontal and vertical layers of an industry. The stack outlined here divides the scientific areas of life sciences into two research layers; the basic research layer and the technologies/applied research layer. The basic research layer covers scientific fields that are relevant across the life science industries, while the technology/applied research layer is organized according to the specific industry each topic relates to. The color coding illustrates Medicon Valley's research performance relative to other clusters.



To evaluate Medicon Valley's scientific performance across life science topics, each topic/activity is benchmarked against eight top life science clusters, namely Cambridge Massachusetts, London, Cambridge UK, Tokyo, Zurich, Silicon Valley, Heidelberg, and New York.

The H-index is used as the benchmark measure as it combines scientific productivity and impact in one number:

H-index benchmarking
The H-index is useful to benchmark scientific excellence as the performance measure combines productivity and impact in one number. An H-index of *n* indicates: at least *n* publications with at least *n* citations. Even though this method has certain pitfalls, such as ignoring author placement or the number of authors per article, the H-index has received world-wide recognition. To calculate the H-index, articles are searched by specifying research topics using Web of Science "category terms". Research areas not covered by these terms are specified by a Scopus unqualified search.

The topic specific H-index scores of Medicon Valley are shown in the figure above. A topic specific H-index is calculated for all regions and Medicon Valley's relative score is calculated against the average of all regions. Hence, the green color means that Medicon Valley performs on average or better compared to the other top clusters, yellow means 0-20 % below the average, while red indicates a performance of more than 20 % below the average of the other clusters. As the benchmark only includes top-of-the-league life science clusters, even an average performance (green) should be considered strong.

The analysis shown above indicates that Medicon Valley has indeed performed strongly across many life science topics. Especially within applied research/technologies related to biotechnology, the agro/food industry, and the processing/energy industry, but also in selected areas in the pharma/medtech industry as well as basic research areas.

As described in the previous chapter, it is important to ensure that a future beacon builds on an area of expertise. Hence, this exercise of identifying the stronghold areas of Medicon Valley can be used to point towards the attractive areas to build future beacons on. The beacons must, however, also combine various scientific fields to create cross-disciplinary synergies. Only then will Medicon Valley's competitive edge become really strong and difficult to copy.

Stakeholder input, the last part of the triangulation process, was obtained through 19 interviews with key stakeholders. The interviews were conducted by BCG prior to the workshop, in addition to numerous regional stakeholder interactions over a longer period of time conducted by MVA. The main objective of the interactions was to obtain a high level understanding of the challenges and opportunities existing in the region and to get the stakeholders' initial perspective on potential beacon candidates. The full overview of stakeholder interviews conducted by BCG in phase I is found in appendix 1.

Besides these interviews, MVA and BCG arranged a student workshop at Copenhagen Business School, where students from the BioBusiness & Innovation Program (established in cooperation by the Danish Technical University, University of Copenhagen and Copenhagen Business School) participated and provided their ideas for future potential beacons in Medicon Valley.

The input from the stakeholders resulted in a long list of 30 potential beacons, that were all validated during the next step.

Step 2: Synthesis of findings

The insights from the analyses above, i.e. the study of global life science trends, the stronghold analysis, and the initial key stakeholder interviews, served as valuable input to identify the long list of potential beacon candidates shown above.

These insights were presented at the two day workshop end of September, where 11 key stakeholders from academia, public organizations, and the industry were present. The workshop participants discussed and presented the potential beacon candidates they found most suitable, by applying the four dimensional framework to analyze the attractiveness and feasibility of the opportunities on a high level. All workshop participants are listed in the appendix.

In addition to the workshop exercise, a number of additional ideas that were previously identified in the stakeholder interview process, but not discussed at the workshop per se, were found highly attractive in terms of market demand, regional strongholds and opportunity for cross-disciplinary synergies.

In the end, the combined process of quantitative market analyses and stakeholder input resulted in a list of nine potential beacons. The initial definitions of the nine identified beacon candidates are listed below.

	Beacon candidates	Initial definitions
1	**Bio-based production of chemicals**	Efficient large scale production of chemicals using biological processes
2	**Functional food**	Applied research center focusing on changing microbiota to improve human and animal health
3	**Healthy mental aging**	Applied research center focusing on age related mental diseases, including Alzheimer´s and Parkinson's disease, to improve quality of living of patients and relatives, and reduce cost to society
4	**Independent living**	Product testing institute focusing on independent living for disabled and elderly. Focusing on matching companies and researchers with test population
5	**Systems Biology**	Center focused on systems biology applied to translational and clinical medicine
6	**Reproductive technologies**	Applied research center focusing on increasing fertility in humans (and possibly animals)
7	**Affordable drugs**	Applied research center focusing on ensuring affordable drugs to third world countries
8	**Immune Regulation**	Cutting edge basic and applied research within immune regulation
9	**'Reegle' – a data platform**	Integrated database / research community for DK and SE patient and life style data to develop e.g. personalized medicine and epidemiology

Source: Initial definition of potential beacons, based on workshop participant and interviewee input. Definitions were revised during the project

To validate the potential attractiveness and feasibility of each beacon, phase II, evaluation of beacon candidates, was conducted as described below.

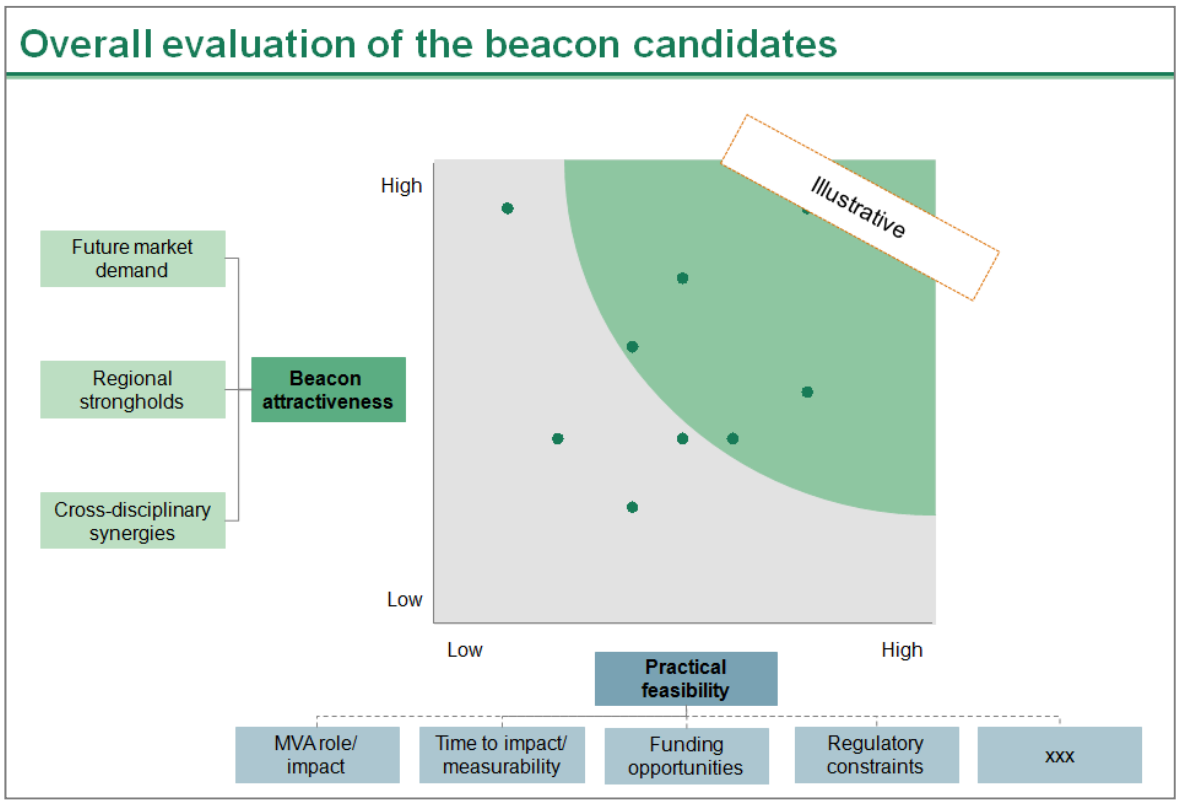
Phase II: Evaluation of beacon candidates

To obtain a better understanding of the potential scope, attractiveness and feasibility of each beacon, BCG conducted ~30 additional interviews following the workshop. As the interviews needed to be targeted towards each potential beacon candidate, the interviewees were identified based on their specific knowledge related to the beacons in question. Three to four stakeholder interviews were conducted for each potential beacon.

BCG utilized the aforementioned framework to evaluate the nine beacon candidates identified in phase I. Overall, each beacon was evaluated based on beacon attractiveness, and practical feasibility, where attractiveness depend on the three sub-dimensions; future market demand, cross-disciplinary synergies, and regional strongholds. Practical feasibility was evaluated on a case by case basis, thus including varying subcategories found relevant

for the individual beacons (illustrated by dotted lines in the figure below). While attractiveness was based on detailed and fact based analysis, feasibility was mainly based on qualitative assessment through interviews and should thus be interpreted with care.

To summarize and provide an overview of the key findings of this study, each beacon received a score from low to high on attractiveness and feasibility in order to plot the beacons into the matrix below. This assessment should only be interpreted as an initial assessment, and high priority beacons should undergo more detailed analysis to validate both the attractiveness and in particular the feasibility of each beacon.



The beacons placed in the upper right corner of the matrix are the beacons that BCG recommends MVA to focus on going forward, as these, according to this study, have the highest potential for success. The following chapter provides the detailed descriptions and BCG's evaluation of the nine potential beacons identified.

5. Evaluations of the Potential Beacons

This chapter includes the evaluations of the nine potential beacons that have been identified. Each evaluation is based on a brief description of the vision and definition of the beacon idea, followed by an assessment of the four dimensions from the 'identification and evaluation framework' outlined previously. As such, each evaluation will include the six dimensions listed below:

- Beacon vision
- Definition
- Trends/Medical needs addressed
- Degree of scientific cross-disciplinary synergies
- Regional strongholds leveraged
- Practical feasibility

The first page of all beacon evaluations is a summary highlighting the key findings of the analysis. This summary includes a 'ranking' of the overall attractiveness and feasibility of the beacon. Based on BCG's initial assessment, the 'rankings' portray rough estimates using a scale from low to high. Following the summary page is the more detailed analysis of the beacon. This chapter ends with an overview of all beacon evaluations coupled with BCG's recommendations of what to focus on going forward.

As pointed out previously, these evaluations are all based on high level market studies and initial interviews with key stakeholders, and require more detailed analysis before actually being initiated.

Beacon #1: Large scale bio-based production of chemicals

SUMMARY

Beacon vision

Becoming a world leader in the development of technologies that enable large scale bio-based production of chemicals in a cost-effective manner.

Definition

Building on the existing Center for Biosustainability (CfB) this initiative could stimulate efforts focused on large scale production of commodity chemicals from bio-mass. Additionally, the initiative could develop technologies that integrate the production of commodity chemicals with the production of other chemicals from biorefinery side streams.

Trends/Medical needs addressed

Rapidly growing industry with huge market potential and strong macroeconomic drivers

- The USD 100B bio-based chemicals market is expected to grow annually by 19 %
- The bio-based production of commodity chemicals is becoming attractive due to increasing oil prices, higher demand for environmentally friendly products, the desire to reduce dependence on petroleum imports, and the emergence of bioproduct subsidies

Degree of scientific cross-disciplinarity

This beacon is related to a wide range of scientific fields and industries, e.g. microbiology, cell- and molecular biology, the processing/energy industry, the food science industry, and pharmaceutical production. Unique synergy potential exists by bringing together the world leading research institutes and companies that are present in the region.

Regional strongholds leveraged

Medicon Valley is considered world leading in bio-based production of chemicals, in the industry as well as academically. Based on H-index, Medicon Valley scores above average in eight out of ten relevant topics, and scores top-of-the class in four of these. The industry is particularly dominated by Novozymes, Danisco, and Chr. Hansen in Denmark, of which the first two are global leaders. Moreover, strong research centers are established at DTU and Lund University. Especially the recent establishment of the CfB at DTU provides a unique platform to build a competitive beacon upon.

Overall attractiveness - High

Very high attractiveness due to current world leading position and unique opportunities to create an even stronger competitive edge through close collaboration between key players.

Practical feasibility - High

At the moment CfB is integrating activities related to the bio-based production of chemicals in Medicon Valley. It is important to identify exactly how MVA could build on this current effort. For this initiative to become successful, it is essential to ensure strong commitment from all main stakeholders, especially CfB.

DETAILED ANALYSES

Definition/scope

This initiative sets out to build on the current efforts ongoing in Medicon Valley (e.g. CfB) with a focus on stimulating the development of technology for large scale bio-based production of commodity chemicals, such as simple platform chemicals and plastics. Moreover, it will offer the region a unique value proposition by integrating expertise on all main stages involved in converting biomass to purified end products, including metabolic engineering, enzymatic hydrolysis, fermentation, large scale bio-process technology, and downstream processing. The scope could also include a focus on the "biorefinery concept"; an approach similar to petroleum refineries, which makes bio-based production more economical by utilizing the biorefinery side streams for different products. By bringing together different stakeholders, the initiative could develop technologies that integrate the production of commodity chemicals with the production of other bio-based products, such as bio-fuel, specialty chemicals, and food items.

Trends/medical needs addressed

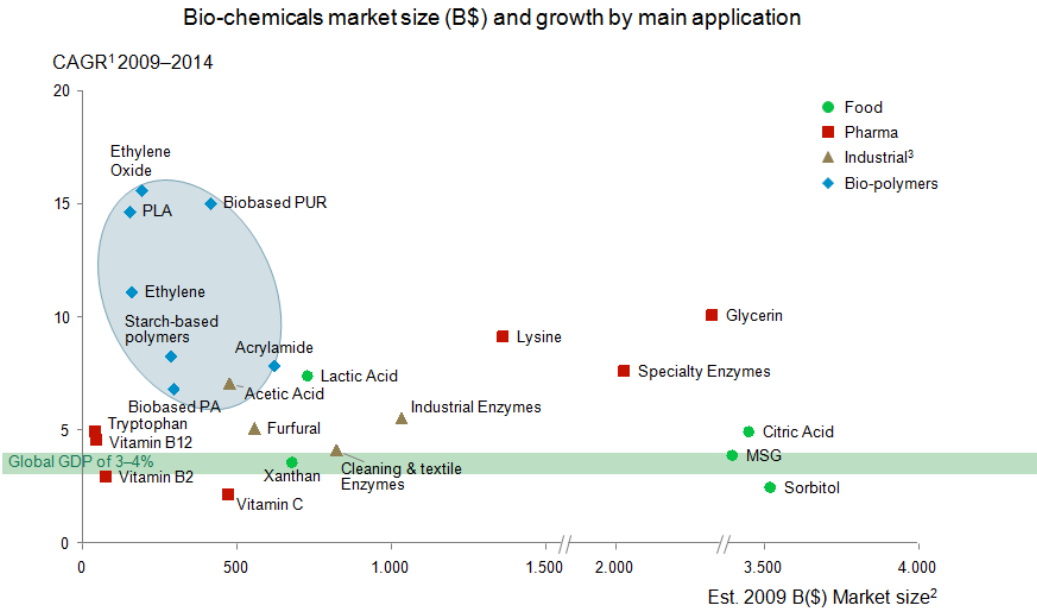
The total chemical market is estimated to be USD 2-3T[9]. Out of this, the bio-based segment is around USD 100B[10] and expected to grow 19 % per year during the next decade[10]. So far, bio-based production has mainly focused on high-value specialty chemicals since bio-based low-value commodity chemicals generally have not been able to compete with production of chemicals from fossil fuels[11].

Recently, commodity chemicals, which make up the largest segment of the chemicals market, have also become attractive for bio-based production. The main drivers behind this are advances in technology, the increased oil price, the higher demand for environmentally friendly products, the desire to reduce dependence on petroleum imports, and the emergence of bioproduct subsidies. The regional stakeholders that were interviewed for this study agree that now is the right time to enter this emerging market.

Despite highly varying market expectations, it is doubtless that the market for commodity chemicals represents a huge potential. A recent BCG study indicates an expected annual growth rate of 5-15% in various bio-polymers or related compounds (see figure below), while other studies indicate that the annual growth in bio-polymers could be 10-30 %[2]. Furthermore, estimates indicate that, with favorable market conditions, the production of bulk chemicals from renewable resources could reach 113 million tonnes by 2050, representing 38% of all organic chemical production[11].

[9] European Chemicals Association, (2011)
[10] Festel capital, (2011)
[11] IEA Bioenergy, *Bio-based chemicals – Value added products for biorefineries* (2010)

Recently bio-chemicals for diverse uses have shown substantial growth – bio-polymers, however, stand out



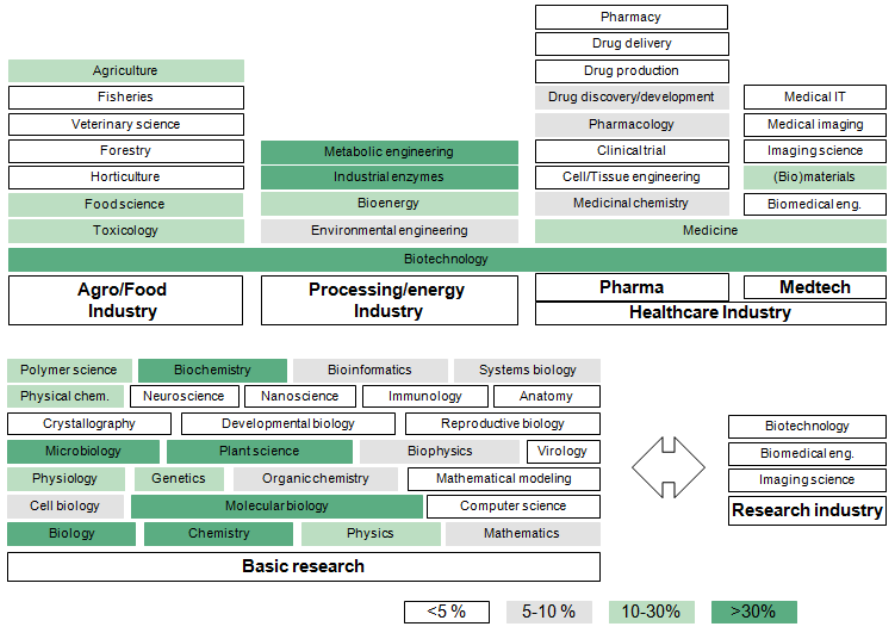
1. CAGR reflects both bio-related capacity build-up and development of total market, incl. volumes from non-biotech production 2. Biotech-related market size 3. Other industrial applications eg. cosmetics, feedstock, dyes & textiles, etc.
Source: BCG analysis; SRI and industry reports

Degree of scientific cross-disciplinarity

The illustration below demonstrates the degree of research overlap between bio-based chemicals and other research topics. These topics are arranged similarly to the stack discussed in chapter 4, but the color coding should now be interpreted as different degrees of overlap. For instance, there is more than 30% overlap between publications on Microbiology and Bio-based chemicals.

As evident below, important research topics related to the production of bio-based chemicals are plant science, microbiology, molecular biology, bio(chemistry), biotechnology, and metabolic engineering. These disciplines are important for different stages of the process from biomass to the end product. Furthermore, the biorefinery concept would bring in another dimension of cross-disciplinary collaboration as expertise on different types of bio-based products would be necessary.

Research related to production of bio-based chemicals



Colors indicate the degree of overlap with topics related to production of bio-based chemicals in scientific publications

Note: Analysis includes articles published after 2000 containing the following keywords: ("biotechnology" and (chemical or chemicals or "primary metabolite") and industrial) or "metabolic engineering"
Source: Scopus

Regional strongholds leveraged

Within bio-based production of chemicals, Medicon Valley has both academic and industrial strengths at all stages of the process, including microbiological engineering, enzymatic hydrolysis, fermentation technology, and downstream processing (purification of products). This allows Medicon Valley to maintain a competitive position among the global leaders including the Netherlands (DSM, TNO, Kluyver Institute), Korea (KAIST), and the US (Dupont).

Scientific strongholds

The significant strongholds within bio-based production of chemicals in Medicon Valley become evident when benchmarking scientific impact of Medicon Valley against other clusters. For this analysis, the Netherlands and Korea were included as these regions were emphasized by interviewees as strong players in this field. However, Medicon Valley performs better within most relevant research areas, and is in fact the leading cluster within fermentation technology, biorefinery, bio-process purification, and bioenergy.

H-index benchmarking: Bio-based production of chemicals

Research area	Average	Medicon Valley	Boston	Cambr. UK	Silicon Valley	Stockh. Uppsala	Zurich	London	Berlin	Tokyo	Nether-lands[1]	Korea[2]
Bio-based chemicals	22	22	19	4	17	17	18	13	12	15	57	65
Bioprocess technology	24	35	28	19	20	25	21	26	19	24	38	36
Fermentation technology	39	68	45	27	34	36	34	34	29	47	60	50
Biorefinery	6	17	6	2	2	6	2	6	1	6	12	8
Bioprocess purification	15	22	13	15	11	18	11	20	13	11	21	23
Metabolic engineering	33	56	57	23	37	18	43	24	30	31	45	32
Generic engineering	71	60	152	77	108	55	61	75	52	85	67	60
Protein engineering	70	77	114	98	106	68	69	84	60	68	57	39
Bioenergy	30	58	30	22	26	39	24	32	17	23	47	29
Industrial enzymes	49	67	53	39	43	51	38	43	38	73	62	51
Biotechnology	96	98	143	98	116	80	69	91	78	90	n/a	65
Molecular biology	41	39	68	47	44	34	26	42	31	37	n/a	23
Chemistry	37	31	50	37	46	29	30	34	32	40	n/a	40

> 0% | -20 to 0% | <-20 %

Colors indicate relative H-index of MV compared to average of leading life science clusters

Note: The search terms: Web of Science "Category terms" Scopus "keywords" and Scopus "unqualified terms". Generally, the analysis was restricted to articles published after 2000. In cases where the number of hits exceeded the limit for citation analysis, the analysis was further restricted to articles published after 2007, 2008, or 2009.
1. Delft, Utrecht, Wageningen, TNO, DSM 2. Seoul and Daejeon
Source: Web of science, Scopus

Several research initiatives related to bio-based production of chemicals are located in the region: The Novo Nordisk Foundation Center for Biosustainability (CfB), the Department of System Biology, LU Biofuels and, formerly, GreenChem.

The Novo Nordisk Foundation Center for Biosustainability (**CfB**) is a DKK 1B investment to date. It is fully funded by the Novo Nordisk Foundation and engages more than 90 people in total across various scientific fields related to bio-based production of chemicals. Moreover, the center engages with many other stakeholders on basic technologies.

The focus of the center is on basic and applied research, while it also has an application unit with a commercial angle to foster start-ups etc. The scope of the center is not yet clearly defined, but primarily covers bio-based chemicals, including everything from small bulk chemicals to more advanced specialty chemicals. It is the intention to build another leg focused on production of compounds for the pharmaceutical industry (e.g., EPO, insulin, etc.). This area is expected to be fully operational by January 2013. Currently, the center has no focus on biofuels as this area is considered a highly competitive, and thus unattractive, field to enter. Additionally, CfB does not focus on research related to upscaling production of bio-based chemicals, which is especially important for the production of commodity chemicals.

Overal, CfB constitutes a major initiative towards the production of bio-based chemicals, connecting most major stakeholders in the region. Therefore, it is important that a beacon focussed on the large scale production of bio-based commodity chemicals will be set-up in close collaboration with CfB to ensure synergies and avoid unproductive duplication.

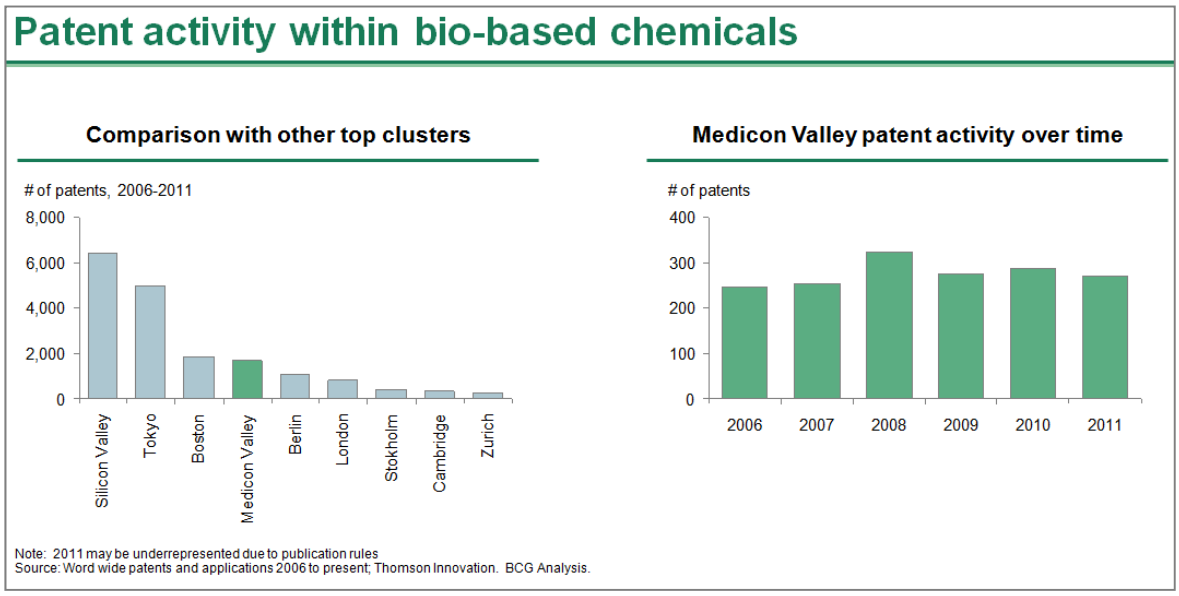
LU Biofuels is a multi-disciplinary research platform that is focused on biological conversion methods of biomass. The key partners of this initiative include a variety of research divisions/departments/centers at Lund University: AgriFood Economics Centre, Applied Microbiology, Biochemistry, Biotechnology, Cell and Organism Biology, Center of Analysis and Synthesis, Chemical Engineering, Environmental and Energy Systems Studies, International Institute for Industrial Environmental Economics.

GreenChem was a center aimed at developing clean, sustainable technology for the bio-based production of chemicals. The center was based at Lund University and comprised of researchers from several departments at Lund University and 8 industrial partners. The program focused mainly on the 2 types of chemicals "coatings, adhesives and lubricants" and "consumer care and cleaning". Although the program ended, many of its participants are still very active in the field.

Industry strongholds

Medicon Valley is more or less considered world leading in the industry of bio-based chemicals due to the representation of a range of very strong companies within the field. E.g. Novozymes and Danisco (now owned by DuPont) are both very strong in fermentation and considered world leading within bio-based solutions. Moreover, Chr. Hansen and Carlsberg, located in the Copenhagen area, are also highly active companies within the field. On the Swedish side of the border the largest and strongest companies are located outside the Skåne region, e.g. Chemrec (Stockholm) and Sekab (Domsjö).

The industry and scientific strongholds in Medicon Valley are exemplified by the fact that the number of patents produced by inventors from Medicon Valley is above the median of the life science clusters included in this study, although far behind Silicon Valley and Tokyo. Over time, the patent activity in Medicon Valley has been stable.



Practical feasibility

Overall, the practical feasibility of this beacon is evaluated to be high. The key aspect will be to identify which role MVA can play to strengthen the already existing platform with CfB.

Potential impact/role of MVA: At the moment CfB is integrating activities related to the bio-based production of chemicals in Medicon Valley. Because the scope of CfB is closely related to the concept of this beacon, it is essential to determine exactly how MVA could build on this. After discussions with the management of the CfB, BCG has identified a range of opportunities for MVA to play an active and important role in creating additional impact:

- Establishing even broader networks and strengthening the cross-disciplinarity
- Discussing overall strategy of the center and the initiatives in the region

- Promoting the center internationally
- Potentially establishing a new center that can leverage findings and test if processes are scalable (e.g. large scale bulk production)
- Continuous mapping of the industry to assure no efforts are duplicated

Time to impact: Given the progression of the CfB, the presence of world leading companies, as well as the very high scientific level in the region, the key pillars of a beacon is practically established already. Furthermore, no particular regulatory circumstances are expected to constrain the implementation or the impact of the initiative.

Funding opportunities: The Novo Nordisk foundation is already a key founder of this initiative and could potentially remain the key investor even with a larger scope. But other relevant investors could be e.g. the Lundbeck Foundation, The Knut and Alice Wallenberg Foundation and Vinnova as the initiative is highly research based. As is the case at CfB today, companies could fund individual projects on case by case basis.

Beacon #2: Better health through functional food

SUMMARY

Beacon vision

Be recognized as one of the world's leading applied research centers focusing on e.g. microbiota related to functional food in order to improve general health and treat diseases.

Definition

Functional food is defined as a modified food that improves health or well-being, by providing benefits beyond that of the traditional nutrients it contains. Focus is both on general health and on living with or treating diseases.

Based on discussions with interviewees, the applied research center could focus on e.g.

- how to change microbiota to improve human (and possibly also animal) health
- shaping the regulatory environment around functional food (incl. documentation)

The center must take a market perspective by ensuring that findings can be commercialized, as some research areas, e.g. probiotics, have yet to prove their commercial potential.

Trends/Medical needs addressed

Functional food is a small part of the food market, but high growth is expected due to increased awareness on health and increases in chronic diseases, e.g. diabetes. The area offers potential to unlock opportunities, e.g. mass-customization, as new technologies arise as microbiome research advances. The main industry challenges today are according to interviewees documentation of results, commercialization of research, and market entry.

Degree of scientific cross-disciplinarity

Functional food is relevant to many disciplines including food science, microbiology, immunology, and various therapeutic areas. It is also possible to extend to other fields, such as dermatology. In defining the research focus it is essential to find an area that many companies would find relevant. According to interviewees, this is the case for microbiota.

Regional strongholds leveraged

Researchers perform very well within e.g. functional food, microbiota, and probiotics in the region. In addition, targeted efforts are ongoing at research centers, and collaboration initiatives such as the Skåne Food Innovation Network also exist, although there is limited cooperation across academia and industry. The region does, however, have a strong base of companies in the field, e.g., Chr. Hansen, Danisco, Arla, Probi, Aventure, and Oatley.

Overall attractiveness: Medium to high

High expected growth and presence of a strong scientific base along with leading industry players make this beacon attractive. The limited market size, difficulty of commercializing research and documenting results decrease the overall attractiveness marginally.

Practical feasibility: Medium

MVA can play an important role in enabling collaboration within the cluster and potentially building a strong platform around existing networks. Regulatory challenges potentially limit the feasibility of the beacon, meaning that an active role must be taken in shaping this.

DETAILED ANALYSES

Trends/Medical needs addressed

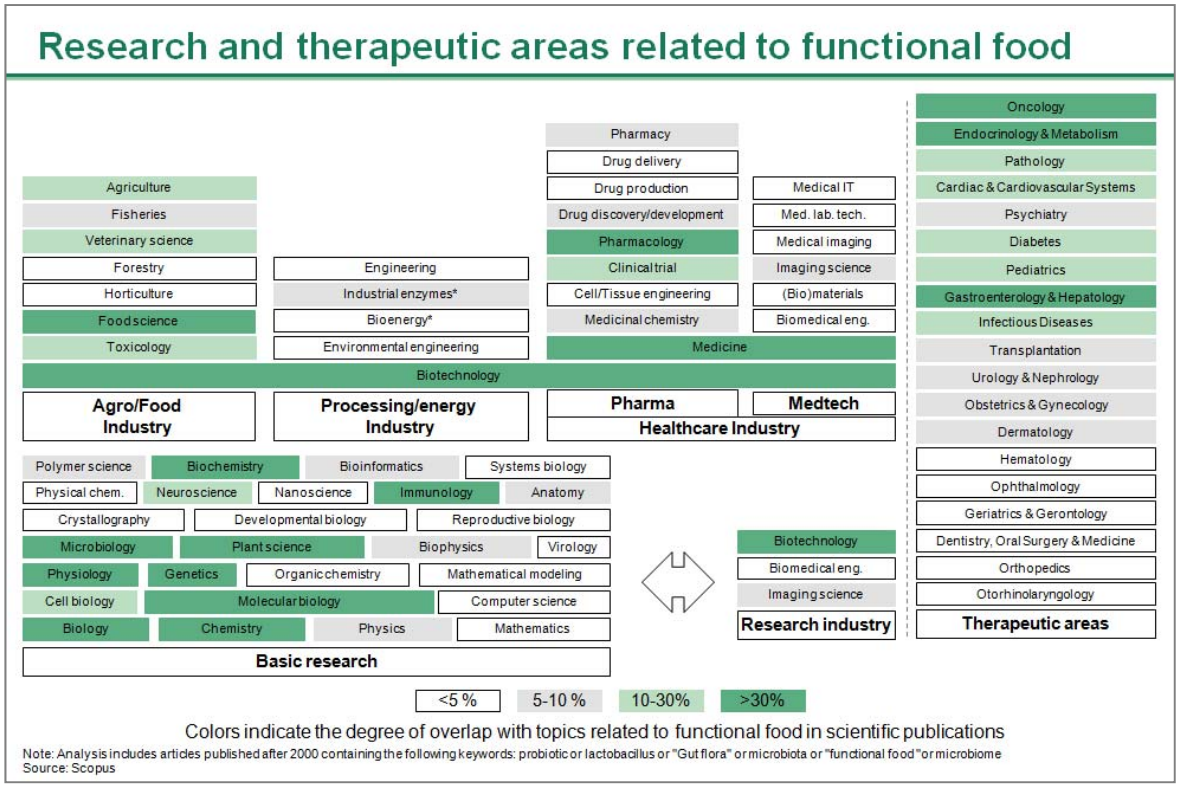
- A BCC study estimates that the entire market for nutraceuticals (including beverages, food, and supplements, i.e. more than just functional food) represents less than 10 % of the total food industry[12]
- Considerable growth is, however, expected, with an estimated CAGR of 6.5 % from 2011 to 2016 for the entire market for nutraceuticals (again composed of more than just functional food)[13]. The high growth is expected due to e.g.
    - Growing concern with quality of life, staying healthy, and preventing illness
    - Demographic changes increase the number of people living with chronic diseases, who could benefit from advances within functional food
- Potential to unlock opportunities such as mass-customization as new technologies arise and microbiome research advances, according to interviewees
    - New promising technologies (e.g., nutrigenomics, imaging techniques, and converging technologies) might enable food and diet design that can regulate gene expression and change the metabolism to reduce/prevent diseases in people of a specific genotype. This is, however, still under development
- The main industry challenges according to interviewees are commercialization of research and documentation of results
    - Documentation of results in order to make health claims is specifically a challenge as functional food typically have small effects that become evident over a longer period of time than is the case for drugs

Degree of scientific cross-disciplinarity

As evident in the illustration below, functional food involves many basic research and therapeutic areas, along with industries, which highlights the potential for collaboration in the field. In the longer run, companies and researchers within e.g. food, beverages, dermatology, and pharmaceuticals could be involved in a cluster wide initiative.

Interviewees state, however, that the heterogeneity of the area *can* be a challenge for researchers, which means that an initiative should be designed very carefully. The main challenge is that functional food is not a science in itself, as it draws upon ideas from biology, chemistry, food science, etc. Due to this heterogeneity, functional food companies typically focus on limited types of functional food, meaning that they might be hesitant towards collaborating with research centers, where they do not see a direct link to their field of interest. For this beacon to succeed and create a sufficient degree of collaboration, it is therefore important to identify an area that would be interesting to many players. According to interviewees, this is the case with microbiota, as several companies would benefit from e.g. understanding the absorption of nutrients better. However, as other potential focus areas for the research center have also been mentioned by interviewees, a thorough analysis should naturally be carried through before selecting the final focus.

[12] BCC Research, *Nutraceuticals: Global Markets and Processing Technologies* (2011)
[13] Ibid.



Regional strongholds leveraged

Scientific strongholds

Scientifically, Medicon Valley performs well within many areas related to functional food. Within the direct scope of the proposed research center, i.e. microbiota, Medicon Valley performs well above average and is even in the top in a few areas. Several institutes in Medicon Valley perform research related to functional food. Institutes cover e.g., the DTU National Food Institute, the Department of Human Nutrition at University of Copenhagen, the Functional Food Science Centre at Lund University (incl. the Antidiabetic Food Center), and Lund University Diabetes Centre. The Antidiabetic food center is a good example of a multi-disciplinary research initiative. The applied research center is financed by VINNOVA, Lund University, Region Skåne and a few Swedish food companies. The center is currently on its fifth year, and has produced patents as well as spin off companies.

H-index benchmarking: Functional food

Research area	Average	Medicon Valley	Boston	Cambr. UK	Silicon Valley	Stockh. Uppsala	Zurich	London	Berlin	Tokyo
Functional food	19	26	20	8	7	21	14	24	19	28
Microbiota	36	41	55	31	38	32	28	45	25	33
Probiotic	29	40	29	17	18	29	24	41	29	38
lactobacillus	45	58	57	28	39	40	38	54	43	45
Gut flora	18	24	18	14	11	19	9	32	14	22
Microbiome	17	12	27	16	23	13	9	26	10	13
Food science	38	61	30	21	24	44	35	37	40	48
Microbiology	115	122	171	102	138	96	84	121	94	110
Immunology	126	109	198	90	178	94	85	144	110	129
Gastroenterology	78	76	103	43	88	88	54	96	78	78
Genetic engineering	81	60	152	77	108	55	61	75	52	85
Biotechnology	96	98	143	98	116	80	69	91	78	90

> 0% | -20 to 0% | <-20 %

Colors indicate relative H-index of MV compared to average of leading life science clusters

Note: The search terms: Web of Science "Category terms" Scopus "keywords" and Scopus "unqualified terms". Generally, the analysis was restricted to articles published after 2000. In cases where the number of hits exceeded the limit for citation analysis, the analysis was further restricted to articles published after 2007, 2008, or 2009.
Source: Web of science, Scopus

Industry strongholds

Many companies within Medicon Valley work either directly with functional food or are related to the area in some way. This includes large, multinational players such as DuPont/Danisco, Novozymes, Chr. Hansen, and Arla, and smaller players such as Swedish Probi, and Aventure. Many of these companies are world leading within their respective fields, and in some shape of form work with microbiota/probiotics. Additionally, research at Lund University related to oats has led to spin-off companies such as CropTailor, Glucanova, and Oatley. In combination, these companies address a broad range of subjects within functional food, e.g. bone health, cardiovascular, digestive, immune, and oral health, as well as infant and sports nutrition.

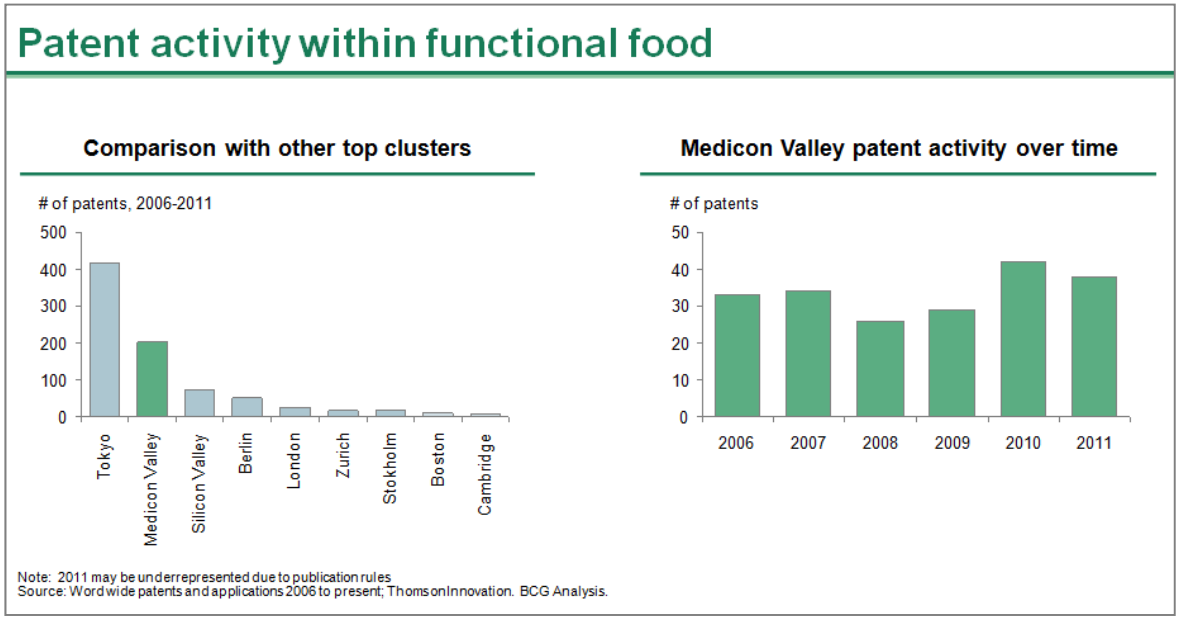
Examples of existing collaboration

The existing degree of collaboration within functional food is somewhat limited. Interviewees directly state that cooperation between academia and the industry is low, and cross border collaboration is also limited. Based on data from Scopus, of all articles published since 2000 that were related to probiotic, lactobacillus, gut flora, microbiota, functional food, or microbiome, only 6 % were co-authored by researchers both from Denmark and Sweden (Lund or Malmö).

That being said, examples of collaboration do exist. One established network related to functional food is e.g. the '**Skåne Food Innovation Network**' (SFIN), which consists of ~90 partners and members from the food and meal services industry in the Skåne region. The network works towards enhancing cooperation in and attractiveness of the industry, and focuses on innovations that can be commercialized. SFIN already focuses on functional food today, but expresses interest in collaborating with MVA to promote the area as a beacon.

Another example is the **Øresund Food Network**, a cross-border network between Denmark and Sweden, which existed until 2010. This network coordinated and participated in various multidisciplinary projects related to food, pharma, ICT, and the environment. The network was a part of the so-called Øresund University, a collaboration between universities in the Øresund region, which was, however, decommissioned in 2010. The projects supported by the network are now continued by e.g. Lund University.[14]

In spite of the limited collaboration, the researchers and companies in Medicon Valley have produced relatively many patents within functional food compared to other clusters. As evident below, only Tokyo exceeds Medicon Valley in terms of the number of patents generated from 2006-2011. Japan is often credited as being the inventor of the functional food concept, and has one of the most advanced markets for functional foods in the world.[15] In case it is decided to prioritize functional food as a future beacon, it is recommended to study the case of Japan further.



Practical feasibility

The overall feasibility of functional food as a future beacon is considered medium, particularly due to the regulatory challenges that exist within this field.

According to interviewees, the field functional food would benefit from increased collaboration between academia and the industry, which means that there is indeed potential for MVA to make an impact and play an active role in shaping the area. Additionally, the beacon could build upon and benefit from the research centers and innovation networks that are in place already today. Finally, funding would most likely be accessible due to the presence of large, international companies that have an interest in enhancing research related to functional food.

On the other hand, the practical feasibility is limited by the fact that legislation related to functional food is still developing, and by some regarded as a 'grey zone'. This is due to the fact that functional food is not a drug per se, but companies want to make health claims for

[14] Malmobusiness, *Øresund Food,* available at: http://www.malmobusiness.com
[15] NutraIngredients.com, *Japan: Functional foods, fads and food scares* (2010)

their products – and these must be documented. According to interviewees, companies and researchers find it difficult to navigate this regulatory domain. Additionally, documenting results can be challenging as benefits from functional food are more marginal and happen over a longer time period than is the case for drugs.

The regulation surrounding the area, which limits the development of the industry according to interviewees, must be taken into account when designing the beacon, and the research center must be prepared to take an active role in shaping the regulatory framework if this area should prosper.

Beacon #3: Healthy mental aging

SUMMARY

Beacon vision

Become recognized as one of the world's leading centers in applied research within age related mental disorders. To improve the quality of life of patients and their relatives and reduce costs to society.

Definition

Focus on age related mental disorders such as dementia, Alzheimer's disease, Parkinson's disease, and possibly depression and pain. The center will not only perform and stimulate research to progress diagnosis and treatments, but also emphasize the implementation of technologies to improve quality of life of patients, and reduce costs to society.

Trends/Medical needs addressed

- Increase in age related mental diseases through aging population
- In the US, total annual costs related to Alzheimer's disease account for almost USD 200B and are expected to rise to USD 1T by 2050

Degree of scientific cross-disciplinarity

- The area covers a wide range of life science topics, including neurodegenerative disorders, aging, psychiatry and depression, and more practical aspects of neurodegenerative disorders such as health economics and primary care
- Potential for synergies through tight collaboration between academic research groups, clinics, and the healthcare industry

Regional strongholds leveraged

- There are several prominent research groups in there region. However, based on H-index analysis, Medicon Valley scores below the average of top life science clusters
- Relevant companies are present, e.g. Lundbeck and NeuroSearch and a range of smaller companies
- High level of interdisciplinary collaboration already exists, incorporating both the biological and social aspects of healthy mental aging

Overall attractiveness: Medium

The center would address issues that are increasingly creating a burden to society, both related to costs and quality of life. There are specific strengths present in the region both in academia and industry, and the present level of collaboration is high. However, the region overall is not outperforming other life science clusters within any of the topics related to healthy mental aging.

Practical feasibility: Medium

There are strengths to build on and there might be potential to create synergies through focused cross-border collaboration. However, the time and funding necessary to set-up a research center that can compete with a top player like e.g. Boston will be significant and it might be difficult to attract talent to the region.

DETAILED ANALYSES

Trends/Medical needs addressed

The population is aging rapidly in the developed world. According to a BCG study, people aged 65+ accounted for 15 % of the population in developed countries in 2005. This proportion is expected to reach 26 % in 2050.

This trend will have a large impact on the prevalence of age related neurodegenerative disorders, most significantly of Alzheimer's and Parkinson's disease. Other diseases/disorders that will rise are age related depression, pain, generalized anxiety disorder, and social phobia. Together, these diseases form an enormous burden to society both in terms of costs and quality of life for patients and relatives.

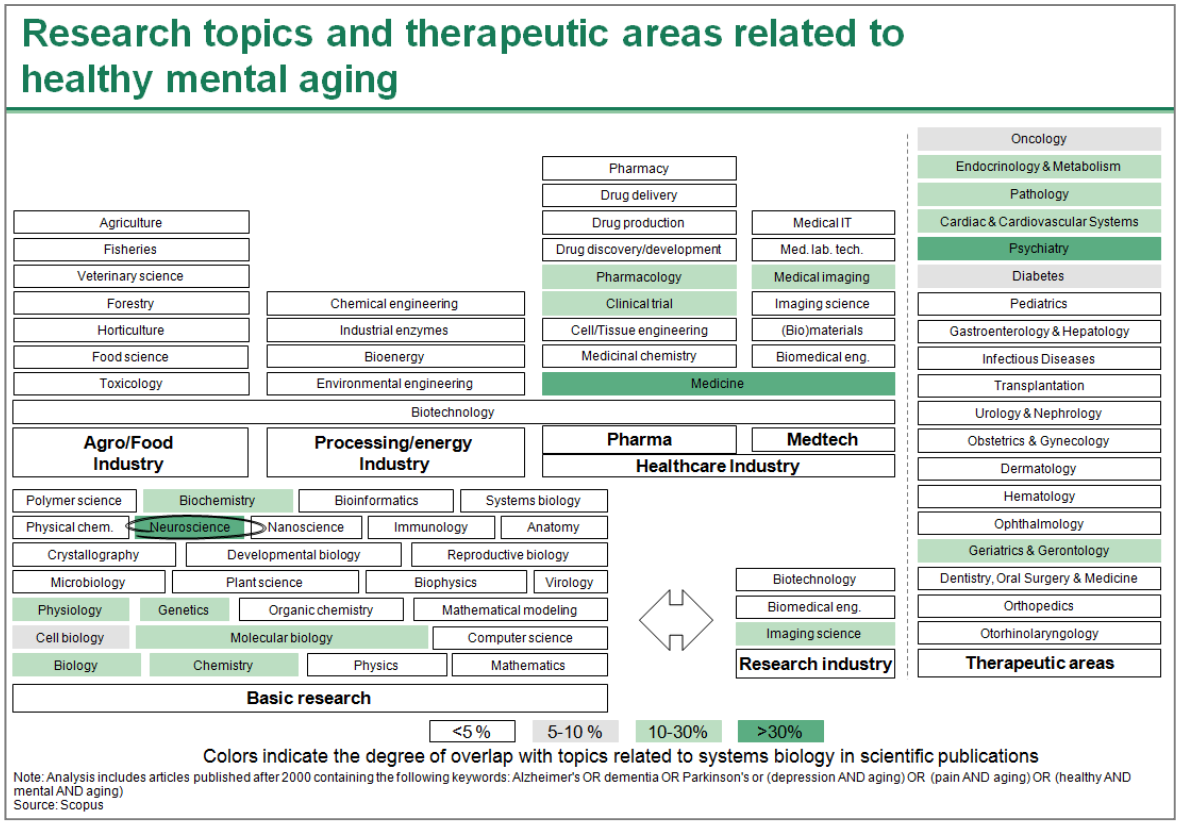
Alzheimer's disease, the most common form of dementia, is a degenerative disorder of the central nervous system. The key risk factor is aging. It has an incidence of 3 % at the age of 70 and 20-30 % at 85. The current drug market of Alzheimer's disease (USD 5.7B in 2007[16]) offers a symptomatic benefit but does not cure nor slow down the progression. Alzheimer's disease is one of the most costly diseases to society. In high income countries the average annual societal costs are USD 32,865 per person with dementia[17]. In 2010, the total US cost of care related to Alzheimer's disease was USD 172B and is expected to rise to USD 1T in 2050[18]. These costs mainly derive from inpatient care and nursing homes.

Parkinson's disease is the most common neurodegenerative disorder after Alzheimer's disease[19]. It affects 1 % of those over the age of 60, to 4 % at the age of 80. Symptoms progress from movement related, including shaking, to cognitive and behavioral problems. Dementia is common in the advanced stages of the disease. As is the case for Alzheimer's, there is no cure for Parkinson's disease. Drugs (global market: USD 2.3B in 2011[20]) and surgery can provide relief from symptoms. In the US, the annual cost per patient is around USD 10,000 and the total cost to society was estimated to be USD 23B in 2007[21].

Degree of scientific cross-disciplinarity

Within the field of healthy mental aging there is a high degree of cross-disciplinarity. It includes research areas such as neurodegenerative disorders, aging, psychiatry and depression, and practical topics such as health economics and primary care. Within neuroresearch there are many sub-disciplines, including blood brain barrier, neuromodulation devices, stem cell, and pain research. Because the stack below does not include social science topics, the analysis below most likely understates the degree of cross-disciplinarity. Topics related to *independent living* are highly relevant for healthy mental aging and there are clear synergies between these two potential beacons. Furthermore, there is a high potential for synergies through tight collaboration between academic research groups, the clinics, and the healthcare industry.

16 Kalorama, *World Alzheimer's Disease treatment market* (2008)
17 Alzheimer's Disease International, *World Alzheimer Report* (2010)
18 The Alzheimer's Association, *Changing the Trajectory of Alzheimer's Disease: A National Imperative* (2010)
19 de Lau LM and Breteler MM, *Epidemiology of Parkinson's disease* – Lancet Neurol (2006)
20 Trung Huynh, *The Parkinson's disease market* – Nature reviews drug discovery (2011)
21 Findley LJ, *Parkinsonism Relat. Disord* (2007)



Regional strongholds leveraged

The Medicon Valley neuroresearch community has several world renowned researchers, especially related to neurodegenerative disorders, e.g. at Lund University, Lund University Hospital, and Rigshospitalet. In interviews, academic stakeholders indicate that brain repair through gene and cell therapy is particularly strong in the region. This could potentially be a specific focus area for this beacon.

However, Medicon Valley might be losing some of its current strengths as several of the renowned researchers are about to retire or recently moved outside the region to continue their research. On the other hand, a next generation of researchers might be ready to continue the strong performance. At the MultiPark network in Lund, three young researchers were recently awarded prestigious European Research Council (ERC) starting grants.

When comparing the H-index of the entire region to other top life science clusters, Medicon Valley is performing slightly below average. The strongest region in this field is Boston, with a top-of-the-class score of 11 out of 12 topics related to healthy mental aging.

Medicon Valley performs strong when it comes to the social and practical aspects of healthy mental aging. The region is known for its high level of care for the elderly and the H-index score for topics such as assistive technology is above average (see the evaluation of *independent living*).

H-index benchmarking: Healthy mental aging

Research area	Average	Medicon Valley	Boston	Cambr. UK	Silicon Valley	Stockh. Uppsala	Zurich	London	Berlin	Tokyo
Dementia	29	27	41	33	40	26	16	38	19	17
Parkinson's disease	44	40	66	43	52	40	26	57	30	39
Alzheimer's disease	31	29	45	36	39	28	22	36	24	22
Neurodegeneration	47	40	72	43	63	34	36	53	34	44
Nerve regeneration	71	61	116	62	93	53	55	85	48	68
Depression and aging	67	56	105	62	102	59	38	93	46	44
Neural transplantation	66	59	114	55	93	51	37	72	38	73
Geriatrics & Gerontology	43	46	71	36	63	41	20	53	27	32
Pain and aging	48	48	86	31	67	45	32	63	30	34
Healty mental aging	57	46	92	59	79	59	32	75	38	34
Deep brain stimulation	28	24	37	17	39	12	12	55	33	19
Stem cells and neurodegeneration	34	29	62	27	41	27	20	38	24	41

> 0% | -20 to 0% | <-20 %

Colors indicate relative H-index of MV compared to average of leading life science clusters

Note: The search terms: Web of Science "Category terms" Scopus "keywords" and Scopus "unqualified terms". Generally, the analysis was restricted to articles published after 2000. In cases where the number of hits exceeded the limit for citation analysis, the analysis was further restricted to articles published after 2007, 2008, or 2009.
Source: Web of science, Scopus

Several research centers and departments focus on healthy mental aging in the region. Examples include:

- **The Department of Neuroscience and Pharmacology**, which is engaged in research and education in the nervous system's development, structure, function and diseases. Research ranges from studies of the nervous system's higher functions and diseases to the study of neural tissue at the cellular level, as well as extensive research in molecular pharmacology
- **Department of Neurology, Psychiatry and Sensory Sciences,** now part of the department of clinical medicine at University of Copenhagen.
- **Center for healthy aging**[22] - a network of research units (41 senior scientists) that is affiliated with the faculty of health sciences at the University of Copenhagen. The research aims to provide new knowledge on how more people can live healthy lives when aging. Research covers subjects ranging from neurobiology and energy metabolism to health care policy and health promotion and innovation. Within the center for healthy aging, the research program on Neurobiology of Aging examines how aging influences brain function
- **The Wallenberg Neuroscience Center**[23] (WNC) is a joint venture between Lund University and Lund University Hospital. It contains twelve research divisions with a focus on research into neurodegenerative diseases, stroke, epilepsy, neuroprotection, neural transplantation, and cell signaling in the central nervous system. The Gene Therapy Center is also housed at the WNC
- **BAGADILICO**[24] is a network consisting of ~120 researchers, students and technicians from the Lund University Faculty of Medicine, Faculty of Engineering and Skåne University Hospital, as well as Cultural Sciences. The goal is to develop and improve

[22] Center for Healthy Aging : http://healthyaging.ku.dk/
[23] http://www.med.lu.se/wnc
[24] BAGADILICO – Excellence in Parkinson and Huntington Research: http://www.med.lu.se/bagadilico

treatments for Parkinson's and Huntington's disease and improve quality of life for patients and relatives.

- **MultiPark**[25] is focusing on multidisciplinary research in Parkinson's disease. It is a broad strategic research area stretching across a wide range of departments and disciplines, mainly at Lund University, but also at Gothenburg University. The aim is to improve life for patients suffering from Parkinson's disease. In this program, neuroscientists are cooperating with researchers from nanotechnology, chemistry, physics, computer science, and social science. A union between experimental and clinical science is at the core of the overarching vision.
- **Swedish brain power**[26] is an interdisciplinary network of Swedish researchers, mainly from Stockholm, who work together to improve the situation for patients with neurodegenerative diseases. The overall aim is to enhance early diagnostics, treatment, and care for patients with neurodegenerative diseases like Alzheimer's disease, Parkinson's disease, and ALS. The research areas cover preclinical research, genetics, biomarkers, diagnostics and treatment, epidemiological research, neuropsychological research, care and rehabilitation research, health economics and primary care, interactive training techniques, and ethics. The leader of the network, Bengt Winblad (Karolinska Institute), is the most prolific researcher within the field of Alzheimer's disease worldwide[27]. The network has several ongoing collaborations with pharmaceutical companies, who use the network for clinical trials.
- **Neuronanoresearch center**[28] is an interdisciplinary research and innovation center, at Lund University, combining neuroscience, nano- and microtechnology, and organic chemistry in the development of a new generation of neural interfaces for communication with the nervous system. The center involves researchers from the Faculties of Medicine, Engineering (LTH), Science, and Humanities.

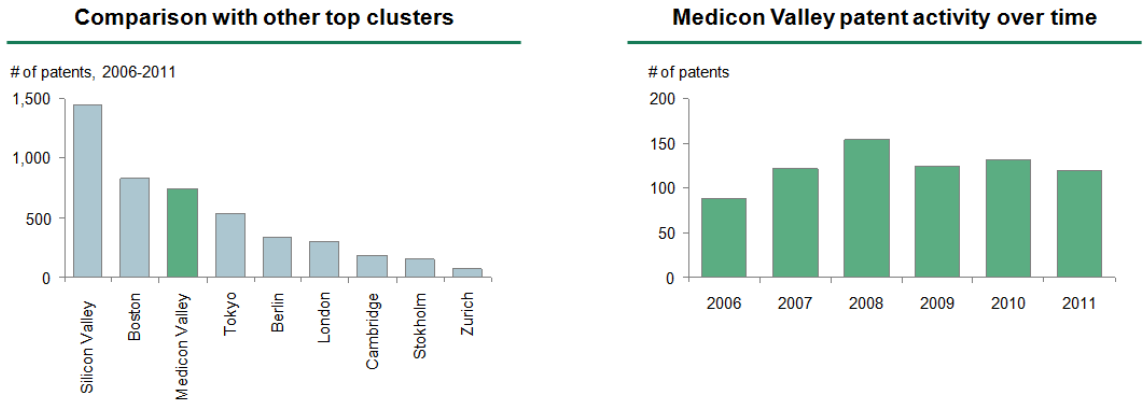
Industry strongholds

Within the region, Lundbeck is the most prominent company specializing in disorders of the central nervous system (CNS), including Alzheimer's disease (9 % global market share), Parkinson's disease (18 % European market share), and depression. Smaller players also exist like Enkam Pharmaceuticals (Alzheimer's disease), Nensius Research A/S (neurodegeneration), NsGene A/S (Alzheimer's and Parkinson's disease and pain), and ParkCell (Parkinson's disease). Other companies with a neurological focus, but not directly related to Parkinson's or Alzheimer's, are Egaled ltd (pain), Active Biotech (multiple sclerosis), and NeuroVive Pharmaceutical AB (neurodegeneration).

In spite of the many successful companies, the number of patents generated from Medicon Valley is far behind that of Silicon Valley and Boston. Furthermore, the patent activity of Medicon Valley has been declining over the past 4 years, as evident below.

[25] MultiPark - Multidisciplinary Research in Parkinson's Disease: http://www.med.lu.se/multipark
[26] Swedish Brain Power: http://swedishbrainpower.se/en/
[27] Journal of Alzheimer's disease: http://www.j-alz.com/top100/Prolific.html
[28] NRC - Neuronano Research Center http://www.med.lu.se/nrc

Patent activity within healthy mental aging



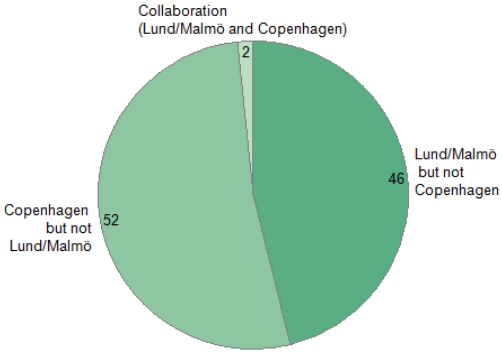
Note: 2011 may be underrepresented due to publication rules
Source: Word wide patents and applications 2006 to present; Thomson Innovation. BCG Analysis.

Current level of collaboration

Medicon Valley has a high degree of collaboration within the field of healthy mental aging. As already illustrated, there are various research centers and research programs, both on the Swedish and Danish side of the border. These centers do not only focus on the biological aspects of healthy mental aging, but also study the social and practical implications. Probably MultiPark is the best example of this. This research center is divided into four nodes focusing on drug discovery, the clinic, health and care sciences, and experimental research. Also on the Danish side there is interdisciplinary collaboration as the Center for Healthy aging in Copenhagen has a unit focused on neuroresearch. Furthermore, several of these centers support collaboration with the clinic and industry.

Contrary to the level of interdisciplinary collaboration, the level of collaboration between the Swedish and Danish researchers appears low. Only 2 % of the articles published are co-authored by research groups from both sides of the border (see figure to the right).

Low level of collaboration between Sweden and Denmark



% of Medicon Valley articles on research topics related to Healthy mental aging

Note: Analysis includes articles published after 2000 containing the following keywords: Alzheimer's OR dementia OR Parkinson's or (depression AND aging) OR (pain AND aging) OR (healthy AND mental AND aging))
Source: Scopus

Practical feasibility

The practical feasibility of this beacon is considered moderate. Scientific strengths are clearly present in the region, both in academia and industry. Furthermore, the amount of research centers and interdisciplinary collaboration is impressive. However, it will be difficult to create a beacon that is able to compete with a top life science cluster like Boston, which dominates the field.

For Medicon Valley to become a leader in this field, substantial investments and restructuring efforts are required, e.g. to strengthen the cross-border collaboration. It will be essential to attract top researchers from abroad to boost

the scientific level of the region. Furthermore, stakeholders have indicated that it would be best to build a new center independent from the universities, to make sure that scientists will be able to focus on research only. However, building a center from scratch and attracting the appropriate people and talent requires a lot of time. It is perceived a major challenge to attract talent to the region when competing with other clusters like Boston, Silicon Valley and London, which are far stronger in this area.

Beacon #4: Independent living for disabled and seniors

SUMMARY

Beacon vision

Be internationally recognized as one of the world's leading test communities focusing on empowering patients and elderly to take ownership of their own health and living independently, for the benefit of patients and health care systems.

Definition

Independent living aims at improving the ability of the elderly and disabled to live independently in their homes. It covers e.g. house modifications, and assistive technologies within communication, health/wellness monitoring, and home safety/security. The test institute should focus on a selection of areas (e.g. smart devices), with two main objectives: I) Perform research into the needs of the elderly and disabled, and II) Provide access to a large test population for products, and assist in interpreting and documenting results.

Trends/Medical needs addressed

- The aging population increases the need for limiting public spending on health care
- High demand for living independently from both elderly and disabled
- The move from conventional patterns of support to independent living has been enabled in recent years through technological advances
- The industry is, however, challenged as documenting results is difficult

Degree of scientific cross-disciplinarity

Potential for cross-disciplinarity within this beacon is high. The area involves both providers of applications, health services, infrastructure, and regulators, as well as several therapeutic areas. In addition, it is relevant for fields such as occupational therapy, physical therapy, diagnostics, monitoring, welfare technology, design aids, and user-driven innovation.

Regional strongholds leveraged

- A scientifically strong region within independent living in general and sub-parts such as assistive technology, telemedicine, and mHealth
- Many small industry players, but lack of large companies to drive industry effort
- Societal strongholds, through historical focus on independent living (exemplified by variety of home-care services and doctor house calls), and through patient registries, communication infrastructure, and a general willingness to test
- Many examples of collaboration that can be build upon, e.g. the Healthcare Innovation Lab, the 'Lev Vel' consortium, and the Welfare Tech cluster

Overall attractiveness: Medium

Market demand and potential for cross-disciplinary synergies is high, and several scientific and societal strongholds exist, along with many existing initiatives within the field. Depending on which focus area is chosen, however, there can be a lack of strong companies to drive the initiative.

Practical feasibility: Low to Medium

There is potential for supporting ongoing initiatives by providing these with test facilities, but coordination can be difficult. Also, the test institution must involve a *large* population, which is challenging due to e.g. the fragmentation of hospitals. Finally, getting initial funding from research oriented foundations can be difficult as the research focus is limited.

DETAILED ANALYSES

Trends/Medical needs addressed

An aging population increases the need for limiting growth in public spending

- As previously mentioned, BCG estimates that people older than 65 accounted for 15 % of the population in developed countries in 2005. This is expected to reach 26 % in 2050

High demand for living independently from both elderly and disabled population

- According to BCG analysis >90 % of the elder population are still living at home and could benefit from remote monitoring to extend their independent living
- Focus on independent living for disabled is high with several organizations working for self-determination, self-respect, and equal opportunities

The move from conventional patterns of support in care homes and day centers requires radical and creative re-thinking, which has been enabled in recent years through technological advances, confirmed by interviewees and BCG analysis

- Current focus of elderly population remains on more basic tools, but increased focus on smart health devices expected as the baby boomers age
- Richness in smart phone and health technology enable patient monitoring and compliance, remote diagnostics, remote data access, health surveillance, etc.
- Example of growth: According to BCC research the global market for telemedicine home services is expected to grow at a CAGR of 22.5 % from 2011 to 2016[29]

According to interviewees, the industry is, however, challenged by the difficulties of documenting results, health benefits, and cost improvements to society

- Large patient groups needed to prove results, but often the industry has only access to small group of patients at test centers
- Buyers' lack of trust in results means that benefits must be continuously proven to e.g. several hospitals

Degree of scientific cross-disciplinarity

Interviewees describe the potential for cross-disciplinarity in this area as high:

- The broadness of senior and disabled citizens' needs means that the area involves several different therapeutic areas
- The area is relevant for both providers of applications (e.g. medical community and specialists), health care services (e.g. governments and hospitals), infrastructure (e.g. telecoms and IT services), and regulators
- Several fields can benefit from progress within the area, such as occupational therapy, physical therapy, diagnostics, monitoring, treatment, welfare technology, design aids, and user-driven innovation

[29] BCC Research, *Global Markets for Telemedicine Technologies* (2012)

Regional strongholds leveraged

Scientific strongholds

As evident below, Medicon Valley performs well within research related to independent living in general, and sub-parts such as assistive technology, telemedicine, and mHealth (the practice of medicine and health care that is supported by mobile devices). The Boston cluster does, however, outperform Medicon Valley within all areas, and is thus a strong competitor.

H-index benchmarking: Independent living

Research area	Average	Medicon Valley	Boston	Cambr. UK	Silicon Valley	Stockh. Uppsala	Zurich	London	Berlin	Tokyo
Independent living	13	13	25	9	18	13	5	20	5	7
Assistive technology	12	18	23	8	10	13	3	17	6	6
Telemedicine	21	21	37	11	26	20	10	32	19	13
mHealth	42	45	60	30	53	39	34	56	30	35
eHealth	14	11	26	9	18	16	4	24	11	9

> 0% | -20 to 0% | <-20 %

Colors indicate relative H-index of MV compared to average of leading life science clusters

Note: The search terms: Scopus "unqualified terms". Generally, the analysis was restricted to articles published after 2000.
Source: Web of science, Scopus

Various research centers within the region focus on areas relevant to independent living. Examples include CERTEC (the Division of Rehabilitation Engineering Research in the Department of Design Sciences) at Lund University, LUMI (the Lund University Research Program in Medical Informatics), the Center for Healthy Aging at University of Copenhagen, the Copenhagen Institute of Interaction Design, and the Center for Pervasive Healthcare in Århus (outside of Medicon Valley, but still potential to support/learn from).

In addition, interesting research initiatives such as the Virtual Hospital and the research unit of telemedicine at Frederiksberg Hospital contribute to the scientific strongholds.

Industry strongholds

As already described, independent living is a broad area involving many dimensions, and the degree to which Medicon Valley has company strongholds thus depends on which area is analyzed. According to Mediconvalley.com and confirmed by interviewees, the cluster holds several companies that are involved in eHealth (healthcare supported by electronic processes and communication) by e.g. providing communication solutions for the health care sector, such as Dencomm, and Welfare Solutions. Although being successful, these are indeed smaller players. In terms of other areas, the region does include larger companies, which is for instance the case for Coloplast that e.g. develops ostomy care products, or the William Demant's 'Phonic Ear' that provides assistive listening devices for the home. The interest to participate in this initiative from these larger players is, however, not verified.

Overall, there is a lot of interest in independent living from companies in the region, and as evident under examples of existing cooperation, the region focuses strongly on developing new products by combining companies with researchers, hospitals, and patients. The number of specific products sold to a wide patient group seems to be limited, however. In case independent living is chosen as a future beacon, a thorough stronghold analysis of the

industry is necessary in order to select a focus area where companies are indeed strong and committed to participate.

Examples of existing collaboration

A range of initiatives are already in place to build a strong competitive platform upon. Many of these focus on developing new products in cooperation with users, but not specifically on large scale testing and documentation. Although challenging to coordinate, the existing initiatives can benefit from this beacon as it provides a test arena for new products. A few initiatives that the implementation of this beacon could build upon are outlined below.

- **Center for Healthy Aging** at University of Copenhagen collaborates with the City of Copenhagen, by inviting citizens into their test center or by visiting care homes. A potential beacon test center would be broader than the City of Copenhagen, but the Center for Healthy Aging expresses willingness to share experiences with MVA

- Another example is the Danish '**Lev Vel**' consortium, which focuses on independent living by creating collaboration between hospitals, researchers, companies, and regions. It has ~50 members and is driven by the Growth Forum of the Capital Region, and the Alexandra Institute. The consortium has six innovation projects planned for a 4 year period, all focusing on independent living. The work in Lev Vel is carried out through networking events as well as specific projects among selected members. According to interviewees, Lev Vel contributes to this process with e.g. project management skills. More information can be found on www.lvvl.dk

- Third, the Capital Region of Denmark and the associated Healthcare Innovation Center have developed the concept of a **Healthcare Innovation Lab**. The focus is kept on solving challenges in the health care sector by finding new, innovative solutions. These solutions should be created through user-driven healthcare innovation by involving 26 partners across research institutions, hospitals/clinics, and the business community. By involving users from the beginning and throughout the process, new product ideas are generated and prototypes tested. So far, three demonstration projects have been developed to prove the innovation methodology, and the vision is now to establish an actual Healthcare Innovation Lab. More information is available on www.centerforsundhedsinnovation.dk

- Fourth, Vinnova, the Faculty of Engineering at Lund University, Skåne University Hospital and Swedish industry players (e.g. Sony Ericsson) have recently invested in '**IT-stöd för Avancerad Cancervård i Hemmet**' which aims at developing new technologies for home care, to make it possible for patients with incurable diseases to receive care in their homes. See more on http://itacih.cs.lth.se

- Finally, **Welfare Tech** is a cluster for healthcare and homecare in the Region of Southern Denmark, with ~130 members from the industry, researchers, hospitals, etc. Welfare Tech is funded by the Growth Forum of Southern Denmark and the European Regional Development Fund with a grant of EUR 10.34M for a three year period (2010-2013). Similarly to Lev Vel, Welfare Tech initiates various projects between members, and so far, projects focusing on primarily robots and hospitals have been initiated. Read more on www.welfaretech.dk/

Society strongholds

In terms of societal strongholds, Denmark and Sweden benefit from having a history of focusing on independent living, through various home-care services and regular house calls by doctors. According to Mary Stuart, Director of the University of Maryland's Health Administration and Policy Program, Denmark's very integrated care system for managing elderly care is indeed widely recognized as best practice.

Additionally, interviewees highlight our patient registries, communications infrastructure, and willingness to test new initiatives as important strongholds. Finally, the relatively homogeneous population in the Nordics is beneficial to studies on documenting results.

Practical feasibility

The overall feasibility of this beacon is evaluated to be low to medium, mainly due to the fragmented activities of the region that might be difficult to bring together.

Impact/role of MVA: MVA has a potential role in supporting the ongoing initiatives by providing test facilities to the many ideas that are currently generated. Although MVA can build upon some of the existing initiatives, complexity also increases with the number of existing initiatives and stakeholders involved, which means that this can become a difficult task.

Access to test groups: Furthermore, a key success factor is to gain access to a large test population, which can prove difficult. Cities and regions will have to collaborate around patient access, and this will require a substantial effort.

Funding opportunities: Finally, although the institute will perform research into the needs of elderly and disabled, and develop methods for documenting benefits, the research focus of this initiative is limited. Large foundations typically fund research projects only, which means that initial funding might be more challenging to obtain for this beacon. Most likely, companies would be needed to fund the test center, but this might prove difficult with a lot of smaller players.

Beacon #5: Systems biology

SUMMARY

Beacon vision

Become internationally recognized as one of the world's leading centers in systems biology applied to medicine and white biotechnology and provide an infrastructure for –omics data acquisition and analysis that will benefit the entire life science community in Medicon Valley

Definition

- Unite regional systems biology efforts by providing the necessary infrastructure for becoming a global leader in this field
- Perform research with a focus on (personalized) medicine, in close collaboration with clinics and retainers of patient data repositories, and white biotechnology, in collaboration with the regional strongholds in industrial bio-based processing
- Provide systems biology services for academic and industrial research groups

Trends/Needs

- Systems biology is one of the most rapidly growing fields within life science and can potentially be integrated with most basic and applied life science topics
- Systems biology is instrumental for the development of personalized medicine
- Growing need for outsourcing systems biology services within academia and industry

Degree of scientific cross-disciplinarity

- Systems biology is highly cross-disciplinary within basic research and is increasingly making an impact on applied sciences and therapeutic areas
- Systems biology incorporates many different research areas by integrating data sets, e.g. clinical and various types of –omics data

Regional strongholds leveraged

- Medicon Valley is considered a strong player in systems biology which is supported by an H-index score that is on par with global top life science clusters
- Systems biology is closely related to fields like applied microbiology and probiotics, which represent regional strongholds
- A systems biology institute is able to support and build on the world leading Danish patient registries (and potentially the 'Reegle Beacon')

Overall attractiveness: High

Systems biology is currently revolutionizing life sciences. The systems approach is especially relevant for developing applied microbiology, one of the major strongholds in the region, and personalized medicine, one of the most promising developments within medicine.

Practical feasibility: Medium to high

The region has a well-connected systems biology community on which a beacon can build, but substantial infrastructural investments will be necessary. Furthermore, the success of this initiative is dependent on the commitment of stakeholders to share a common data pipeline.

DETAILED ANALYSES

Definition/Scope

According to one definition[30], systems biology studies the interactions between the components of biological systems, and how these interactions give rise to the function and behavior of that system. Systems biology uses a quantitative holistic approach as opposed to the semi-quantitative reductionist way that has mostly been used within life sciences. Specifically, this is done, e.g. by integrating gene, protein and metabolite data, and formulating mathematical models that describe the system.

Creating the right infrastructure is essential for setting up a successful platform within systems biology. A key infrastructural element is equipment, but new equipment is generated continuously and even for a large department as DTU Systems Biology it is a challenge to secure all necessary resources. Moreover, a shared data analysis pipeline is key, but challenging. The Boston area has managed to lift its systems biology related activities by creating a shared data analysis pipeline, allowing researches from different departments to share and integrate data. So far, such a shared analysis pipeline has not been set up in Medicon Valley.

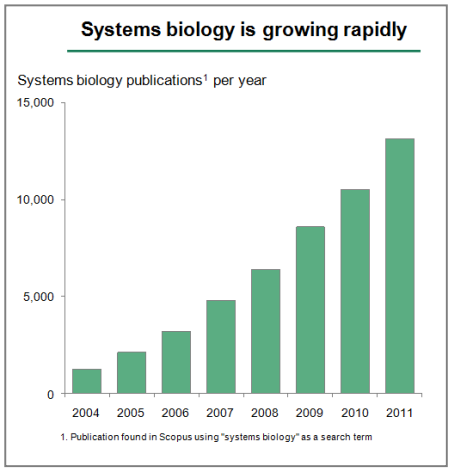
Within Medicon Valley, there are two different focus areas that are especially attractive for an applied center for systems biology: 1) (personalized) medicine 2) industrial biotechnology. Both these areas relate to strongholds in the regions (see next page) and can be leveraged by a systems approach.

Specific activities of this beacon could include:

- Establish an infrastructure, including a shared analysis pipeline and equipment
- Conduct research on (personalized) medicine in close collaboration with the clinics and retainers of patient registries
- Conduct research on white biotechnology (industrial biotechnology) in close collaboration with the regional strongholds related to industrial bio-based processing (see Beacon #1: Large scale bio-based production of chemicals)
- Create a platform for systems biology services, e.g. offering analysis of large integrated data sets

Trends/Medical needs addressed

During the last decade, systems biology has been growing rapidly (see graph on the right). This trend is driven by technological advances and the realization that biological processes can only be understood when analyzed in a more holistic/integrated and quantitative manner.



Systems biology is widely recognized as being important for the development of medicine[31]. Traditional approaches within medicine over generalize pathophenotypes and cannot be used to individualize disease diagnosis or therapy. By integrating personalized metabolomics, endocrinomics, proteomics and clinical phenotyping, systems biology is well equipped to define disease conditions at a more

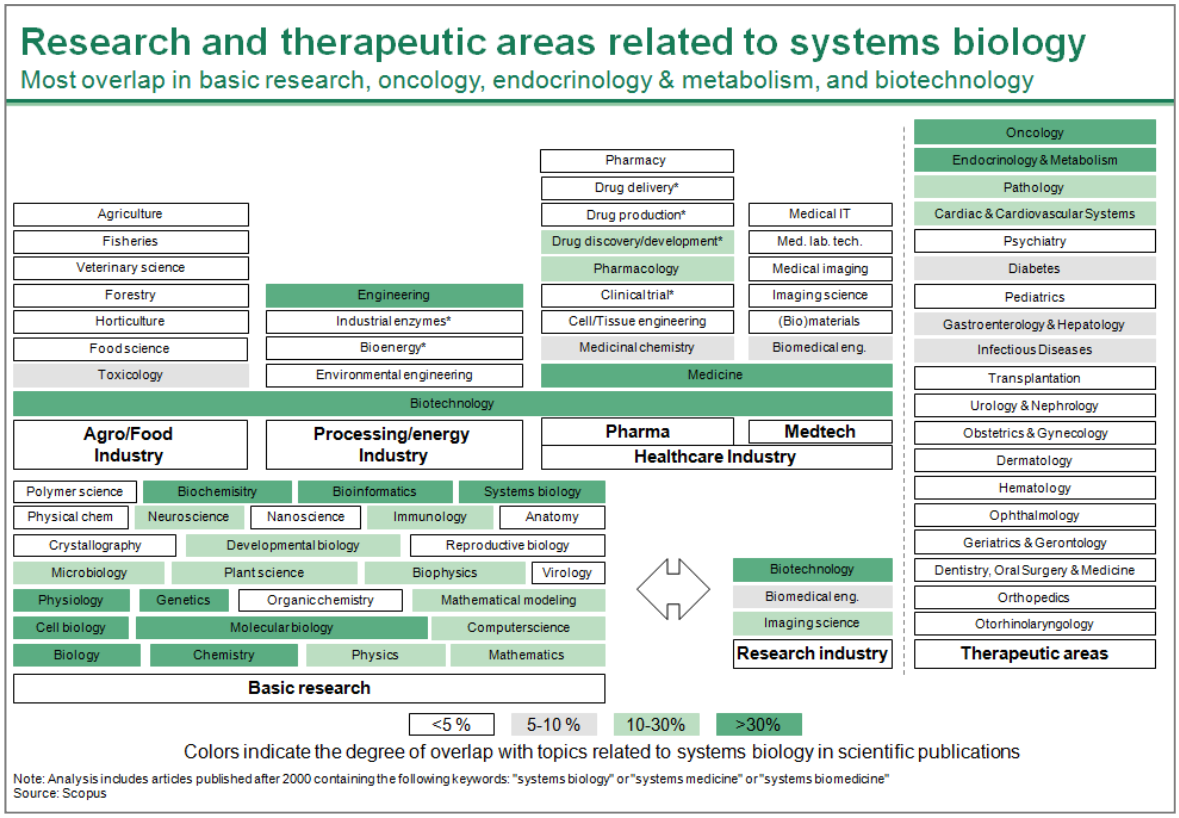
[30] Snoep et al., *"From isolation to integration, a systems biology approach for building the Silicon Cell"* (2005)
[31] European commission, *Directorate of health workshop, From systems biology to systems medicine* (2010)

personal level[32]. Related to this, systems biology is believed to be important for combinatorial therapy and combinatorial drug screening, and the discovery of effective biomarkers for disease progression**Error! Bookmark not defined.**.

At the moment, institutes focused on systems biology and medicine are emerging all over the world, i.e., European Institute for Systems Biology & Medicine, Center for Systems Medicine (Shanghai), Indiana Center for Systems Biology and Personalized Medicine, Department of Systems Biology and Translational Medicine (Texas), and Computational Medicine - Systems Medicine (Karolinska Institute).

Degree of scientific cross-disciplinarity

Systems biology is closely related to mathematical modeling, bio-informatics, and all the –omics, including genomics, proteomics, transcriptomics, metabolomics, etc. The systems biology approach is so far mainly used within a wide variety of basic research areas (including biochemistry, microbiology, cell biology, and molecular biology), applied research topics such as industrial biotechnology and drug discovery, and therapeutic areas like oncology and metabolism where network analysis is highly relevant. Over the years, systems biology has become more interdisciplinary and this trend is expected to continue.



[32] Loscalzo and Barabasi, *Systems biology and the future of medicine* (2011)

Regional strongholds leveraged

Overall, the region is considered a major player in systems biology. The H-index is competitive among the leading life science clusters. Furthermore, a conference on Systems Biology, one of the most prominent events in the field, will be held in Copenhagen in 2013.

Medicon Valley is strong in bottom-up systems biology (studying the interactions between a set of known components), which is applicable to e.g. applied microbiology. However, in this segment there are several strong competing regions, especially in the US, UK, Netherlands, and Zurich. Nevertheless, a focus on applied microbiology could still be attractive because Medicon Valley is a world leader in this field and its related industries, such as industrial biotechnology and probiotics.

Medicon Valleys is especially competitive in top-down systems biology (utilization of –omics data), which is most relevant for applications towards medicine. Combined with the world leading patient registries that are present in Medicon Valley, this provides a compelling opportunity to create a unique position.

H-index benchmarking: Systems biology

Research area	Average	Medicon Valley	Boston	Cambr. UK	Silicon Valley	Stockh. Uppsala	Zurich	London	Berlin	Tokyo
Systems biology	33	30	63	42	44	21	26	29	24	22
Systems medicine	11	10	15	8	14	5	3	18	3	26
Computational biology	99	88	170	130	133	72	57	91	74	79
Bioinformatics	40	38	60	54	41	32	18	41	25	49
Proteomics	32	33	48	34	41	26	28	27	27	27
Metabolomics	30	31	38	32	24	20	27	48	22	28
Transcriptomics	76	62	125	84	102	59	49	70	56	73
Interactomics	37	28	86	48	48	18	26	28	28	25
Mathematics	51	54	72	45	62	39	42	51	44	50
Personalized medicine	18	19	32	12	26	16	9	21	12	16
Microbiology	115	122	171	102	138	96	84	121	94	110

> 0% | -20 to 0% | <-20 %

Colors indicate relative H-index of MV compared to average of leading life science clusters

Note: The search terms: Web of Science "Category terms" Scopus "keywords" and Scopus "unqualified terms". Generally, the analysis was restricted to articles published after 2000. In cases where the number of hits exceeded the limit for citation analysis, the analysis was further restricted to articles published after 2007, 2008, or 2009.
Source: Web of science, Scopus

Examples of research centers and existing collaboration

There are several strong research centers directly related to systems biology in the region:

- DTU Systems Biology
- Novo Nordisk Center for Protein Research, DTU
- Create Health - A Strategic Center for Translational Cancer Research, LU
- The Bioinformatics Center, KU
- Department of Biomedical Sciences, KU
- Computational Biology & Biological Physics, LU
- Lund University Diabetes Centre, LU
- The Division of Applied Microbiology, LU

Practical feasibility

The feasibility of this initiative is assessed as being medium to high. The region appears to have a great foundation to establish a unique beacon within applied systems biology. However, the infrastructure investments and stakeholder buy-in required to make this successful are expected to be substantial.

Medicon Valley has a well connected systems biology community that is already collaborating with the industry. However, to make a center on applied systems biology truly world leading, it is essential to build a comprehensive infrastructure including a shared analysis pipeline. Moreover, a significant amount of researchers will need to be mobilized to collect, store and analyze data. This requires not only substantial funding, but also broad stakeholder buy-in to use a common data platform. Buy-in also has to be secured on a political level, as the use of patient data is tightly legislated. Possibly, this could be done in close collaboration with a beacon on integrating patient data repositories (see beacon number 9, 'Reegle').

Because of the infrastructural investments required for this beacon, it could take considerable time before the center can make a real impact. This timing will depend on the amount of funding that is available at an early stage. Because this beacon provides an infrastructure for the entire region, public funding seems most appropriate. Industrial support could be obtained on a fee-for service on a project basis. Still, other opportunities could be probed such as public private partnerships.

However, as the potential impact of this beacon can be substantial and moreover lift the general scientific level of other life science fields in the region, even a fairly high investment level would seem acceptable.

Beacon #6: Reproductive biology and technology

SUMMARY

Beacon vision

Successfully maintain the region's leading position within reproductive biology in humans and animals, and assist in developing novel technologies through increased interaction between academia, clinics, and the industry.

Definition

Applied research center focusing on increasing fertility in humans (and possibly animals)

Specific activities could include

- collaborating with industry around trials and commercialization of research
- improving technology relevant for fertility research
- utilizing knowledge from veterinary science

Contraception and plant reproduction most likely out of scope

Trends/Medical needs addressed

- Need for fertility treatments rising, e.g. as women have children at higher age
- Potential to unlock further opportunities through technologies in development stage
- Regulatory demand for e.g. safety and control means new need for documentation

Degree of scientific cross-disciplinarity

- Several basic research and therapeutic areas relate to reproduction, and potential for valuable collaboration by applying knowledge from agro to health care industry
- Potential for collaboration between researchers, clinics and industry for e.g. trials

Regional strongholds leveraged

- MV among leading clusters in research within reproductive biology, veterinary reproduction, human fertility, reproductive technology, and IVF
- Strong base of fertility clinics, sperm banks, and companies present
    - Some of the largest Nordic fertility clinics present in the cluster
    - Two sperm banks, several laboratories, & leading pharma company (Ferring)
- Already a cross border initiative in place to build upon: "ReproHigh", an EU sponsored project among hospitals in CPH and Malmö, and Lund University
- Societal strongholds through registries, and a population willing to donate e.g. oocytes to research, and test new methods

Overall attractiveness: High

High expected growth and new technological advancements combined with clear scientific strengths, an existing strong cross border initiative to build upon, and presence of clinics and a strong industry leader make this beacon highly attractive.

Practical feasibility: Medium to High

MVA can play an important role in enabling a stronger collaboration between the players in the region and build this beacon on existing infrastructure with limited investment requirements. The main potential challenge is the risk of regulatory changes affecting the area.

DETAILED ANALYSES

Trends/Medical needs addressed

- Need for fertility treatments rise as infertility increase
    - As women work more than before, an increasing number of females chose to have children at a higher age. After age 35, however, the chance of conceiving falls at a dramatic rate, thus increasing the need for fertility treatments[33]
    - Rising obesity rates and drinking increase in alcohol consumption among women along with declining sperm counts in men also believed to have increased infertility[34]
- Potential to unlock further opportunities according to interviewees through technologies in development stage (e.g. cryopreservation of ovarian tissue, reprogenetics, comparative genomic hybridisation screening, in vitro derived gamates), and increased use of biobanks
- Further regulatory demand for e.g. safety and control of treatment methods, culture media, etc. increases the need for research and documentation related to this

Degree of scientific cross-disciplinarity

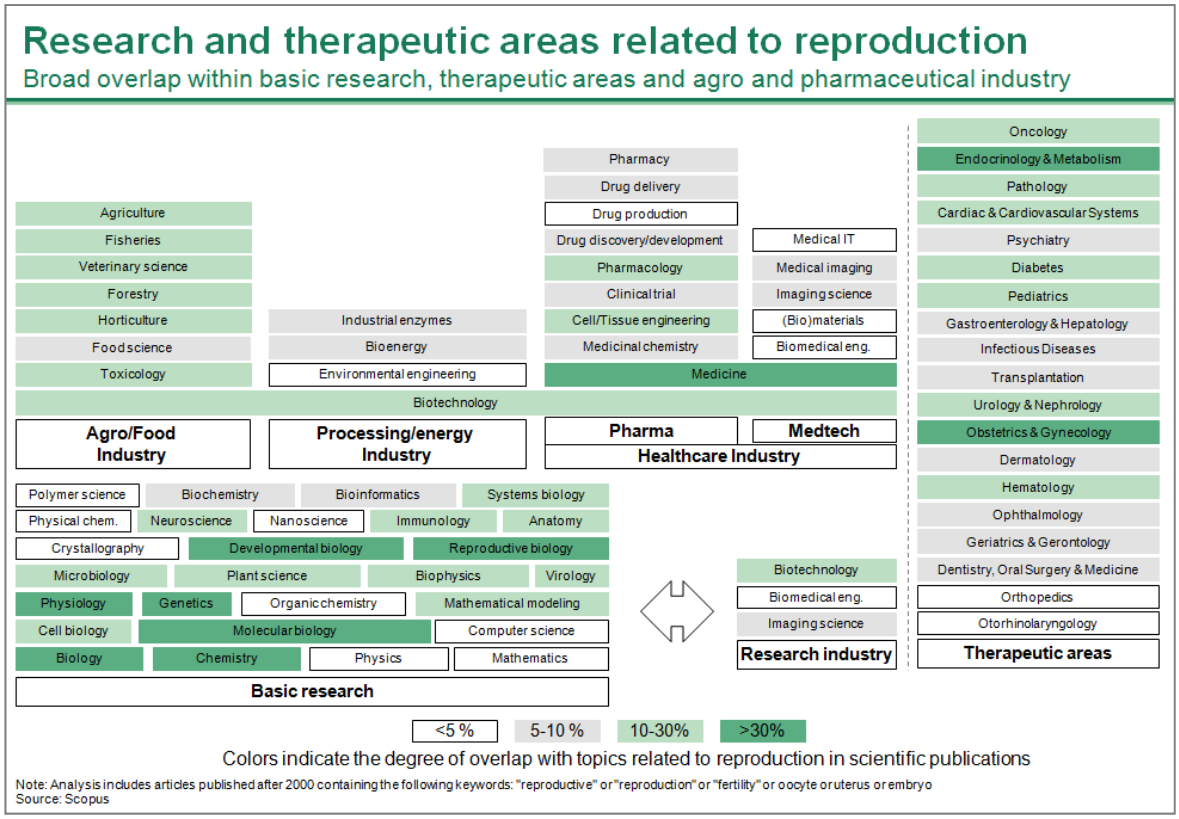
As evident below, several areas relate to reproduction, and there is broad overlap within basic research, therapeutic areas, and industry types.

Although there are several possibilities for cross-disciplinary synergies, interviewees have specifically mentioned three potential areas:

- First, the potential for cross-disciplinarity between human and veterinary scientists has been highlighted, as e.g. findings from animal models from veterinary science could be used for studies relevant for humans
- Second, reproductive technology has a clear link to other therapeutic areas, such as oncology or diabetes, where Medicon Valley's performance is strong. Utilizing cross-disciplinarity across several stronghold areas can naturally lead to great results
- Third, the need for increasing collaboration between companies, clinics, and researchers around e.g. phase II trials or commercialization of results has been highlighted by interviewees. See further information on this in the next section

[33] Human Reproduction, *Estimating the prevalence of infertility in Canada* (2012)

[34] National Post, *Infertility on the rise in Canada: study* (2012)



Regional strongholds leveraged

Scientific strongholds

Medicon Valley's scientific strengths within reproductive technology become evident when benchmarking the cluster against other clusters. Interviewees have highlighted e.g. Australia, Edinburg, and Chicago as important areas within the field, but Medicon Valley consistently performs better within most areas, and is in fact the leading cluster within three of the areas mentioned below (although ovarian tissue transplantation is still a small research area).

One of the things that also distinguish Medicon Valley from other clusters is the researchers' unique approach of combining knowledge from both male and female fertility research within the region. According to interviewees, this is currently not done elsewhere.

H-index benchmarking: Reproductive biology and technology

Research area	Average	Medicon Valley	Boston	Cambr. UK	Silicon Valley	Stockh. Uppsala	Zurich	London	Berlin	Tokyo	Sydney Melb.[1]	Edin-burgh[1]	Chicago[1]
Human fertility	34	36	47	37	40	34	23	40	31	31	29	30	28
Obstetrics & Gynecology	52	68	70	40	61	53	24	78	39	33	56	40	58
Reproductive technology	56	67	89	43	64	59	41	70	38	64	48	41	44
Reproductive pharmacol.	53	59	81	36	72	55	29	65	48	57	41	48	49
Veterinary reproduction	39	50	40	39	32	41	29	41	36	43	36	37	24
In vitro fertilisation	41	61	58	32	41	44	12	62	28	39	44	33	42
Reproductive biology	46	61	55	39	45	47	21	61	34	44	47	48	44
Ovarian tissue transplant.	8	15	6	3	8	11	1	9	9	7	12	7	7
Developmental biol	84	57	147	80	116	54	56	100	55	90	29	55	62
Genetics	144	126	223	165	169	113	81	180	114	125	91	97	129
Physiology	68	83	91	55	77	56	53	80	52	69	61	38	71
Molecular biology	41	39	68	47	44	34	26	42	31	37	28	29	26
Biology	48	42	75	53	56	41	35	49	37	44	34	32	34

> 0% | -20 to 0% | <-20 %

Colors indicate relative H-index of MV compared to average of leading life science clusters

Note: The search terms: Web of Science "Category terms" Scopus "keywords" and Scopus "unqualified terms". Generally, the analysis was restricted to articles published after 2000. In cases where the number of hits exceeded the limit for citation analysis, the analysis was further restricted to articles published after 2007, 2008, or 2009.
1. Not included in the calculation of average H-index
Source: Web of science, Scopus

Fertility clinic strongholds

Several hundred fertility clinics operate around the world, and it is difficult to benchmark these against each other. One method is benchmarking clinics on their success rate, i.e. the % of cycles performed that result in live birth(s). However, various success rates are reported for different treatments, and different patient groups (e.g. different age groups) mean that success rates cannot easily be compared.

According to interviews, however, Medicon Valley's fertility clinics perform well. A high number of cycles enable clinics to gain experience and test new methods, and relative to the population size of the region, the clinics in Medicon Valley do indeed perform many cycles every year. In terms of specific methods, interviewees state that the fertility clinic at Rigshospitalet is the best on the clinical side within ovary tissue preservation (also evident from H-index), and almost on par with the best within IVF.

Industry strongholds

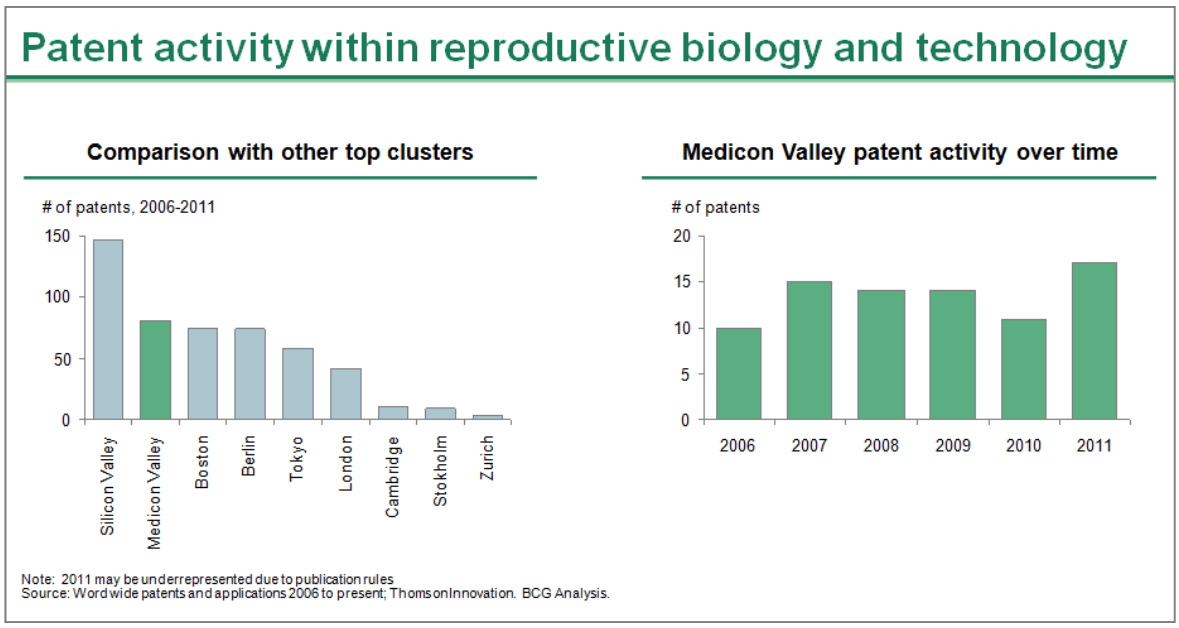
Several companies in the cluster are related to reproduction, e.g. Ferring, ORIGIO, K-Systems, ARTS Biologics, NUNC, Vitro life (placed in Gothenburg), and Unisense (Aarhus).

According to interviewees, the world leader in pharmaceuticals for fertility treatments is Merck Serono, which has R&D facilities in Boston, Darmstadt (Germany), Beijing, and Tokyo. Two other major international players exist; Merck, and Danish Ferring. Danish Ferring has R&D facilities in Copenhagen in addition to five other places in the world. The presence of a major international player in the cluster represents a clear stronghold.

Another successful and growing company is Danish ORIGIO, which specializes in assisted reproductive technologies and produces culture media, pipettes, and various devices. As an example of their performance, ORIGIO has recently in the world's largest clinical trial on IVF media shown, that growth factor molecules are critical to ensuring optimal embryo development[35].

[35] Science Daily, *IVF Breakthrough to Hit the World Market* (2011)

In combination, the presence of successful companies and researchers within reproduction in Medicon Valley is illustrated by the cluster's relatively high patent activity compared to other top clusters. Only Silicon Valley produced more patents than Medicon Valley from 2006-2011, and Medicon Valley's historic patent activity has been consistently high.



Examples of existing collaboration

An additional strength in the region is the existing degree of collaboration in the area, which MVA could build upon.

The best example of this is 'ReproHigh', an EU sponsored project driven primarily by hospitals in the CPH region and Malmö, and Lund University. The overall aim is to establish a center of excellence focusing on both clinical research and commercialization of ideas related to reproduction. The project is cross-disciplinary by nature as also non-fertility related companies, such as communication companies, are included to when possible. The project period lasts from September 2012 to December 2014 with a total budget of EUR 3.8M (hereof an EU grant of EUR 1.9M).[36] No physical center is planned so far, and the specific structure of the setup is still to be defined. Two stakeholders from this initiative were interviewed and both express high interest in involving MVA going forward.

Society strongholds

Interviewees also stress a range of societal strongholds related to the beacon. Contrary to some other countries, fertility, infertility, and contraception are perceived as less controversial subjects in the Nordics. Furthermore, the fact that fertility treatments are subsidized in the Nordics means that the population is willing to participate in tests. The population is also generally willing to donate e.g. oocytes for research.

[36] Interreg IVA (2012) & Reprosund (2012)

Practical feasibility

Overall, the practical feasibility of this beacon is evaluated to be medium to high.

As already indicated, MVA could play an important role within the field, by building upon and supporting e.g. ReproHigh. MVA would be able to contribute with an organizational setup and structure, and not least a network to the industry to ensure commercialization of findings. However, ReproHigh is also an Interreg funded project and has overlapping goals with this potential Beacon. The exact role of MVA and how MVA can add more value to the already ongoing initiative must be evaluated as the first next step.

In terms of potential challenges, interviewees state that industry dynamics are sensitive to regulatory changes. This was e.g. seen in 2011 where the Danish government introduced a user payment system for fertility treatments. Although this was reversed as of January 1st 2012, it did prove that the industry is sensitive to legislative changes. On the other hand, interviewees also state that the Nordics have relatively relaxed legislation around reproductive technology compared to other countries, which positively impacts researchers and what can be tested.

Beacon #7: Affordable drugs

SUMMARY

Beacon vision

Become internationally recognized as a world leading research community focusing on achieving affordable drugs for 3rd world countries.

Definition

The Millennium Development Goals acknowledges the need to improve the affordability and availability of medicines for the world's poor.

According to the WHO[37], a range of national and global initiatives are needed to ensure the availability and affordability of medicine in developing countries. These cover:

- **National initiatives:** E.g., eliminate taxes and duties, update policies and adopt generic substitution policies, reduce trade and distribution markups, ensure adequate public availability of medicines, monitor medicine prices and availability
- **Global initiatives:** E.g., encourage pharma companies to price differentiate to reduce prices in developing countries, find ways to reduce drug manufacturing costs, reduce R&D costs by reducing costs for clinical trials, and promote generic medicines

A research center initiated by MVA needs to focus on an area where it can create impact. Implementation of national initiatives as the above requires close collaboration with governments in the 3rd world, so global initiatives remain the only feasible option for MVA. Interviewees state that the most likely area for MVA to create impact is through an initiative aimed at reducing costs of pharma manufacturing using e.g. continuous manufacturing: shifting from the traditional batch production of pharmaceuticals to production on continuous basis. According to MIT (a leading player through the MIT-Novartis Center for Continuous Manufacturing), continuous manufacturing offers huge potential for cost reductions (15-50 % savings through smaller footprint, less capital intensity, and lower operating costs[38]). But interviewees state that it is questionable whether lower production costs alone will actually lead to more affordable drugs in 3rd world countries.

Overall beacon evaluation: Medium attractiveness and medium to low feasibility

Ensuring affordable drugs is an important task, but MVA's potential impact in the area is limited, as the success of an initiative depends on regulation in developing countries, the risk of parallel imports, etc., which MVA cannot affect by establishing a research center.

MVA could potentially impact the development of low cost methods for biopharmaceutical manufacturing. But the link between affordable drugs and low cost manufacturing is weak, as e.g. the risk of parallel imports will still be present in spite of lower manufacturing costs. Instead, continuous manufacturing could be a potential beacon by itself, but according to some interviewees, such an initiative might be relevant to only few industry players in the region (e.g. Lundbeck), who would investigate this area regardless of a cluster initiative due to the high attractiveness of this production method. To other interviewees, the potential feasibility is higher, as researchers are present to drive a future initiative (e.g. the researchers behind the KU project 'Continuous Manufacturing of Personalized Medicines'[39]). There are, however, already examples of centers in both the EU and US focusing on continuous manufacturing, and competing against these will be difficult.

[37] United Nations, *Delivering on the Global Partnership for Achieving the Millennium Development Goals* (2008)
[38] MIT News, *Continuous drug manufacturing offers speed, lower costs* (2012)
[39] Read more on http://www.fi.dk

Beacon #8: Immune regulation

SUMMARY

Beacon vision

Creating a Danish-Swedish platform for cutting-edge basic and applied research within immune regulation

Definition

Immune regulation is a broad field addressing various therapeutic areas that, even though partially overlapping, require different scientific approaches. Novel high-potential areas that this initiative could focus on include autoimmune diseases (e.g., rheumatoid arthritis, type 1 diabetes, inflammatory bowel disease), autoimmune diseases related to the central nervous system (e.g. multiple sclerosis), and oncology.

Trends/Medical needs addressed

Immunotherapy is widely perceived to be increasingly important for the treatment of a large range of serious disorders ranging from multiple sclerosis to cancer. Big pharmaceutical companies are heavily investing in this field. An established market closely related to immune regulation is monoclonal antibody therapy, which is one of the most promising and best performing segments of the pharmaceutical industry.

Degree of scientific cross-disciplinarity

Immune regulation as a research field has a high potential for cross-disciplinary synergies. Almost all basic research topics within life science have some overlap with immunology. Furthermore, there is extensive overlap with research related to the pharmaceutical industry and a wide variety of therapeutic areas.

Regional strongholds leveraged

Even though many research groups in Medicon Valley are focusing on immune regulation, and KU is developing a new center to put more attention into this field, these developments are fairly recent. The regional H-index score (backward looking) on different topics within immune regulation is below the average of the life science clusters included in this study. Medicon Valley has numerous strong companies with activities related to immune regulation (e.g., Novo Nordisk, Ferring, Symphogen), but several of these have chosen to collaborate with research groups outside the region.

Overall attractiveness: Medium

Immune regulation is a highly attractive research topic and the presence of a world leading center in the region would certainly be beneficial for companies that are active in this field. However, at the moment there are no clear scientific strongholds present in the region. This makes it difficult to create a unique scientific platform with a competitive edge.

Practical feasibility: Low to Medium

Despite several research centers focusing on this area, especially at KU, it will require significant further investments and efforts to create a center that is world leading within immune regulation.

DETAILED ANALYSES

Trends/Medical needs addressed

Immune regulation is an attractive research area based on the large number of severe diseases it could potentially treat and the current size and growth of the market for immunotherapy.

Therapeutic areas which are considered most promising within immune regulation are listed below. Understanding of the pathogenesis is still in its infancy but the major pharmaceutical companies (Pfizer, Novartis, Abbott Laboratories, etc.) are heavily investing into these areas.

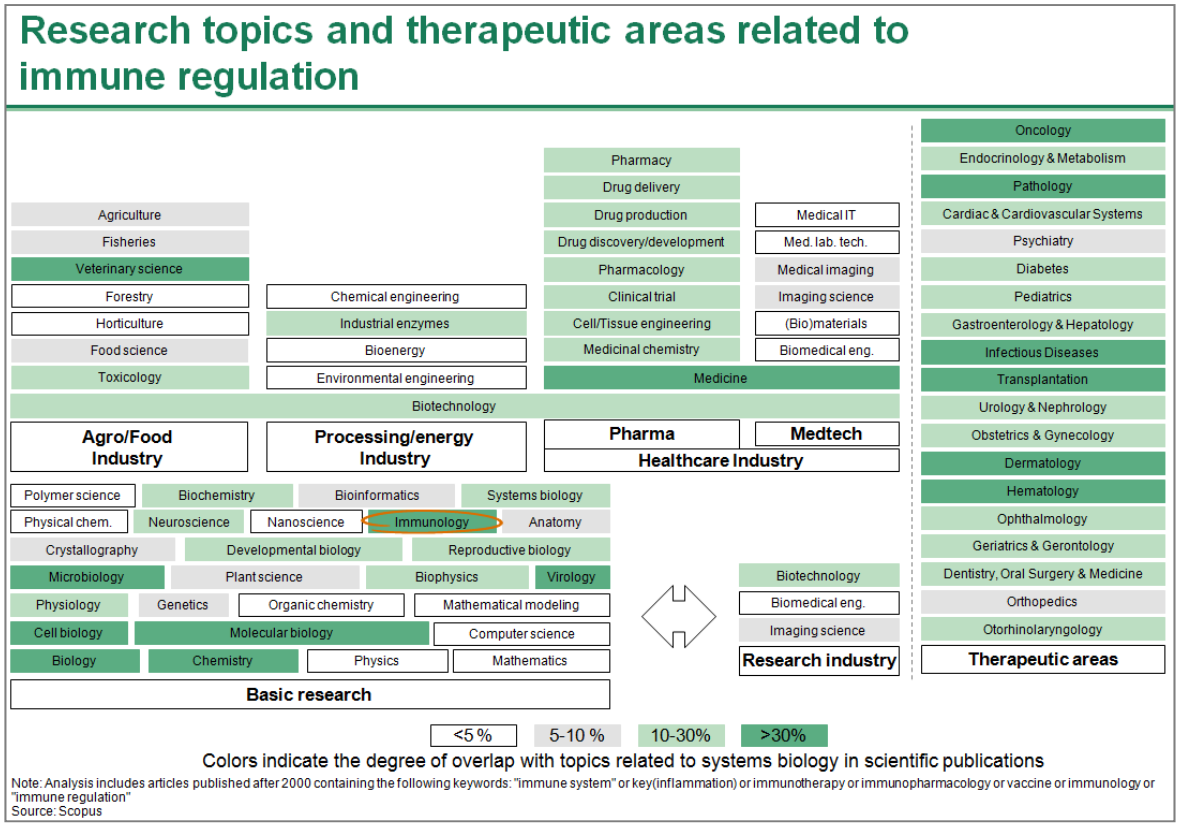
1) Autoimmune diseases. Arise through aberrant behavior of the adaptive or innate immune system. There are more than 80 illnesses caused by autoimmunity[40], including rheumatoid arthritis, type 1 diabetes, multiple sclerosis, Sjögren syndrome, systemic lupus erythematosus, and inflammatory bowel diseases
2) Autoimmune diseases in the central nervous systems. The most prominent of these is multiple sclerosis
3) Oncology. This field covers research that aims to discover immunotherapies to treat and retard the progression of cancer. In 2011, the FDA approved Ipilimumab, a drug developed by Bristol-Myers Squibb that treats melanoma by activating the immune system

Other therapeutic areas that can be addressed by immunotherapy include allergic diseases, rejection of organ transplants, and graft-vs-host reactions. The market of more established forms of immunotherapy comprises a significant portion of the overall market for pharmaceuticals: monoclonal antibodies therapy (USD 40B in 2010 and 19 % CAGR 2006-2010)[41], allergic therapies (USD 14B in 2009 according to BCG analysis), and the vaccines market for infectious diseases (USD 17B in 2007 according to BCG analysis).

Degree of scientific cross-disciplinarity

Research related to immunology is highly cross-disciplinary. There are strong links to nearly all therapeutic areas and it is an important field for the pharmaceutical industry. Furthermore, immunology related research builds on a wide range of basic research subjects.

[40] US National Library of Medicine: http://www.nlm.nih.gov/medlineplus/ency/article/000816.htm
[41] Kalomara, *The Market for Advanced Drug Delivery Systems* (2010)



Note: Analysis includes articles published after 2000 containing the following keywords: "immune system" or key(inflammation) or immunotherapy or immunopharmacology or vaccine or immunology or "immune regulation"
Source: Scopus

Regional strongholds leveraged

Scientific strongholds

Historically, Medicon Valley was a strong player within immune regulation, with several important research groups. Currently, the region is not a scientific leader in this field. The H-index score related to immune regulation is far below the average of the top life science clusters included in this study. The same is true for the H-index on hot topics within immune regulation; such as autoimmune disorders, oncology, and the central nervous system. Supporting this, companies in the region with a focus on novel immune regulation technology are mainly working with research groups outside the region.

H-index benchmarking: Immune regulation

Research area	Average	Medicon Valley	Boston	Cambr. UK	Silicon Valley	Stockh. Uppsala	Zurich	London	Berlin	Tokyo
Immune regulation (IR)	42	28	74	36	55	25	24	58	34	48
IR and oncology	65	44	127	46	95	47	33	69	55	65
IR and autoimmune diseases	86	57	153	61	121	63	55	100	70	91
IR and CNS	49	40	79	42	64	40	39	48	39	46
Autoimmune diseases	48	37	68	44	66	42	27	61	39	45
Autoimmunity	51	40	78	45	70	41	38	60	42	46
Monoclonal antibody therapy	32	24	47	24	51	23	25	44	27	25
Vaccine development	44	42	79	35	49	32	27	54	39	35
Immunopharmacology	53	56	80	32	56	50	31	65	48	55
Inflammation	35	31	55	27	42	27	27	45	31	30

> 0% | -20 to 0% | <-20 %

Colors indicate relative H-index of MV compared to average of leading life science clusters

Note: The search terms: Web of Science "Category terms" Scopus "keywords" and Scopus "unqualified terms". Generally, the analysis was restricted to articles published after 2000. In cases where the number of hits exceeded the limit for citation analysis, the analysis was further restricted to articles published after 2007, 2008, or 2009.
Source: Web of science, Scopus

Current level of collaboration

Within Medicon Valley there are various initiatives with a focus on immunology:

- **Copenhagen Cluster of Immunology** (KU): This platform is part of a larger reorganization at KU to gather the regional forces within immunology in one faculty, The Faculty of Health and Medical Sciences. The new organization is still in the early phases of being developed, but is a very promising initiative to strengthen the collaboration across KU, and with external partners. The cluster includes ~50 senior scientists from four university departments and two hospitals and collaborators at various companies including Novo Nordisk, ALK, Novozymes, Lundbeck, Leo-Pharma, and Nycomed. To strengthen the cluster and internationalization aspect, two researchers from Lund University have been hired recently to be part of this new combined department of Immunology at KU, and one researcher from the U.S. is in process. The Faculty of Health and Medical Sciences is moreover in the process of offering a specialized master degree in Immunology, Allergy, and Inflammation.
- **Chronic inflammation program.** (LU): 12 research projects covering a variety of topics, including autoimmune disease, immune modulation, and skin treatment.
- **Tissue in motion** (LU): Consists of 17 research groups working on topics including rheumatoid arthritis, arteriosclerosis, inflammatory skin disease and respiratory disorders, like asthma and COPD
- **Cellular autoimmunity at the Lund University Diabetes Center** (LU)

The regional research groups related to immunology have shown the willingness to increase cross-border collaboration by planning "The Øresund Center for Immune Regulation" initiative. The proposal for this initiative, which has not received funding yet, includes more than 20 research groups, covering a wide spectrum of basic and applied research topics related to immunology and high-throughput methodology.

- University of Copenhagen (12 professors; Faculty of Pharmaceutical sciences, Department of International Health, Immunology and Microbiology, Faculty of Pharmaceutical sciences, Faculty of Health sciences)
- Rigshospitalet in Copenhagen (1 professor; The Institute for Inflammation Research)

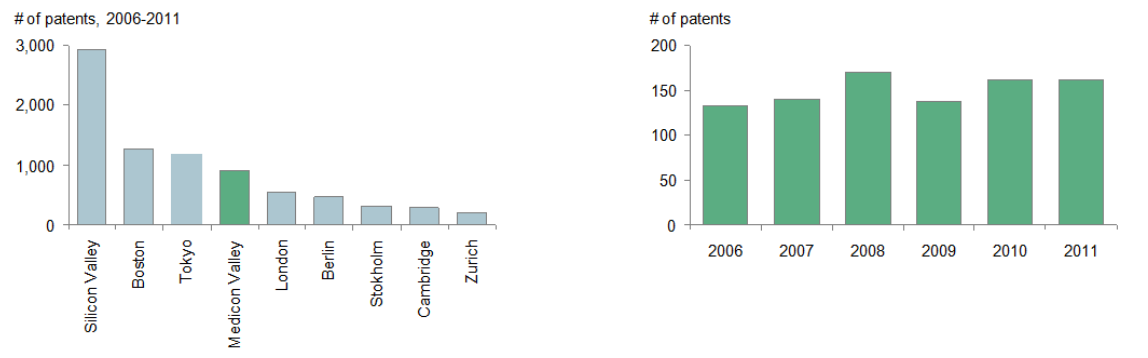
- Lund University (6 professors)
- Technical University of Denmark (3 professors; National Veterinary Institute, Department for Systems Biology, Institute of Nanotechnology, Bioneer A/S)

Industry strongholds

Medicon Valley has lost a significant portion of its industrial strength in immunology and inflammation with the departure of AstraZeneca's respiratory research center in Lund. However, there still is a wide variety of companies with activities related to immune regulation in the region. Novo Nordisk has a strong focus on inflammation research, although many of these activities take place at their Seattle R&D site. Ferring has several products on the market related to inflammation. Within the region, there are several companies with a main focus on immunotherapy, including ALK, Veloxis Pharmaceuticals, Symphogen, Bioinvent, and Aisonett AB. Furthermore, there are several companies that produce immunodiagnostics and allergy tests. In interviews, stakeholders from several of these companies could see the benefits of having a regional center focused on immune regulation. However, the same interviewees also expressed that the current strongholds in the region are limited and that many collaborate with research groups outside Medicon Valley.

The number of patents generated by inventors from Medicon Valley is above the median of the life science regions included in this study, but it is still substantially below that of Silicon Valley, and also below Boston and Tokyo. Over time, the patent activity of Medicon Valley has remained fairly constant.

Patent activity within immune regulation



Note: 2011 may be underrepresented due to publication rules
Source: Word wide patents and applications 2006 to present; Thomson Innovation. BCG Analysis.

Practical feasibility

The practical feasibility of this initiative is considered fairly low to medium.

Medicon Valley is not a scientific leader in immune regulation overall nor in any of its high-potential focus areas. Therefore, this beacon cannot take advantage of regional strongholds and has to rely on the recruitment of top-scientist from abroad. Creating a world class institute will naturally require significant time to develop.

Furthermore, the industry stakeholders BCG interviewed expressed that they are hesitant to invest in such a center. They already have great access to world-class researchers outside the region, and although they do see the potential benefits of having a center of excellence in immunology in the region, they believe that the local companies will be willing and able to invest in this field as needed without a coordinated effort.

However, the new combined Immunology center at KU certainly seems to a step in the right direction to create a stronger base for immunology in the region. It is still in the early days of the development, why it is difficult to evaluate the actual benefits of it yet, and whether the region will be able to compete with other world-class clusters within immune regulation. But this center could potentially be a starting point to build a beacon upon in the future.

Beacon #9: 'Reegle' – A health data platform

The vision of this beacon is to establish a research community internationally recognized for its access to unique, integrated patient data, which is searchable and available to researchers within all fields. The name 'Reegle' arises from the combination of register data available in search form with a setup similar to that of Google.

The beacon idea has attracted high interest from stakeholders, due to the expected benefits of such a database. It would benefit several research areas, and most likely attract global talents in the form of interested researchers and companies, with a desire to interact with the surrounding research community, and affect the structure and use of the database.

The initiative would to a large extend become possible through the Nordics' existing health outcomes data and the region's use of personal identifiers. Reegle goes beyond an MVA beacon, however. Setting up the infrastructure around the database requires large investments and coordination with many public organizations. As this initiative is considered a long term investment, and involves the entire Danish and Swedish society, Reegle is considered more than a cluster initiative and outside the scope of the Beacon Initiative.

After the two day workshop in September, a meeting has taken place between representatives from MVA, the industry, and the Danish Agency for Science, Technology and Innovation, on how to establish 'Reegle'. In this forum, it has been discussed to initiate a pilot on a Danish cancer registry in order to evaluate which potential challenges a Reegle concept could face. Although Reegle is not considered a potential Beacon for MVA, the database could be leveraged by all selected beacons, thus increasing the likelihood of success for the entire project as well as lifting the general scientific research level in the region. For this reason, Reegle is briefly described, although overall attractiveness and feasibility will not be evaluated. Going forward, the CEO of MVA, Stig Jørgensen, will drive the initiative together with various stakeholders.

Definition

In the long run, Reegle covers two elements, namely I) building an integrated database with Danish and Swedish patient and life style data, and II) establishing a research community surrounding this. Naturally, setting up the database will be the initial focus, and Reegle should cover only a limited number of systems in the beginning. In the longer term, the potential scope could be much larger.

Trends addressed and the degree of cross-disciplinarity

Reegle addresses the general need for better data, and offers large potential benefits to researchers, companies, and policy makers. The data in Reegle could be used across more or less all health related research fields, including genomics, personalized medicine, clinical research, health economics, translational research, and epidemiology in general, and would be highly relevant for longitudinal studies.

Regional strongholds leveraged

BCG's health care specialists have benchmarked countries on the degree to which they collect, aggregate and use health outcomes data. In this benchmark, Sweden and Denmark come out as leading countries within collection of data. Both countries have some of the world's oldest and most comprehensive clinical databases, and utilize personal identifiers across the health system. This gives the Nordics a unique foundation to build Reegle upon.

In addition to this, Nordic citizens are characterized by a high level of trust and willingness to share personal data (relative to e.g. the United States), and a tradition and culture of collaboration among public and private institutions.

Next steps

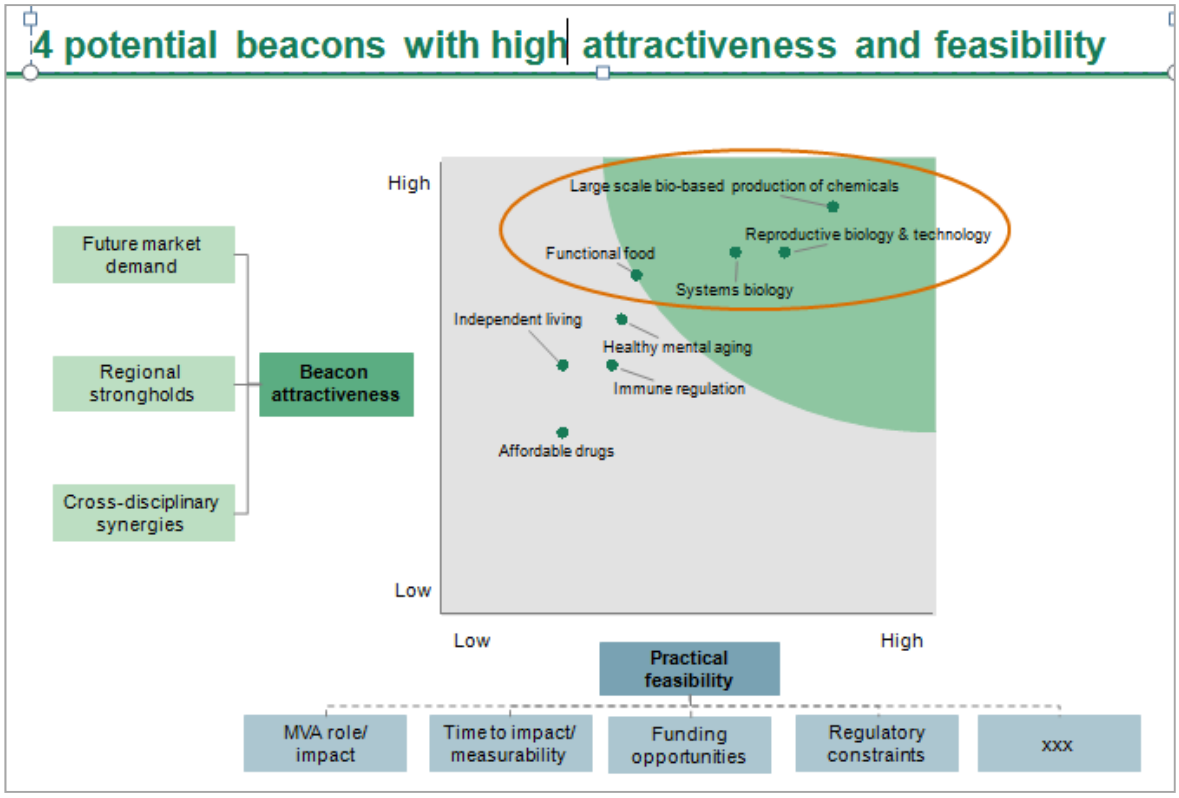
Although Denmark and Sweden are at the forefront when it comes to collecting data, further integration between systems is still needed. Depending on the ambition level for the Reegle, this will require significant time and investments, as integration of systems is key to making the database attractive for researchers. In addition to this, regulatory and ethical constraints must be analyzed as e.g. the anonymity of data must be ensured, which can prove to be a challenge.

In order to better understand these potential challenges when establishing Reegle, a pilot combining databases within one therapeutic area is an attractive idea, and it is recommended to continue analyzing this further. Reegle has the potential to benefit the life science industry in Medicon Valley greatly, so although not being a beacon as such, MVA will continue to follow the initiative closely, and assist in various ways by e.g. mobilizing stakeholders and providing input.

Summary of findings and BCG recommendation

The above evaluations include a rough 'ranking' of the overall attractiveness and feasibility of the identified beacons. This ranking represents BCG's assessment of the beacons. The objective of the ranking is to provide a simple overview of the opportunities that exist and enable a prioritization of the beacons. The overview and prioritization outlined here thus portray the view of BCG. It will subsequently be up to the board of MVA to conduct an assessment and prioritization of the potential beacons and agree on where MVA should focus their efforts in taking the Beacon Initiative forward.

The evaluations are based on the 'identification and evaluation framework' explained previously. As already described, this framework enables a mapping of the beacons in a matrix, with attractiveness portrayed on one axis and feasibility on the other axis. The figure below shows the immediate assessment of the eight evaluated beacons (disregarding 'Reegle' which is not considered within the scope of MVA).



As evident from the above, BCG believes that four potential beacons stand out as having the highest potential to create a unique competitive edge. These four areas are 'Large scale bio-based production of chemicals', 'Reproductive biology and technology', 'Systems biology', and 'Functional food'. The close runners up are the beacons 'Healthy mental aging' and Immune regulation'. These beacons could also be interesting to look more into as many regional research centers have a dedicated focus on these fields and potentially could form a strong platform of excellence in the near future. Below are the four most attractive beacons briefly outlined, as these seem to have the highest near term potential.

Large scale bio-based production of chemicals

BCG finds this potential beacon highly attractive for several reasons. First of all, the future growth potential is substantial, making this is a highly lucrative market to tab into. Second, Medicon Valley already has a world leading position in this field with strong companies and researchers present in the region. Third, with the existence of several strong science centers focused on bio-based production of chemicals, and in particular with the recent establishment of The Center for Biosustainability (CfB), Medicon Valley has a unique platform upon which they can build an even stronger competitive edge.

BCG perceives this potential beacon as an obvious opportunity and recommends MVA to investigate the possibility of establishing this beacon immediately. MVA should initiate a close dialogue with key stakeholders, e.g. CfB, to quickly identify if MVA can play a significant role that will benefit the already ongoing activities.

Reproductive biology and technology

BCG also finds a focus on reproduction highly suitable for Medicon Valley. In particular, the area is made attractive by the already existing collaboration between Sweden and Denmark, which has resulted in the ReproHigh initiative. Moreover, the substantial scientific industry strongholds that are present in the region and the large market potential matched and make this area very interesting to focus on in the future. But again, MVA will need to identify which specific role is needed in order to support the area in the best possible way.

Systems biology

Although substantial investments will be required to establish a beacon within systems biology, BCG also finds this beacon highly attractive. Systems biology is not only revolutionizing research methods across many life science areas, but can even act as a catalyst to increase the scientific research level in Medicon Valley in general. Thus, by establishing a research center aiming at becoming world leading in this novel research approach, MVA can substantially enhance the chances of becoming world leading in other selected beacons. Moreover, the systems approach is especially relevant for developing personalized medicine, one of the most promising developments within medicine.

As the region already has a well-connected systems biology community on which a beacon can build, a systems biology beacon has the potential to create a truly unique platform that will attract highly skilled scientists from all over the world.

Functional food

Functional food is found particularly interesting because of the growth potential combined with scientific and company strongholds which enable Medicon Valley to really become world leading within this field. At the same time, however, the feasibility of functional food is more limited than that of the three other highly prioritized beacons. This is primarily due to functional food being sensitive to regulatory changes and limitations, but also due to the low existing collaboration between academia and the industry. If this beacon should succeed, it is essential that new ways and incentives for collaboration can be created.

A closely integrated system of beacons

The figure below shows how cross-disciplinary synergies not only emerge from collaboration within one specific beacon, but how synergies can emerge even between the beacons.

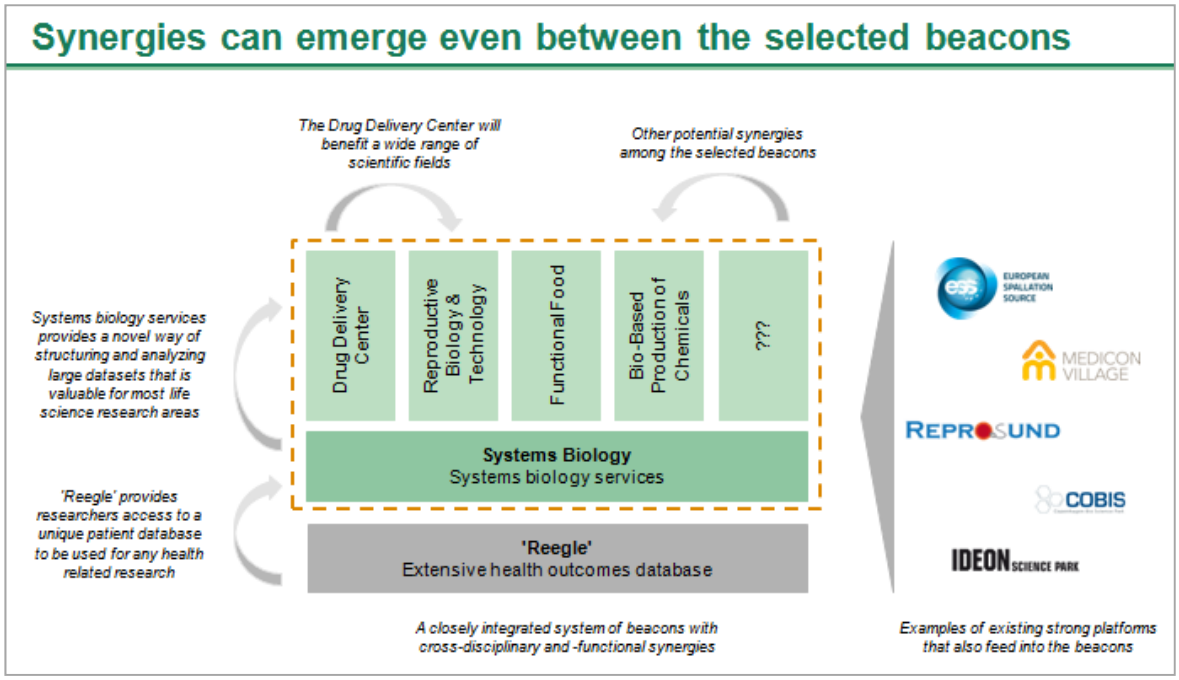
By focusing on the beacons highlighted above, MVA can create an integrated system of beacons that will strengthen the cross-disciplinary synergies further. Together, these beacons can create not just a center of excellence, but an entire region of excellence, thus increasing the chances of becoming a world leading life science cluster.

The 'Reegle' initiative, which will run as a separate effort simultaneously with the Beacon Initiative, will provide Medicon Valley with access to unique, integrated patient data that can be applied across a wide array of health related research areas. Researchers from all over the world will flock to Medicon Valley to be able to test their research on large, relatively homogeneous population groups.

On top of this, the systems biology services will provide novel ways of structuring and analyzing large data sets that enable scientific advances across most life science fields. As mentioned previously, this novel research approach will have a positive impact on the research level of other beacons as well. Hence, the 'Reegle' initiative and the 'Systems biology' beacon can be viewed as structural platforms that will lift the general level of research in the region.

Synergies can also emerge across beacons covering more specific scientific fields. As such, the 'Drug delivery' beacon can benefit e.g. the 'Reproductive biology and technology' and 'Functional food' beacons by improving the target specificity of a drug/product. Likewise other beacons could potentially benefit each other from new research discoveries.

Existing scientific platforms and organizations in the region should be utilized to the extent possible to boost the beacons. E.g. the recent investment in the European Spallation Source (ESS) in Lund provides a source of neutron experimentation that can foster major advances in many fields, e.g., nanotechnology, biomaterials, health and aging, etc.[42] Similarly some of the existing science parks or research centers in the region can be used as hubs or joint facilities to establish a strong collaboration culture around the Beacon Initiative.



[42] http://ess-scandinavia.eu

6. Key Success Factors of the Beacons Initiative

As evident in the previous section, several of the evaluated beacons do have the potential to form a unique competitive edge for Medicon Valley. Although the beacons are all different in terms of focus area, stakeholders involved, structural setup, etc., the success of the beacons will to a large extend depend on the same list of key success factors. These factors are essential to fulfill to make the Beacon Initiative a success. Thus, the following must be ensured:

- Involvement of a broad range of stakeholders
- Strong initiators to drive the beacon forward
- Organizational setup in place
- Collaboration and pre-competitive behavior
- Availability of funding

Involvement and acceptance from a broad range of stakeholders

The Beacon Initiative is a *cluster* initiative. Therefore, as already discussed, an individual beacon must involve a broad range of stakeholders from various scientific areas, and also extend across academia, the industry, public institutions, and importantly, Sweden and Denmark. Some regions, companies, and researchers will naturally be stronger than others for the various beacons, but to ensure broad commitment within Medicon Valley, it is essential that the beacon participants represent a wide variety of stakeholders. Just as importantly is it to assure that stakeholders from various academic, public, and industry organizations buy-in to the project and accept the prioritizations made by MVA. The leadership/project team of MVA plays a critical role in aligning and mobilizing these stakeholders during the next phase of the project.

Strong initiators to drive the beacon forward

Getting initial interest from stakeholders in new research initiatives is not a challenge. Instead, the main challenge relates to ensuring progress and keeping stakeholders engaged and motivated. For instance, researchers are typically involved in several research projects while simultaneously working on commercialization of ideas, or teaching at universities. To ensure that the beacon initiative is not just another task on a highly busy schedule, it is important that there are strong initiators involved that can drive the initiative forward. These initiators must be strong personalities that are both committed to the project and have the skill set to create momentum. This can be in the form of e.g. a strong center leader, or highly engaged industry players with a strong commercial interest in the field. The most important factor is that these initiators keep motivation and engagement high. In order to support this, it is necessary to relatively quickly build an organizational setup around the beacon.

Organizational setup in place

To assure the progress of the Beacon Initiative and support the beacons in general, it is important to set up an organizational structure surrounding each of the beacons quickly. This structure should contain I) a steering group consisting of key stakeholders within the field, II) a project leader selected among this group to take responsibility for progress, realization, decision making, etc., and III) one or two representatives from MVA to for

oversee the overall process of the beacon, assure alignment across stakeholders, compile and share key insights across all beacon initiatives, etc.

Furthermore, a time line for the beacon development and realization should be drafted, including when workshops are scheduled, when specific milestones should be achieved, etc. As part of this exercise, the expected time allocation needed from stakeholders in various phases should be clearly communicated.

Collaboration and pre-competitive behavior

For a beacon to create real impact, it is not enough to have committed stakeholders and a strong leader. If a beacon is to create benefits to the entire cluster, stakeholders must also be encouraged to share knowledge and ideas, which will lead to the creation of new, groundbreaking knowledge. To enable pre-competitive behavior where stakeholders cooperate instead of compete, it is essential that stakeholders trust each other, and realize the benefits of working closely together. Thus, the beacons must be structured in a way where they encourage collaboration and provide benefits to all participants.

Availability of funding

The prioritized beacons must be attractive to investors, as the availability of sufficient funding is essential to create results. Therefore, buy in to the beacons from investors must be achieved along with long term support. It is important to keep in mind that different beacons will be attractive to different investors, which means that the investors approached will differ from beacon to beacon.

Overall, beacons can attract funds from two types of investors, namely I) private and public foundations, and II) companies.

The traditional, private foundations cover e.g. the Novo Nordisk Foundation, the Lundbeck Foundation, and the Knut and Alice Wallenberg Foundation. These foundations generally support research oriented initiatives and will most likely be relevant to approach for the beacons that are highly research oriented. Public organizations likely to sponsor beacons could e.g. include Vækstfonden, the Danish National Advanced Technology Foundation, the Capital Region of Denmark, and Vinnova in Sweden.

Companies could most likely also support some of the beacons although on a more project-based level when the companies are the direct beneficiaries. This could e.g. include the more commercialization focused beacons (e.g. Bio-based production of chemicals), or be through user payment at the test centers (e.g. for Independent living, and Reproductive biology and technology).

7. Recommended Next Steps

The previous chapter highlights the key success factors needed to ensure the success of the Beacon Initiative. These dimensions must all be fulfilled in the longer run, but as immediate next steps after the MVA board meeting on December 5, 2012, BCG recommends MVA to focus on a few key actions that will take the Beacon Initiative forward. These actions include

- Prioritization of beacons for further analysis
- Draft a high level implementation plan for the prioritized beacons
- Estimate the required resource needs to run the Beacon Initiative
- Approach potential funding organizations

Prioritization of future beacons

As the evaluation included in this study highlights, many great opportunities exist for MVA to create real impact and shape the future life science industry in Medicon Valley. But in a fast-paced and highly competitive environment, it is essential to capture these opportunities before someone else does. As an immediate next step BCG therefore recommends MVA to prioritize the potential beacons outlined in this study and appoint 1-3 beacons that they want to take forward for further analysis.

This should be done through a detailed discussion around the potential beacons during the MVA board meeting. This discussion should be based on the expertise of the MVA board and management team as well as the key findings of this study. BCG recommends the outcome of this discussion to be a prioritized list of the eight potential beacons, and from this list appoint 1-3 beacons that can be carried forward for further analysis. This prioritization should ideally happen during the board meeting or alternatively immediately after.

Prioritizing 1-3 beacons is *not* to be considered a de-selection of other potential beacons. The intention with this is simply to foster immediate action. In case a more detailed analysis of a beacon finds it less attractive than initially assumed or reveals significant implementation challenges, MVA should reconsider which other potential beacons on the list that they could focus on instead.

Once a few beacons are appointed for further investigation, MVA should assign a dedicated steering group to each beacon. As pointed out in the chapter on key success factors, these steering groups will conduct more detailed analysis to validate the potential and feasibility of the initiative. Moreover, this group will bring the initiative into action by approaching and involving regional experts, identifying potential funding organizations, outlining detailed implementations plans, etc. as is the case with the Drug Delivery Initiative.

Draft a high level implementation plan

After the initial prioritization of beacons has taken place and steering groups are assigned, these groups should draft a high level implementation plan for each beacon. The plans should naturally be coordinated with MVA to be in line with the overall project plan of the Beacon Initiative. Such input will help MVA in setting and adjusting specific targets for different phases of the project, as well as obtain a better overview of the resources that will be required to implement the initiatives.

Estimate the required resource need

MVA most likely have to set aside additional resources to drive the Beacon Initiative going forward. The required resources will naturally depend on the number of beacons that are appointed. However, BCG believes that a resource need of ~1-3 FTEs per beacon will be required to ensure a successful implementation. The role of these people will be to act as project leaders for the beacon steering groups; i.e. to take charge on required actions, ensure that the project progresses as planned, and report back to the MVA management team and board on a regular basis. On top of this, substantial effort from MVAs side will be required to identify, involve, and mobilize key stakeholders from academic, public, and private organizations to ensure commitment to the project. Acceptance and support will be required from all parties, and it will be important for MVA to clearly communicate what will be the role of MVA and what will be required from the various stakeholders to successfully implement the beacons.

The exact resource needs will vary across the beacons depending on scope and exact implementation requirements. For instance, the potential beacon "Bio-based production of chemicals" could to a large extend build upon the Center for Biosustainability (CfB). Thus, the role of MVA for this beacon could be limited to strengthening the collaboration and networks in the region as well as the branding of the center. Such an effort might require only one FTE from MVA.

Besides these resources, it will still be required to have at least one internal resource from MVA to keep overall track of the progression of the individual beacons. The key responsibility for this person will be to ensure that all initiatives progress as planned and are in line with the overall objectives of the Beacon Initiative and within the scope of MVA.

Approach potential funding organizations

One of the key responsibilities of the individual steering groups will be to prepare a prospectus and approach potential funding organizations for the individual projects. However, MVA can play an important role in approaching relevant funding organizations already at an early stage. These could potentially be the Novo Nordisk Foundation, the Lundbeck Foundation, the Knut and Alice Wallenberg Foundation, and public foundations such as Vinnova in Sweden, or the Danish National Advanced Technology Foundation and Vækstfonden in Denmark. By approaching such organizations in the initial phases, MVA will get the opportunity to create awareness and buy-in to the overall project and hopefully increase the chances of raising funds to one or more of the individual beacons later on.

Moreover, MVA and other project stakeholders should prioritize attending relevant regional and international conferences or networking communities to brand the initiative and increase the awareness across the industry and academia even further.

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Creating a world class cluster – the vision of the Beacon Initiative – is an ambitious target. But from the extensive analyses done in relation to this study and from talking to numerous stakeholders in the region, it becomes clear that the skills, willingness, and support needed to succeed are indeed present in Medicon Valley.

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Center for Sundhedsinnovation: www.centerforsundhedsinnovation.dk
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Welfare Tech: www.welfaretech.dk/
WNC – The Wallenberg Neuroscience Center: http://www.med.lu.se/wnc

9. Appendix

Phase I: 11 stakeholders participated in the MVA workshop

Stefan Bengtsson

- Vice Chancellor, Malmö University
- Professor in Solid State Electronics, Chalmers University of Technology

Sylvie Bove

- Innovation Officer, Lund University
- Executive MBA, SIMI Copenhagen

Martin Edwards

- Senior Partner, Novo A/S
- MD, Manchester University

Ivan Jensen

- Co-founder & owner at GestaltPartner
- MD, KU

Michael Lange

- Head of Public Affairs, Novartis
- Regional Councillor, The Capital Region

Mats Lindhoff

- Partner, EMA Technology
- Honor Doctor, LTH

Hans Müller-Pedersen

- Director General, Danish Agency for Science, Technology and Innovation
- M.Sc in Sociology, KU

Anker Lundemose

- Managing Partner, BioTesch
- MD/PhD, Molecular Microbiology, University of Århus

Morten Otto Alexander Sommer

- Professor MSO in Systems Biology, DTU
- Group Leader, Novo Nordisk Foundation Centre

Arvind M. Hundal

- Senior Vice President and Chief Business Officer, Zealand Pharma
- PhD, Institute of Genetics, Glasgow University

Lovisa Sunesson

- Business Development Manager in Life Science at Invest in Skåne
- PhD in Molecular Medicine

Total of 47 interviews conducted in phase I and II

Phase I: Prior to the workshop BCG conducted 19 interviews

10 out of 11 workshop participants interviewed...

- Anker Lundemose, Hans Müller-Pedersen, Ivan Jensen, Lovisa Sunesson, Martin Edwards, Mats Lindoff, Michael Lange, Morten Sommer, Stephan Bengtsson, and Sylvie Bove

...along with 9 additional Medicon Valley stakeholders

- Aros Pharma
- Zealand Pharma
- Rigshospitalet
- LIF
- Aventure
- University of Copenhagen
- TAT
- Faculty of Medicine, Lund University (x2)

Phase II: 28 beacon specific stakeholder interviews conducted

1. Bio-based production of chemicals	• Center for Biosustainability, DTU (x2) • Chr. Hansen • LU Biofuels
2. Functional food	• Probi • Skåne Food Innovation Network • Chr. Hansen (simultaneously with beacon 1) • Lund University Diabetes Centre
3. Healthy mental aging	• Lund University Neuronano Research Center • Center for Healthy Aging, University of CPH • Invest in Skåne • Bagadilico, Lund University
4. Independent living	• Dencomm • Center for Healthy Aging, University of CPH • Division of Occupational Therapy & Gerontology, Lund University
5. Systems biology	• Systems Biology, DTU (x3)
6. Reproductive technology	• The Fertility Clinic, Rigshospitalet • Laboratory of Reproductive Biology, Rigshospitalet • The Reproductive Medicine Center, Lund University
7. Affordable drugs	• NNE Pharmaplan • Lundbeck • Department of Pharmacy, University of CPH
8. Immune regulation	• Symphogen • Dept. of Experimental Medical Science, Lund University • BioInvent • Novo Nordisk

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The Boston Consulting Group