For a to be published book:

"An Executive's Guide to Nanotechnology"
Edited by Lynn Foster

Section 5 – Entrepreneurs
Written by Jeff Lawrence

March 11, 2005
Version 1.5

Introduction

There are thousands of people with ideas. There are thousands of people that can lead and manage. There are thousands of people that can get things done. There are far fewer people with the unique combination of these qualities that can be labeled as an entrepreneur. Entrepreneurs aren't just satisfied when they can see a vision and express it; they will only be satisfied when that vision becomes real. Entrepreneurs exist in all areas and at all scales of human endeavor - from a local business on a street corner, a large technology businesses spread across the world or an organization trying to bring about social, political or economic change. Entrepreneurs become possessed by their vision and will persevere in developing, refining and spreading that vision until it has changed the world in some way, large or small.

There are many theories, stories, and how-to descriptions of entrepreneurship. This chapter will briefly discuss a framework for thinking about entrepreneurship, the role of entrepreneurs, what they are, what they do, what they can expect, and why they do what they do.

Lions, tigers and bears

What is the role of an entrepreneur?

Human and technological progress is both the cause and the effect of a rich and complex set of interlocking relationships and cycles; similar in description to many aspects of natural ecosystems. Natural ecosystems consist of small and large thermodynamic, chemical and biological loops necessary to sustain, proliferate and advance life. By the time an ecosystem matures, either at a local, regional or even global scale, there are diverse species, stable populations and complex interdependencies among the members of the ecosystem's communities.

The technology ecosystem is very similar. The loops necessary to sustain an ecosystem consist of people, information, technology and capital. Capital (i.e. money), although very real, is also an abstract method for transferring energy (in the form of work and labor) within and between communities. The food chain (also known as the food web because of a potentially large number of interconnections), describes the various populations and their relationships to each other. In nanotechnology the food chain consists of users, businesses (technology, products, and information), investors, government, academia, industry forums, and standards organizations.

Each population is trying to sustain itself and proliferate in the context of the development stage and available resources of its community and ecosystem. Ecosystems develop and become populated over time by different populations. Some ecosystem populations reach maturity while others never fully develop or fail. Occasionally populations fail because of natural disasters or severe disruptions (e.g. meteorite, forest fire, stock market crash). Businesses and industries development progress along the population curve is also typically affected by their movement along the hype curve. The vertical axis of the hype curve is visibility and the horizontal axis is time, divided into periods including the start, the peak of inflated expectations, the trough of disillusionment, the slope of enlightenment and the plateau of productivity. To some extent, how well businesses and industries negotiate the hype curve will determine whether the population of the ecosystem follows an S curve to maturity or a J curve to failure and removal from the gene pool. The early stages of a developing ecosystem are sparsely populated and typically have low species diversity, low inertia (resistance to change) and high resilience (ability to restore itself after a disturbance). As an ecosystem develops species diversity and inertia increases and resilience decreases.

Interestingly, some don't consider nanotechnology an industry per se but rather a series of technologies and products that are applied to solve a wide and possibly unrelated range of problems. In many cases it is unclear whether business synergies can be developed between the disparate uses of the technologies and products. Some of these technologies and products

include materials, medical devices, other devices, and processes and tools. Materials take a long time to get to the market and replace or supplement existing industrial process flows. Planning, procurement and testing cycles can be very long and are usually tied to capital budgets. Medical devices are expensive and take a long time to get to market because of scientific peer review requirements, government testing requirements, and the resolution of potential reimbursement issues. Other devices may be less expensive or quicker to get to market but the value proposition may be more difficult to define. In all cases, success will depend on having a clear value proposition (either in the form of lives saved, quality of life improved, costs or expenses saved, or markets opened up) and having sufficient capital available to ensure survival until product sales can scale. In the early stages of the ecosystem the development of infrastructure and tools to support the rest of the ecosystem may offer the best possibilities for success.

Nanotechnology today resides primarily in academic institutions, federal laboratories, large corporations, and to a lesser extent in small entrepreneurial businesses. There is significant research and some development going on. Nanotechnology is people and capital intensive. The tools, processes and techniques to monitor and control the structural, electronic, optical and magnetic properties on the atomic scale are expensive. Capital to fund these activities is coming from taxpayers in the form of federal research grants and to a lesser extent from large corporation research and development budgets. There is some private equity available. The private equity market in the form of angel investors or venture capitalists has fairly high expectations that must be met to engage its interest. These are:

- Strong, transparent, predictable, and ethical management team.

- Large and identifiable addressable market.

- Good product or service value and strong, defensible market position.

- Strong, growing and consistent revenue and earnings performance.

- Understandable story and strategy leading to a future liquidity event (in the form of acquisition, buyout or public financing).

There is still disagreement about whether the prodigious sums of capital that were available for the Internet, telecommunications and pharmaceutical industries will become available for the nanotechnology industry. Many investors feel that public equity funding will become available as privately or self funded companies mature and show the predictability and financial performance the public markets expect. Private equity is not the only way to fund a start up. Self funding is possible, but very difficult, because of the capital intensive requirements of nanotechnology. It can take millions of dollars to perform nanotechnology research and development although it may not be as capital intensive as the semiconductor industry on the backend. Licensing or using open source technology or products, rather than creating them from scratch, and using shared labs, facilities, and tools can make self funding more viable.

The nanotechnology ecosystem has analogous models in the information technology, pharmaceutical and energy industry ecosystems. These industries can be looked to as examples of how nanotechnology might evolve over time in terms of the landscape, the food chain, how they operate in regulated or unregulated environments, capital requirements, infrastructure requirements, innovation and development models and paths to liquidity. Survival and proliferation through all stages of nanotechnology ecosystem development will depend on the entrepreneur's ability to create or fill a niche that provides some unique value and becomes an integral part of the relationships and loops of the ecosystem. As the ecosystem develops, like it has in analogous industries, adaptability and flexibility will be essential for proliferation and advancement. Interestingly, there is a fundamental difference about how adaptability and flexibility are realized in nature and industry. In nature members of the food chain "float" around but in industry entrepreneurs can make deliberate and conscious choices of how to adapt, stay

flexible and innovate. The ability to make choices and innovate is important because in the "early" days of most ecosystem (industry) development the fast rate of change disfavors large, slow moving organisms (organizations) and will favor organisms (organizations) that are smaller, more adaptable and responsive. Large organizations in general don't innovate as well as small ones – not necessarily because that they lack the vision, but because risk taking is judged and supported differently than in small organizations.

The power of an idea

What is a good idea?

All organizations, institutions and creations of humans have started with an idea. The power of a good idea cannot be underestimated. An idea by itself is a necessary, but not sufficient, condition to successfully effect change, develop a technology or product, or start a business. There have been many ideas that have not gone beyond being just an idea. To have an impact, the idea must be wrapped in a vision and an understanding of who the vision serves. This is where the entrepreneur enters the picture. He works with an idea, either his own or somebody else's and molds it into a vision that is part possibility (i.e. what can be) and part reality (i.e. what needs to be). The entrepreneur powers the vision into reality by his or her time, energy, and most importantly, belief about the importance of the vision. Entrepreneurs may find that keeping people focused on their vision over the long time horizons of nanotechnology may be challenging.

For many entrepreneurs ideas come out of methodical thinking and planning. For others, ideas may be stumbled or thrust upon them by a life event or epiphany. Good ideas address a real problem or need for change, are realizable, are easy to communicate and provide understandable value. In many cases good ideas have come from what were perceived as problems by some but seen as solutions by others (e.g. post-it notes, penicillin). Ideas can be sustaining or disruptive in their nature. Sustaining ideas improve the performance or capabilities of existing technologies or products along dimensions that have been previously valued by customers. They tend to be cumulative in their effect. Disruptive technologies bring to market a different value proposition than had been previously available. They tend to be revolutionary in nature and at least initially, must be sufficiently resilient and flexible to tolerate ambiguity, incoherence and uncertainty as the relationships and loops of the ecosystem rearrange themselves to support the new value proposition. In the beginning, successful disruptive ideas are embraced by a few but as their value proposition becomes obvious, adopted by many.

Importantly, even though an idea may be good, its timing must also be good. Many ideas coming from academics must be tempered with the realities of business. New ideas may take significant time and effort to educate others about. Nanotechnology as an industry is still fairly new and although many are interested in its possibilities, few totally understand the technology, its application and value in the ecosystem yet. Some ideas may simply be too early in the ecosystems development to be successful. It is up to the entrepreneur to be keenly aware of the state of the ecosystem and whether or not it is ready to accept and embrace the idea. If the ecosystem is not ready for the idea, either the idea has to be walked away from or the ecosystem has to be prepared for its adoption.

Entrepreneurs are generally not ideologists but they are pragmatists and innovators at heart. They enjoy seeing their technology, product or services established in the ecosystem and understand that the value of their vision must be unique, real and understood to be adopted.

A single person can change the world

What is an entrepreneur?

A vision doesn't exist by itself. It is a very personal view of a possible future (i.e. what can be). The literature is filled with stories of successful entrepreneurs. Every vision and story behind it is

as unique as the individual entrepreneur. Stories serve to show possibilities, focus, and inspire. Although each story is unique, the commonalities in the motivations, risks, and challenges are many.

Entrepreneurs are not born, they are made; sometimes consciously and many times unconsciously. Their path to success tends to go through three phases; learning, epiphany and doing. The learning phase is usually a lifelong process. A college degree in business may be helpful but history shows, is not necessarily required to be successful. Knowing the theories and practices of business, technology and other disciplines is important but many other skills such as listening, learning, judging, deciding and communicating may need to be developed and refined by personal experience. Entrepreneurs, more or less intuitively, put themselves through a long apprenticeship during which they develop the knowledge, experience and skills they will need in the future. To some extent, entrepreneurship is about constantly preparing ones self to deal with the opportunities and challenges that may cross their path in the future.

During the learning phase an entrepreneur's life may be building towards an epiphany or may experience a jolt from a completely unexpected source or direction that pushes them out of their comfort zone. The epiphany may be incremental or dramatic in nature. The epiphany is the defining moment when a new idea or a life event forces a change or rethinking of the entrepreneur's path in life. It is a crystallization of the inklings, intuitions, desires, beliefs, and learning leading up to that moment. Put simply, from the epiphany forward, the entrepreneur feels and believes that they must pursue the path they have seen for their vision and themselves. They are driven to have an impact on technology, industry, society or people; to gain new knowledge and skills; to make money; to control their own destiny; to prove they can do it and / or to gain recognition.

Having an epiphany is one thing, making it real is another thing. Getting between those two points requires extraordinary persistence and entails numerous risks and uncertainties. Entrepreneurs generally see opportunity where others might see risk or uncertainty. There is usually greater opportunity associated with greater risk and uncertainty. Risk and uncertainty are judgments about the ability or inability to influence or control a situation or about the results or consequences of an action or inaction. Risk is relative to the people judging the risk, the situation itself and whether the person judging the risk is looking forward or looking backward in time. Entrepreneurs manage risk and uncertainty by understanding their goals, the environment, the players, worldviews, languages, perspectives, intentions, motivations of possibly affected parties; recognizing what they don't understand and their ability or inability to position, influence or control the situation; judging the alternatives and scenarios against their own and others experience, knowledge, information, principles, goals; deciding on action or inaction; and adapting as necessary. Engineers and scientists are often given to amassing data before making a decision. Entrepreneurs realize that it can be dangerous to avoid making a decision because of a lack of information, sometimes the information is simply not available or non-existent, and learn to work with what information, opinions and views are available at the time to reach decisions and take actions.

Look forward, think backward

What does an entrepreneur do?

To be realized, a vision requires time, energy, capital, belief and drive. It is not enough to talk, it is as important to lead and do. Some will look at where they are and what they have to see where they can go (i.e. look forward, think forward). Others will see where they want to go and look at what they need to get there (i.e. look forward, think backward). The approaches sound similar but in fact, are very different. The former is limited to using what resources and information are available, the latter doesn't accept this limitation and determines what needs to become available (i.e. enabling) to realize the vision. The practice of looking forward and thinking backward will identify the enablers and changes needed for future success. Once identified, these enablers and

changes must be encouraged and developed. Incremental visions can be realized with either approach but more disruptive visions usually are realized by looking forward and thinking backward. Disruptive visions may require significant changes to the ecosystem before they can be realized. A handful of individual grains of sand will have very little impact when it is thrown against something. When that same handful of sand is molded into a ball it will have a much greater impact. Entrepreneurial leadership is about molding the individual grains of sand into a coherent whole. Entrepreneurs lead by:

- Giving a voice to the vision and ideas.

- Building and inculturating a team or organization and giving it purpose.

- Identifying and acquiring resources (people, capital, information).

- Removing obstacles and solving problems.

These activities should be performed in the context of a set of values and principles that guide the entrepreneur's behavior. The values and principles will vary from entrepreneur to entrepreneur and should represent his or her's views about how to develop, manage and value relationships with employees, customers, investors and others; what success it and how to create the conditions necessary for success. These values and principles do not necessarily have to be articulated in detail but at as a minimum they should show themselves consistently in the everyday actions and behaviors of the entrepreneur. Transparency and consistency will allow others to understand the motivations, and expectations as well as the likely directions and actions of the entrepreneur which in turn will allow them to act in concert and contribute to the entrepreneur's vision.

The entrepreneur must understand and carefully consider all aspects of the vision and what steps it must be moved through to become real. Entrepreneurs must constantly deal with and move back and forth between broad general issues to mundane detailed issues. Building a company has many challenges, including:

- Creating value through technologies, products, services or content.

- Measuring value in its tangible, intangible, financial and strategic forms.

- Protecting value using trade secrets, copyrights, patents, trademarks, agreements and contracts.

- Positioning the products, services, content and company in the ecosystem.

- Building and managing relationships with customers, employees, shareholders, advisors, media, analysts and suppliers.

The day to day activities of addressing these challenges consist of listening, learning, judging, deciding and communicating. Entrepreneurs are judged by their ability to meet these challenges and the expectations of themselves and others.

The Good, Bad and Ugly

What should an entrepreneur expect?

Entrepreneurs generally commit themselves full-time to realizing their vision. If they are unwilling to make this commitment, then the entrepreneur probably hasn't developed the vision to the point where he or she is confident that it will be realized, or he or she is not an entrepreneur. True

entrepreneurs cannot rest until their ideas have succeeded. During the journey from idea to success entrepreneurs will experience many different feelings and emotions. The hours are long and the personal commitment is usually complete, especially in the early stages of the vision's development. It is not unusual for the entire journey to take many years. The entrepreneur will wake up in the morning thinking about their vision and go to sleep at night thinking about their vision. Work, play and family blur together. The single mindedness of purpose an entrepreneur feels is hard to explain to others. A supportive, patient and understanding family and social network is helpful. Finding somebody to talk to that is familiar, but without a personal stake in, the entrepreneur's vision is also helpful as a means to test, practice and refine thinking and communications skills.

The best idea and vision in the world will not be realized if others can't understand it and can't become excited by it. This is not always easy. Sometimes the vision is too complicated to explain easily, sometimes the markets do not exist or are not fully developed, and sometimes institutions and organizations are not ready for the necessary changes to realize the vision. It is important to understand the worldview and language of the audience the entrepreneur is trying to influence. Scientists, engineers, finance, sales, and marketing people all have very different mental models and views about how they believe the world operates and behaves. These differences manifest themselves in many forms, particularly in language. Entrepreneurs must use this knowledge and make an effort to communicate using the target audience's own world view and language, which is not necessarily the entrepreneur's own, to influence those things that need to be influenced. Indeed, an entrepreneur must be prepared, especially at the leading edge, to create and teach a new vocabulary so that his vision can be understood and embraced the target audience.

Entrepreneurs generally lack some or all of the information, knowledge, experience and skills they need to realize their vision. Entrepreneurs learn very quickly, if they don't know it already, that they can't do everything by themselves. A large part of entrepreneurship consists of on-the-job training and building a team to do the things the entrepreneur can't do his or her self. An interesting question an entrepreneur in nanotechnology must consider as they build their team is whether they should use proven experts from other fields or novices from nanotechnology itself. The former may bring experience to the challenge but the latter may bring energy to the challenge. Time and windows of opportunity are usually short and moving targets so points of view must be established and decisions usually must be made under uncertain and ambiguous circumstances. There are high degrees of uncertainty, risk and ambiguity in trying to realize a vision and it is important to recognize and accept that mistakes will be made. If they aren't made, there won't be progress. Sometimes taking an informed, calculated risk is the best that can be done. It is also important to not take false comfort in numbers since they can be manipulated to represent or support almost any point of view.

The worlds of large and small companies are very different. Resources (i.e. people, capital, and support), systems, awareness and reputation can vary dramatically. The transition between these worlds, although not impossible, can be difficult. Large companies offer an opportunity to learn and make mistakes in a relatively safe environment. They have already established themselves as part of the ecosystem and their survival is usually not an immediate concern. Small companies, on the other hand, tend to be focused on their survival and establishing a niche in the ecosystem. This means that day to day operational issues take priority over more strategic or long-range issues. The advantage small companies have is that their small size and organizational looseness provide them some adaptability and flexibility to move through the ecosystem in ways a large company cannot.

As a practical matter, whether self financed or investor financed, the entrepreneur can at best, expect to sustain their existing lifestyle. The financial rewards of pursuing ones vision, if they are ever realized, probably won't come for many years into the future through some form of liquidity event such as an acquisition, public financing or buyout.

At its heart, any successful business depends on its people. People and their behaviors are not always logical or predictable. Engineers and scientists sometimes have a difficult time dealing with this. During the development of a business the entrepreneur will experience the full breadth of human behavior. Small organizations tend to be self selecting and usually don't represent the entire range of human behavior. As an organization grows in size the odds are that a broader range of human behaviors will be observed, encountered and in some instances be surprising and challenging. Delegating responsibility and authority and letting others do things differently than the way the entrepreneur would do it is also very difficult transition for many entrepreneurs to make. Once they can get through this transition it can be very liberating as they are able to give up things to others and free themselves to do new and interesting things. They must understand their own and evolving value and niche within the ecosystem of their organization and how this will change over time.

Moving a vision forward will be fraught with skepticism, criticism, conflict, surprises and mistakes. The entrepreneur must listen to skepticism or criticism openly, not take it personally, and understand, accept and deal with any truths that may have been expressed, no matter how ugly they might be. It is important to learn from adversity and delight in the surprises. Confidence in ones ability will develop over time. Leadership in its simplest form is about getting people somewhere they don't know they need to be. Inertia will be a strong counter force to change and the act of overcoming it may take large amounts of time and energy. There will be the constant need and opportunity to change and adapt to new situations.

Closing

Is it worth it?

Many people start down the path of entrepreneurship but only a few are successful at fully realizing their vision and other aspirations. Entrepreneurs are driven by the chance to make an impact, to learn, to prove something to themselves or others and / or to make money. Every entrepreneur has their own unique definition of success and list of expectations that they must meet of themselves and others. Successful entrepreneurs have a vision, understand who they serve, understand the visions place in the ecosystem and give purpose to the organization they build. They must throw themselves whole heartedly into realizing their vision and be comfortable with risk, uncertainty and ambiguity; good listeners and learners; strong communicators; adaptable and flexible; and pragmatic problem solvers. The necessary experience and skills are can be developed on the job and by learning from others. Even though there are many things the entrepreneur can control and influence there is also a certain amount of good luck required to be successful. One cannot underestimate the importance of being at the right place at the right time or meeting the right person. An entrepreneur's days can be long, stressful and tiring, but they can also be exhilarating and joyful. The team building and shared struggle of trying to realize a vision can be very intense and satisfying. The potential rewards can be huge. Entrepreneurship is a unique and privileged opportunity to pursue ones vision. Even though the challenges are daunting at times, true entrepreneurs would say their experience, whether or not they were successful, was worth it and in fact, it would be hard for them to imagine having done anything else in their life.

References:

The Tipping Point – Malcom Gladwell

The Innovator's Dilemma – Clayton M. Christensen

The Minding Organization – Moshe F. Rubinstein and Iris R. Firstenberg

The Cartoon Guide to the Environment – Larry Gonick and Alice Outwater

The Road Since Structure – Thomas S. Kuhn

The Wealth of Nations – Adam Smith

Hype cycle – Gartner Group

Personal communications – Larry Bock