"REASSEMBLING THE SOCIAL" IN ENTREPRENEURIAL INNOVATION AND ACADEMIC ENTREPRENEURSHIP STUDIES: THE "AMPHIBIOUS SCIENTIST" PHENOMENON

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First draft (September-October 2015)

A short (and quite different) version of this work was published in: *Fast growing new firms in a slow growth economy: Institutional conditions for innovation,* eds. Francesca Visintin and Daniel Pittino, Edward Elgar Publishing (Chapter 8)

(*) This paper is a collaborative effort as reflected in the alphabetical ordering of authorship. We thank Miranda Lewis and Martina Romano who have served as junior researchers for this case study in the first steps of data collecting and data analysis.

INTRODUCTION

This paper aims to "translate" the research strategy of the Actor-Network Theory (ANT) in Management and Organization Studies (MOS), with reference to research on Academic Entrepreneurship.

First, the concept of “amphibious scientist”, recalled in the title, was introduced in a research program that addresses the emergence of markets and organizations from a sociological perspective. John Padgett and Walter Powell (2012) have investigated the development of biotechnologies, the operation of laboratories dedicated to life sciences and the role of venture capitalists (VCs) in front of the possibilities offered by the new technologies of genetic manipulation developed in the academic field. In particular, Powell and colleagues (Powell, Sandholtz 2012; Powell *et al.* 2012; Powell, Owen-Smith 2012) analyzed the first generation of dedicated biotech firms (DBFs): these companies were founded between 1968 and 1981 by an *amphibious scientist* “who carried scientific practices into the world of commerce”, creating, as a result, “a science-based firm, which was the product of overlapping networks of science, finance, and commerce” (Padgett, Powell 2012, p. 73).

Second, *Reassembling the social. An Introduction of Actor-Network Theory* is the title of a book by Bruno Latour (2005): as Jensen B. Casper recalls, referring to the ontology of technology objects in *Health Care* (2010), the ANT takes into account the social, political and technical dimension of sciences and technology not as indistinct spheres, but as mutually constitutive processes, taking place in “socio-technical networks” (p. 10). The emergence of the amphibious scientist phenomenon allows to investigate the entrepreneurial innovation as a process in which actors and contexts are

co-created; while, entrepreneurial processes are "ongoing process involving embedded actors who contextualize innovation through performative efforts" (Garud *et al.* 2014). In terms of academic entrepreneurship, therefore, the amphibious scientist is an "actor-network", a collective actor where "human and non human materials" (social components, organized practices, artifacts) are"assembled" and stabilized as a result of their field of relations (scientific, business, financial relations) (Padgett and Powell 2012).

The work is developed as follows: the theoretical context problematises the literature on entrepreneurial innovation and academic entrepreneurship. In developing our subjects, the empirical context and the method's section describe the combination between the first DBF and the creation of the Applied Genomics Insitute (IGA) and the IGA-Technology Services (IGA-Tech). The emergence of the amphibious scientist phenomenon as "actor network" characterizes the survey results and discussion in terms of stages of translation process and narrative dimensions of entrepreneurial innovation.

THEORETICAL CONTEXT

In this piece of work, we will deal with "translating" the ANT (or "sociology of translation") (Callon 1986, 1998; Latour 1987, 2005; Law 1986, 1991, 2009), as part of research on academic entrepreneurship. With a view to a *critical investigation* (Alvesson *et al.* 2009), proposing a new vocabulary and emphasizing the emergence of specific and little evident phenomena in other conceptual apparatus, we will pay attention to: (i) the materiality of entrepreneurial processes; (ii) and the role played by

the practice knowledge in these processes; (iii) connecting entrepreneurial innovation in life sciences to academic entrepreneurship in biotechnologies.

The ANT is a research strategy originally linked to the studies on science and technologies and the use of the concept of translation is part of the contributions that the approaches of Science and Technology Studies (STS: Latour 1988, 1999; Latour, Woolgar 1979/1986; Law 1986, 1991) and Social Construction of Technologies (SCOT: Bijker et al. 1987; Knorr Cetina 1981, 1999) gave to the evolution of the MOS (Czarniawska 2005). In this perspective, actors and structures acquire form and features through their relationships with other entities, “through their process of emergence” (Latour 1987). In the case of academic entrepreneur as “actor-network” (Callon 1986; Law 1986; Latour 1987), the phenomenon can be traced back to a process in which “human and non human materials” (social components, organized practices, artifacts) are “assembled” and stabilized as a collective actor, effect more than cause of the field of relations in which the academic entrepreneur is inserted. In different research traditions of the MOS (Czarniawska 2005), actors (individual or collective) develop interactions that "stabilize" in structures, which in turn act as constraints to the following interactions. But if, as suggested by Barbara Czarniawska (1997), you shift the focus on “networks of action”, you may think that these networks produce both identity ("actors") and institutions ("structures"), questioning: (i) both the traditional hierarchy between the "levels of analysis" (micro vs. macro); (ii) and in ontological terms and units of analysis, the customary “individual”, “group”, “organization”, “society” labels. The problem of the relationship between structure and agent resolves, or rather "dissolves", in the priority given "to actions that, when repeated, produce and

reproduce themselves, the individual identities and institutions of a given field" (Czarniawska 1997).

Entrepreneurial innovation. The literature on entrepreneurial innovation, between the role of actors and the role of contexts, let you identify a complementary path within the research program that includes this work (see Chap. 1, in this volume).

In the famous research note, "The Promise Entrepreneurship as a Field of Research", Shane and Venkataram (2000) synthesized three main questions related to the phenomenon of entrepreneurship: "(1) why, when, and how opportunities for the creation of goods and services come into existence; (2) why, when, and how some people and not others discover and exploit these opportunities; (3) why, when, and how different modes of action are used to exploit entrepreneurial opportunities" (p. 218). In the following passages, the same authors questioned some arguments on which research currents were based until then. First, "entrepeneurial behavior is transitory" and, therefore, is not based on the reproduction of situations of "optimal balance" in terms of decision-making. In fact, assuming that only certain people respond to situations where there are signs of opportunities is not a stable characteristic, and entrepreneurial behavior differentiates in time and space. Second, "entrepreneurship does not require, but it can include, the creation of new organizations": namely, existing individuals and organizations can already take advantage of opportunities or be able to exploit them. Furthermore, the proposed framework takes into account the "sociological and economic work in which researchers have examined the population-level factors that influence firm creation" in a complementary way (p. 219). Finally, the authors point out the importance of completing research that examine "the process of firm creation [in terms of] resource mobilization, firm organizing, and market making", based on the

assumption that opportunities are already existent and should be exploited just through the creation of new organizations.

Therefore, based on the suggestions by Shane and Venkataram (2000) and the subsequent developments of the literature (Sarasvathy 2001; Sarasvathy, Venkataram 2011; Shane 2012), building and formulating “innovative” research questions on the evolution of entrepreneurship seems to involve the dialectic comparison between familiar theoretical positions and other needs and approaches (“problematization”) rather than investigating the literature in terms of "gap-spotting"” (Alvesson, Sandberg 2013).

In this respect, the work by Garud and colleagues (2014) opens “new” theoretical and empirical spaces based on the different conceptualization of “contexts” in the entrepreneurial processes (p. 1177): a), identifying the dynamics between the assumptions that characterize *agentic-centric* and *context-centric* perspectives of entrepreneurial innovation (micro-macro approaches); identifying and organizing the development of alternative assumptions derived from observations of "real context" and the "historical context" in the *multilevel approaches*; evaluating these assumptions derived from observation in relation to a “new” point of view, comparing them with the role of entrepreneurial innovation in terms of “ongoing process involving embedded players who contextualize innovation through performative efforts”.

Table 1 summarizes the logic that led to "problematize" the literature on entrepreneurial innovation, based on the conceptualization and different theoretical assumptions related to the role of "context".

Table 1 Perspectives on entrepreneurial innovation (Garud *et al.* 2014)

The combination of "constitutive approaches" to micro-macro approaches (in terms of different units of analyisis) and multilevel approaches (which emphasizes a different object of research), takes place through the different nature of the basic assumptions: on the one hand, the agency component is located in an "ecology of interactions"; on the other hand, actors are "translated through social and material networks". The latter perspective, in particular, comes out from the real observation of phenomena related to ANT perspective: entrepreneurship as collective action "through their process of emergence" (Callon 1986); where to pay attention to "processes of interactive modification between multiple kinds of actors [humans and non humans]" (Latour 1987); and where to understand that market creation (as "calculation centers") implies tracing "how the webs of heterogeneous material and social practices produce them [in a performative sense]" (Law 2009).

In particular, in this paper, we talk about narrative dimensions and processes of signification (Polkinghorne 1988; Czarniawska 1997) produced by actors who are committed to get out "ad hoc" organizational forms for research in life sciences and technology transfer of biotechnologies: i) both in their original configurations of the seventies (Hughes 2011); ii) and in "hybrid" organizational forms of a research laboratory based on the complex semantics of modern molecular biology and bioinformatics (Myers 2015). As we shall see, based on what is proposed by Garud and colleagues (2014): "a narrative perspective draws attention to attempts by entrepreneurs to contextualize innovation through relational, temporal and performative efforts" (p. 1181).

Academic Entrepreneurship. According to Schatzki, social sciences are interested in the concept of *practice* on the basis of a simple idea: "phenomena such as

knowledge, meaning, human activity, science power, language, social institutions, and human transformation occur within and are aspects or components of the field of pratices" (2002, p. 2). In the MOS, practice-based theories (Nicolini 2012) represent the most common theoretical framework where to set the ANT in terms of research strategy (Gherardi 2012; Nicolini 2012): "a pragmatic effort of respecifying the study of the social in terms of networks, assemblage, nexuses, and textures of mediated practices" (Jensen 2010). As recalled by Jensen (2010), the first approach to practices in the STS is as much an "analytical starting point" as an "empirical focus for social inquiry". Thereofore, from one hand, it is not too difficult thinking of practices as an empirical category, a "natural" component of the social world in the form of "meaningfulness": namely, in terms of actual activities through which a group of scientists and technologists works to define and achieve its goals. By contrast, in a more difficult way, problematic practices also designate an analytical approach, that is to say, in Latour's words: "it is as if scientific practice, technical practice, and political practice led into entirely different realms than those of theory of science, theory of techniques, theory of politics" (1999, p. 266).

Emphasizing the inseparability between the conceptual and the empirical leads to a situation of "mutual constitution" for which the same Latour coined the neologism "factish" (1999). In this paper, the amphibious scientist phenomenon is introduced just with empirical and anlytical purposes.

With regard to the first aspect, it is possible to observe scientists and technologists struggling with organizational and management practices that "shape" new models for technological transfer from *life sciences* through biotechnological products. From the analytical perspective, innovation in academic entrepreneurship in

terms of new organizational forms “emerges across multiple, intertwined social networks” (Powell e Sandholtz 2012a, 2012b). In other words, in the theoretical proposal by Padgett and Powell (2012), new practices and organizational models are the result of processes of combinations between attributes and practices coming from the different social dimensions in which the amphibious scientist acts at the same time. The research program by Padgett and Powell (2012) enables a particular connection between the levels of analysis in this work: “combining biochemical insights about the origin of life with innovative and historically oriented social network analyses”; and through two temporal dimensions of the phenomenon for which “in the short run, actors create relations, [and] in the long run, relations create actors” (2012, chapter 1).

In description terms, the amphibious scientist phenomenon simply refers to the figure of a scientist who, simultaneously, has a leading position in the laboratories and university departments where he/she works, as well as in the relevant DBFs, meant as an emerging organizational form. In analytical terms, the amphibious scientist as actor-network allows to reconstruct the way in which the meanings that the collective actors give to a commercial entity to exploit a science-based innovation are formed. Initially, a DBF assumes unstable configurations through the overlapping of *scientific*, *financial* and *commercial contexts* in which the scientist is located strategically and “in which relational practices flow”, stabilizing the form (Powell and Sandholtz 2012a). This perspective uses a biological metaphor (“extention of autocatalytic theory to social applications [in terms of] production and biographical autocatalysis”: Padget, Powell 2012, p. 10), an evolutionary proposal: *à la* Schumpeter, in terms of relation between invention and innovation; and, in some ways, *à la* Nelson and Winter when addressing the "recombination" of conceptual and physical materials as vital components of

"novelty" and change processes in "socio-technical" systems. In the case of academic entrepreneurship, Powell and Sandholtz (2012b) "examine how entrepreneurs cobble together different practices and templates to fashion ner organizational forms", conceptualizing the distinction between two types of recombination (p. 94): a) "*reconfiguration*, a mechanism through which familiar attributes and elements are put together in new but recognizable ways"; b) "*transposition*, a mechanism through which attributes and elements are introduced into foreign domains, spawning new-to-the-world forms of organizing".

In terms of practice-approach (Nicolini 2012), what is important from the perspective of context of analysis is not so much "what is done in terms of execution as how it is done, what sense it has and what relations it establishes" (Gherardi 2012, p. 196). The bases of this proposal are to consider the work of scientists and technologists not just as an interaction, but in terms of "knowledge in action", a practical "knowing-how" that links "the elements of practices within a texture" (*ibidem*, p. 197).

EMPIRICAL CONTEXT

The amphibious scientist phenomenon came out by investigating two specific empirical situations: the entrepreneurial events that "shaped" the first corporates dedicated to biotechnologies (1968-1981); the foundation of a research center of applied genomics and a spin-off for the management of the laboratory and scientific services related to it (between 2005 and 2009).

The concept of amphibious scientist let us to go over the history of biotechnology again in terms of academic entrepreneurship, to understand what will

happen later, starting from early 80s: how they managed to establish the idea that universities, through research in scientific and, specifically, academic fields (life sciences), could contribute directly to economic growth through innovation (technological and organizational innovation in biotechnology), and literally building new markets or changing existing sectors (as in the pharmaceutical sector or therapeutic diagnostics).

When connecting the two contexts of research, this paper will address the issue of academic entrepreneurship assuming that the "translation" of new ideas (scientific knowledge) in the "real"economy and the impact of such innovations (technologies as artifacts) was the consequence, rather than the cause, of a collective movement based on the meaning given to the relation between "academic science" and"commercial world". The organizational practices that Elizabeth Bernman (2012) traces back to "biotech entrepreneurship", "university patenting" and "university-industry research centers" (p. 10) are the emergence of new organizational forms (such as DBFs). In terms of entrepreneurial innovation, the DBFs emerge within the phenomenon of amphibious scientist, a "social object" able to create a network of relationships around three issues: how the DBFs, as identities, could approach the world of science from which they came; how they "enrolled" the necessary funding for the evolution of life sciences; and how they "stabilized" their position in a market created by themselves.

Creating the "Market University": Life Science and Biotech between 1968-1981. Any sociology of organizational components of technology transfer in life sciences seems due to what happened in two specific areas in the United States (San Francisco and Boston), starting from the 80's. This paper will pay particular attention to the "background" of the history and a different period in which to "follow actors and the

sense of their action" (Latour 1987), considering the "pioneers" of the academic entrepreneurship in biotechnologies (tables 2a and 2b).

Table 2a and 2b – Distinctive features of early biotech firms

(Powell, Sandholtz 2012a)

In the fervor of findings in the *life sciences*, scientists have not expected that "others" formed a sociology that redefined the "society" (Latour 1987). In that particular historical period, before the "technical usability" of recombinant DNA (rDNA) became a "black-box" (a ready to use technology) and the "social legitimacy" of biotech terms was reduced to a matter of "technological transfer" (an obliged stage), scientists redefined "the concept of society and what constitutes it" (Latour 2005; Law 2009). In early 70s Harvard, the MIT and Cambridge University, as well as California and Stanford University, played a considerable role for the creation of the rDNA. Moreover, the seminal works by Herbert Boyer (UCSF) and Stanley Cohen (Stanford), published in 1973 and 1974 within the *Proceedings of National Academy of Sciences* (Cohen *et al.* 1973; Morrow *et al.* 1974), had huge consequences in terms of economic development linked to cloning techniques and the subsequent emphasis on the commercial exploitation of the first biotechnology products (synthesized antibiotics, hormones, and enzymes). In April 1977, the Time cover story titled: "The DNA Furor: Tinkering with Life"; and just a few years later, in May 1981, the title "Shaping Life in the Lab: The Boom in Genetic Engineering" celebrated, on the front page, with the moustached big face of Herbert Boyer, the huge financial success of the Genentech (Hughes, 2011). Between November 1977 and June 1978, "three policy decisions were made that

contributed to the unleashing of a wave of entrepreneurship in the biosciences" (Berman 2012a: p. 98): the decision of not acting, from a legislative perspective, to regulate the use of rDNA; the"Revenue Act", which cut "capital gain taxes", favoring investments; the change in the regulation on the investments of pension funds, allowing the entry in the "venture capital funds" (ERISA and "Prudent Man" rulings). Powell and Sandholtz (2012a, 2012b) and Berman (2012a) agreed that "policy decisions and innovation arguments were not the most important factors in explaining the take off of the market logic [in the university system]" (p. 102). At the beginning of 1978, in fact, only three start-ups (Cetus, Genentech and Genex) marketed products related to rDNA technology. On the other hand, the growing number of scholars (including many Nobel Prize Winners), which was involved in biotech start-ups in the following years, does not seem justifiable only with these interventions of industrial policy. Similarly, the famous "Diamond v. Chakrabarty" ruling in June 1980, through which the US Supreme Court recognized the right to patent living microorganisms produced by the development of molecular biology, cannot be considered as the starting point of a movement with a more structured origin. Companies, research institutions, investors (for example, the same Genentech, the Pharmaceutical Manufacturers Association, the University of California, the American Society for Microbiology) have long bet on the importance of patents in this field to encourage technologic innovation, genetic engineering, and the competitiveness of the entire high-tech system of the United States.

A laboratory in a research center. The timeline of Figure 1 shows the whirling development of NGS technologies in a decade, overlapping the temporal sequence of some research projects that, at an international level, have characterized the scene of molecular biology studies (for example, HapMap Project, 1000 Genomes Project, or

ENCODE-ENCyclopedia Of DNA Elements). The decade after the publication of the first sequence draft of human genome (2001) and the end of the Human Genome Project, studies on genomics developed strongly (source: http://www.genome.gov/10001772). For example, the National Human Genome Research Institute, in the USA, constantly publishes updatings and highly detailed long research programs based on the evolution of genomics and molecular biology (source: http://www.genome.gov/ResearchAtNHGRI/). Currently, scholars seem to agree on the nature and future scientific developments, linked to: i) five fundamentals (understanding of the genome structure; study of genome biology; understanding of disease biology; advances related to science; development of an effective health care system); ii) and three important cross-cutting areas to the entire spectrum of findings in life sciences and their application in biotechnologies (bioinformatics and computational biology; training and refresher courses; the relationship between genomics and society).

Figure 1 A timeline of events

The IGA was founded in 2006 by four scholars interested in the development of research applied to the genome of plants, in an important phase of this historical path: both from the perspective of technological development that would have characterized the sequencing techniques; and with regard to the development of research programs that linked the genome biology to medical therapy (Hughes 2011, Myers 2015).

Raffaele, Michele, Alberto and Gabriele (see table 3) came from three different departments of the same university: Agriculture, Biology, Mathematics and Computer Science. Raffaele played a crucial role in linking research to agriculture,

biotechnologies and patenting on agricultural plants. Moreover, thanks to his high status and availability, Raffaele played an important role as link during the establishment of the Institute and for the work teams within the IGA, guided by Gabriele (the youngest scholar in the team), Michele and Alberto. The last two are the senior scientists on which the IGA research activity is based; they belong to the same generation and, for their respective areas of research, have a scientific profile recognized worldwide. In particular, Michele was able to complete his education by making a direct experience, between Italy and the USA, of what has been achieved within the IGA later on. Several times, until 2002, Michele worked in the Agriculture Products Department of the DuPont Labs in Wilmington (as post-doc and Senior Scientist) being at the head of the research group dedicated to the maize genome and the construction of its physical map. In the same years, Alberto laid the foundation of a group of biocomputer scientists that still work to plant genomics projects, between the University, the IGA and the IGA-Tech.

The IGA-Tech was established in 2009 to independently manage the research lab that had recently been re-equipped with NGS machinery, as a result of the substantial funding related to the project for the grapevine genome, officially launched in 2005.

The cases identified by Powell and Sandholtz (2012) (in tables 10.2) and the analysis of the IGA and the IGA-Tech (considered as a single research site) are interesting research contexts for different reasons. First, the different stories have proven to be excellent examples of "stories from the field" (Czarniawska 1997), allowing to observe just the "action networks" that constitute the unit of analysis of this survey. Furthermore, with regard to the object of the research (the emergence of the

amphibious scientist phenomenon), the two research situations (the origin of DBF in the seventies and the formation of a contemporary version) allowed to face the evolution of organizational practices in their respective generative periods, which is a very rare aspect in the MOS. Finally, connecting the two events, it was possible to overlap the origin of the first DBFs and the evolution of the symbiotic relationship between the IGA and IGA-Tech: i) by retrospectively identifying the relational feautures that stabilized the configuration of the amphibious scientist as actor-network (configuring the DBFs); ii) describing and analyzing the phenomenon of the amphibious scientist "in action", in the case of a contemporary and necessarily "hybrid" DBF, i.e. before the organizational practices would let it take a"stabilized" form.

METHODS

Data collection

To introduce the research strategy of the ANT and analyze the emergence of the amphibious scientist phenomenon, this paper is considered an ethnographic case study (Garfinkel 1967; Van Maanen 1988; Agar 1996), following an interpretative approach (Marcus, Fischer 1999) between historical institutionalism and historicism in entrepreneurship theory (Bucheli, Wadhwani 2014).

Table 3 summarizes the material used in the research, the categories of interviewed informers and the different types of collected material. To investigate the origin and the functioning of IGA and IGA-Tech, we have reconstructed the history of the first project (the grapevine genome), collected the documents on the following major research projects, business plan, financial documents, articles from national and

international press review, scientific publications linked to the team of founders and the network of research partnerships. The interviews took place between spring and summer 2014; in a following research stage, until spring 2015, the work team focused on the history of the entrepreneurial team and the research groups within the IGA and IGA-Tech, with a particular attention to the core skills of the bio computer scientists.

Table 3 Informants, data and archives collected in the research sites

To develop the analyisis on the origins of academic entreprenurship in life sciences, we started from the research project by Powell and Sandholtz (2012a, 2012b), recovering the rich archives materials and the stored interviews from the "Oral History Project-Regional Oral History Office, The Bancroft Library", of the University of California, Berkley. Moreover, other secondary sources have been collected (Hughes 2011; Stevens 2013; Myers 2015) as well as the stories from the *Life Sciences Foundation* (published, in particular, in the six-month magazine).

Analytic process: ANT as research strategy

Based on the suggestions by Padgett and Powell (2012), also in this paper, the two mechanisms (reconfiguration and transposition) that characterize the founding models of the DBFs, bolster a two-level innovative process compared to the time factor: both in terms of "historical time" (long-term) and "biographical time" (short-term). In line with the proposal of the constitutive approaches in the literature of entrepreneurial innovation (Garud *et al.* 2014), in any case, "history works through and within individuals" (p. 15).

In the long term, relationships produce actors, so that the historical institutionalism (Suddaby, Foster e Mills, in Bucheli, Wadhwani 2014, chapter 4), suggests to pay attention to (p. 101): i) how “diffused practices change as they move through time and space”; ii) the fact that “there is a sedimentation effect in which the adoption of earlier practices influences the expression of later practices”; iii) and, at the end, what is “the role of history in processes of diffusion”.

By contrast, the “biographical time” dimension is a historical reasoning more inclined to investigate how the "context" and "change" are essential for the collective construction of entrepreneurial processes (Wadhwani and Jones, in Bucheli, Wadhwani 2014, chapter 8). The narrative approach to entrepreneurial innovation, in fact, gets an idea of temporality that “includes not only an individual’s personal experience of time, but also one’s awareness od a ‘social’ past that shape one’s relationship to social groups […] and to collective identities” (*ibidem*, p. 208).

The theoretical context of the research comes out just from what was found by the empirical observation of the context described in the previous section: both the characteristics and features that *assemble* the original DBFs in terms of entrepreneurial innovation; and their “dynamic” dimension, linked to the fact that the academic entrepreneur *translates into practice* the social components of the field strengths that contain and produce him/her as actor-network.

Table 10.4 summarizes “some proofs or signals of organizational features that led to the creation of new roles and amphibious identities, novel organizational practices, and the invention of the science-based firms” (Powell et al. 2012, p. 438).

Table 4 Constructs supporting three models of DBFs (Powell, Sandholtz 2012a)

In particular, it is just in the ethnomethodology field (Garfinkel 1967) that the empirical ability of the ANT is shaped ("describe networks by following the actor into translations", Latour 2005), as in the case of the studies of scientific laboratories (Latour, Woolgar 1979; Latour 1987). The language that we have introduced so far revolves around the concept of *translation*, which is pivotal in the ANT, and according to Callon (1986), it provides: "the existence of a unified field of meaning, attention and interest, that is, the expression a common desire to achieve the same result. Translating involves creating confluences and homologies by relating things that initially were distant" (p. 211). On the one hand, with a perspective of *materiality of the social world*, actors (people and things) are effects of the relationship field where they are included, which defines their features in a social ordering process. On the other side, the ethnomethodology and the ANT complement each other without considering the existing structures but conceiving the modes of ordering as a *performance* that needs to be continuously developed (Garfinkel 1967).

Through the lexicon of the ANT, in the intepretive part of this work, we will reconstruct: i) the work of the first scientists called to impose themselves and to say to others their definition of technology transfer in the life sciences through the artifacts of biotechnology (the four phases of the translation process: problematization, interest, assolement and mobilization); ii) and we will see how, from an organizational perspective, the amphibious scientist phenomenon allows to define "the social, institutional, conceptual and material" through the way these dimensions are related narratively (Gherardi 2012), so that "to study their configurations [...] it is enough to follow their associations" (Latour 2005).

FINDINGS

If the technological, institutional and regulatory developments seem not to be enough factors to understand the emergence of the DBFs, the focus shifts on:

a) how elements coming from scientific, commercial and financial contexts can flow in the form of networks of action from those domains, so as to create new organizational boundaries;
b) how these social dynamics can be fueled by new practices able to stabilize the meaning given to it in terms of collective action.

Overlapping the two stories in terms of institutional history and biographical time, we will see the characteristics of the first generation DBFs come out (in the first part) and how these characteristics are mixed when the amphibious scientist is "in action" in search for a new "stabilization" in hybrid organizational models (the symbiotic relationship between the IGA and IGA-Tech).

"Attack of the cloners": DBF emergence (1968-1981)

Arthur Kornberg was one of the most important and influential biochemists in the 20th century, Nobel Prize winner and protagonist of great scientific findings in Stanford. He was an ALZA consultant and cofounder of DNAX, and he described the atmosphere of the "race to patents" in life sciences as follows:

"Is biotechnology good or bad? […] I think like any new technology, any invention, [rDNA technology] can be some of both. […] The heroes and heroines of Stanford-UCSF patent have many accolades at the moment. But in the very long run, one wonders about the negative consequences of that patent, not so much the patent itself, but the whole climate that it generated here and everywhere else" (Kornberg 1998).

As suggested by Kornberg, when people try to cope with new organizational situations, such as in the case of the atmosphere of optimism about biotechnologies, they "survey their social worlds for cues about appropriate action, drawing on their existing knowledge and routines" (Powell, Sandholtz 2012b). The "assembly" process outlined in table 5 gives the analogy between organizational dynamics and the biochemistry of the theoretical proposal by Padgett and Powell (2012), on which the concept of coevolution of "multiple social networks" through the first order constructs described in table 5 is based.

Table 5 Two variants of a new form (Powell, Sandholtz 2012b)

The features of the two DBF versions (that combine "science and finance" or "finance and commerce"), identified in the enterprise groups proposed by Powell and Sandholtz (2012a, 2012b), seem to stir the assumptions of the linear processes of scientific discovery and the exploitation of technological opportunities, at the root of much of the literature on entreprenurship. In fact, there is the presence of a good deal of "chance, necessity, and naïveté – rarely mentioned in explanations of entrepreneurial outcomes – [but] essential in the invention of new organizational models" (2012b: p. 94). The original meanings of a DBF are present in the entrepreneurial experience regarded as the reference model. The case of ALZA, founded by Alejandro Zaffaroni, let us appreciate what thinking in terms of "relational materialism" implies, considering the heterogeneity "within and between overlapping networks" (Law 2009). For the DBFs, the social domains where the founders' team is startegically located and from which the relational practices flow into the new organizational entity, are the sources of

meaning for "cognitive materials" and "artifacts" that converge in the emerging entrepreneurial experiences.

ALZA: A First Prototype of DBF. Kornberg himself was long reluctant to the idea of supporting the climate around the "heroines and heroes of the rDNA". Consider this passage (Kornberg 1998):

"Chemistry departments traditionally were tightly linked with industry. Stanford, when I got here in 1959, had as one of its guidelines that faculty members could spend one day a week outside the university in some other activity. One day a week! But in biology it was utterly unknown. That's where the revolution was [in the late 1970s]. […] It was completely novel. No one expected the extent of it. I had avoided consultantships or any dealings with the pharmaceutical industry. […] My virginity ended when Zaffaroni started ALZA. I liked him so much and he was so inspiring as a colleague that when he started this new venture and asked me to join his advisory board, I was interested and felt flattered. I served on that board for twelve years and I learned a lot about applied science and business – production, chemical trials, regulatory approval, and marketing. I learned how difficult it is to translate a good discovery to a point where it is a marketable, profitable product. Without that you're out of business. For example, growing polio virus in a kidney cell in a test tube was an important feat and earned John Enders and colleagues a Nobel prize. But until it was put into children in a reliable, acceptable, marketable form and proved its utility, the job was not finished".

The figure of Zaffaroni was instrumental to define the identity of actors and build meaning through the ties that would unite them: it was about describing a system of alliances (*associations*, in the ANT language) where the scientific values could become the way through which the new entrepreneurial realities were "credible", "acceptable" and "legitimate", especially for the protagonists.

Zaffaroni was probably the first "serial entrepreneur" in the history of science-based start-ups (Kornberg 1998): during his very long experience, Zaffaroni launched at least half a dozen of biotech enterprises (DNAX, 1980; Affymax, 1988; Affymetrix, 1991; Symyx Technologies, 1994; Maxygen, 1997; Alexza, 2000). Powell and Sandholtz (2012a) considered ALZA as a real prototype: like Cetus (table 10.2a), it was

founded before the publications on the “gene splicing” (1973) and “monoclonal antibodies” (1975). Moreover, it was based on the previous experience of Zaffaroni at Syntex, a small pharmaceutical company in Mexico that would become the first company in the industry to move to the United States.

Zaffaroni was born in Uruguay and, after the death of his parents, left his country to follow his passion for biochemistry. In his stories, he often recalled the journey to New York by sea from Montevideo: between July 29 and August 16, 1945, it coincided with the sad event of the launch of the two atomic bombs that marked the end of the war (D’Andrade 2001). He managed to get his education and training at the main academic institutions of that period: despite he was admitted to Harvard, he decided to study at the University of Rochester, “It offered what I have sought all my life: intellectual freedom and professional autonomy to pursue my own interests” (LSF Magazine, 2014, p. 22). Between 1949 and 1951, he completed his PhD thanks to a grant by the NIH (National Institutes of Health), developing an original work on steroid hormones. Driven by leading academic institutions, he immediately began his adventure at Syntex, Mexico City, contributing to the technical and commercial success of that small chemical enterprise for the following ten years. Founded thanks to private funding, the direction of Zaffaroni, the then CEO George Rosenkranz and the biochemist Carl Djerassi, Syntex became an advanced research laboratory that was definitely turned into a pharmaceutical enteprise. In 1962, Zaffaroni was among the proponents of Syntex relocation to Palo Alto, in the heart of the Silicon Valley.

In 1968, Zaffaroni left Syntex to develop “novel drug delivery technologies” in his own enterprise, ALZA. Zaffaroni explained his incredible attraction for entrepreneurship as follows: “Truly exiting innovations rarely come from large,

established companies. It's the new, small groups that risk life and death for innovation. I always liked taking risks and proving myself" (LSF Magazine, Spring 2014, p. 23).

Every story of this entrepreneurial venture has at least one common element. Zaffaroni loved to gather the best talented people, young scientists, engineers, managers round himself who should, first of all, show a certain willingness to "think outside the box": "He possessed a singular ability to inspire talented people, and to imbue collective projects with his own unique enthusiasm and spirit. Most remarkable was the rare combination of all these attributes embodied in the same person" (LSF Magazine, Winter, 2013).

The recruitment of his deputy financial manager was significant. Martin Gerstel was the expression of the evolving environment of the Business Schools in the USA: one of the best MBAs class 1968 students in Stanford, was destined to one of the many offers from Boston and Detroit. "We sat, had tea, and talked about the world. We discussed nothing about business – zero!" Gerstel recalls, thinking back to the first meeting at Syntex headquarters, "and he asked me about my philosphy of life". Later, Gerstel was acquainted with ALZA foundation, and although he did not know anything about the pharmaceutical industry, "Instantly, I said 'Yes, I'd love to'. There was just something about him" (LSF Magazine, Fall 2012, p. 30). Similarly, young scientists and engineers had to be not only talented, but they had to accompany their potential with passion and enthusiasm; as well as "the company's business and finance professionals also had to understand the founder's commitment to excellence" (LSF Magazine, Winter 2013, p. 29). ALZA organizational culture reflected the soul of its leader and his clear vision on what Zaffaroni considered as "business maturation": "We would grow, I hoped, not by expansion, the way most American corporations did, but in a much

stronger and more creative, even been biological way, the way cells themselves grow: we would grow by division".

ALZA was a huge technical success: in 1974, the Food and Drug Administration (FDA) approved the first product and, in the following years, the innovative drug delivery technologies by ALZA were used in thirty commercial products, sold in more than seventy countries and based on different medical platforms. ALZA inventors produced over a thousand patents and, in the same years, the financial evolution of the company was characterized by clever choices that guaranteed its independence for a long time (only in 2001, ALZA was taken over by Johnson & Johnson for $10,5 billion). With respect to these circumstances, the following description by Powell and Sandholtz (2012a) is very interesting:

"As part of the original separation agreement between Zaffaroni and Syntex, Syntex was granted 25 percent of ALZA's stock. As it became clear in 1969 that ALZA was developing a birth-control product that would compete directly with Syntex's pill, the two companies agreed that Syntex would distribute all of its ALZA shares to existing Syntex shareholders. The SEC, initially resistant, eventually approved the plan. In effect, ALZA instantly became a publicly traded company with an army of shareholders and market capitalization close to $100 million – all without a single product or any assurance that it would ever have any sales, much less profits. The company consisted of only a handful of employees and Zaffaroni's vision for revolutionizing drug delivery. For ALZA to go public at such an early stage established a precedent followed by many fledgling biotech companies in subsequent years" (p. 410)

Transposition: A Science-Based Variant. The first DBF variant has a particular configuration of the general features (table 10.6): a) noted scientists on the founding team; b) founder who alternated between academia and the start-up; c) and the absence of a senior executive from Big Pharma. Different episodes and situations in the stories of Genentech, Cetus or Biogen are representative.

Robert Swanson (co-founder, CEO and Chairman of Genentech until 1996) described the "research based" characteristics of the organization, led by a scientist-founder as Herbert Boyer, as follows:

"*Boyer's philosophy, which I agreed with, was that you gain more from interaction with your academic peers than you give up by telling the competition where you are. So with interaction you can move quicker; you gain more people willing to collaborate with you. We knew then we weren't going to have all the best ideas, and we said, where do the academic scientists go when they have an idea that they think needs to be commercialized? We want them to think of us first. We want them to come to Genentech first, because this is a group of scientists that are well published and that a university scientist would be proud to collaborate with on a scientific basis, and where I know they can get this product developed and make it available. So that was a goal from the very beginning".*

Swanson had graduated from the MIT (BS in chemistry, MS in management): "I started work at Citicorp VC [and] in 1973 I was chosen to come out to California to set up our West Coast office" (Hughes 2011). In 1974, Swanson decided to leave the Citicorp to meet Eugene Kleiner and Thomas Perkins, VCs in San Francisco (Swanson 2001; D'Andreade 2001; Perkins 2002). Swanson had the task of monitoring the investment of Kleiner and Perkins in Cetus (Cape 2006): a few years later, the VCs left the company, while their young partner decided to stay there since he was fascinated by the story of Donald A. Glaser (Nobel Prize winner a few years before and Cetus co-founder with Ronald Cape and Pete Farley) on bio sciences (Boyer 2001; Glaser 2006). In the first years of rDNA spreading, Cetus was not the only company to have hesitated a long time about the opportunities that this technology could provide. Only in 1978, "Cetus lab become operational and the first explanatory rDNA experiments were launched" (Cape 2006). By contrast, Genentech was founded around the quite complementary trends that characterized both founders: on the one hand, Boyer went on

publishing his scientific works with dynamism; on the other hand, Swanson developed a coherent business idea with the VCs. As a result, a few years later, Kornberg himself recognized the uniqueness of Genentech: "Unlike other biotech ventures, with a seasoned scientist or a distinguished board of scientific advisors for guidance, Genentech relied on its 'Young Turks', unheralded but talented, industrious, and highly motivated to succeed". Between 1980 and 2001, "Genentech published more highly cited bioscience papers than any other institution except MIT" (Powell, Snadholtz 2012a: p. 420).

For many ventures like that, scientists-founders did not have the problem of legitimizing their actions and the arrangement of Science Advisor Board composed of "all-star" scholars was unnecessary for them: what should be preserved and that could be already ensured by founders without relying on "high-powered external committee" (Cape 2006), was the ability to maintain connections with the high level scientific world, both in terms of relationship and academic field.

Conversely, from a strategic point of view, financial and commercial dimensions were strongly affected by the "good science": "networked enterprises", around the research projects in life sciences, became a sort of "tacit blueprints" (Powell, Snadholtz 2012a). The following story of the VC Perkins (2002) is representative and refers to the period of the IPO by Genentech in 1980:

"We didn't have a clue how to price the stock. We knew it was going to be a hot issue, and oversubscribed. But Swanson, the board, the management, the investment bankers – we were all caught somewhat by surprise. We could have sold less stock at a higher price. It came out at thirty-five, shot up to eighty-five, then drifted back down. But that spread brought world-wide publicity. Everybody knew about Genentech. It was fantastic. It established the idea that you could start a new biotechnology company, raise obscene amounts of money, hire good employees, sell stock to the public. Our competitors started doing all of that, so much so that it became an impediment for us to

hire and retain employees. We started to lose employees to other biotech startups. Our employees had originally acquired our stock as common stock. We were able to justify a ten-to-one difference in price. So if the preferred stock was at thirty-five a share, then employees got common at three-fifty a share... But you can only do that once. Once it becomes a public stock, the preferred shares convert to common and everyone is on the same platform. So how are we going to continue to attract these people? Continue to hold these people? It was a big problem"

A further example is that of Biogen, "a company run by its scientists" as defined by Hugh D'Andrade (one of the first members of the Board) (D'Andrade 2001). In 1978, some important VCs met some of the most influential molecular biologists in the world (LSF Magazine, 2014, Spring). Walter Gilbert (physicist and molecular biologist, Nobel Prize in 1980) played a key role in negotiating between the proposals of the VCs and the positions of scholars. Gilbert had a strong credibility, even for his contrariness to the relationship between industry and biosciences that he had since the period of Harvard. Gilbert had a bright and influential personality; he was appreciated for his intellectual honesty and he was highly respected by his peers and students. Therefore, his change of opinion persuaded Philip Shape, another highly respected molecular biologist from the MIT, gaining the approval of the entire group of the Geneva conference later on. After three weeks, during another meeting in Paris, the biologists signed a first agreement for the establishment of a start-up, with a "memorable" business plan assuring that "they would retain control of the company's research programs" (LSF Magazine, Winter 2013).

Reconfiguration: Different Commerce-Based Variants. DBF variants based on the connection between financial and commercial dimensions, have these general features (table 10.6): a) active publishing was not constitutive in their formative years; b) science and scientists stayed in the firm but were less connected to the broader scientific domain; c) and interaction between finance and commerce flows indicated an

investment strategy based on “commercialization” into profitable and existing markets. Processes of reconfiguration of organizational practices related to these features can be traced back to experiences such as Amgen, Centocor, or Hybritech.

As suggested by Powell and Sandholtz (2012a), “a unifying theme in these firms’ histories is separation of the academic from the commercial” (p. 107), where in the first DBF variants, the “academic” dimension *is translated into* the “commercial” dimension. In the case of Centocor, the vision was quite clear, “to be the bridge from the academic research laboratory to the established health care supplier”, based on an innovative strategy of licensing from academic and non-profit laboratories (Rathmann 2004; Byers 2006). However, some episodes revealed the criticality of some practices. For example, Hilary Koprowski, manager of the Wistar Institute, strongly believed in the commercialization of monoclonal antibody technology, as scientist-founder of Centocor and scientific person in charge of the Institute: but just before the IPO in 1982, this situation led him to clash with several colleagues as to resign from Centocor managership to avoid jeopardizing the action, which was necessary to refund his research. On closer inspection, the disagreements with the Wistar began during the first licensing experience of Centocor, exclusive holder of the license of a patent from the Insitute: on that occasion, many colleagues in the Board blamed Koprowski for being in a difficult situation of conflict of interests (Byers 2006; Cape 2006). After these episodes, in order to ride the explosion of commercialization of biotechnologies in the early eighties and to pursue the goal of becoming a fully integrated pharmaceutial company, Centocor broadened its activities to diagnostic and therapeutic tools (Powell, Sandholtz 2012a):

«Hubert Schoemaker (the firm's first executive hire in February 1980), "bet the company on FDA approval of Centocor's first drug, […] making costly investments in proprietary manufacturing and sales capabilities. When the FDA denied [drug's] application 1992, Centocor barely survived. Michael Wall [the original founder and executive], then in semi-retirement, came back as chairman and helped Schoemaker cut two-thirds of the company's workforce, regrouping around a pair of promising therapeutics. This marked a return to the "bridge" model of drug development» (p. 415).

Wall was an entrepreneur and experienced manager within the group of Centocor founders. He was an electronics engineer who graduated at the MIT and worked at different electronics start-ups. In 1960, "he shifted his focus to health care and founded a medical products firm that he and his partners sold in 1969 for $3 million" (Powell, Sandholtz 2012: p. 414). Schoemaker was Dutch, had a PhD in biochemistry and a funny personality: as recalled by Powell and Sandholtz (2012), "in a way, [he was] a mixture of the other founders. Like Wall, Schoemaker had ample business and managerial experience; like Koprowski and Zurawski, he had extensive training from an elite institution in a discipline relevant to the new venture's scientific goals" (p. 415). If, on the one hand, this did not prevent him from making risky choices, on the other hand, he stayed cool, turned back and asked his predecessor for help. This managerial/commercial dimension comes out also by the stories of Gordon Binden, CEO and CFO at Amgen, who considered this structural component significant: "Much of Amgen's success in raising capital can be attributed to the fact that every one of our senior managers had worked for large corporations" (p. 411). George Rathmann (CEO, and president of Amgen, 1980-1988), in his turn, underlined how Amgen was characterized "to be science based but not science led" (Rathmann 2004). Rathmann (PhD in chemistry at Princeton) spent the first twenty years of his career in important private ventures (3M, Minnesota Mining and Manufactuing

Company and Litton Industries). Later on, he joined the Abbott Labs as R&D vice president. In that period, also Rathmann began to fit in the plots of the financial circles of the industry: a famous VC like Moshe Alafi (investor in both Amgen and Biogen, as well as one of Cetus founders), "tried to recruit Rathmann to run the US operations of Biogen. In the end, Rathmann opted for freedom and control offered by Amgen" (Powell, Sandholtz 2012: 411).

Ivor Royston (biomedical research at UC-San Diego, and Hybritech founder) moved to the same direction, but with a more remarkable entrepreneurial spirit:

«Hybritech was a successful IPO in 1981 and was sold to Eli Lilly in 1985 for nearly $400 million – the first biotech company to be sold at a premium to an established pharmaceutical company. The acquisition turned out to be a commercial failure, but an overwhelming institutional success: disaffected with corporate life but wealthy, Hybritech's founding executives and scientists went on to found dozens of biotech ventures and establish San Diego as one of the three dominant hubs of biotech activity in the US» (p. 426).

In terms of commercial and financial contexts, Royston was in the position "to observe the Bay Area biotech scene during its formative era", and as Powell and Sandholtz (2012) underlined, "he saw as his role model Herb Boyer at UCSF" (p. 426). Sally Hughes (2011) recalls how, in spite of the criticism and the general disapproval of the scientific community in San Diego, Royston kept a quite clear position: "Genentech's IPO transformed Herb Boyer, the small-town guy of blue-collar origins, into molecular biology's first industrial multimillionaire. He became a conspicuous inspiration for how their own research might be reoriented and their reputations enhanced" (p. 253).

On March 17, 1980, the US Supreme Court ruled in *Diamond vs Chakraharty* that living things were eligible for intellectual property protection. The Cohen-Boyer

process patent was granted on December 2, 1980. In August 1982, the NIH's rDNA Advisory Committee issued revised and relaxed "Guidelines for Research Involving rDNA Molecules". "All was settled. The revolution was bureaucratically approved, and the world had been irrevocably changed" (LSF Magazine, 2013, Summer: p. 75).

An Organizational Hybrid: IGA e IGA-Tech as a DBF variant

IGA and IGA-Tech are "symbiotic" components of a single body: a non-profit organization between scientists interested in genomics and a research insitute having the same name; a scientific laboratory equipped with last generation expensive machinery for genome sequencing (NGS); three "facilities" sharing the same 400 square metres of University Technological Park, founded a year before. Financial uncertainty for scientific research, people working for years on the issue of plant genome, joint decisions on how to compete and collaborate in the genetic improvement of plants and the latest scientific debates (eg on genome editing), are some dimensions that bind this "body" and the university departments it comes from (in terms of governance guidelines, see: excerpt A4, table 6; source: IGA_2007; IGA-Tech_2010).

In 2007, some important scientific publications by the IGA show the international community a first detailed analyisis of the grapevine genome: "*The public release of the grapevine sequence is both a fundamental accomplishment and a starting point for a deeper characterization of gene function"* (press release, August 2007).

The project on the grapevine genome, set up for the establishment of IGA and IGA-Tech, reveals the role that, for both bodies, scientific production (abstracts A1a and A1b) had to play. As "building block" of the new organizational form, for the founders, quality of publications represents an automatic and renowned "validation

mechanism", compared to the "new way" (in terms of organizational model) and "new tools" (managerial and commercial) that they had decided to work with the two realities. Moreover, the issues of epigenetics and DNA methylation mentioned in abstract C3, are linked to the particular attention to the scientific practice "organized" within the new "facilities". From the one hand, the "weak rhetoric" of the scientific literature (in the language of ANT) makes use of IT tools that make NGS adoption possible. On the other hand, to produce "ready to use knowledge" from the information coming from NGS machines, the new "organizational model" has the need to mobilize many more resources ("human and non human") with respect to different division models of the scientific work. The production of physical maps in modern genomics projects urges to different research organization models compared to the past, in which dozens of research institutes, departments and laboratories have: "to ensure high quality data and extensive utility with robust data standards; of computational intensity in terms of data analysis, data integration, visualization, computational tools and infrastructure, and continuous training" (Stevens 2013; Myers 2015). Alberto, Gabriele and Michele, driven by Raffaele suggestions and example, formed the three work groups within the IGA to meet the needs arisen from the 2005 project, having a shared perspective of the most advanced developments at international level, and being aware of how these pathways could be original or seemingly unusual.

Table 6a, 6b, 6c Representative qualitative evidences

The stories of Federica, current CEO of IGA-Tech (PhD in Plant Biotechnologies, 2001, under Michele guidance), reveal different ideas on what is

implied by always anticipating the most promising research topics in order to make research projects potentially able to change the reference scientific scene.

If this logic characterizes the current focus of IGA and IGA-Tech to select research groups in which to operate, it is a "de facto" feature common to different levels:

"[Even at the time of the PhD] being next to [Michele], for all my colleagues and me, was about being always updated on all scientific and technological news from the USA, five or ten years before Europe or Italy. I remember that during one of the first travels in the USA, he welcomed my colleague and me at the airport telling us that the following day he would leave us alone in the lab due to a lunch with J. Craig Venter. In the same period, we attended doctorate seminars where they discussed on the impending sequencing of the human genome and the possible technological revolution of the latest tools that were going to be spread [in 2005]." (Inter_#01).

Abstract A2 refers to an incubator recently opened in the Boston region and dedicated exclusively to life sciences. The layout of the laboratory, which is fully open space, the characteristics of the architecture and the atmosphere are not different from those of the laboratory managed by IGA-Tech. Compared to the early 60's, what really changes in a "contemporary" lab is what is outlined in abstract B2: in parallel with what happened in medicine, when the relations between engineering disciplines, biology, and medicine were laboriously labeled with terms such as "biomedical computing", "computer medicine" or "medical electronic data processing"" (Casper 2010); similarly, the "digitization", "computerization" or "dematerialization" of a molecular biology laboratory do not characterize adequately the real ongoing change in the life sciences (Stevens 2013). First, this aspect is linked to the management of a laboratory that acts directly as a support of research projects as scientific partner rather than as simple service provider.

In 2006, Federica went back to Udine to join her managerial and scientific skills in the new IGA labs. Then, it is obvious that the long experience in molecular diagnostics companies and private labs in the human and veterinary field could be useful. In 2009, Federica becomes CEO of the newly formed IGA-Tech and person in charge of IGA lab and all its scientific and research equipment:

« Learning how to perform many tasks, continuously overlapping lab work with management issues, going " from one thing to another" with ease had become something ordinary for me, something that was linked to the way of conceiving the scientific work I had learnt from Michele: just as in the period of the PhD when I had to test even non ordinary protocols or follow investigation paths linked to Michele's intuitions rather than following a consistent work schedule; similarly, when I went back to Udine and became coordinator of the new IGA lab, where I knew almost everyone, I necessarily went on developing these skills, even for the need to get into a very new job. With the foundation of IGA-Tech, the management responsibility of the lab operation was added to the work on the spot, which was more and more challenging due to the growing number of research projects and orders coming from IGA scientific partners and other research centers. I definitely noticed the change when I began to spend most of my time giving quotations and designing / evaluating experimental designs bycolleagues and scholars: the design of the experiment became the client's project and an integral part of a relationship that was, at the same time, scientific and commercial. (Inter_#01)

At the bottom of the open space, close to the balconies and the shelves of the biologists, the laboratory is equipped with three computer stations and a large room with servers for the acquisition and processing of data coming from sequencing machines that are arranged in the nearby air-conditioned room. The way computers were redirecting molecular biology, "towards large-scale questions and statistical methods" (Stevens 2013), attracted the attention of the original IGA Departments since early 2000. The current group of bioinformatics grew steadily under the guidance of Alberto: Cristian, Simone, Alessandro and, more recently, Alberto C., completed a

necessarily interdisciplinary program, with practices of biology, computer science, mathematics, statistics, software engineering and other research fields (Inter_#04).

Just between 2002 and 2003, laboratories, machinery and "new" professions began telling stories on computers, biological databases, algorithms as part of a story where people should be able to *associate* considerable resources, talk with local and national authorities, *recruit* other people and institutions and convince universities, farms, private and public financers that equipping laboratories and research institutes properly was an integral part of their "entrepreneurial opportunities". The grapevine genome project was an important step to establish a direct link between research and industry in agriculture. Between 2007 and 2009, the issue on the choice of the sequencing platform to be installed became crucial: abstract B1 reveals that the main "bottleneck" in genome sequencing technologies is not characterized by data generation: among other things, at the time of choosing the investment to do (see figure 10.1) there were different available technologies, although the market of NGS machinery was extremely concentrated (Stevens 2013). As underlined by Cristian, only after a few years they could carry out an assessment to confirm or disclaim the choice they were called to do "in terms of quality in data processing, storage, management and interpretation – with the use of new algorithms and robust computational tools – according to a data integration approach" (Interv_#03). In this statement, Cristian describes the effects of the choice on the nature of the work they were going to do:

«After the thesis, on an issue about bioinformatics & systems biology, Alberto told me about the possible establishment of a facility that had not a name at that time yet [in 2005]. The then server was certainly less powerful than my mobile phone and it had not been placed in the current IGA office yet. The main work was about acquiring data coming from the four sequencer that worked all day long.

In early 2007, a super-computer we got thansk to the help of a financer, was equipped with a storage of about 15 TB raw. A few months later (2008), with the first sequencer Illumina, the storage became 45 TB. Today, a sequencer can produce 350 billion base pairs in about two weeks (from 1 to 2,5 TB of data) and the parallel execution of 6 different DNA mappings can lead the IGA-Tech to generate up to 15 TB of raw data to be stored in a few days. Thanks to the arrival of Alessandro, at the end of 2013, the entire information architecture of IGA-Tech was renewed based on the real needs of the laboratory» (Inter_#04a)

Abstract A2 highlights the role of the creation of "local strongholds" around hybrid professional profiles, young scholars and a hybrid organizational model where the academic component (university departments), the research institute, the scientific lab are interdependent. The project EPIGEN, for example, is multidisciplinary for its purposes and involves 70 Italian research groups that are engaged in different international projects. Here, experimental models and the use of innovative technologies become an integral part of a training program that involves young scholars committed in the same research groups, with a specific focus on the whole pipeline linked to the application of the NGS and bioinformatics.

To understand "the strenght of weak ties" (*à la* Granovetter) in the case of ecology of relationships created by IGA and IGA-Tech and their symbiotic relationship, figure 10.1 suggests a comparison with one of the most significant and ambiguous biotech clusters in the world: located in Shenzen, a city having 15 million inhabitants in the Guandong, the BGI (formerly the Beijing Genomics Insitute) is currently able to produce about a quarter of the world's genomic data (LSF-Magazine 2015, Winter). In 1980, Shenzen was a small village of fishermen on the other side of the great river that separated it from Hong Kong areas and, later, it was changed in a few years (Stevens 2013). A recent reportage by the Life Science Foundation (LSF-Magazine 2015, Winter) describes the scientific aptitude of the BGI as a strange combination of skills

and practices between the culture of a start-up and the commercial logics of an electronics company: “BGI is often called a ‘biology factory’. Many of its projects are notable for their size and their scaling trajectories – more and more people and machines are being deployed to sequence genomes at accelerating rates with increasing efficiency” (p. 34-35). In all stories about the “BGI world” (e.g., a recent documentary by Bregtje van der Haak, “DNA Dreams”, in 2013), the representation of the organizational and entrepreneurial model gathers as many skeptics as enthusiastic people. Seemingly, the BGI would follow the atmosphere of a start-up in California: on closer inspection “Shenzhen has become China’s Silicon Valley, and BGI aspires to be its Google. Google’s mantra is *Do No Evil*. BGI urges employees to *Build a Magnificent Industry* and *Experience a Brilliant Life*” (*ibidem*: p. 35).

In the last decade, various academic departments of life sciences and many biotech areas are competing together with the most prestigious academic institutions at an international level. As many professionals and scholars tell, “history matters in this evolutionary process” (LSF Magazine, 2015 Winter, p. 3): and in this stories, research institute and self-sustaining centers of biotech have been established only when strong science, entrepreneurial cultures, and business friendly policies meet robust infrastructures, and skilled knowledge workers.

In this exclusive and elite context, the story of IGA and IGA-Tech seems to rely on a strong and growing reputation linked to the ability to turn the “local strongholds” into “longer research networks”, built around major research topics (see table 10.3: PON Citrus; BIOWINE, WATBIO DISCO; and ITA-TS CLONI). In the scientific field, “long range networks” in terms of research projects, together with “local strongholds” in the professional expertise, become the foundation to widen the attention towards new

directions: medical diagnostics and clinical practices must be supported by NGS technologies (for example, in clinical care, clinical utility in oncology or in diagnosis of rare diseases): «perhaps the most competitive market in the global industries connected to the future of biotechnology and life sciences» as Federica said, «but, this industry is naturally developing along NGS pipeline considering the pre-analytic, analytic, and the post-analytic phases» (Inter_#01). In a recent reportage on "Nature Biotechnology" (vol. 32, n. 10, 2014), "interviewed industry leaders generally agree that the platform manufacture market […] is quite narrow. [And], the price and quality of the current market leaders are substantial hurdles to overcome. In addition, the prospect of unpredictable new regulatory standards further accentuates the risk" (p. 981). In contrast, interviewees agree that there is considerable "room for expansion" in the post-analytic section of the pipeline. In this context, IGA and IGA-Tech can play a further role in terms of growing relationships and skills, enabling further processes of reconfiguration of new practices and transposition of well-known practices. An example is the project DNAMICA, described in abstract C2(b): "a platform for molecular and personalized medicine, one of the first examples of "industrial research" on these themes in Italy". As Federica point out in a brief video about the project: «The science of medicine and the practice of medicine are distinct domains. Our knowledge of the human genome is beginning to transform the former, and there are already examples where genomic information is now part of the standard of care».

DISCUSSION AND CONCLUSION: AMPHIBIOUS SCIENTIST AND NARRATIVE PERSPECTIVES IN ACADEMIC ENTREPRENEURSHIP

The goal of this paper was about introducing the study of the processes of academic entrepreneurship in terms of *translation* of scientific, financial and commercial practices from the social contexts of life sciences in new organizational forms for the exploitment of biotech products.

ANT research strategy originates from the study of scientific knowledge and technology as historically situated social practices (Knorr Cetina 1981, 1999; Latour 2005).

A technology transfer program involving biotechnologies through the processes of academic entrepreneurship stems from beliefs on social order (the relationship between science and industry) and a set of values (research in life science) that produce an "institutionalization trajectory" (Czarniawska 1997) and organizational models that stabilize: working practices and professional communities (biologists, bioinformaticians, computer scientists, software developers); interest groups and demonstrations of power (academic world, agricultural and pharmaceutical industry, medical diagnostics multinational companies, VCs and public investors, policy makers).

In terms of problematization (Alvesson, Sandberg 2013) and formulation of research questions within the MOS, the ANT provides concepts and languages to investigate new issues or formulating the same issues in a different way. In this regard, the topic of academic entrepreneurship is quite promising for the ANT: as social scientists, we should be interested in entering the scenario of the "new knowledge" produced by life sciences to assess social relationships that gather around the

development of biotech products. The phases of the translation process concern the emergence of the features that assemble the original DBFs; the narrative component of the entrepreneurial innovation allows to cope with the "dynamic" dimension, the academic entrepreneur "in action" who "translates into practice" the social component of field strengths (action nets) that contain him/her and produce the amphibious scientist (actor-network).

How the biotech market becomes a(n) (arti)fact (1968-1981). The creation of "new markets" and the emergence of "new organizational forms", in this paper, are a field strength that contains and produces the amphibious scientist, a collective actor resulted from a translation process characterized, in the ANT language, from the succession and repetition of maneuvers and typical stages. Michel Callon (1986) traces them back to: problematization, interessement, enrollement and mobilization.

When Zaffaroni founded the ALZA, scientific articles, protocols, software, artifacts, Nobel Prizes, contracts, patents, funding (*intermediaries*, in the ANT language), began redefining the existing relationships between the players in life sciences. *Problematization* is not only the formulation of a research field, but redefining the nature of the technology transfer problem in that scientific field, it activates a series of actors defining their identity and ties. The amphibious scientist begins to become a "net-like translator" who triggers a subsequent phase of *interest* in which to implement "exclusion" maneuvers (etymologically "inter-est" means "interposing"): problematizations and alternative alliances tend to be excluded, testing and accepting the associations that have been able to act in order to impose the identity they have defined in the problematization. Joining the network involves a negotiation that produces stable alliances: in the phase of *enrollment,* actors accept and carry out the

roles given to them, so that the issue of academic entrepreneurship becomes secondary. The IPO by the Genentech, in 1980, had definitely changed the general attitude: if the "values of science" revolve around the expansion of human knowledge, and the "market" could in some way help to facilitate this process, then the "financial rewards" were entirely appropriate. DBFs organizational practices are stabilized to the extent that the figure of the amphibious scientist becomes a "spokesperson" of *mobilization*: the transfer of technology through new forms of organization became credible and indisputable, forming alliances and acting as a single force.

Amphibious entrepreneurs and narrative dimensions. The process of translation is related to what the narrative approach to entrepreneurial innovation defines as: "an appreciation of the efforts by players to organize and imbue experiences with meaning" (Garud *et al*. 2014, p. 1181). The theory of the amphibious scientist becomes "significant" through collective narration: different actors "scattered" in the rising biotech market find a common identification point and converge on it to give it a shape (DBFs). The process of progressive agreement of new supporters to "represent concretely" the actor-network produces a "scientific caravan" (a "bandwagon effect") or an "ecology of action" (Law 2009) having an inherent narrative nature. Dimensions in the entrepreneurial narration are those identified by Garud and colleagues (2014, p. 1181):

- the relational aspect, namely "the constitution of agency through existing and anticipated relationships across social and material elements";
- the temporal point of view, which refers "to the various accounts of the past, present and future that are offered as innovation unfolds";

- the performance aspect that "highlights how narratives serve as triggers for action towards goals that are forever changing".

In the case of IGA and IGA-Tech, we could appreciate how the amphibious scientist "in action" has shown the typical dimensions of a DBF struggling with all the specific needs of a body that is, in turn, composite and temporary. Each component of the two entities contributes to the narration as an "amphibious entrepreneur" in the context of a hybrid organization with respect to the processes of recombination of practices that, for the features of the body, leave room for negotiation to the same actors in order to adapt to local circumstances. The same intermediaries of the translation process are stakeholders in the narration: they define the audience, contribute to retain it, allow connecting financial, technical and human resources, make the innovative process intelligible for stakeholders and return plausibility and coherence to the collective stories. If intermediaries do not produce anything, translation stops. In addition, intermediaries have the function of *transating* the collective action into stories that imply "time, timing, and temporality" (Polkinghorne 1988). Time in the sequence of events merges with the entrepreneurial experience; moreover, time of narration emerges in terms of temporality in the form of "founding myths" or "historical passages" in the roadmap of the company (both commercial and scientific). Finally, from a performance perspective, recruitment and mobilization are two narrative phenomena, traced back to what Pinch and Bijker (in Bijker *et al.* 1987) call: "rhetorical closure" and "problem redefinition", mechanisms that, in the translation process, stabilize an artifact. John Law (1999) recalls that in the ANT, relationships do not stand alone, but they should be "enacted into being" to produce social order (*performativity*).

Implications and future research. The narrative perspective of entrepreneurial innovation and the ANT research strategy can lead to interesting implications for at least three levels: policy level, academic entrepreneur level and research level. First, the most interesting stories can be extended to the level of institutional innovation and "collective action". Furthermore, from the academic entrepreneur perspective, processes of growth and development paths can be classified as relational and qualitative growth to manage heterogeneity in terms of "social boundaries" and "collective practices". At the end, in a logic of complementarity, the research perspectives that are based on the dichotomy "discovery-creation" may find interesting developments by the comparison with process perspectives.

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Table 1 *Perspectives on entrepreneurial innovation (Garud et al. 2014)*

Approach	**Micro-macro approaches**		**Multilevel approaches**		**Costitutive approaches**	
Analytic focus	**Antecedents:** Factors that explain entrepreneurial innovation		**Events**: Episodes when entrepreneurial innovation is "found" or "made"		**Journeys**: Dynamics whereby entrepreneurial innovation emerges	
Perspective	Agentic-centric	Context-centric	Discovery	Creation	Co-creation	Narrative
Emphasis	Emphasis on entrepreneurial agency	Emphasis on entrepreneurial contexts	Emphasis on opportunity discovery	Emphasis on opportunity creation	Emphasis on dynamic equilibrium and ongoing change	Emphasis on meaning making through interplay of entrepreneurs and environments
Locus and nature of agency	Agency established by actor attributes	Agency prescribed by institutional structures	Agency cultivated by being alert or by spanning structural holes	Agency derived from capacity to bricolage and effectuate	Agency located in ecology of interactions	Agency "translated" through social and material networks
Role of context	Contexts are not explicitly considered	Contexts explain entrepreneurial innovation	Contexts moderate availability of opportunities	Contexts moderate viability of creations	Contexts are both the medium and outcome of action	Contexts are constituted through performative efforts
Notable research streams	Personality; Cognition; Teams	Nations; Regions; Industries	Alerteness; Brokerage	Bricolage; Effectuation	Structuration; Complexity; Disequilibrium	Actor-Network Theory; Path creation

Table 2 *Distinctive features of early biotech firms (Powell and Sandholtz 2012a*)

	(A) SCIENCE	**(B) FINANCE**	**(C) COMMERCE**	**What Happened?**
Alza (1968)	• Assembled an all-star science advisory board • Chose a campus-like setting near a major research university	• Went public with no products, breakthroughs, or revenue • Used research partnerships with Big Pharma to generate funds	• Funders went on to start numerous biotech firms	Ahead-of-his-time founder creates a prototype for future biotech firms. Acquired by Johnson & Johnson in 2001
Cetus (1972)	• Assembled an all-star science advisory board • Chose a campus-like setting near a major research university • Offered "free space" for scientists • Scientific founder stayed at the university and consulted with the company	• Used research partnerships with a diverse array of large corporations • Achieved a record-breaking IPO in 1981	• Explored a wide range of commercial applications for biotech	First-mover advantage doesn't hold due to lack of focus; acquired in 1991 by Chiron
Genentech (1976)	• Insisted that staff scientists publish and contribute to public science • Scientific founder stayed at the university and consulted with the company • Launched as a "virtual" start-up: all initial research was conducted by contract with UCSF and City of Hope Hospital	• Received meager funding until scientific "proof of concept" • Invented "milestone payment" form of incremental financing • Achieved the first biotech IPO (1980): "gene dreams" for Wall Street • Used research partnership to share cost and risk	• Pursued a "swing for the fences" strategy focused on blockbuster medicines	Science married to finance creates novel model that produces an enviable record of innovation. Despite considerable resistance, became a fully owned subsidiary of Roche in 2009
Genex (1977)	• Assembled an all-star science advisory board • Scientific founder stayed at the university initially	• Established numerous research contracts with large companies	• Pursued low-cost, high volume strategy (e.g., biotech production of industrial chemicals) • Made early investment in manufacturing plant • Scientific founder went on to start addutuibak biotech firms	Low-margin business model becomes unsustainable without investment by corporate partners; acquired in 1991 by Enzon
Biogen (1978)	• Designed as an international consortium of top academic labs (i.e., science advisory board was the company) • Launched as a "virtual" start-up: all initial research was conducted in founders' labs • Scientific founders stayed at their respective universities full-time	• Received modest initial VC founding • Out-licensed early breakthroughs to Big Pharma	• Targeted blockbuster medicines • Scientific founders ran the company for its first seven years	"World class research seminar" makes corporate governance challenging; licensing model proves robust. Merged with IDEC in 2003
Hybritech (1978)	• Scientific founder stayed at the university full-time and consulted with the company • Talented research assistant played a key founding role • Chose a campus-like setting near a major research university (UCSD) and research institute (Salk)	• VC played dual role as investor and CEO	• Scientific founders become serial entrepreneur and/or VCs • Recruited senior exec from Baxter run the company • Focused on diagnostic products: avoided long clinical trials • Introduced the first-ever commercial product based on monoclonal antibody technology	Entrepreneurial scientist finds world-class VC, who recruits a pharma escape to run the show; bred for eventual sale and acquired by Eli Lilly in 1986

	(A) SCIENCE	(B) FINANCE	(C) COMMERCE	What Happened?
Centocor (1979)	• Pursued aggressive in-licensing of research from public science • Initially located in a business incubator on the University of Pennsylvania campus • Enjoyed a close relationship with research institute (Wistar)	- / -	• Served as a bridge between academic labs and Big Pharma manufacturing/marketing • Recruited a senior exec from Corning's medical products business to run the company • Focused on diagnostic products	"Academic scavengers" almost lose their company due to grand inspirations to become a fully integrated pharmaceutical company. Acquired by Johnson & Johnson in 1999
Amgen (1980)	• Assembled an all-star science advisory board (SAB)	• Went public in a lastditch effort to save the company, despite no products or patented breakthroughs	• Served as a bridge between academic labs and Big Pharma manufacturing/marketing • Recruited a senior exec from Corning's medical products business to run the company • Focused on diagnostic products	Savvy VCs set out to "do biotech right" by recruiting stellar SAB and putting talented pharma escapee in charge; a biopharma titan is born
Chiron (1981)	• Founder stayed at university initially • Applied the skills of academic administration to business • Insisted that scientists publish and make contributions to public science • Transferred a founder's existing research grant from the university (UCSF) to the company • Used research partnerships with pharma companies and universities as a mode of exploration	- / -	• Focused on large potential market underserved by Big Pharma: vaccines • Scientific founder ran the company	Scientist-entrepreneurs move the invisible college model to a business setting. Acquired by Novartis in 2006
Genzyme (1981)	• Transferred a founder's existing research grant from the university (Tufts) to the company • Talented research assistant played a key founding role • Hired its science advisory board intact (Bio-Information Associates, a consulting firm of MIT and Harvard professors)	• Used tracking stocks to compartmentalize risk • Grew through numerous small acquisitions	• Founder was a serial entrepreneur from the packaging industry • Focused on niche markets and orphan drugs • Recruited a senior exec from Baxter to run the company	VC group goes shopping fora new venture; builds business around orphan drug opportunities. Acquired by Sanofi-Aventis in 2011
Immunex (1981)	• Insisted that scientists publish and make contributions to public science • Founding scientists resigned from academic jobs to avoid conflict of interest • Chose a campus-like setting near a major university (University of Washington) and research institute (Hutchinson Cancer Center)	• Out-licensed early patents to Big Pharma, then later reacquired them	• One of the founders was a proven executive and turn-around artist	Despite stellar scientific record, business success comes late. Acquired by Amgen in 2002, resulting in the loss of local "Immunoid" culture.

Figure 1 *A timeline of events*

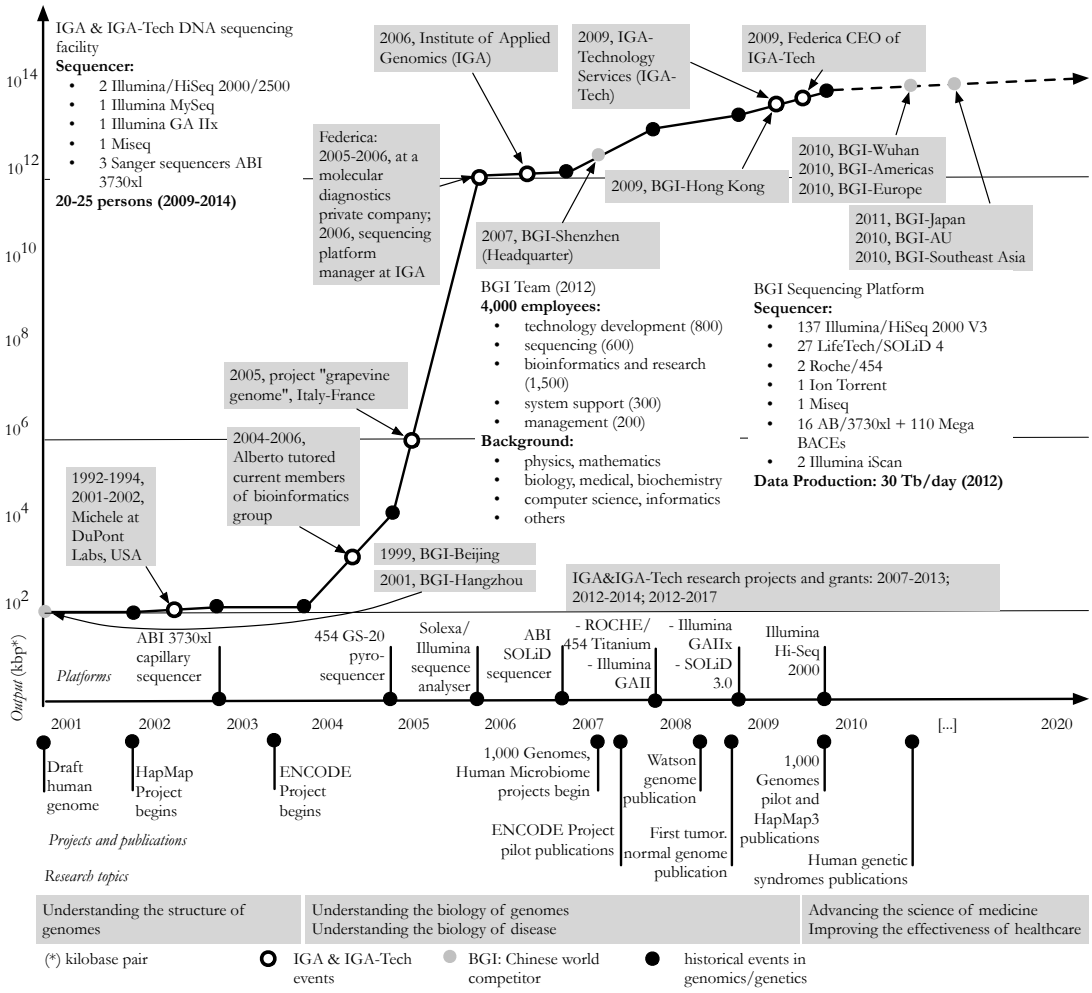

Table 3 *Informants, data and archives collected in the research sites*

Code	Sources	Description
	a) Interviewees:	
Inter_#01		Chief Executive Officer, IGA-Tech (Federica, 3 interviews)
Inter_#02		Founder of IGA (1 interviews)
Inter_#03		External Stakeholders (2 interviews)
Inter_#04a-c		Bioinformatics Research Group (5 interviews, 3 interviewees) a. Cristian; b. Simone; c. Alessandro
	b) The Board & Founding Members (IGA & IGA-Tech):	
		• **Michele** (1987, degree in Agriculture), Professor of Genetics, *Founder, Scientific Steering Committee and Scientific Director-IGA* • **Alberto** (1984, degree in Mathematics, MSc in Computer Sciences), Professor of Informatics, *Founder and Director of Bioinformatics Research Group-IGA* • **Raffaele** (1977, degree in Agriculture), Professor of "Fruit Science" and "Genetics resources in agriculture", *Founder, Chairman (Board of Directors) and Chief Executive-IGA* • **Gabriele** (1999, degree in Agriculture), plant molecular geneticist, *Group Leader Molecular breeding-IGA* • **Federica** (1994, degree in Biology), *Chief Executive IGA-Tech and Scientific Steering Committee-IGA*
	c) Archival Records:	
IGA_#year		Financial Statements IGA, 7 years, 2007-2013
IGA-Tech_#year		Financial Statements IGA-Tech, 3 years, 2010-2012
IGA-Tech_00		01) Technology: • sequencing (Illumina; ABI3730xl); • datacenter (computing and storage: www.inasset.it) 02) Services: • NextGen Sequencing (NGS) and Sanger Sequencing; • NGS Data Analysis and Sequencing Data Storage 03) Bioinformatics and NGS Training
	d) Research Projects/International & National grants/Publications:	
EPIGEN		Italian Ministry of Education, University and Research and the National Research Council: "how epigenetic mechanisms regulate biological processes, determine phenotypic variation and contribute to the onset and progression of diseases", web: http://www.epigen.it
DNAMICA		POR-FESR 2007-2013 - Platform for Molecular and Personalized Medicine, web: http://www.dnamica.it
PON Citrus		PON Ricerca e Competitività 2007-2013 - Functional genomics, genetic improvement and innovation to enhance the value of the citrus supply-chain
BIOWINE		PO FESR Sicilia 2007-2013 - Multidisciplinary approach for quality improvement in wine production.
WATBIO		EU FP7 - developing drought-tolerant biomass crops for Europe
DISCO		EU FP7 - From DISCOvery to products: A next generation pipeline for the sustainable generation of high-value plant products
IGA-TS CLONI		Regional project LR47/78 - Innovative diagnostic platform for grape clone identification
IGA-pub_Journal		n. 52 scientific publications (analysis of research programs, network of scientific partnerships, evolution of research topics)
	e) Local and National Newspapers:	
News_local		n. 22 articles (2006-2013): Messaggero Veneto (local newspaper)
News		n. 54 articles: National & International newspapers

Table 4 *Constructs supporting three models of DBFs (Powell and Sandholtz 2012a)*

	IGA-Institute of Applied Genomics	IGA Technology Services
(A) SCIENCE		
(i) Insistence that scientists publish their findings		
(ii) Campus-like setting near a major research university		
(iii)Founder(s) continued at or returned to university or institute		
(iv) All-star science advisory board		
(B) FINANCE		
(i) Research contracts with large corporation		
(ii) Scientific founder(s) became VCs or angel investors		
(iii)Active VC involvement in early management		
(iv) IPO with no products and no predictable revenue stream		
(C) COMMERCE		
(i) Founder(s) with entrepreneurial track record		
(ii) Early hiring of senior exec from health care or pharma		
(iii) Initial emphasis on non-therapeutic applications		

Table 5 *Two variants of a new form ((Powell and Sandholtz 2012b)*

A Science-Centered Variant	A Commerce-Centered Variant
Science takes the lead, with VC and management support	Management takes the lead, supported by VC funding and academic science
Renowned scientist-founders straddle domains, often occupying key executive and academic roles simultaneously	Scientifically-trained business leaders play crucial early roles
Science Advisory Board (SAB) is used for peer review	Science Advisory Board (SAB) is used as a signal of approval
Firms exhibit a strong commitment to publishing research findings	Publishing is not encouraged
Investors take an "empirical" approach: minimal funding of laboratory research (proof of principle), with further investment contingent on scientific results	Investors weigh commercial considerations such as size of market, current competitors, projected cash flow, speed to profitability, etc.
Academic headwaters: William Rutter's interdisciplinary lab at UCSF	- / -
Commercial headwaters: ALZA Corp.	Commercial headwaters: entrepreneurial divisions of health care or pharma companies (i.e., Baxter, Abbott, Corning)
Exemplars: Genetech, Biogen, Chiron, Immunex	Exemplars: Hybritech, Centocor, Amgen, Genxyme
Failed attempt: Cetus (lacked strong scientific leader)	Failed attempt: Genex (lacked strong commercial leader)
Mechanism of genesis: **transposition**	Mechanism of genesis: **recombination**
(1) Established routines prove lacking... (2) so founders draw on existing knowledge... (3) and scan their social worlds for cues... (4) forging unique elements of a science based organizational form.	

Table 6 *Representative qualitative evidences*

(A) SCIENCE	IGA-Institute of Applied Genomics	IGA Technology Services
(i) Insistence that scientists publish their findings	**A1(a)** - «Physical maps provide an essential framework for ordering and joining sequence data, genetically mapped markers and large-insert clones in eukaryotic genome projects. A good physical map is also an important resource for cloning specific genes of interest, comparing genomes, and understanding the size and complexity of a genome. Although physical maps are usually taken at face value, a good deal of technology, molecular biology and statistics goes into their making. Understanding the science behind map building is important if users are to critically assess, use and build physical maps» (*source*: "Mapping and sequencing complex genomes: let's get physical!", in Nature Reviews Genetics, 5, 2004).	**A1(b)** - «Whole-genome physical maps facilitate genome sequencing, sequence assembly, mapping of candidate genes, and the design of targeted genetic markers. An automated protocol was used to construct a Vitis vinifera 'Cabernet Sauvignon' physical map. The quality of the result was addressed with regard to the effect of high heterozygosity on the accuracy of contig assembly. Its usefulness for the genome-wide mapping of genes for disease resistance, which is an important trait for grapevine, was then assessed» (source: "A physical map of the heterozygous grapevine 'Cabernet Sauvignon' allows mapping candidate genes for disease resistance", in *BMC Plant Biology* 2008, 8:66.
(ii) Campus-like setting near a major research university	**A2** - «With its cookie-cutter windows and boxy brick exterior, the building here on Main Street could be just another former 19th century warehouse or factory. Today, a nonprofit organization called LabCentral has taken up that entrepreneurial heritage. The renovated 2600 square-meter facility, now owned by the MIT and leased to LabCentral, functions as a life science "incubator" that helps budding biotech firms combat the soaring costs of lab space and equipment in the red-hot Boston-Cambridge region. Any scientist with an idea and ambition can rent a bench and an office, sharing space, services, and high-cost tools with others pursuing their own entrepreneurial dreams. "It is very exciting because we are there at the nascent moment of many really, really cool companies," says molecular biologist Johannes Fruehauf, a LabCentral founder. » (*source*: "Got a Startup? Rent a Bench. Biotech incubators such as LabCentral are lowering barriers to entrepreneurship", in Science, 12 June 2015, Vol. 348, iIssue 6240 .	
(iii) Founder(s) continued at or returned to university or institute		**A3** - «One of the main goals of EPIGEN is to train young scientists through a dedicated program that covers the main areas of interest of the project, with special focus on the applications of Next Generation Sequencing, bioinformatics and cellular imaging technologies. The activities involve practical workshops, seminars, congresses and we have recently launched a fellowship program to finance travel and accommodation costs for short visits to other labs, in order to favor the exchange of young researchers among EPIGEN labs and the establishment of collaborations with research teams abroad.». (http://www.epigen.it/training)
(iv) All-star science advisory board	**A4** - «**Board of Directors:** The Board of Directors is responsible for the management and administration of the IGA and for long-term development of the institute in accordance with the Scientific Steering Committee. The BoD includes representatives of the founders and of the financial supporters. **Scientific Steering Committee:** Science at the IGA is driven by a Scientific Steering Committee. The Founders are permanent members of the Scientific Steering Committee. Temporary members of the Scientific Steering Committee are appointed among outstanding scientists with competence in the research fields of the Institute. **Scientific Director:** The Scientific Director is the main executive figure of the Institute and coordinates the day-to-day direction of the scientific programmes. **Scientific Advisory Board:** The SAB is composed of internationally recognised scientists and regularly reviews science at the IGA. The Scientific Advisory Board advises the Scientific Steering Committee on changes of research field and strategy to achieve the goals. It undertakes evaluation of the research carried out at the IGA by comparing the scientific performance against the best achievements of equivalent research organisations worldwide. The outcomes of the Scientific Advisory Board's reviewing can affect the decisions of the Board of Directors on both funding and management of the IGA» (source: Corporate Governance Guidelines)	

(B) FINANCE	IGA-Institute of Applied Genomics	IGA Technology Services
(i) Research contracts with large corporation	**B1** - ILLUMINA SEQUENCING TECHNOLOGY. The Illumina massively parallel sequencing technology makes multiple gigabases of data from several million templates economically available, enabling new approaches to genomic characterization. The Illumina technology allows tipically genome center-like studies to be accomplished at the individual laboratory level. A single technology workflow is capable of supporting genome-wide analyses as different as DNA sequencing (de novo and resequencing), gene expression, transcriptome characterization and expression control including small RNA discovery, protein-DNA interactions and CpG methlyation status. IGA Technology Services is a certified service provider (CSPro) of Illumina genomic sequencing (source: IGA-Tech brochure).	
(ii) Scientific founder(s) became VCs or angel investors	**B2** - «Our multidisciplinary team made of biologists, bioinformaticians, computer scientists and software developers has worked in the last four years to design, build and automate pipelines for the analysis of NGS data for the most common applications using a mix of Open Source and newly developed software. The pipelines have been validated directly on real case and different kinds of organisms/biological problems in humans and other animals, plants and microorganisms. We have developed a management tool that allows our data analysts to build their own pipelines using a growing set of software tools. The tool is totally customizable in terms of software parameters, scalable and adaptable over different technologies [...]. The pipeline automation guarantees the traceability and repeatability of the analysis on all the samples coming from one experiment or from different experiments.» (Federica, interview_#01)	

(C) COMMERCE	IGA-Institute of Applied Genomics	IGA Technology Services
(i) Founder(s) with entrepreneurial track record	**C1** - **«**BS-SEq. We have a proprietary software package for **WGBS-seq**, **RRBS-seq** and **Targeted BS-seq** data analysis. Quality control; Post-sequencing estimation of conversion rate using Lambda spike-in; Alignment to a reference; Methylation calling at single cytosine level; **Whole genome methylation statistics** (including distribution of methylation in the CG, ChG and Chh contexts in plants); Visualization of methylation distribution across the genome using CIRCoS images; Identification of Differentially Methylated Regions (DmRs) between samples. Our team is always available to consult with you on study design to ensure correct sequencing and bioinformatics strategies are used to meet your goals» (source: IGA website).	
(ii) Early hiring of senior exec from health care or pharma	«**C2(a)** - IGA iniziava a pensare e vedere in modo diverso il ruolo del bioinformatico perché i dati adesso non possono più essere osservati, ma serve l'elaborazione del bioinformatico per i dati più complessi. Molte aziende creano strumenti per sostituire il bioinformatico, ma questi strumenti non funzionano perché i problemi da affrontare sono troppo difficili, le macchine risolvono un unico problema, questo può andar bene per la diagnostica ... ma per una sola malattia!» (Cristian, interview_#04a, Alessandro, interview_#04b)	«**C2(b)** - Project D.NAMICA foresees to study the methodologies for the implementation of a computing platform for the integration of clinical and genetic indicators with the purpose to support research for the personalization of medicine. D.NAMICA is cofunded by ERDF - European Regional Development Fund - Friuli Venezia Giulia Region Operational Programme 2007 - 2013. It fosters the cooperation between research organizations, universities, technology transfer centres and enterprises. Project D.NAMICA will implement three pilot projects to help research activities to better understand the genetic characteristics of patients and their answers to personalized treatment in the following sectors: cardiology (DCM - dilatative cardiomyopathy), oncology (HCC - Hepatocellular carcinoma) and neurodegenerative diseases (SMA - Spinal muscular atrophy). (source: IGA-Tech website)
(iii) Initial emphasis on non-therapeutic applications	**C3** - «BISULFITE SEQUENCING (BS-SEQ). **DNA methylation has been shown to play an important role in a wide variety of biological processes, including silencing of transposable elements, stem cell differentiation, embryonic development, genomic imprinting and inflammation**. Alteration of methylation patterns has been identified in many diseases, including cancer, diabetes, cardiovascular disease, inflammation and neurological disorders. By combining bisulfite treatment of genomic DNA with NGS, it is possible to sensitively measure cytosine methylation on a genome-wide scale within specific sequence contexts. By using restriction enzymes and bisulfite sequencing, it is possible to enrich for the areas of the genome that have a high CpG content. This approach, termed RRBS-seq (Reduced Representation Bisulfite Sequencing), reduces the amount of nucleotides needed to be sequenced to 1% of the genome size, allowing for a cost-effective single-base-pair resolution of methylated cytosines. The third alternative is targeted bisulfite sequencing, which is able to specifically capture selected genomic regions of interest associated with a disease or phenotype» (source: IGA Tech brochure).	