From Bio to Nano: Learning From The Past to Shape the Future of Technology Assessment

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Abstract

In many Western countries over the last 35 years, the quest for more scientific governance on crucial technological issues led to a broadening of the political world's sphere of competences. Indeed, various countries decided that dealing with global, invisible, irreversible and irreparable risks had to be handled by an appropriate tool of management of technological innovations. So the usefulness to institutionalize parliamentary Technology Assessment (PTA) offices emerged. Nowadays, PTA is an instrument particularly suitable to study the new shape of science and society's interface and it represents a remarkable attempt to reform the institutional settings of innovation.

However, while the overall uncertainty surrounding science and technology has been used by public actors like parliamentarians or ministers in the past to legitimize a first generation of PTAs, the emergence of a second generation in the 1990's – centred on the constructive, interactive or participatory TA approches – emphasizes the co-evolution of technology and society rather than the former linear determinist rationale. In this context, the STS community of scholars is increasingly called upon by the public authorities to provide a "professional service role" (RIP, 1994), that is to say to take a step into action out of the border of their intellectual engagement.

Then, we suggest to compare two successive periods by looking at the institutional management of two distinct-but-complementary technological issues: biotechnology and nanotechnology. The former has been taken into account by public actors at a time when the second generation of PTAs was not yet rooted in the political practices. Thus, the management of the public debate related to biotechnology has been characterized by a lack of sensitive, fruitful and interactive communication between the stakeholders involved in the TA process, while the first applications were already being commercialized. On the other hand, the latter is currently being tackled at a moment when the social shaping of technology is widely acknowledged as well as the STS community may be invited to pass from observation to participation in the political sphere. Given the uncertainty and complexity encircling nanotechnology as well as its huge potential in many interconnected disciplinary fields, the need to avoid the pitfall of the biotechnology's experience is commonly accepted.

We offer to take nanotechnology as one of the most challenging technological issue to look beyond the biotechnology's roadblock and to show in which proportion the same scenario is reasonably thinkable today, in order to spotlight whether we have learnt from the past in considering what is

sometimes called “a new industrial revolution”.

We will raise some research questions like: how different are current TA practices as compared to former ones? Are there new regimes emerging? Given the current technological convergence, how complicated would it be to deal with NBIC technologies if we missed the point with biotechnology alone? How suitable is PTA to engage in such interdisciplinary issues? Are we assisting the emergence of a third PTA generation around the growing role of the STS community? How does this scientific community dialogue with the historians of science who analyzed the earlier industrial revolutions?

Introduction

The scientific progress associated with the globalization of the economy can have a deep/strong influence on the transformations of our modern societies. These transformations are not only related to the economy but also to ethical, social and political issues. Therefore, biotechnology and nanotechnology are not only “pure” technological innovations, but are also producing new rules and conditions shaping our societies.

In other words, we could say that these new technologies are influencing the nature of our “socio-political landscape”, which is itself co-constructed by the interplay of actors, institutions, regulations and technological regimes. In return, this landscape constrains and enables the agents (Rip, 2002).

Hence, we consider biotechnology and nanotechnology as strong potential political decision-making processes escaping all traditional forms of parliamentary democracy. Therefore, one of the most unexpected consequences of these technological domains is their political dimension. According to Beck (1992), this specific kind of sub-politics is simultaneously producing its own contradictions and political explosiveness which are visible through the emergence of modern risks. These risks are considered to be the political motor of the reflexive process of late modernity.

I) Biotechnology: overview

1. Introduction

Since the 1970's, the world has been discovering the potential fields of application of this technological development as well as its social, political and ethical (unattended) consequences. In fact, the domains of application are numerous. Indeed, some domains like pharmacological industry, food production, medicine (gene therapy), military industry, chemicals are some activities in which biotechnology is becoming increasingly more important. By definition, everything is conceivable or possible using gene technology. Therefore, talking about biotechnology is a very difficult challenge according to the fact that this subject could be analyzed from many different contexts of application.

Nevertheless, we suggest a general perspective on the development of biotechnology in our modern society. We shall distinguish three (distinct but sometimes overlapping) historical periods in order to understand the dynamic of the interactions between biotechnology and society. Of course, it is a matter of historical re-construction.

2. Historical presentation

1) Laboratory time (1953-1980)

At the very beginning of scientific research on biotechnology, genetic engineering issue was still very confined within the small scientific community specialised in this field. Citizens and other potential stakeholders such as private actors and industry were not directly or indirectly involved because questions on genetic engineering were only addressed by science to science. When the possibility to modify and to master the genetic inheritance by scientists was confirmed in 1974, a moratorium on research was decided by the scientific community because of the great uncertainty related to this new scientific field of research. However, in 1975, a hundred and forty specialists in genetic engineering were assembled during the Asilomar's conference (Krimsky, 1985). They decided to lift the moratorium and to impose safety conditions on research in genetic engineering. The practical output of this decision was the elaboration of good laboratory practices. Those measures were only applied to the scientific sphere without any strong public information. In other words, the laboratory time was characterised by a physical, chemical and political confining of biotechnology to the scientific community (Brunet, 2002). Then, in the late 1970's, scientists began to face great scientific uncertainties about the potential risks related to biotechnology. Eventually, in the process of Asilomar's conferences, the scientific community did only take decisions about safety and confinement issues with very few questions about any social impact of biotechnology. By doing science this way, that is to say by keeping it confined in a space protected from external influences, scientists were thinking their activities clearly separable from politics. Because of their exclusion from the scientific sphere (which they had been agreeing on for a long time until recently), politicians were not keen on discussing and foreseeing social implications of biotechnology because they were unable to understand what was going on in the scientific field. So, at that time, nobody was really thinking about the interactions between science and society. However, the need for policy-makers to be enlightened on increasingly complex technological issues led to several institutionalizations. As a matter of fact, the Office of Technology Assessment (U.S. Congress) was settled in 1972. At that time, this has been understood as a “proud reaction” (Mironesco, 1997) from the US members of Congress willing to rebalance the powers with the executive. This first attempt aimed to provide to members of Congress some secure, “objective” expert-based intelligence and unbiased information about technological options. This discussion about science's consequences on society was held by experts outside the scientific sphere and only for members of the Congress. The official goal of such a knowledge production was to facilitate the public decision-making power of politicians in many scientific and technological fields. This instrumental Technology Assessment produced its first report on biotechnology in 1981.

However, in the meantime of this first phase of development of biotechnology, industrial and financial actors were becoming more and more interested into potential applications of biotechnology. This foreshadows the next period. Although GM products don’t leave the laboratory, they begin to interest the economic and financial worlds. Already here was visible an emerging techno-economic network (TEN), that is to say a future coordinated set of heterogeneous actors (like for instance public laboratories, centres for technical research, private companies, financial organisations or the government) who participate (or will do at a later stage) collectively in the conception, development, production and distribution or diffusion of procedures for producing goods and service, some of which give rise to market transactions. (Callon, 1992).

2) Business time (1980-1990)

About 60% of biotechnology companies were created in the U.S. between 1980 and 1984. The majority of these industries was mainly focused on public health problems -pharmaceutical industry (OTA, 1991) because expectations in terms of profitability were greater than in the foodstuffs domain.

Therefore, pharmaceutical companies developed their own capacities of production and innovation using genetic engineering. This last one did not change radically the internal structure of pharmaceutical industry, but gave new tools and techniques to improve their position and to reach their objectives. For example, the human growth hormone shall be produced into some specific bacterium and will not be extracted from human bodies. In this case, genetic engineering could be very useful to avoid transmission of diseases.

The financial feasibility of biotechnology depends on several factors such as the size of the market, the existence of substitution products, the possibility to take out a patent, and last but not least, the social acceptability of those new products. For example, biotechnology is very well accepted for medical or pharmaceutical use, but reveals itself a big problem for human food.

In the US, this second phase of biotechnology's development was accompanied by the first report of the Office of Technology Assessment (OTA, 1981). This report focuses on three industries: pharmaceutical, chemical and food. Among the issues identified and discussed, we can mention the governmental support of R&D, the methods of improving the germ-plasm of farm animal species, the risks of genetic engineering, the patent living organisms and the public involvement in decision-making. The report ends by addressing the issue of science and society interactions and more specifically the issue of public participation. Nevertheless, public participation is addressed in few pages and more in terms of public information than real public involvement in decision-making. Here, like it has always been the case for the OTA's way of producing policy reports, participation is mainly instrumental and involves a broad range of external stakeholders called upon to frame the issue, elaborate a study plan and feed the report with scientifically-based information.

The second OTA report related to biotechnology was focusing on the role of genetic testing in the prevention of occupational diseases (1983). The third report was published in 1984 and was entitled "Commercial Biotechnology: An International Analysis". Several other reports were published during this business time period[1], but always adopting the same guidelines, with the obvious objective to reinforce the existing representative decision-making mechanisms without considering useful for the public to be involved at an earlier stage.

During this period, the OTA did not foster public debate about biotechnology but played a crucial role by informing politicians about biotechnology's socio-economical implications. The TA reports produced during this period showed the instrumental side of the technology assessment activities by providing information for public-decision makers in order to facilitate the financial and economic development of biotechnology. Nor was considered as important to have social scientists working together closely with scientists involved in biotechnology development in order to reduce the social or ethical challenged posed by the technology's further development.

However, two elements have to be pointed out in the late 1980's. First, the increasing importance taken by the Science and Technology Studies (STS) as a widely acknowledged scientific discipline entrenched in recent evolutions related to a more constructivist than determinist approach of science and technology. Then, the first parliamentary TA to be born in Europe was in France (1983),

[1] See all the OTA reports available on www.princeton.edu/~ota/.

according to an instrumental approach comparable to OTA at first sight, but which took a sensitively different shape afterwards, through a broader involvement of the French members of Parliament in conducting TA studies. Anyway, important is to underline that the American idea of settling a TA office seduced many European countries in the 1980's and later on. Nonetheless, for a set of political, cultural and institutional reasons, some of the European TA offices took a shape radically different from the American one. Although the instrumental TA approach consisting in producing scientific knowledge concised in reports to facilitate public decision-making took place in places like the European Parliament (1987), the United Kingdom (1989) or Germany (1990), another discursive TA was developed in Denmark (1985), the Netherlands (1986), Switzerland (1992) or Flanders (2000). Under this discursive TA approach, the most important is less to provide the politicians with objective expert-based knowledge than to emphasize the social learning around specific technological issues. These TA configurations leave a space for interaction among stakeholders (including the general public) in order to work more specifically on social acceptability and understanding of new and emerging technologies. To do so, it is common for discursive TA's to mobilise a large set of participatory methods like consensus conference, citizen jury, scenario workshop or focus group.

3) Social acceptability time (1990-...)

At that time, scientific innovations were leaving laboratories from both physical and political points of view. Products of biotechnology were emerging in the whole society. This confrontation was notably working through the mechanisms of the market economy and in an increasingly globalised world. Indeed, the most important motor of the social exportation of biotechnology into society is economics and not dialogue between science and society organised for example through participatory technology assessment. With GM products to be placed on the market, the need for regulation was essential and requested in terms of risk management. In Europe, public authorities elaborated some specific laws at the European and national levels in order to match potential harmful effects of biotechnology to the public health and the environment. Those political and legal initiatives focused mainly on the confined use of genetically modified micro-organisms and voluntary GMO release into the environment.

The Directive 90/219 on the confined use of genetically modified micro-organisms (laboratory) applies the principles of good laboratory practices. In other words, it is a political confirmation of scientific customs in the domain of modern biotechnology. This regulation concerns the use of GM products within laboratories in order to avoid their uncontrolled release into the environment. The second most important European legal act is the Directive 90/220. It constitutes a common and minimum regulation in Europe about the obligation for the states to conduct preliminary assessments and controls before all kinds of GMO release. This legal condition allows to follow the leaving of GM products outside the laboratory.

These regulations, were founded mainly on the previous economical and scientific approaches on risks. But the *social acceptability time* implies a different definition of risks. The later is suggested by Ulrich Beck (1992) through the concept of modern risks. It does mean that risks identified by genetic engineering are characterised among others by:

- Extensive temporal and spatial dimensions;
- Democratic consequences;[2]
- Irreversibility;[3]
- Invisibility.[4]

Finally, the *social acceptability time* is suggesting a broadening of the risk definition within the domain of biotechnology. Indeed, this social contest on risks expresses a strong confrontation between technology and society. Through the issue of risks, technological development is questioned on its social and political dimensions. Do people accept this social evolution induced by biotechnology? Modern risks could be analysed as a story line expressing this rejection of scientific and technological progresses, at least in European countries where it was decided to adopt a precautionary attitude towards biotechnology.

This increasingly emerging socio-political contestation on the irreducible accompanying biotechnology also led to transformations in the way scientific research was conducted, especially from the early 1990's when it became more and more common to include an ELSA (for Ethical, Legal and Social Aspects of technology) sub-programme in any important R&D initiative. Like

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[2] To express this idea, we would like to quote a very famous and powerful formula of Beck: *poverty is hierarchic, smog is democratic.* Nobody can escape the risks because all distinctions of classes, culture and identity don't make sense anymore. Nevertheless, Beck recognises that some categories of people could be able to avoid certain risks because of their social, economical or cultural position.

Beck U. (1992).

[3] According to Ewald, irreversibility occurs when the nature or substance of nature is definitively changed. See Ewald F. (1996).

[4] Modern risks are not accessible to human senses. For example, it is impossible to hear, to touch, to see, to smell or to taste radioactivity and genetic modifications, see Beck U. (1992).

Arie Rip notes it, the United States Human Genome Programme (US HGP) was conceived in the mid 1980's. The two responsible institutes, the Department of Energy (DOE) and the National Institutes of Health (NIH), presented their plans for the programme in 1990. One of the components of the US HGP was the Ethical, Legal and Social Aspects programme. Although whether ELSA was born out of sincere intentions or as a mere lubricant for getting financial support of the HGP is not clear. Anyway, the fact remains that there are now such programs, that funds are reserved for them, and that social science and humanities understanding is brought to bear on issues of science in society. They have become one component of what one might call the "re-contextualization" of science and technology in society (Rip, 2002).

4. From the usefulness to compare biotechnologies and nanotechnologies

As showed above, « marketization » of biotechnologies has started from the 1990s, by a time nanotechnologies were just leaving laboratories to become a political stake. It is not obvious that the development of both biotechnologies and nanotechnologies is to be compared. Nevertheless, both of them can be described as generic fields of research, bringing potential applications in a broad range of areas. In a context of growing uncertainty, their impacts are linkable to each fields of classic sustainable development – economic, social and environmental. They have become major strategic issues for policy makers (UNESCO, 2006).

Even though, establishing a uniform parallel between those two technologies would be unsatisfactory. Nanotechnologies, broadly speaking (including nanosciences), are concerning the novel properties of matter at the nanoscale. Therefore, many fields of science are to be taken into account such as biology, chemistry or even physics (with manifestation of quantum effects – Joachim, Plévert, 2008). As we will stress below, nanotechnologies are uneasy to define and cross traditional boundaries so that some authors evoked a "plurality of nanotechnologies" (Barben, Fisher and al., 2008). The purpose of this paper is to show that, despite any kind of difference that may exist between biotechnologies and nanotechnologies, the development of the former have led to decisive evolutions for the latter. By adapting the three-periods cutting above, we may identify a "laboratory time", a "gouvernmental strategy time" and a still hesitant "market time". We stress that the development of nanotechnology and, therefore, its assessment, has been hugely influenced by development of biotechnology. Likewise, as it has been the case for biotechnology being assessed in the framework of parliamentary Technology Assessment offices, nanotechnology has been tackled under various perspectives by every major TA office, would be it according to an instrumental or discursive approach.

5. Historical presentation

Once more, it must be said that this theoretical approach remains limited in order to understand precisely every interaction between those periods which have actually been interwined at some level.

1. Laboratory time (1981 – 2001)

It is widely aknowledged that the nobelized Feynman launched the nanoscale era without even knowing it, with his speech "There is plenty of room at the bottom" (1959). But, on the one hand, real nanotechnology was concretely made possible with the creation of the scanning tunneling microscope (STM) and with the manipulation of single atoms or molecules in 1989. On the other hand, the impact of Feynman's speech on first nanotechnologists is quite often overestimated (SHEW, 2008). This may seem anecdotic but is definitely not, especially because of Drexler's works. Indeed, partly because of the biotechnological development, nanotechnology's laboratory time has been influenced in at least two distinct ways.

First, Drexler is the one who made nanotechnology become very popular through his well-known book *Engines of Creation* (DREXLER, 1986). It can be stressed that this book draws both utopias and dystopias. For some reasons undoubtably linked to biotechnological development, the worst case scenario – the one with the *grey goo* – will cross time borders until now. The focus on disaster side of nanotechnology may partly result from public governance of biotechnologies (DAVID, THOMPSON, 2008). In this matter, it is widely acknowledged that public governance of GMOs has in some way driven the development and some policies related to nanotechnologies into the way of "responsible innovation" (BARBEN, FISHER and al., 2008). So here we are with a really paradoxical situation whereby one of the scientist who has contributed to popularize nanotechnology is one who brings fears in public opinion, in a context having already been marked by biotechnologies' fictional histories.

Second, a very schism is running along the nanotechnological development, between what could be called "bottom-up" and "top-down" approach (UNESCO, 2006). As to say, first nanotechnologists (and Drexler among them) intended to create molecular manifacture atoms by atoms, starting from nothing, discovering a broad range of novel and unsuspected properties at this nanoscale. For some of those, the translation of this scientific project into political strategies has been oriented and even misappropriated by policy-makers. Nowadays, funding is going to some more technical projects, starting from technical components – such as transistors – in order to get them miniaturized, in a "top-down" approach, using well-known scientific laws (DREXLER, 2004 ; JOACHIM, PLÉVERT, 2008). As a result, there is no broadly accepted or even consensual definition of nanotechnology for today. Furthermore, finding such a definition is getting more complicated in a context of borders erasing.

Emerging technologies such as biotechnology "confuse the settled categories of pure and applied research, and of publicly and privately funded research" (UNESCO, 2006). So, from a purely scientific point of view, we found rise of fears and definitional struggles about nanotechnologies like it has been the case for biotechnologies.

2. Governmental strategy time (2001- …)

Quickly, nanotechnology has become a huge political stake in research policies, given the high economic potential of further marketable nano-applications. The following issues will focus on US and EU policies, even Japan invest nanotechnology with high voluntarism. It can be stressed that a turning point is reached in 1994, when Senator Al Gore underlines the strategic interest of nanotechnology in a report entitled *Science for National Interest*. This report is told to relay in some ways claims of some industrial consortiums, escaping from initial nanotechnological project and launching technical applications (Joachim, Plévert, 2008).
In a first time, strategic plans are adopted in order to launch nanotechnology programs and no to be distanced by other technological zones (Barry, 2006). The Japan Government has been involved in this crucial issue since 1992 (*Atom Technology Project*), but massive public investment comes first from the USA, with the *National Nanotechnology Initiative* launched in 2001. This program was granted $ 300 millions, growing every year until it reaches $ 1,5 billion (prevision for 2009) [5]. The European Union finances nanosciences and nanotechnology through its "Nanosciences and nanotechnologies: an Action Plan for Europe 2005-2009", with a public budget of about € 3 billions [6]. Nanotechnologies are sharing with biotechnologies an important investment from public authorities. Like them, there's seen like a major political stake in research policies.

In a second stance, learning from biotechnologies and, as mentioned above, from GMO case in particular, public authorities realized the importance of getting public involved and informed about those technological evolutions. As a consequence, they adopt two main attitudes.

From one side, public authorities are asking for more public involvement in decision-making process, especially in EU. It has been noticed that, doing so, they don't even imagine that public could refuse some technological innovation if well informed. The key point is seen to be the public education, so that "a consumer backlash does not occur", in order to win "public relations war" (Einsiedel, Goldenberg, 2004). Public acceptance of new technologies is seen to be driven by public information, more in EU than is US. In a more cynical way, in may be said that involving public in decision-making process prevent him for further contesting resulting decisions.

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[5] http://www.nano.gov/html/about/funding.html.

[6] See European Commission, "EU Policy for Nanosciences and Nanotechnology", retrieved October 2008, http://ec.europa.eu/nanotechnology/policies_en.html.

From the other side, both EU and USA have implemented frameworks on an entirely voluntary basis to regulate the development of nanotechnologies. EU have worked a lot on "A code of conduct for responsible nanosciences and nanotechnologies", adopted on 7th of February 2008 [7]. As a recommendation, this code doesn't have any legal force. However, it draws clear lines for improving governance of nanotechnology, inspired by the precautionary principle and the necessity of clear information, communication and to make nanotechnologies evolutions understandable. As for them, US are currently using the DuPont framework [8], which is a mean to assess the risk at best given the state of knowledge. This very pragmatic approach is process and result oriented and is designed to be incorporated in R&D of nano-products. It must yet be said that this framework is particular in the sense that it is a result of private initiative, from DuPont and Environmental Defense. This indicative framework doesn't get into account social equity, national security, economic development or privacy (Nano Risk Framework, p. 12).

3. Market Time (just starting)

This short point may just mention that the first products from nanotechnology have just been launched on the markets, for instance in care and beauty products or in sun-screens. They came on markets with almost total uncertainty as for their potential impacts on health and environment (CLIFT, 2006). Just to say that this point is really important to STS scholars. As for now, they have been involved a lot in projects future-oriented (scenarios) but they now have to consider current issues at stake (BARBEN, FISHER and al., 2008).

For the moment, it seems that EU and US have different approaches of the market and the launching of new technological products. On the nanotechnology issue, EU seems to have learned some lessons from biotechnological front, which is not yet very clear concerning US policies. In general, both EU and US are pushing forward the development of nanotechnology and make it a crucial stake of research and, therefore, for economic growth (EINSIDEL, GOLDENBERG, 2004). Nevertheless, EU's approach is more preventive and even sometimes precautionary, especially in regard of the burden of proof issue (knowing whether industry must proof a product to be safe before selling it or whether public authorities must proof it to be dangerous for health or environment). Concerning nanotechnology, the Royal Society and the Royal Academy of Engineering recommended to treat nanoparticles or nanotubes as brand new substances, placed at the highest hazard category, in order to shape risk assessment (CLIFT, 2006).

Conclusions

[7] A Commission recommandation, C(2008) 424 final, 07/02/2008, http://ec.europa.eu/nanotechnology/index_en.html.
[8] http://nanoriskframework.com.

The point for the agents evolving in a co-constructed socio-technological landscape (Rip, 2002) like the one our Western societies are currently living through is that there is a pressing need to balance the development of a as-socially-harmless-as-possible technology while taking more and more rapidly significant financial benefits from its exploitation. In addition, nowadays, the challenge has definitely become the growing interdependence of major science and technology provinces, known as NBIC convergence[9].

More than ever, the need for knowledge production adapted to the current contingences has become of highest importance. Would it take the form of instrumental of discursive knowledge in the frameworkd of TA, the need to bridge the gap between science and society — hopefully with the collaboration of scientists and STS scholars is a necessary requisite to undertake an "opening up" approach when appraising a technology by posing alternative questions, focusing on neglected issues, including marginalized perspectives, testing sentitivities to different methods, considering ignored uncertainties, examining different possibilities or highlighting new options. Either way, it becomes clearer how to frame transparency and structure responsibility and accountability in decision making and wider governance processes (Stirling, 2008).

Anyway, from the work-floor of a lab to the wider world, Technology Assessment more than ever emerges as a unique public arena to deal with the existing tough boundary between science and society, where STS scholars definitely have a part to play[10] in order to contribute to bridge this gap and to take the pathway towards what Helga Nowotny (2007) calls a "serviceable and reflexive STS expertise".

If we go a step further, this means the "outsider status" of STS scholars being widely — but most of the time reluctantly — accepted by scientists to facilitate a smoother intoduction of technology into society (and to give a hearing to societal concerns) has to evolve towards a more open science where Technology Assessment would not be product nor process-oriented but, instead, part of science in the making in order to meet the best possible and satisfactory way future technological challenges[11].

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[9] NBIC refers to the convergence of (1) nanoscience and nanotechnology, (2) biotechnology and biomedicine, (3) information technology and (4) cognitive sciences. See for example the STOA's report on converging technologies: http://www.europarl.europa.eu/stoa/publications/studies/default_en.htm

[10] We e.g. refer here to the "sociological enlightenment" evoked by A. Rip (2006), p.362.

[11] On this point, see Barben D., Fisher E., Selin C. & Huston D. H. (2008).

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