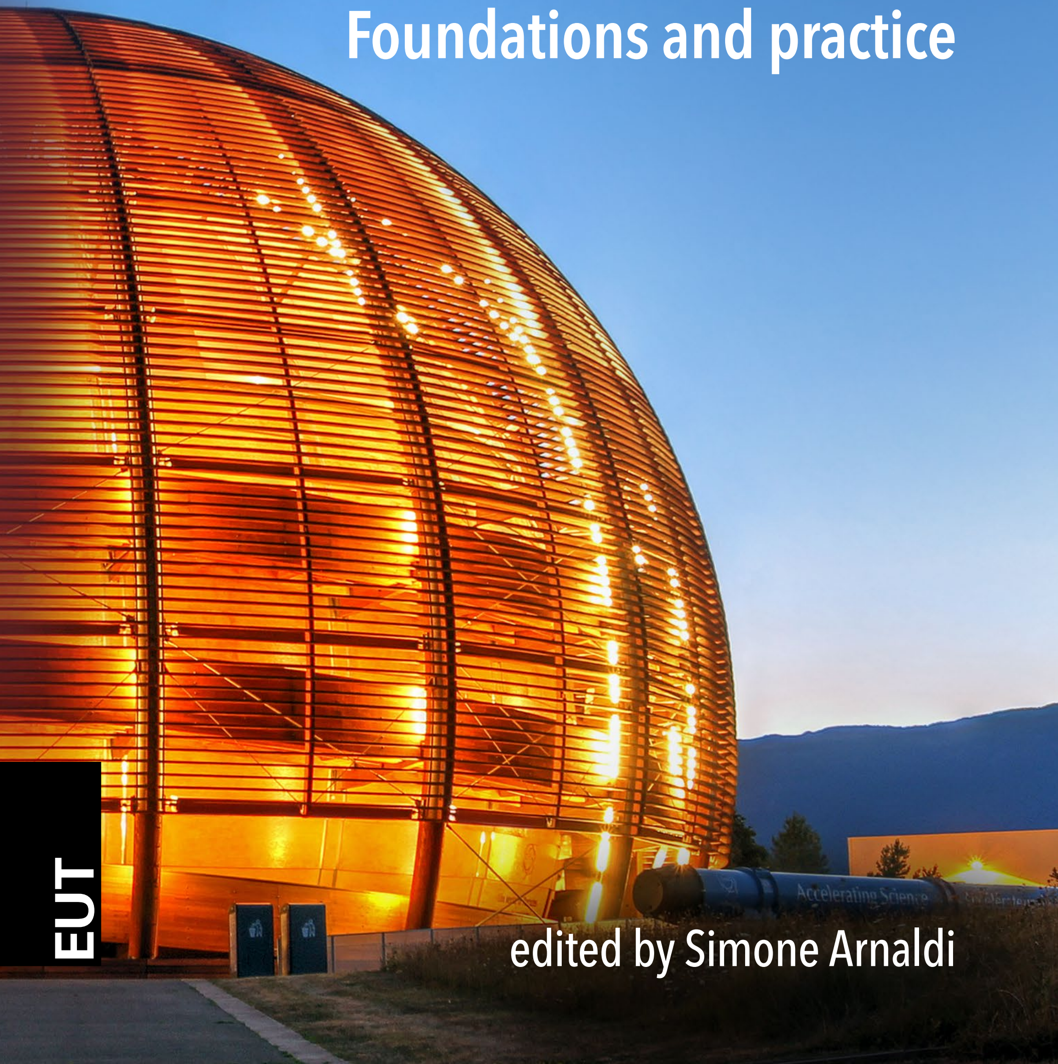
SCIENCE DIPLOMACY

Foundations and practice



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edited by Simone Arnaldi

What is science diplomacy? Why is it important in a world marked by global challenges such as climate change and confrontation between great powers? What knowledge can be mobilised to study this emerging field of practice and research? The chapters in this volume provide initial answers to these questions, examining different aspects of science diplomacy, both from a theoretical point of view and by presenting real world case studies. The intent of the book is to offer an introduction to an increasingly important theme in the relations between science, society and politics. Consequently, it is addressed to all those (students, researchers, decision-makers) who are approaching science diplomacy for the first time.

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Introduction

Simone Arnaldi

What is science diplomacy? Why is it important in a world marked by global challenges, such as climate change and confrontations between great powers? What knowledge can be mobilized to study this emerging field of practice and research? The chapters in this volume provide initial answers to these questions. Each chapter is devoted to exploring a different aspect of this issue, both from a theoretical perspective and by presenting case studies on science diplomacy «in action».

While in itself not new, the topic of science diplomacy has recently received considerable attention. The importance of science and technology in public policy and international relations (Krige and Barth, 2006; Simon, 2019; Weiss, 2015; Weiss, 2005); the interconnections, including competitive ones, between state and non-state actors, multiplied by globalization (Turekian et al., 2015); and the overbearing emergence of complex and multifaceted global challenges — such as climate change, food security, pandemics, and migration — that require science-based policy responses have motivated a growing interest in the mutual influence of science and diplomacy (Kaltofen and Acuto, 2018), thus facilitating «the emergence of science diplomacy» (Flink and Schreiterer, 2010: 3) as a specific «area of international relations where science and foreign policy interests intersect» (Ruffini, 2017: 3).

Its hybrid nature makes science diplomacy an activity that crosses the boundaries between science and foreign policy. On the one hand, it finds justification in the public image of science as a universalistic and non-partisan institution capable of looking at problems and finding solutions in a rational, transparent, and disinterested manner (Ziman, 1996). On the other hand, diplomacy—as a «nonviolent approach to the management of international relations characterized by dialogue, negotiation, and compromise» (Turekian et al., 2015: 4) — is inseparable from the protection and promotion of special interests, albeit pursued through «persuasion, not coercion» and seeking to achieve «a balance of results that allows each side to return home with at least some degree of satisfaction» (Fréchette, 2013: xxxiii). In the field of science diplomacy, these universalistic and pluralistic aspects coexist and balance each other differently depending on whether the activities deployed pursue exclusively national interests, issues of transnational significance, or genuinely global needs and challenges (Gluckman et al., 2017). This political dimension is ineliminable and is what makes science diplomacy different from international scientific cooperation, as it does not focus on scientific advances as such but frames them within a broader strategy of national or international foreign policy objectives (Turekian et al., 2015).

What, however, are the activities classified under this label? As will be mentioned several times in the chapters of this volume, many, often divergent definitions of this field have been proposed. For example, it has been said that «a country's science diplomacy refers to all practices in which actions of researchers and of diplomats interact» (Ruffini, 2017: 16). But what forms do these interactions take? A now «classic» definition, though not the only one possible, was proposed by the Royal Society and the American Association for the Advancement of Science (AAAS). It distinguishes three main dimensions of science diplomacy: supporting from a scientific–technical perspective the definition and achievement of foreign policy objectives (science in diplomacy), facilitating international scientific cooperation (diplomacy for science), and using international scientific cooperation to improve relations between different countries (science for diplomacy) (Royal Society and AAAS, 2010). In other words, this definition implies a two-way relationship between science and diplomacy in which the latter is used as a tool to facilitate scientific progress, while the former becomes an instrument of foreign policy.

This book sheds light on some aspects of these relations between science and diplomacy, bringing together contributions that, in its first part, introduce the topic of science diplomacy, and in the second part, present some successful initiatives in the field being promoted or supported by research institutions and international organizations based in the Italian region of Friuli Venezia Giulia.

In the first chapter, Pierre-Bruno Ruffini introduces the topic of science diplomacy and presents an overview of this field of studies and practices. Using examples from the history and current state of international relations, Ruffini outlines the main features of this concept, highlighting the main objectives pursued by states that engage in this field: attraction, cooperation, and influence. In the second chapter, Mitchell Young examines the relevance of science diplomacy in European Union (EU) policies. Young notes how science diplomacy has become an increasingly important tool in the foreign policy portfolio of the EU, which has made significant investments in this field. This chapter describes EU-led science diplomacy activities and outlines their current developments to illuminate the potential and specificity of a European strategy. In the third chapter, Simone Arnaldi explores the link between science diplomacy and science policy. In particular, the author identifies similarities between certain aspects of the discourse on science diplomacy (the representation of the scientific community, the relationship between scientific knowledge and the purposes of its use, the multistakeholder nature of activities in this field) and some models of science policies proposed in the scientific literature.

The second part of the volume opens with a chapter by Mounir Ghribi, who describes the 5+5 Dialogue Initiative on Research, Innovation, and Higher Education, a transnational policy platform that represents a successful example in the field of science diplomacy. As evidence of this success, Ghribi notes how the 5+5 Dialogue has effectively fostered relations between public policy, industry, and academia in Western Mediterranean countries, helping to disseminate a scientific, evidence-based policy approach to sustainable development. In the next chapter, Alessandro Lombardo illustrates the science diplomacy initiatives of the Central European Initiative (CEI), an intergovernmental forum for regional cooperation in Central and Southeastern Europe. Lombardo sketches a brief history of the CEI and of regional cooperation as a policy tool. He then analyses the effects of the activities implemented by this organization on the multiple divisions in this region of Europe and highlights their impact on strengthening cohesion along the eastern and southeastern borders of the European Union. The second part of the volume continues with a chapter by Peter F. McGrath, who examines the science diplomacy initiatives implemented by The World Academy of Sciences (TWAS). Aiming to contribute to the achievement of the 17 United Nations Sustainable Development Goals (SDGs), these initiatives consist of promoting the international mobility of scientists along the South–South axis, raising their awareness about the impact of scientific research on the SDGs and enhancing the civic engagement of researchers in support of the scientific communities in the countries where they work and live. The final chapter, by Giorgio Paolucci, describes the genesis of SESAME (Syncrotron-light for Experimental Science and Applications in the Middle East), the Middle East's first synchrotron light research infrastructure, which is based in Jordan and has been realized through the collaboration of Cyprus, Egypt, Jordan, Iran, Israel, Pakistan, the Palestinian National Authority, and Turkey, under the auspices of UNESCO (United Nations Educational, Scientific and Cultural Organization). Reviewing the history of SESAME, the chapter demonstrates the diplomatic potential of international scientific collaboration, highlighting how, in this case, it has promoted international cooperation among political authorities in a region of the world characterized by very high geopolitical tensions.

Taken as a whole, this book, which stems from a collaboration between the Department of Political and Social Sciences of the University of Trieste, the Executive Secretariat of the Central European Initiative, and the Autonomous Region of Friuli Venezia Giulia, aims to provide an initial response to the lack of introductory materials and content in this area of research, especially for an Italian audience — a context in which the topic of science diplomacy is still relatively neglected. I therefore hope that the volume will be a useful tool for those who intend to study these issues.

Part I. Foundations of science diplomacy

Science diplomacy. On several basic notions and key questions

Pierre-Bruno Ruffini

Abstract

«Science diplomacy» appeared some ten years ago in the vocabulary of international relations but it still remains poorly known, a frequent mistake being to confuse it with international scientific cooperation. Drawing on examples taken from history and from the present nature of international relations, this text can be read as a general introduction to science diplomacy, which belongs to the field of public policies and covers various practices. We identify these from the main objectives pursued by the states that engage in science diplomacy: attraction, cooperation, influence.

1. Introduction[1]

Science diplomacy refers to the particular area of international relations in which the interests of science and those of foreign policy intersect. The first scholarly definition of the term «science diplomacy» was devised only about ten years ago. In 2010, the Royal Society and the American Association for the Advancement of Science (AAAS) published a seminal report from a meeting titled *New frontiers in science diplomacy* (Royal Society and AAAS, 2010). In 2012, the quarterly journal *Science & Diplomacy* was launched by AAAS. First applied and analysed in the United States and the United Kingdom, which are both pioneering countries in this field, this particular class of activities is now part of the diplomatic portfolio of a growing number of countries. France is one of these countries, as demonstrated by the Ministry of Foreign Affairs' publication of a scoping report titled *Science diplomacy for France* in 2013 (Ministry of Foreign Affairs, 2013). If science diplomacy is an area that is becoming more salient within the field of public policy, it is also an emerging theme in academic research. Theses and other academic works and research programs have been devoted to science diplomacy, such as those launched by the European Commission in 2015 and 2016 under the auspices of the European H2020 program.[2] The following text is an introduction to this particularly rich dimension of contemporary international relations. The following sections define science diplomacy, frame the field from an international perspective and clarify its objectives.

2. What is science diplomacy?

Broadly speaking, diplomacy is a set of practices based on dialogue, negotiation and representation, by which a sovereign country defends and promotes its interests (and its values, according to some) in its relations with other countries. How do scientific research and its approaches and results relate to diplomacy? This question is the starting point for any discussion of science diplomacy. Following the pioneering approach of the Royal Society and the American Association for the Advancement of Science, which is an essential entry point into this subject, science diplomacy is defined on the basis of its three complementary dimensions, which are presented and commented upon here.

2.1 The three dimensions of science diplomacy

2.1.1 Diplomacy for science

Every country strives to promote its research community on the international scene and to facilitate scientific cooperation with other countries. To achieve this, public authorities use two main levers. The first involves scientific and technological cooperation agreements between governments, which are intended to establish an official framework for shared research priorities. Bilateral agreements, which are agreements signed between two governments, are the most common. Agreements signed by several governments are less frequent but often more publicised. Such agreements preside in particular over the construction of large research infrastructures, for which the involved countries share the costs and risks and derive benefits through the participation of their researchers in multinational programs. The International Thermonuclear Experimental Reactor (ITER) project is one example. Based on an idea that arose from the world of science, this colossal facility, currently under construction, should make it possible to verify the scientific and technical feasibility of nuclear fusion as a new energy source. However, this idea could never have become a reality without the ardent and enduring commitment of the leaders of the most powerful countries and the persistent negotiations of diplomats, who had to resolve difficult questions concerning the choice of the site (Cadarache, France) and the financing of the experimental reactor until the final signature of the agreement at the Élysée Palace on November 21, 2006.

The diplomatic networks abroad are another major vector of «diplomacy for science». The embassies that a country deploys around the world have among their missions the facilitation of bilateral scientific exchanges: the scientific advisors and attachés who work at embassies promote the mobility of researchers (by initiating or facilitating contacts, by granting financial aid, etc.) and assist them in certain negotiations (for intellectual property aspects, for example).

2.1.2 Science for diplomacy

In certain situations, scientific relations can foster diplomacy. This is the case when, for example, political tensions between countries do not allow traditional diplomacy to manifest itself. By helping to maintain or restore links between countries that officially find it difficult to communicate with each other or that no longer communicate with each other, science acts as a surrogate and vanguard of diplomacy. This is the most unique dimension of science diplomacy, but it applies only to particular instances of international relations. It is thus well known that during the Cold War, scientific exchanges between civilian researchers in the Soviet Union and the United States were never interrupted (as were commercial relations) and were only possible because the authorities of both countries issued the necessary visas: Researchers from both sides were sometimes even the liaisons of a form of parallel diplomacy. Another example is the relationship between the United States and Iran, two countries which have not had diplomatic relations since 1980. Nonetheless, their respective scientific communities have never interrupted their exchanges, and they have even intensified them: an agreement between the two countries' academies of science was concluded in the early 2000s, yielding around 20 bilateral research seminars over the following decade. Another example is President Obama's speech at Al-Azhar University in Cairo eight years after the 9/11 attacks. This inspiring, peace-making and constructive speech was a conciliatory gesture toward a community of countries that needed to be shown that America can speak a language other than that of belligerence. In addition to offers of scholarships for students from the Arab–Muslim world and the announcement of a new fund to support technological development in these countries, the American president announced his willingness to send «science envoys» to the Middle East: to date, more than 20 renowned American scientists have travelled to the Middle East to examine the possibilities of cooperation in the fields of health, engineering, energy and climate research.

2.1.3 Science in diplomacy

Some foreign policy issues require scientific insights, such as those arising from the implementation of international conventions regarding environmental, health or security issues. Diplomats responsible for negotiating and monitoring these conventions must be guided in their decisions by scientific expertise. All of the conventions whose subject matter lends itself to this need have had scientific councils and have used external experts and consultants. Some conventions with a particularly broad and complex scope (e.g., the environment, biodiversity, etc.) benefit from sophisticated structures of collective expertise referred to as «science policy interfaces». These structures are based on congregations of large groups of experts (panels) responsible for reporting on the available knowledge and formulating diagnoses. The Intergovernmental Panel on Climate Change (IPCC), created in 1988, is undoubtedly the most widely known of these interfaces. Another example is the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which was officially created in 2012. In international arenas, the analyses and conclusions provided by experts contribute to negotiations between diplomats, hence the term «science in diplomacy». These various examples demonstrate that science diplomacy can operate in the traditional framework of relations between countries in a bilateral fashion, as well as in the framework of relations involving many countries, being referred to as multilateral science diplomacy. The threefold characterisation of science diplomacy by the Royal Society and the AAAS is as brilliant as simple. However, it warrants some comments and elaboration.

2.2 Comments and elaborations

2.2.1 The three parts are interdependent

Between these three compartments of science diplomacy, the boundaries are porous, and the relationships can be two-way (see for example Copeland, 2016; Penca, 2018). The «Cairo speech» illustrates this; the announced dispatch of high-profile American scientists to their counterparts in the Arab-Muslim world was part of an overall diplomatic effort to restore the image of the United States in these countries and to renew ties that had been eroded, particularly following the American intervention in Iraq. However, this relationship between science and diplomacy is inseparable from the reverse one. Although these contacts between American scientists and scientists from the targeted countries are supposed to favour the options of American diplomacy, they also provide American researchers with new perspectives of exchange and cooperation: with science envoys, science works for diplomacy, and diplomacy also works for science.

2.2.2 Science diplomacy is a matter of national interest

To fall within the scope of the theme analysed here, the scientific relations that are established between countries must necessarily have a diplomatic dimension. This means that science diplomacy is a matter of public action and is therefore neither spontaneous nor passive; rather, it is part of the broader framework of the external actions of the states that practice it. When combined with the adjective «scientific», the word «diplomacy» introduces the (geo)political dimension (in science): science diplomacy is one of the levers available to states to promote, directly or indirectly, their interests on the world stage. What kind of interests, then? It is useful to distinguish between scientific and non-scientific interests. The former interests refer to the desires of states to acquire scientific (and more broadly, technological) resources to increase their national potential and to change the international balance of power in a manner that is more favourable to them: the attraction of high-level foreign researchers typically falls into this category. The second category refers to situations in which international scientific relations are primarily guided by a political agenda: this was illustrated by the opening of European research programmes to Eastern European countries at the beginning of the 1990s within the framework of a «neighbourhood» policy preparing the docking of these countries to the European Union, here regarded as the political entity initiating the process. In observing international scientific relations, it is therefore important to identify the dominant objective (scientific or non-scientific, most often political) with the awareness that, in practice, objectives are often linked. For instance, the seminal Royal Society-AAAS report provides the following definition of «science for diplomacy»: «using scientific cooperation to improve relations between countries» (Royal Society and AAAS, 2010: vi).

Scientific cooperation reveals its dual nature: it allows each of the participating countries to benefit from sharing new research results, international co-publications and scientific capacity building. However, this scientific added value — which is the immediate objective of any cooperation between laboratories in different countries — can be associated with other forms of added value: the virtues of dialogue between researchers from different countries, the creation of relations of trust that can encourage the thawing of political tensions between countries that are accustomed to confronting each other, the transformation of the public's image and representation of other countries, etc. This relates to the argument most often proposed in the first writings devoted to science diplomacy: the power of science, by virtue of its «universal values», can contribute to pacifying international relations. In these situations, it is within the shared interest of each country to encourage scientific cooperation by signing international agreements, by issuing the necessary travel visas to researchers and by financially supporting collaborations in the framework of specific bilateral programs.

Similar arguments can be developed in the context of multilateral scientific relations, in which the interests of each country coalesce into a common interest. This applies to certain achievements which are frequently presented as emblematic of science diplomacy, such as those of the European Organisation for Nuclear Research (CERN) or the SESAME project. Created by 12 European countries in 1954 under the auspices of UNESCO, in a period marked by a strong desire for peace and for the development of European institutions, CERN has made it possible to restore bridges between nations that were eroded by the fractures of history. The replication of this model on a smaller scale, which is currently underway in the Middle East with the launch of the SESAME project, has been driven by similar intentions: to develop physics research for peaceful purposes and to promote cross-border cooperation in a region of the world embroiled in conflict. These multilateral scientific initiatives convey a specific vision of relations between nations that is based on the noblest values of science, dialogue, sharing and the public interest; this vision aims to help reconcile disparate groups of people. Nonetheless, the positive values of science never fully obscure the reality of international power relations. The aforementioned examples, in which the national interests of the signatory countries do not disappear, merely provide a partial view of the landscape of science diplomacy. In the context of this diplomacy, the national interests of the countries involved are not only present; rather, they are generally predominant. There is therefore no form of science diplomacy that does not have a direct relationship with the interests of the states that promote it. The link to national interests is the determining criterion that allows us to identify, in the vast array of international scientific relations, the endeavours that deserve to receive the label «science diplomacy».

2.2.3 Science diplomacy should not be conflated with international scientific cooperation

This cautionary note follows directly from the section above. International scientific cooperation and science diplomacy are not synonymous and should not be conflated with each other. Scientific cooperation refers to the work of researchers who are driven by the desire to advance science and who find renewed means to achieve this goal through working alongside their counterparts in other countries. There is not necessarily a national interest at stake, nor any expected diplomatic benefit. However, there are many situations in which international scientific cooperation and science diplomacy coincide and when the international work of researchers and their research institutes is part of diplomatic strategies that aim to favour contacts with certain countries, promote negotiations leading to international agreements or increased influence. Finally, science diplomacy can exist beyond the framework of international cooperation. Policies that aim to attract scientific and academic brainpower are a clear illustration of this. A country practices a particular form of «diplomacy for science» when it approaches and recruits students and researchers abroad with the support of its embassies. This can be conceptualised as a zero-sum game, since any resource gained by this country is lost to another, and it therefore deviates from the positive-sum game that generally characterises cooperation. While it is collaborative when it satisfies the joint interests of two or more countries, science diplomacy becomes competitive when the «every man for himself» rationale prevails (Ruffini, 2018). To the logic of cooperation, science diplomacy adds the logics of attraction and influence, which will be detailed later.

To speak of science diplomacy is to invoke a recent vocabulary that dates back about ten years. However, the novelty of the vocabulary should not obscure the historical links between science and foreign policy. A quick overview of history reveals that the great voyages of exploration undertaken by the European major powers in the 18th century were not devoid of geopolitical objectives, although they also had scientific goals (discovering distant lands or procuring unknown mineral or plant species). More recently, the Cold War period provided numerous examples in which foreign policy was strongly impregnated with science. This galvanised the ideological competition between the US and the Soviet Union, particularly in the fields of nuclear energy and space. The conquest of space, in particular, appeared to be the juncture *par excellence* in which scientific and technical issues converged with those of «systemic» competition. Retrospectively, this period appears to be the one in which the foundations of science diplomacy were established and the period in which the concept was incubated. However, in the post-Cold War period, the contemporary forms of the relationship between science and foreign policy have truly manifested themselves. This will result in the dissemination of a new vocabulary and the participation of a growing number of countries.

Why is this happening right now? This recent development can be attributed to the growing awareness of the existence of global issues, which intensified in the last quarter of the 20th century, and the increasing interest in «global public goods». Additionally, today's major challenges, such as climate change, food security and the spread of infectious diseases, have a scientific component. Facing these challenges is in the interest of the international community and calls for collective action. To inform this action, the use of experts is indispensable. Much of the interest in science diplomacy has arisen from the fact that these global issues are on the international agenda.

The growing role of non-state actors in diplomacy is a second reason for the emergence of science diplomacy. Non-governmental organisations and businesses occupy an important position in the debates that precede or surround major international negotiations: diplomacy is generally recognised today as being more inclusive than it was in the past (Hocking et al., 2012). The scientific community, which has always been accustomed to dialogue and exchange, has the necessary assets to make its voice heard in international forums and to take advantage of the attention now devoted to civil society actors.

Finally, the third reason is that soft power is asserting itself in the post-Cold War world as a means of expressing the power of nation-states on the international scene, alongside the traditional forms of military and economic power. Soft power can be defined as «the ability to get what you want through attraction rather than coercion or money» (Nye, 2004: x). Science is generally recognised as an effective vector of soft power. According to the available surveys, the United States are most respected in the world thanks to science and technology, in addition to the appeal of its music or cinema. Additionally, China, whose growing influence in Africa is often discussed today, has established a positive reputation in Africa through science and technology.[3] A country can therefore attract and influence through its scientific and technical achievements or its potential in this arena. The values of openness, sharing and universality inherent to the scientific approach are congruent with the expression of «soft» forms of influence and power, and this explains why they attract the interest of diplomats.

Thus, states have long been involved in science diplomacy, although they did not always invoke the vocabulary that is used today. The fact that science diplomacy is now named, claimed and conceptualised is a characteristic of the post-Cold War period, and increasingly more states now understand the benefits that they can draw from it in contemporary international relations.

4 The objectives of science diplomacy

What are the forces that govern the development of science diplomacy? Countries that wish to defend and promote their interests in the world are not unaware of the asset that scientific development represents. More precisely, they are committed to three objectives, namely to attract, cooperate and influence (Ruffini, 2017). The sections below illustrate these objectives with examples taken from the field of international scientific mobility.

4.1 Attract

Any country that wishes to have a significant impact on the world's knowledge economy and scientific affairs must have an attractive research and innovation system. Attractiveness is a major issue and a key word in science diplomacy. It is measured by the ability to attract and retain the best «brains», which, for our purposes, are those of professional researchers and doctoral students: increasing their incoming mobility is a central objective of science diplomacy. The countries, or at least the most powerful among them, are in direct competition to influence the global distribution of this brainpower. The challenge is to accumulate science-intensive human capital and to increase the national endowment by importing «brains».

According to UNESCO data, about 5 million students were in international mobility in 2017. This figure rapidly increased: internationally, there were only 800,000 mobile students in 1975, and according to forecasts, there will be 8 million by 2025 (OECD - Organisation for Economic Cooperation and Development, 2014). One area in which mobility is growing particularly rapidly is amongst doctoral students. According to UNESCO data, 359,000 doctoral students were internationally mobile in 2012. Many were writing their dissertations in the United States (40.1%), the United Kingdom (10.8%) and France (8.3%), to name the top three host countries. More than half of them were preparing a science or engineering thesis (UNESCO - United Nations Educational, Scientific and Cultural Organization, 2015).

Regarding the international mobility of researchers, the available statistics are unfortunately substantially less precise. The data collected by international organisations (OECD or UNESCO) concern the migration of highly qualified people, of which the population of researchers constitutes a portion. In the absence of an overall census specifically regarding researchers, this section focuses on the results of a survey conducted to study the different models of international mobility (Franzoni and Scellato, 2012).[4] Two broad categories of countries emerge: The first includes those in which the proportion of researchers who are foreigners represents 40 to 50% of the total number of researchers. Sweden, the United States, Australia, Canada and especially Switzerland, where more than one half of researchers are foreigners, belong to this group. At the other end of the spectrum, other countries have only a small proportion of foreign researchers: India, Japan, Italy and Spain are in this category. France occupies an intermediate position:

For public research alone, one researcher out of 10 is of foreign nationality, typically hailing from another European country. Regarding the countries of origin of expatriate researchers, India comes out on top, with approximately 40% of its researchers abroad, followed by Switzerland, the Netherlands and the United Kingdom. On the other hand, the researchers who expatriate the least are the Japanese, Americans and Spaniards. In addition to this summary, more specific data attests to the dynamism of the international mobility of researchers.

The «grey matter» of researchers and students who will be amongst the research elites of tomorrow is an essential fuel for the collective knowledge of society: foreign researchers, recruited within a global market that has become highly competitive, are a source of dynamism for the national research system. Doctoral studies are another strategic issue: welcoming students from abroad to prepare their thesis means broadening the pool from which the host country can draw to ensure the replenishment of its pool of researchers. The propensity of doctoral graduates to remain in their host country is high, whether they stay for a post-doctoral internship or to hold a permanent research position (Auriol, 2010).

To attract professional researchers or doctoral students, the means implemented by public authorities cover a broad spectrum that includes benevolent policies for granting visas, doctoral scholarships, material facilities for settling in the country, assistance to facilitate the return of expatriate researchers, etc.

4.2 Cooperate

In its essence, science has no borders, and cooperation between researchers from different countries strongly demonstrates the values of dialogue, sharing and universality. International scientific cooperation fosters a harmonious mode of communication between states and between peoples. It plays a role in the moderation of international tensions, the normalisation of inter-state relations and the reinforcement of existing solidarities. It also makes it possible to execute projects that no single country could accomplish independently. For diplomats, taking advantage of the positive values of science on a multilateral scale means working towards the realisation of projects, such as CERN or ITER. Another example is the cooperation between states in the framework of the International Space Station. In bilateral relations, diplomats are involved in the establishment of framework cooperation agreements and in their execution, due to the periodic meetings of bilateral commissions. These few examples suggest that international scientific cooperation is a terrain of choice for diplomatic action that lies at the heart of «diplomacy for science».To extend the discourse regarding international scientific mobility, it may be fruitful to give it another reading. We cannot reduce all matters to national logic alone, nor to the notion that what one country gains in «grey matter», another must lose. In addition to the logic of competition between countries, there is another logic, namely of cooperation. Thus, the mobility of «brains» between countries is not a zero-sum game; rather, it is a positive-sum game. Internationally co-authored publications that are the fruits of cooperation are on the rise: their share of all scientific publications increased from 16.7% in 2006 to 21.7% in 2016 (National Science Board, 2018).

International cooperation between researchers thus enriches the world's knowledge capital. In addition, international scientific mobility is gradually changing in nature: Alongside brain drain and brain gain, which describe the long-term or even permanent expatriation of researchers, the approach is now being extended to brain circulation. This encompasses all forms of international scientific mobility: brain drain and brain gain, as well as the temporary mobility (from a few days to a few months) of researchers. Temporary mobility, which refers to the ebb and flow of researchers between their laboratories and those of their colleagues abroad, is generally part of a cooperation process.

4.3 Influence

How can a country be influential and exert an impact on world affairs? In response to this question, J. Nye has supplemented the usual answers by introducing the now-classic distinction between hard power and soft power. Compared to hard power, soft power is based on the use of more subtle means. It allows a country to be influential via seduction and persuasion, the objective being to convince others to share its values, to reproduce its models and to adopt its modes of thinking. A country is thus influential because, rightly or wrongly, in the collective imagination, its way of life, its values and its success seduce, inspire and attract.

As demonstrated above, science is a vector of soft power. However, there are other channels through which a country can subtly influence the choices of others and attract foreign actors to the national research system or encourage them to cooperate with the system. Amongst these main channels, first and foremost is the presence of nationals in international scientific organisations. All countries attach importance to being well represented in these organisations, especially in positions of responsibility. Aside from considerations of prestige, some hold the conviction that nationals can be a source of information and influence. Expertise applied in an international context is another source of influence, as it allows technical standards, working methods and good practices to be disseminated in the country of intervention. This is particularly true for scientific expertise, whose link with foreign policy is particularly salient in multilateral diplomacy regarding global public goods, such as the climate or biodiversity. Finally, another little-known but effective vector of state influence is foreigners who, as former students or researchers who were temporarily hosted, ultimately return to their country of origin. Provided that they have been well received, they generally serve as ambassadors of the country where they were trained or where they worked.

5 Some questions, in conclusion

To conclude this overview of science diplomacy, it is important to recall that the intersection of science and foreign policy is not new: what is now called «science diplomacy» encompasses historical practices in which the interests of science and those of foreign affairs have been combined. However, even if science diplomacy did not originate in the 21st century, this century has placed it at the forefront. A growing number of countries now recognise its importance and make it one of the assets of their overall diplomacy. Science diplomacy is a factor of renewal and enrichment in the conduct of international relations.

In the necessarily limited format of this presentation, many issues have been excluded. This section formulates a few final remarks and questions. First, the rise of science diplomacy redefines the place of the researcher in society. It is trivial to presume that the researcher and the diplomat belong to drastically different and distant worlds and that they frequently ignore each other. Science diplomacy transcends this traditional vision by demonstrating that the initiatives and actions undertaken by researchers can uncover meaning, not only for science and for researchers, but also for diplomacy. However, in science diplomacy, is there a risk of the political exploitation of the researcher? In «science for diplomacy», geopolitical stakes are not absent, and the choice of words nearly suggests the subordination of science to the interests of diplomacy. Finally, what is the true scope and effectiveness of science diplomacy? To what extent does science facilitate diplomacy? To what degree can diplomacy support science? It is clearly difficult to make this kind of evaluation, and no country has produced any tangible assessments. However, it is evident that science benefits from the facilities offered by the cooperation agreements negotiated between countries and from the support provided by diplomatic networks for the implementation of research programs. Additionally, science helps the diplomat in action through the values it conveys, namely those of neutrality and universality. Fundamental research is an instrument of peace, in addition to being a factor of development; its results are a public good, and science is a common language of humanity, allowing it to transcend borders. Therefore, diplomacy accrues advantages in relying on science, as science does in relying on diplomacy. However, to ensure this symmetry of advantages and to evaluate the efficiency of the science diplomacy approach, a more thorough observation of concrete situations and a refinement of the concepts of analysis are indispensable.

Endnotes

1 This chapter is a translation of: P.-B. Ruffini, Diplomatie scientifique. De quelques notions de base et questions-clés, in: "Philosophia Scientiæ", n. 3, 2019, pp. 67-80. We thank the author and the publisher of "Philosophia Scientiæ" for allowing us to include a translated version of the original article in this volume. Simone Arnaldi edited the English translation.

2 These distinct but complementary projects are named as EL-SCID (*European Leadership in Cultural, Science and Innovation Diplomacy*), InsSciDe (*Inventing a shared Science Diplomacy for Europe*) and S4D4C (*Using Science for/in Diplomacy for Addressing Global Challenges*). The author of this text has participated as an expert in the InsSciDE project.

3 According to periodic surveys by the Pew Research Center.

4 This survey was conducted in 2011 among 17,182 researchers from 16 countries.

Science diplomacy and the European Union

Mitchell Young

Abstract
Science diplomacy is an increasingly important tool in the foreign policy portfolio of the European Union (EU), which has made significant investments in this domain. This chapter assesses what science diplomacy activities are implemented in the EU and describes the current developments in this policy field on the EU level, to examine whether and how an EU strategy for science diplomacy can be organized and implemented.

1. A brief history of the EU's science diplomacy

There is both a long and a short history of science diplomacy in the European Union (EU), depending on how the concept is characterized. If we judge by when the term «science diplomacy» was first used, then it is relatively recent. It first appears towards the end of the first decade of the 21st century and is generally seen to have congealed around the report *New frontiers in science diplomacy* (Royal Society and AAAS, 2010), which was based on a transatlantic conference organized in 2009 by the Royal Society and the American Association for the Advancement of Science (AAAS). It was first mentioned in the official discourses of the EU in 2012. On the other hand, if we judge by when the European Union and its Member States began to practice the activities which have come to be considered science diplomacy, then there is a history that traces back to the 1950s. The Royal Society report mentioned above constructs the term science diplomacy as a composite of three practices which each have a distinct meaning and history: diplomacy for science, science for diplomacy, and science in diplomacy. Diplomacy for science is about the ways in which diplomats help advance and facilitate international science cooperation – i.e. helping scientists link up with other scientists across borders and creating joint research programs; science for diplomacy is when scientists and scientific relationships affect foreign affairs, i.e. improving relations between countries, or push diplomatic efforts forward, a quintessential example being the Antarctic treaty of 1959. This understanding of science diplomacy is more controversial than the first and falls under more recent understandings of networked, rather than traditional, diplomacy (Cooper et al., 2013), in which non-state actors can and do have an active role. Finally, science in diplomacy is a way of describing the use of scientific expertise in diplomatic affairs, that is, the ways that science informs foreign policymaking; for example, the Intergovernmental Panel on Climate Change (IPCC) or the Iran nuclear agreement represent situations in which effective diplomacy needs to be rooted in deep scientific expertise. This characterization of science diplomacy is relatively new, but it comes out of an older tradition of science advising and epistemic communities (Haas, 1992). By looking at these three practices separately, we can trace a history of science diplomacy within the EU and its Member States going back to the 1950s. An example of diplomacy for science can be found in 1954 with the establishment of the European Organization for Nuclear Research (CERN). Evidence of science for diplomacy can be found in the Antarctic treaty, a classic example of science for diplomacy (Berkman, 2011), signed in 1959 by France and Belgium. And examples of science in diplomacy can be found in the establishment of Science Advisory Councils in France, Sweden, West Germany and Belgium in the 1950s and early 1960s, as well as the European Commission's Joint Research Center that was founded in 1957. The EU's practice of other forms of science diplomacy began in the later 20th century as it extended its science cooperation policies and support to countries outside of what was still called the European Community. In 1990, a Commission report stated: «scientific and technological cooperation with third countries has become a matter of increasing importance for and an essential part of the external relations of the Community...». The claim that science was an «essential part» of foreign relations suggests that the EU was at the forefront of what would come to be called science diplomacy. This belief in science as an important part of international affairs continues to the present day. The Marseille Declaration of 2022 states: «international cooperation in R&I, as well as in higher education, is of geopolitical and strategic importance for the European Union» (French Presidency of the Council of the European Union, 2022). The main difference is that in the more recent text, science diplomacy is depicted as a tool that can be used actively and purposefully in foreign affairs.

The first use of the term «science diplomacy» in official EU policy discourses is found in the 2012 communication *Enhancing and Focusing EU International Cooperation in Research and Innovation: A Strategic Approach*. This document came from the science policy discourses and was written as preparatory material for the establishment of the Horizon 2020 research funding framework. It states: «"Science diplomacy" will use international cooperation in research and innovation as an instrument of soft power and a mechanism for improving relations with key countries and regions. Good international relations may, in turn, facilitate effective cooperation in research and innovation» (European Commission, 2012a). From this, we can see that the emphasis is more on diplomacy for science and the improvement of science, though it is recognized that there can be a positive feedback loop in which the improvement of science relations leads to the advancement of political relations. In 2021, the Commission's communication *A Global Approach to Research and Innovation: Europe's strategy for international cooperation in a changing world* argued that «a stronger focus on science and technology in the EU's foreign and security policies in terms of "science diplomacy" would help the EU to project soft power and pursue our economic interests and values more effectively, meeting demand and interest from partner countries and playing to the EU's strengths as a research and innovation powerhouse» (European Commission, 2021). Here we can see the EU linking science directly to power, particularly economic and normative power.

In sum, we can characterize the EU's understanding of science diplomacy as two-pronged: first, it addresses science itself, aiming, through cooperation and openness, to improve scientific results in ways that reflect the discourses of diplomacy for science; and second, as part of its foreign policy and global strategy, reflecting the ideas behind science for diplomacy and science in diplomacy. Its role in these areas is in pursuing solutions to global challenges, in supporting development and developing countries, often as part of the United Nation's Sustainable Development Goals (SDGs), and finally, as a means of exerting geopolitical power.

2. The fractured dimensions of EU science diplomacy

As might already have become clear, an understanding of science diplomacy as it pertains to the EU is fractured in a number of ways. There are different levels, actors, tools, and types of power at play. In order to make sense of the EU's science diplomacy, it is, therefore, necessary to dig into the four dimensions that structure the EU's practices of science diplomacy. Each dimension is multiple in nature.

2.1. Multi-level

The EU is a system of multi-level governance (Piattoni, 2010), and this directly affects the practice of science diplomacy in a number of ways (Rüffin, 2020). Understanding science diplomacy within a multi-level system raises issues of jurisdiction and competencies as well as cooperation and coordination. The fundamental question of which level of governance has the competence and jurisdiction to practice science diplomacy is complicated. In practice, we find science diplomacy on all three levels: the supranational, national and subnational. In terms of competencies, as an offshoot of the EU's science, research and development policies, the EU can claim a shared competence in this area, one which is bolstered by the development and expansion of the European Research Area (ERA) beyond the bounds of the EU. However, we cannot hope to understand EU science diplomacy without also incorporating the science diplomacy of the Member States. These states practice science diplomacy in different ways. They also may have different aims: science diplomacy can be used to obtain access, promotion, and/or influence. Research shows that Germany and France tend to emphasize more the «access» rationale, which sets them apart from the anglophone countries which seek influence (Flink and Schreiterer, 2010). In part, this is due to the long-established and institutionalized networks of scientific cooperation that these states have coordinated. It has also been shown that European countries differ in the type of science diplomacy that they consider legitimate; for example the Czech Republic understands it almost exclusively as a practice of diplomacy for science (Young et al., 2020). Further, Member States put different levels of emphasis on different topics and issues; for example, responding to the Zika virus was important in Spain but far less so in the Czech Republic (Šlosarčík et al., 2020).

Finally, the sub-national level needs to be considered. Cities are increasingly becoming diplomatic actors. Barcelona, with its Science and Technology Diplomacy Hub, is an example and leader in this area. The Hub has a «mandate to elevate the role of science, technology and cities in foreign policy and make Barcelona a more influential player on the global stage by representing its knowledge and innovation ecosystem worldwide» (SciTech DiploHub, n.d.). Also at the subnational level, universities and academies of sciences are increasingly engaged in diplomatic activities, so much so that a fourth element to the Royal Society framework has been proposed that would incorporate them: «diplomacy in science» (Langenhove and Burgelman, 2021).

2.2. Multi-actor

The multi-level character of science diplomacy also overlaps with a multiplicity of actors on each level that ranges from politicians to academics and NGOs, as well as to different types of institutions and entities such as cities and universities. On the EU level, science diplomacy efforts extend across the Directorate Generals (DGs). We can categorize these into two types (Young and Ravinet, 2022). The first is connected to the overall external strategies of the EU which, while centred in the European External Action Service (EEAS), also involves other DGs. The second type is connected directly to the science policies of the EU and comes mainly out of the DG Research and Innovation. The Global Strategies of the EU have, since their inception in 2016, increasingly begun to recognize the importance of various aspects of science diplomacy. These are not always explicitly called science diplomacy, but they refer to the importance of scientific knowledge in solving global challenges: «responsive external action must be underpinned by a strong knowledge base» (EEAS - European External Action Service, 2016: 48). From 2020, the Science in Diplomacy aspect was institutionalized in the EEAS with the creation of a Science and Technology Advisor position. In 2022, a section of the EEAS website appeared which includes science diplomacy in its list of «What We Do», stating that «science and technology play an increasingly important role in the geopolitical arena» (EEAS - European External Action Service, 2022). Science diplomacy cuts across both the geographically delineated and the globally oriented parts of the organizational structure of the EEAS. Other DGs which are significantly involved in science diplomacy include DG Education, Youth, Sport and Culture, DG Communications Networks, Content and Technology, DG

International Partnerships, DG European Civil Protection and Humanitarian Aid Operations, DG Neighbourhood and Enlargement Negotiations, DG Agriculture and Rural Development (AGRI), DG Climate, and DG Trade.

DG Research and Innovation (RTD) has been practising science diplomacy for three decades, as seen in the earlier quote from 1990. In 2008 it updated its position with the concrete aims of putting the «European Research Area on the global map» and arguing that global challenges «highlight the need for effective S&T cooperation» (European Commission, 2008: 2-3). Setting the stage for more explicit science diplomacy discussion in the EU was the 2016 report *Open Innovation Open Science Open to the World*, which stated that: «science diplomacy should become an element of the renewed Global Strategy on the EU's Common Foreign and Security Policy» (European Commission, 2016: 75). DG RTD promoted the idea of a «global research area» based on the European Research Area, in which openness would be paramount. This championing of open science continues, but recently in a more cautious manner. As awareness of the geopolitical implications of knowledge have became clearer, openness is increasingly becoming a privilege which is provided to trustworthy partners rather than an absolute principle applicable to all countries.

The multi-actor aspect of European science diplomacy can be seen more clearly by unpacking the example of research funding cooperation in the area of food security between the EU and the African Union (Ravinet et al., 2020). Food security addresses all three dimensions of science diplomacy; it relates to «diplomacy for science» by facilitating international scientific cooperation, providing joint funds for researchers and developing relationships between EU and African researchers. It relates to «science for diplomacy» improving international relations, as it was the first topic agreed on in the Joint Africa-EU Strategy adopted in 2007. The strategy, in addition to supporting research efforts, also aimed more broadly at creating conditions of peace, security, and socio-economic growth. In fact, the inclusion of scientific cooperation into the EU's external policies began with development cooperation with Africa in 1982 (Prange-Gstöhl, 2018). Thirdly, it relates to «science in diplomacy» by concretely providing scientific knowledge that informs international policymaking and global governance around a specific challenge. Of the major societal challenges that were considered for the partnership strategy (that included climate change, global health, supporting livelihoods), it was decided that the first priority would be «food and nutrition security and sustainable agriculture» (European Commission, 2013). The Partnership on Food and Nutrition Security and Sustainable Agriculture (FNSSA partnership) was established, and implemented in large part through the funding of the EU framework programmes. The process of writing the work programmes for Horizon 2020, which define the calls for projects on food security, illustrates the multi-actor character of EU science diplomacy. This development of the work programme involved not only DG RTD, but also DG International Cooperation and Development (DEVCO) and DG AGRI. The JRC is involved in support activities and has built a Knowledge Centre (see the section below) on food security. Each DG has distinct specializations; for example, DG AGRI focuses more on areas of soil and food systems. The DGs also differ in their rationale for supporting research. While the overarching aim of «excellence» in Horizon 2020 is emphasized by both DG RTD and AGRI, who seek «scientific impact» through groundbreaking research, DEVCO is more interested in «development impact», which can be achieved with more «applied» and «scalable» research. DG ENVI is interested in how food security and climate are intertwined, and for EEAS, beyond their interest in solving the problem of food security, there is also a more instrumental aim. Funding research cooperation can be an incentive for obtaining other types of cooperation that the EU needs, for example, on migration control, good governance, etc. The multiplicity of actors thus shape food security research cooperation according to a range of interests: impact, excellence, relevance, scalability, economic growth and competitiveness.

2.3. Multi-tool

The EU has engaged a range of tools in its science diplomacy efforts that each has a different character: some are strategic, dealing with governmental communications as we have seen above, and others are operational or supporting, which provide the means to put science diplomacy into practice (Langenhove, 2017). Christopher Hood and Helen Margetts (Hood and Margetts, 2007) provide a useful model to organize these operational and supporting tools. They identify four main categories of tools based on the type of resource that the government mobilizes: treasure, authority, organization, and nodality. The European Union's science diplomacy activities use all types. Treasure-based tools mobilize financial resources and can be used both by providing and withholding funds (as was done with Switzerland in 2014 when it broke free movement treaties with the EU). Research, innovation, and educational mobility are the third largest funding line in the EU budget and are one of the few areas in which the EU can use its funding to shape governance. The bulk of this funding comes under the framework programs, which as of the eighth, Horizon 2020, was open to the world, meaning that Non-Member States could join these projects, and if they wished, could deepen the relationship by becoming an associated country. In Horizon 2020, there were 16 associated countries which had over 9000 participations in projects, and another 110 countries which participated even though they remained unassociated (European Commission, 2019). That means that over half the countries in the world were involved in Horizon 2020, though in most cases, they funded their own participation. Most calls have no explicit external outreach aims but draw in international participants because of their expertise and what they bring to the project in scientific terms; however, there are some calls which are organized and designed to bring in international participants, such as the food security-related projects in conjunction with the African Union discussed above. The Article 185 of the Treaty on the Functioning of the European Union instrument is a more specific funding channel which brings together Member States and third countries to address common challenges. These are longer-term actions and are identified as partnerships rather than projects. Some of them are among the most discussed science diplomacy efforts, for example, the European and Developing Countries Clinical Trials Partnership (EDCTP) and Partnership for Research and Innovation in the Mediterranean Area (PRIMA). The EU has also directly funded research on science diplomacy, aiming to improve its own practices by funding three projects between 2015 and 2022: *European Leadership in Cultural, Science and Innovation Diplomacy* (EL-SCID), *Inventing a shared Science Diplomacy for Europe* (InsSciDe), and *Using Science for/in Diplomacy for Addressing Global Challenges* (S4D4C). Out of those projects, an EU science diplomacy alliance was formed, and its web pages contain a trove of reports and publications to support EU science diplomacy and academic research (Science Diplomacy Alliance, <http://www.science-diplomacy.eu/>). Finally, the Erasmus programs supporting international mobility have an important role to play in fostering international cooperation and relationship building. Since 2014 all countries in the world have some access to this program; there were 30,000 scholarships for international students to take part in Erasmus Mundus Joint MA programs, and it was projected that 180,000 students would use Horizon 2020 for mobility outside of the Member States.

In addition to project-based funding, the EU also funds infrastructures. CERN was mentioned earlier, but there are many others; of recent importance is the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) that has become a broadly proclaimed success story of Middle-East peace-building through scientific cooperation, though the on-the-ground reality is more nuanced (Rungius et al., 2022).

Authority-type tools have to do with the government's ability to regulate and exercise legal power. In science diplomacy terms, we can place here the EU's science and technology cooperation agreements, which have been signed with 20 countries. The association agreements to the framework projects discussed above are authority-type tools.

Organization-type tools are ones which the government engages its own bureaucracy to act. The EU has established Science and Technology attaches in Brazil, China, Egypt, India, Japan, Russia and the USA, whose role is to provide scientific advising as well as to practice diplomacy for science, helping to improve and increase scientific cooperation between the country of their placement and the EU. Within the EU, science diplomacy has become institutionalized in the Science Advisory Mechanism (SAM) which ensures that there is high quality scientific input into policymaking processes, and at the EEAS, the already mentioned Science and Technology advisor. The Joint Research Center (JRC) is itself a unique example of the integration of science and policy-making; it functions as a science service providing scientific advice and support for EU policy making, but organizationally it is a Directorate General of the European Commission.

Finally, there are nodality-type tools which draw on centrality in networks and information. Becoming more central has been an aim of the EU, as can be seen in this statement calling for the EU to «act as an agenda-shaper, a connector, coordinator and facilitator within a networked web of players» (EEAS - European External Action Service, 2016: 43). This neatly encapsulates all the aims of nodality, and the EU has established several tools for accomplishing this: the Strategic Forum for International S&T Cooperation (SFIC) is an advisory group co-led by the European Commission and the EEAS that aims to develop the ERA's international dimension. As well, an informal Network of Science Advisors and Science Diplomacy Coordinators in EU Ministries of Foreign Affairs was created in 2021 to foster better cooperation and coordination between the EU and the Member States. The Knowledge for Policy initiative, implemented by the JRC, creates open Knowledge Centres which consolidate and share knowledge resources on a range of global and societal challenges.

2.4. Multi-power

Finally, there is the question of what sorts of power are relevant for science diplomacy. What gives the EU the ability to act and exert leadership on a global level, and what role does science diplomacy play in that? The European Council in 2019 declared that «The EU will use its influence to lead the response to global challenges» (European Council, 2019: 11), and in 2021 the Commission stated, «the EU should leverage its role as a global powerhouse in research and innovation to ensure that multilateral action is informed by the best possible scientific evidence» (European Commission, 2021: 11). How those aims will be accomplished requires understanding both the type of power that the EU has, and more generally, the nature of power in the context of science and knowledge. The Europe-as-a-power debates over the past two decades have identified many types of EU power, but two have stood out: the first arose in the early aughts with Ian Manners (Manners, 2002) argument for Europe as a normative power, that is, one that derives power from its norms and the ability to transfer those norms to other states. There have been numerous articles, both by Manners and others, following in this line of thinking. The second approach argues that the size and strength of the internal market (and the ability to regulate access to it) provides the EU with power. This approach appeared in the mid-2000s (Meunier and Nicolaïdis, 2006) and has been most recently championed by Chad Damro (Damro, 2012) with his coining of market power Europe. While normative power falls strongly on the soft power side of the spectrum, market power is something closer to hard power. Both types are relevant for science diplomacy, as each assists with different roles of the EU in foreign affairs (López de San Román and Schunz, 2018). More recently, it has been argued (Young and Ravinet, 2022) that the EU is a knowledge power, and that science diplomacy is the means by which the EU can mobilize that type of power. This approach suggests that the EU derives power from its knowledge resources (rather than its norms and market) and its governing architecture as a knowledge-based society and economy as framed in the Lisbon strategy. As the quote above states, the EU is a «global powerhouse» in the production, application, and transfer of knowledge, as can be seen through its academic publication and citation statistics, patents filed, and its share of top universities. Knowledge power is grounded in the ages-old idea that knowledge is power, and it can be useful in overcoming some of the limitations of the other types of power as it aligns well with multilateral approaches, particularly for dealing with countries that do not share its norms, enables leadership around problem-solving, and it is rooted in the physical world context that frames global challenges and the Sustainable Development Goals.

3. Conclusions

In sum, we can see that the EU has begun to champion the ideas and practices of science diplomacy. It has an extensive range of actors involved at multiple levels and uses the full range of tools and power resources at its disposal. Science diplomacy provides a way for the EU to pursue its international agenda, which is rooted in multilateralism and global solidarity in responding to global challenges. Science diplomacy is not, however, without its challenges: in today's world of increasing military and geopolitically driven power relations, the EU cannot rely on science alone; nor can it ignore the potential consequences of post-truth trends that challenge scientifically established facts and undermine the shared credibility built on them. Nevertheless, the opportunities of science diplomacy mesh well with the EU's positioning in global affairs and the increasing number of global challenges. These include also the need to develop governance mechanisms for non-jurisdictional spaces such as the internet, oceans and outer space. Science diplomacy, despite the historical tradition we have mentioned, is still a relatively new entrant in foreign affairs, and there is much to be worked out both in terms of its mechanisms and its integration across the EU's institutions and Member States. The Council has called for the development of a European Science Diplomacy Agenda by 2023, the process of which will shape and define further what science diplomacy is and how it can be harnessed and mobilized to pursue European and global interests and challenges.

The science diplomacy discourse and science policy

Simone Arnaldi

Abstract

This chapter discusses the convergence between the discourses of science diplomacy and science policy, highlighting the possible influence of the latter on the former. After presenting the concept of science diplomacy, the chapter goes on to illustrate the main characteristics of four models of science policy as described in the literature: the linear, demand pull, systemic and transformative models. Three themes common to the two domains of science diplomacy and science policy are then listed and discussed – namely, the representation of the scientific community, the social relevance of scientific knowledge and the role of stakeholders in the processes of scientific research, technological development and innovation – showing how science diplomacy draws on the discourse of science policy for their framings.

1. Introduction: looking at science in science diplomacy

«Science diplomacy» has recently emerged to describe the «field of international relations in which science and foreign policy interests intersect» (Ruffini, 2017: 3). Although these intersections are far from new, interest in this field of activity has grown significantly, among practitioners and scholars, in the recent past and has gained an increased recognition precisely through the introduction of the vocabulary and concept of «science diplomacy» (Ruffini, 2020). In defining it, one can say that science diplomacy includes both diplomatic activities supporting international collaborations in science and technology, on the one hand, and scientific research activities fostering diplomatic relations or facilitating policy collaborations between states, on the other hand. This twofold nature of science diplomacy distinguishes this field from the «normal» international scientific cooperation, as the former does not focus primarily on scientific and technological advances as such, but on science and technology as a means to achieve national or international foreign policy objectives (Turekian et al., 2015).

Within this generic framework, there have been many attempts to define science diplomacy, but the results have not always been convergent. The classic definition by the Royal Society and the American Association for the Advancement of Science (AAAS) classifies science diplomacy activities into three groups: «scientific advice to foreign policy activity (science in diplomacy); facilitation of international scientific cooperation (diplomacy for science); and use of scientific cooperation to improve international relations among states (science for diplomacy)» (Royal Society and AAAS, 2010: 32). According to Ruffini (2020), this definition exemplifies a diffused, «mainstream» representation of this field, whose key assumptions are: (1) the belief that science diplomacy can transform international relations through the application of science's own normative principles of disinterestedness, objectivity and rationality; (2) the conviction that, because of this very reason, science diplomacy can successfully address global challenges transcending national borders. However, as Ruffini notes, these definitions fail to consider the essential role played by national interests in science diplomacy initiatives, lacking a meaningful recognition of the political and power dimension that is characteristic of this field (see also Turekian et al., 2015). Other definitions consider this (geo) political dimension in a more explicit way. For instance, Gluckman et al. (2017: 3) differentiate three types of science diplomacy actions according to the different scale of the interests at stake, by distinguishing: «(a) actions designed to directly advance a country's national needs; (b) actions designed to address cross-border interests; and (c) actions primarily designed to meet global needs and challenges». Flink and Schreiterer (2010) place as much emphasis on the type of activities implemented to pursue them. Accordingly, the Authors differentiate between initiatives: (1) aimed at gaining access to researchers, findings, resources and markets related to science, technology and innovation (Access); (2) aimed at promoting a country's achievements in R&D to attract foreign partners for collaborations, to gain, regain and retain talent and to attract foreign investments for R&D (Promotion); (3) aimed at projecting influence on other countries' public opinion, decision-making and leadership (soft power) (Influence). The recognition of competition as a driver of science diplomacy becomes manifest in approaches focusing on innovation rather than scientific research cooperation. The more recent concept of *innovation diplomacy* is telling, as it emphasises international competition to connect «new knowledge with markets and investors in order to foster a return in terms of trade, investment, and technology» (Leijten, 2017: 19). Despite science diplomacy being at the intersection of foreign policy *and* science, this field has primarily been studied from the viewpoint of international relations. Instead, this chapter applies insights from science and technology studies (STS) and science policy to look at science in science diplomacy, thus exploring how science and society relations are represented and constituted in science diplomacy discourses. Science and Technology Studies (STS) is a research area that explores the interactions between science and society, studying, on the one hand, how social, political and cultural dimensions influence the trajectory of scientific research, technological development and innovation, and investigating, on the other hand, how technological artefacts and scientific knowledge influence society, politics and culture (Rohracher, 2015). In the study of these relations, STS has emerged as an interdisciplinary field, connected and partially overlapping with, among others, innovation studies (Martin, 2012), history (Dear and Jasanoff, 2010), philosophy of science and technology (Moreno and Vinck, 2021) and international relations (Orsini et al., 2017; Kaltofen and Acuto, 2018; Lidskog and Sundqvist, 2015). The relationship between science and policy is also among the areas of interest of STS, both in terms of the role played by scientific knowledge in decision-making processes (Weingart, 1999), and in terms of policies that address science, technology and innovation (STI) as their specific object, here referred to in brief as «science policies» or «research policies» (Lundvall and Borrás, 2005; Hofmänner and Macamo, 2021).

Drawing on this research perspective, the chapter makes the case for a closer investigation of science policy, acknowledging its influence on the discourse and practice of science diplomacy. In so doing, it focuses on one of these potential directions of influence, arguing that the framings of science-society relations developed in the science policy discourse have affected how science diplomacy conceives and represents the connections between scientists, policymakers and other social actors. It is important to state that these frames and framings have been shifting over time; in order to explore these changes, the chapter reviews four different models – linear, demand pull, systemic and transformative – of science policy (Section 2) and investigates how science-society relations are framed (see Arnaldi 2020a, 2020b for a more extensive analysis of some of them). While these models are analytical constructs, and their features are imperfectly implemented in actual policy decisions, their framings of science and society relations – and of science policy's role in their rapport – have been crucially influential in legitimising specific constellations of policies and practices, which makes them useful to identify *the essential elements* of science policies.

After this review, the chapter explores the subject of whether and to what extent these essential elements can be found in science diplomacy discourse to confirm the influence of science policy models (Section 3). This exploration results in the identification and brief examination in this section of three of these «essential elements» that appear in both science policy and science diplomacy discourses. The first element is the depiction of science as a universalistic, dispassionate and impartial social institution and of scientists as bound to normative principles that privilege autonomy, cooperation and disinterest; the second is the coexistence of and sometimes conflict between a view that prioritises the production of new scientific knowledge per se and an alternate perspective that emphasises the social utility of applied knowledge and innovation as a driver of diplomatic actions; and the third is the sharing by science policy and science diplomacy of an inclusive view of STI and their advocacy for the inclusion of a wide variety of stakeholders (i.e. beyond the scientific community, industry and policymakers).

Finally, a brief concluding section (Section 4) discusses some of the implications of this analysis, both in terms of research themes and in terms of disciplinary perspectives that are useful for the study of science diplomacy.

2. Science policy from the linear model to systemic transitions

Sarewitz and Pielke (2007) define science policies as the set of processes and tools used to reconcile the meeting of demand and supply of scientific knowledge, articulating the relationship between the needs and the social aims to which science is called to respond, and the knowledge that can be used in those responses. It is certainly true, and the two authors are aware of this, that this clear distinction between the demand and supply of knowledge represents a simplification of the relationship between science and society, for at least two reasons. First, while scientists have, by definition, an essential place in producing scientific knowledge – determining its «supply» –, the scientific community is also involved in articulating the «demand» of science, because of the relative autonomy that scientists, individually or collectively, have to define the research questions to be answered (see Miller and Neff, 2013), and because of the important role they have in defining the problems they themselves help solve (Hoppe, 2005; Weingart, 1999). Second, thinking in terms of supply and demand overshadows the fact that the influence of science on society is often indirect and dispersed, far exceeding the intentional effects of specific research results (Latour, 1998; Nahuis and van Lente, 2008). Despite these clarifications, it is nonetheless undeniable that analytically, (1) we can distinguish between «people, institutions, and processes that have to do with the supply of scientific knowledge, and others that have to do with its use»; (2) it can be argued that science policy choices are based on the definition of hypothetical links between investment in a research activity and its expected results; and (3) we can recognize the existence of «feedback between the (perceived) demand for science and the (perceived) characteristics of its supply» (Sarewitz and Pielke, 2007: 6).

By following this simple but useful approach, we can try to distinguish different models of science policies, starting from how they frame the relations between science and society by reconciling, in different ways, the demand and supply of scientific knowledge. Drawing from existing literature, four distinct models are briefly described and examined: linear, demand pull, systemic, transformative. As already clarified in the introduction, it is important to underline that these alternative configurations of science policy are, in fact, models, so that their characteristics do not always find an exact empirical correspondence, nor have any of them known a generalized application during a particular period of time nor have been completely replaced by another. Nonetheless, it is indisputable that all of them have exercised, to varying degrees in different geopolitical contexts and in different historical periods, a considerable legitimizing influence on specific constellations of policies and practices in the domain of scientific research, technology and innovation (Flink and Kaldewey, 2018). Examining their features is therefore useful to identify the essential elements attributed to research policies, albeit in the face of imperfect implementation.

The best known model is probably the so called «linear model of science policies» (or, more frequently, «linear model of innovation») (Godin, 2006) that characterized the debate on science policies in the United States and, subsequently, in the other industrialized, market-economy countries, immediately after the Second World War. The linear model makes basic research a priority for public policies, since it is considered a source of new knowledge that can be used in applied research and technological development to produce economic and social benefits (Logar, 2011). According to this model, if these benefits are seen as certain, however, the ways in which scientific knowledge produces them are largely unpredictable. As a consequence, public policies are called upon to financially support the scientific community, ensuring ample freedom in the choice of research questions and guaranteeing decision-making autonomy in resource allocation, so that knowledge can be expanded in the most diverse and potentially fruitful directions. Academia has a key role in scientific research and universities are entrusted with the main responsibility in conducting basic research (Hessels, 2013).

In the 1960s, the linear model is challenged in both scientific and political terms (Brooks, 1996; Godin and Lane, 2013). The growing public visibility of problems such as industrial pollution fuels the critique of the model, which targets especially the assumedly unproblematic link between new knowledge and societal benefits. This criticism results in a request for a more accurate assessment of the impacts of scientific knowledge and technological development on society and the environment, as well as in the search for a closer connection between scientific research and technology, on the one hand, and social, political, and industrial needs, on the other. As a consequence of these shifts and unlike what happens in the linear model of innovation, the crucial element in science policies becomes the demand for socially relevant knowledge, instead of knowledge production per se. «The most critical element [...] is need-pull forces (opportunities pulling from peoples' needs and the market) rather than by supply-push forces (technological opportunities pushing forward from scientific discoveries)» (Godin, 2017: 9). For public policies, therefore, the support of socially relevant knowledge becomes a strategic priority, with the goal of maximizing the return on investment (Johnston, 1990). In defining what social relevance means and what research and development priorities are, the concept of social need ends up being translated into the much narrower concept of market demand. Therefore, the task of aggregating and selecting social expectations regarding new applications of scientific knowledge and innovative technologies is entrusted to market mechanisms and institutions (Godin and Lane, 2013).

The problem of efficiently linking knowledge (market) demand and supply, as well as of effectively maximizing the diffusion and application of relevant scientific knowledge, leads to a further shift towards a systemic and processual view of research and innovation (Smits and Kuhlmann, 2004). An important codification of this model is the concept of «national innovation systems». This notion came to maturity in the context of the Organization for Economic Cooperation and Development (OECD) in the 1990s (OECD - Organisation for Economic Cooperation and Development, 1997). According to Lundvall, one of the architects of OECD's innovation policies in that period, innovation systems are «constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge» (cited in Godin, 2009: 478). In the systemic model, the relations between the elements of the system become the target of public policies, which are oriented to building the necessary conditions (economic, social, and regulatory) to foster the effective collaboration of the actors in the system. The creation of intermediary structures to bridge the gaps between knowledge, skills, and needs of the system actors (science parks, industrial liaison offices, etc.) (Howells, 2006), as well as the creation of «protected» spaces and structures (incubators, fablabs, makers' space, acceleration programs, etc.) to favour the experimentation of new collaborations and new entrepreneurial ideas, become tools widely used for this purpose (Smits and Kuhlmann, 2004). In this systemic model of innovation, scientists find themselves in an almost opposite position to the one they had in the linear model of science policy: from being the dominant protagonists in the production of scientific knowledge, they become (just) one of the many actors in a system in which knowledge and its production are «socially distributed» (Gibbons et al., 1994). The general political-economic framework of this model is market-oriented and seeks to expand the role of the market as a regulatory mechanism of the economy and society. Once again, the market articulates the social demand for innovation and is «driven by the dynamics of economic globalization and the growth of international competition, especially in advanced technology sectors» (Ancarani, 1999).

Discontents with the economic and social consequences of market-driven globalization, the negative impact of economic growth on the environment and climate, and a series of crises undermining the public confidence in science and technology (for example, the Chernobyl nuclear disaster, the so called «mad cow disease», and controversies over genetically modified organisms in agriculture), however, challenge the close link between scientific knowledge, innovation, and the market. The conviction that research, technological development, and innovation must be normatively oriented toward achieving socially desirable objectives that are not formulated solely in market terms, found legitimacy in research, in public opinion, in the scientific community, and among decision-makers. A fourth model of science policy, which Schot and Steinmueller call «transformative», emerged from this belief. This new policy approach does not limit itself to introducing more or less radical innovations, but aims to initiate a real socio-technical system transition: «it is about radical change in all elements of the configuration», it is «about changing skills, infrastructures, industry structures, products, regulations, user preferences, and cultural predilections» (Schot and Steinmueller, 2018: 1562). The explicit normative orientation of this transition is a response to the perceived directionality failure of the previous models, their lack of «means for making social choices over alternative pathways of development» different from economic competitiveness. Participation of stakeholders is a key feature of this model, as «it involves multiple actors in negotiating alternative pathways that have the potential to achieve system change [and it] is only through the accumulation of experience by a variety of actors with different motivations and priorities that an acceptable pathway or pathways can be discovered and pursued» (Schot and Steinmueller, 2018: 1563). While, as in the previous cases, one cannot say that this approach to science policy is dominant or exclusive, there is no doubt that several important policy initiatives refer to this logic of systemic transition. For example, the Sustainable Development Goals (SDGs) of the United Nations (http://sdgs.un.org/goals) define a general framework for radical change towards greater sustainability. In that framework, the topic of STI is included in a specific goal (SDG#9, Industry, innovation and infrastructure), but, more importantly, it is also seen as a means to achieve most, if not all, of the SDGs (United Nations Industrial Development Organization and United Nations InterAgency Task Team on Science, Technology and Innovation for the SDGs, 2022). A second example is the notion of Responsible Research and Innovation (RRI), which was introduced in the EU research and innovation funding program for the 2014-2020 period to support the realignment of STI process and outcomes with social values, needs and expectations. This approach identified key areas (Ethics, Science Education, Gender Equality, Open Access, Governance and Public Engagement) to address in order to help solve the grand societal challenges for European societies in the 21st century (European Commission, 2012b). A third and last case in point regards again the EU context, where the 2021-2027 STI funding program has prominently embraced the notion of «mission-oriented policies», that are «systemic public policies that draw on frontier knowledge to attain specific goals» (Mazzucato, 2018: 8).

3. Science diplomacy and science policy: three convergent elements

After briefly presenting alternative policy models, this section of the chapter looks at their influence on science diplomacy. This analysis is meant to highlight how the framings of science-society relations developed in the science policy discourse have affected the ways in which science diplomacy conceives and represents the connections between scientists, policy makers and other social actors. Acknowledging that this is a partial and preliminary analysis, three elements of convergence between science policy and science diplomacy discourses stand out to suggest the possible existence of such a connection.

The first element concerns the representation of the scientific community. As Rungius and Flink (2020) noted, the narrative that science diplomacy would be capable of fostering international collaborations and of solving global challenges is deeply rooted in a view of science as a universalistic, disinterested, and impartial institution capable of bringing together (political) actors who would act otherwise out of self-interest. This view of science recurs frequently in the representations of science diplomacy made by practitioners, so much so as to become a sort of canon (Ruffini, 2020). The same perspective returns in various policy documents, which often refer to the «universality» of science and of its language (European Commission, 2016: 7; Royal Society and AAAS, 2010: vi). Such a universal nature of the scientific enterprise makes science a «common language and [a] common basis for relations and trust» (European Commission, 2016: 74), even between conflicting parties. This vision of the scientific community and of science reflects closely the views developed in the linear model of science policy: (1) science is an institution with a normative structure that differs from that of society as a whole (Merton, 1973); (2) it freely and selflessly pursues the knowledge of nature; (3) decisions about the use of of this knowledge is a responsibility of politics, which is the realm of particular values and partisan interests.

The second element of convergence regards the valuation of scientific knowledge. The description of science policy models has shown the transition from the centrality of pure research which is characteristic of the linear model, to the importance of producing socially relevant knowledge. This transition is accompanied with the increasing significance of technological innovation over fundamental research, the latter untethered from a defined application context and practical considerations. The expected benefits of knowledge and innovation have taken on different characteristics, either as economic returns in the demand pull or systemic models of science policy, or as broader socially desirable outcomes, such as sustainability and equity, in the transformative model. Again, these two framings of socially relevant knowledge can be found in the science diplomacy discourse, too. The focus on innovation that is typical, for instance, of innovation diplomacy (Leijten, 2017; Carayannis and Campbell, 2011), prioritizes the potential returns in terms of trade, investment, and technology over international scientific collaboration per se. In doing so, science diplomacy adopts an emphasis on competitiveness that is typical of the demand pull and systemic models of science policy. In a similar way, science diplomacy shares with the transformative model of science policy an often explicit normative orientation which is well described, for instance, by the notion of «challenge». As Flink and Kaldewey note, the concept of «grand challenges», «societal challenges» or «global challenges» does not fit with the classical distinction between pure and applied research as defined in the linear model. Rather «the concept is embedded in a discourse about the role and future mission of the scientific community. Most definitions conceive of grand challenges as long-term and large-scale research goals, determined by heterogeneous societal stakeholders. Thus, communicating grand challenges is a way to talk about the goals and ends of scientific research» (Flink and Kaldewey, 2018: 17). These challenges are part of a systemic transition narrative that: (1) depicts a looming crisis «that do not only affect a single nation state anymore but the entire mankind» (Rungius and Flink, 2020: 3); (2) advocates for a cooperative response on the international level; and (3) envisions a desirable final state of the normatively oriented transition realized by way of this cooperative response.

The third and final element concerns participation of stakeholders in science, technology and innovation processes. Inherently diverse because it concerns scientists *and* policy makers (Lord and Turekian, 2007; Langenhove, 2016), the circle of the social actors involved in science diplomacy is now significantly larger and goes beyond states and research organizations to include business and civil society (Chaban and Knodt, 2015; Pearlman et al., 2016). The enlargement of participation is consistent with the gradual inclusion of more numerous and more diverse stakeholders in STI that followed the succession of science policy models. Whereas in the linear model the scientific community, and academia in particular, played an outsized and unique role in knowledge production, the broadening of participation that accompanies the emergence of the systemic and transformative models makes policy, and STI in general, much more open to a variety of actors, so that the benefits of STI can be effectively delivered to society through collaboration.

4. Closing remarks

This work makes the case for examining the influence of science policy on the discourse and practice of science diplomacy. In so doing, it focuses on one of these potential directions of influence, arguing that science diplomacy draws on science policy discourse to i) outline the representation of the scientific community, ii) address the issue of stakeholder participation in policy design and implementation or iii) explain the tension between collaboration and competition in STI.

First, the science diplomacy view of science as a universalistic, autonomous, disinterested and impartial institution has its roots in the linear model of innovation and its framing of academic research as a self-regulating endeavour, free from external influence and obeying peculiar norms that set science apart from society. Second, in both science diplomacy and science policy, this view of science as a disinterested enterprise coexists and collides with an alternative one that prioritises the social relevance of scientific knowledge – where the social relevance is also differently understood. The representation of science diplomacy either as a tool for fostering economic competitiveness or for solving societal challenges rests upon this second perspective regarding the valuation of scientific knowledge, which ultimately results from the demise of the linear model of science policy. Third, both science diplomacy and science policy adopt an inclusive stance on the social actors that can (and must) be involved in STI. Just as science policy has gradually expanded the number and diversity of the stakeholders to be included in the deliberation and implementation of science-related decisions, so does science diplomacy acknowledge the utility of engaging and empowering stakeholders to leverage their resources and expertise for a greater impact of international collaborations.

Overall, this discussion indicates a potentially useful direction of study on the subject of science diplomacy, suggesting how our knowledge of this field can be improved by looking more closely at «science» in science diplomacy. In terms of disciplinary perspectives, this effort invites the collaboration of multiple disciplines, including STS. In terms of content, it suggests the need for a closer examination of STI policies in order to chart the similarities, convergences and genealogies that influence the discourse and practice of science diplomacy.

Part II. Science diplomacy in action

The role of science diplomacy in strengthening cooperation between the two shores of the Mediterranean

Mounir Ghribi

Abstract

The Mediterranean is facing multiple pressures and combined impacts of anthropogenic and natural disturbances at different scales and contexts, along with increasing social and economic risk perceptions and concerns about serious threats, such as political instability, fragile health systems, youth unemployment, climate change, poverty, and migration, among others. Mediterranean socioeconomic activities rely on marine resources and maritime services. However, its sea and coasts are under pressure, with an urgent need for effective, efficient, and successful solutions for the protection of its habitats and ecosystems and for the safety, security, and prosperity of its population.

Recognizing the value of each country's specificity as a strength for the Mediterranean region, there is an opportunity for a cultural transformation to create a proud community that shares the same region as a common value for the benefit of the Mediterranean (Mare Nostrum). This chapter focuses on the role of the 5+5 Dialogue for research, innovation, and higher education in facilitating *scientific cooperation among countries on the Western Mediterranean shores. It presents the Dialogue as a best practice for using the instrument of science diplomacy and as a concrete contribution of Italy to the 5+5 Dialogue through the Blue Skills initiative, which supports the development of skills, capacity building, and mobility in the sustainable blue economy sector and aims to promote youth employability, valorize investment conditions to ease the interconnection between governance, industry, and academia, and create appropriate conditions for dialogue to pave the way toward spreading evidence-based policy and supporting decision-making across Mediterranean borders.*

1. Introduction

The Mediterranean Sea is one of the most complex areas in the world (UFM - Union for the Mediterranean, 2021a). It is the largest of the semi-enclosed European seas and is surrounded by 22 countries, which together share a coastline of 46,000 km and are situated across three continents: Africa, Asia, and Europe. With approximately 542 million people living in the Mediterranean Basin in 2020, the number is expected to increase to 657 million by 2050 and 694 million by 2100 (Hilmi et al., 2022).

The Mediterranean is also one of the world's top biodiversity hotspots (United Nations Environment Programme/ Mediterranean Action Plan and Plan Bleu, 2020). This semi-enclosed sea presents multiple types of coastlines, including islands, deltas, coastal plains, high cliffs, and mountainous areas, providing various natural and anthropogenic landscapes and multiple types of seabeds hosting diverse ecosystems and habitats. It is home to more than 17,000 marine species. While only representing around 1% of the global ocean volume, the Mediterranean has the highest rate of endemism at a global level (20% to 30% of species are endemic) (United Nations Environment Programme/Mediterranean Action Plan and Plan Bleu, 2020).

Land of civilization and place of inestimable cultural heritage and traditions, the Mediterranean is the world's leading tourist destination. It is also one of the busiest shipping routes. It is the crossroads of major global maritime routes, from the Strait of Gibraltar to the Suez Canal (Hilmi et al., 2022). The Mediterranean is, in fact, a sea of opportunities: 30% of trade and transport of oil goes through the Mediterranean, 20% of global maritime transport goes through the Mediterranean, and 10% of the global GDP is generated in the Mediterranean (United Nations Environment Programme/Mediterranean Action Plan and Plan Bleu, 2020).

With various levels of development and democracy and many differences from the cultural, religious, social, and economic viewpoints (Riccaboni et al., 2020), the divergent growth paths in the two shores of the Mediterranean have increased the gaps, creating new challenges that overlap with other crises. State fragility, conflicts, insecurity, and socioeconomic inequalities have turned the area into one of the world's most vulnerable regions, whose geo-strategic importance goes far beyond its geographical borders, thus intensifying its fragmentation and instability.

To quicken the response to this urgent need to protect the Mediterranean and to promote socioeconomic development of the whole area, the use of an instrument such as science diplomacy could be of great benefit to ease dialogue among Mediterranean countries, spread transboundary cooperation at multi-level governance, support policy and decision-making at national levels, and, above all, give value to each country's specificity, which could be considered a strength for the Mediterranean region.

2. Mediterranean and youth unemployment

Unemployment affects 67.6 million young women and men, representing 13.6% of the youth labor force (ILO - International Labour Organization, 2020). Youth unemployment is on the rise in the Mediterranean. It is highest in Northern Africa and in the Arab states, at around 2.2 and 1.7 times the global rate, respectively.

The average youth unemployment rate in the Mediterranean is 25%. The eastern and southern shores of the Mediterranean witness an even higher youth unemployment rate, especially for women. Indeed, young women in the Southern and Eastern Mediterranean are 70–100% more likely to be unemployed than young men. Moreover, higher education (HE) graduates living in these areas experience higher unemployment rates than do people with basic education.

According to the Union for the Mediterranean (UFM - Union for the Mediterranean, 2021b), «almost 60% of the regional population is today under the age of 30, and the number of young people under the age of 15 is forecasted to increase over 18%. This represents an asset for the region; therefore, a positive and action-oriented regional agenda on youth employability is indispensable for unleashing the region's human and economic potential capital. As requisite for peace and stability in the region, priority actions must be built on promoting competitiveness and enhancing job opportunities, in particular for youth».

Despite youth in the Southern Mediterranean being the most educated generational group ever, young graduates in the region, especially in North Africa, experience the highest level of unemployment among higher education graduates in the world: around 29.8%.

To improve the current situation characterized by political instability, economic difficulties, social regression, and environmental problems, national labor markets in the Mediterranean region need to focus on job creation for youth based on innovative employability models. Thus, universities and research centres are key actors in generating innovation and developing skills that help build vibrant and sustainable development in the Mediterranean and contribute to knowledge transfer to societies and economies. The recent pandemic situation has made the socioeconomic situation more critical and urged quick and strong policy responses.

One of the immediate actions is to look for a way to use and provide available skills to end unemployability. Another remedial action to unemployment is to develop those skills that are really needed by the existing labor market and reply to the requested workforce (the job I need, needs me). For a long-term strategic plan, developing specific skills, taking into consideration labor market needs, should be applied to both the evolution of the global labor market and the availability of skills, thus responding appropriately to local economies. By skills, we mean both vocational education and training (VET) and HE. VET responds to the needs of the economy (productive sector) but also provides learners with skills that are central for personal development and active citizenship, whereas HE helps create new profiles (the leaders of tomorrow), such as project managers in the specific economic sector.

To consolidate the development of skills, partnerships are needed to foster joint programs in HE and to facilitate the circulation of talent. This includes joint master's and Ph.D. programs, specialized training courses and workshops, and fostered scientific mobility and international science cooperation to establish joint university departments and labs in the Mediterranean region, including training-of-trainers and enhanced curricula that can respond to the labor market at any age.

3. The 5+5 Dialogue as a mechanism for regional cooperation

Over the last decade, science diplomacy has been conceptualized and institutionalized as a policy tool, diplomatic framework, and transdisciplinary research field, becoming increasingly adopted by national governments and multilateral and intergovernmental organizations, including the European Union (EU), the United Nations (UN), and the Union for the Mediterranean (Gual Soler and Perez-Porro, 2021). The EU is now carrying on a stakeholder engagement process with the aim of developing an EU Science Diplomacy Agenda, and there is an increasing number of scientific papers, conferences, workshops, webinars, and training courses organized by national and international institutions and scientific agencies all over the world, obviously showing wide attention to the topic.

Moreover, in view of the urgent need to spread evidence-based policy and support decision-making across the Mediterranean, there is a need to strengthen the interaction between science, diplomacy/policy, and society.

Specifically, considering the Mediterranean context, science diplomacy is a powerful tool, a set of practices, and a promising mechanism to address cross-border interests, taking into consideration each country's specific needs, to meet global challenges, and to strengthen collaborations between stakeholders for a common interest and give value to countries' specificities as a strength for the entire Mediterranean.

In 2015, 10 ministers in charge of research, innovation, and higher education of the 5+5 Dialogue countries of the Western Mediterranean met during the Ministerial Conference held in Madrid with the participation, as observers, of the European Commission, the Secretariat General of the

Arab Maghreb Union, and the Secretariat of the Union for the Mediterranean. The ministers signed a declaration (Madrid Declaration) that aims to strengthen cooperation in research, innovation, and HE for promoting sustainable economic growth and social inclusion and creating new opportunities for youth in the Western Mediterranean.

As an intergovernmental forum, the *raison d'être* of the 5+5 Dialogue is to ensure closer collaboration between the five EU Member countries (France, Italy, Malta, Portugal, and Spain) and the five Arab Maghreb countries (Algeria, Mauritania, Morocco, Libya, and Tunisia) through political dialogue and cooperation and by encouraging more effective resource management as a means of strengthening interdependence, development, and regional dialogue.

The declaration underlines the importance of research, innovation, and HE for addressing challenges such as unemployment, economic underdevelopment, environmental degradation, shortage of natural resources, water scarcity, and food and energy security. Ministers emphasize the common determination to strengthen collaboration to reinforce the potential of youth and access to HE as fundamental to the development and prosperity of the Mediterranean region.

4. Boosting cross-border cooperation in the sustainable blue economy in the Mediterranean

The world ocean is the largest existing ecosystem on our planet. Oceans cover over 70% of the Earth's surface, carry out about 50% of global primary production, and support the greatest biodiversity. They are also one of the largest carbon reservoirs in the Earth's system, holding up to 54 times more carbon than the atmosphere. Therefore, the oceans, seas, and inland waters are very important in regulating the Earth's system, supplying living and non-living resources, and providing social and economic goods and services. Water gives life and provides humanity with food, energy, and oxygen and regulates climate, but it can take life away as well when its scarcity leads to hunger and poverty and when its excess causes floods, landslides, and extreme hydrogeological instability.

Besides natural risks, anthropogenic activities damage the planet by overexploitation, leading to the depletion of natural resources and the destruction of ecosystems and pollution, causing severe socioeconomic and environmental impacts. Therefore, it is fundamental to reverse the process and maintain an ecological balance to benefit from the myriad opportunities that emerge from nature and oceans.

The objective is to encourage researchers of the 5+5 Dialogue countries to develop north–south and south–south collaborations dedicated to public and private research and HE through the interaction of experts and institutions across the Mediterranean. These collaborative networks will address priority issues with anticipated scientific, technological, and societal challenges, thus enabling researchers from both shores of the Mediterranean to formulate European collaborative research projects and submit them successfully.

The blue economy is the sustainable use of ocean resources for economic growth, improved livelihoods, jobs, and ocean ecosystem health. The blue economy concept was introduced in 2004 by Gunter Pauli (Pauli, 2012), who launched it «based on the ZERI (Zero Emissions Research & Initiative) philosophy, to engage a global network of experts and creative minds to seek solutions inspired by nature's design principles». His book *The Blue Economy: 10 Years – 100 Innovations – 100 Million Jobs* highlights that the «blue economy business model» will shift society from scarcity to abundance by using available resources and tackling ecosystems' issues in an innovative way (Waldegrave, 2017).

Several initiatives fostering the blue economy ecosystem in the EU have seen the light. According to the European Integrated Maritime Policy (Breuer, 2022), macro-regional sea basin initiatives are being implemented in the seas bordering Europe, promoting growth and development strategies that exploit the strengths and address the weaknesses of each large sea region in the EU.

The cross-border blue economy alliance has been nurtured by some specific bilateral cooperation agreements that strengthen and consolidate integration among partner countries, such as the partnership agreement signed between the cluster Blue Italian Growth (BIG) and the Cluster Maritime Tunisian (CMT) in June 2020 as drivers to accelerate employability, entrepreneurship, and capacity building, especially in countries on the southern shore of the Mediterranean (Gibson, 2020). The importance of the marine and maritime industries will continue to grow in the Mediterranean region. The blue economy sector is an engine of human and economic development for the entire region. Taking full advantage of this sector's potential will require a multi-skilled workforce from a wide variety of marine and maritime professional backgrounds, which necessitates new knowledge, skills, and innovation. To achieve this goal, HE and VET must innovate and gain relevance and quality.

Therefore, digital transformation and ecological transition, along with the development of skills, cluster development, and marine spatial planning (MSP), represent key tools to «drive» priority actions at national and regional levels and build conscious governance at local, national, macroregional, and Mediterranean levels to optimize the skills and improve existing investment mechanisms.

Fig. 1. Cross-border sustainable blue economy in the Mediterranean region.

5. Various initiatives and activities that seek to impact policymaking in the Mediterranean

The Mediterranean has seen the development of various initiatives and activities that seek to impact policymaking by introducing a more systematic approach, such as the Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution; the BLUEMED initiative and its Strategic Research and Innovation Agenda (SRIA); the EU Cooperation in Science and Technology (COST) Action on «Ocean Governance for Sustainability»; the EU COST Action for advancing knowledge and unifying concepts and approaches in the emerging field of Marine Functional Connectivity (Sea-Unicorn); the UN Mediterranean Action Plan for the UN decade of ocean science for sustainable development and various training on science–society–policy interface in the Mediterranean promoted by UNESCO, the Union for the Mediterranean (UfM), and other actors. All these policy development and regional cooperation initiatives consistently speak of a gap in the skills and mindsets of policymakers and urge greater integration of knowledge and its proper communication, thus investing in a new generation of policymakers through dedicated capacity building, providing timely science advice to policy, and fostering dialogue within the knowledge triangle (academia–society–policy).

Research, innovation, and HE play an important role in facilitating cooperation, promoting youth employability, and valorizing investment conditions to ease the interconnection between governance, industry, and academia. The UfM is supporting this through various engagements tailored to specific stakeholders and target audiences, particularly youth and women, such as the Blue Skills project of the Italian National Institute of Oceanography and Applied Geophysics (OGS), which is headquartered in Trieste. The Blue Skills project promotes opportunities for «Blue» careers by developing skills, exchanging knowledge, and valorizing research for a more sustainable Mediterranean Sea. Its aim is to develop new curricula, increase employability in the marine and maritime sectors, and promote dialogue through the instrument of science diplomacy. The latter has the potential to spread the evidence-based policy and decision-making approach across borders through multilateral negotiations, transboundary cooperation, multi-level governance, and multi-stakeholders' approaches. Recognizing the value of countries' specificities as a strength for the Mediterranean region, there is the opportunity for a cultural transformation to create a proud community that shares the Mediterranean Sea as a common value.

The UfM's policy dimension is structured around regional dialogue platforms involving representatives from governmental institutions and experts, regional and international organizations, local authorities, civil society, the private sector, and financial institutions. The UfM is also advancing regional and sub-regional cooperation by supporting integration and partnerships within shared objectives, including strengthening cooperation on the blue economy and maritime governance and facilitating the transition to a sustainable blue economy.

In addition, the EU, through its several programs and dedicated actions, such as the European COST organization enabling research and innovation networks; Horizon Europe, particularly under the emerging «Ocean» mission; the EU's European Neighbourhood Instrument (ENI) for regional and bilateral cooperation projects; and the Erasmus+ program particularly for the actions that aim at forging partnerships (for innovation, knowledge alliances, etc.), is also exposing the academic communities from the non-EU neighbouring countries in the Mediterranean to the knowledge about the EU policies and motivating them to internalize them. Its ultimate objective is stimulating discussion and reflection with policymakers and the public on sustainable development of the Mediterranean Sea and its hinterland and the role and impact of the EU on European and non-European citizens—for example, the role of the EU in selected global policy processes related to the oceans (e.g., negotiations on the agreement related to marine plastic litter), which contributes to promoting the EU's sustainable imprint globally, and the role of the EU in engaging institutions of marine and maritime sciences that are not typically concerned with EU studies and institutions from outside the EU that are partners in implementing the EU's policies but too rarely targeted, thus being treated as mere instruments.

Acting as an intergovernmental platform at the interface between science and policy and open to all EU Member States and associated countries that invest in marine and maritime research, JPI Oceans identifies strategic joint actions to foster regional research and innovation and to implement the Mediterranean SRIA. The size, scope, and methods identified for each action vary depending on the research needs and the objectives to be achieved. To generate an impact through collaboration, JPI Oceans builds on national capacities and networks in the participating countries and on engagement with policy and science policy units in the EU and intergovernmental institutions: the Intergovernmental Oceanographic Commission (IOC), the Food and Agriculture Organization (FAO), the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), the Union for the Mediterranean (UfM), the Organisation for Economic Co-operation and Development (OECD), and others. It allows countries to participate on a case-by-case basis according to their different priorities, needs, and capacities. JPI Oceans aims to enrich countries' coordination to encourage the development of integrated marine and maritime strategies and incentivize cross-ministerial and cross-institutional conversations.

All the above-mentioned initiatives target mid-career marine scientists and professionals who seek to streamline marine conservation and marine science into maritime spatial planning and the management of marine spaces and marine resources using participatory mechanisms that engage stakeholders, resource managers, and policymakers.

6. The need for an innovative economic model

Interactions between academia (scientific research and university), industry (business and labor market), and governance (policy and the State) are important. More overlap between the three components contributes to generating ideas for innovation coming from industries to universities to feed jobs with the required skills according to the labor market needs and to creating dedicated financial schemes to respond to the socioeconomic requirements.

Governments should raise awareness about the potential of the blue economy and learn from industry how to develop more innovation to minimize the loss of jobs. Additionally, they should ensure viable and lasting solutions for creating new opportunities, encourage private–public partnerships, and ease the dialogue between academia and the productive sector.

Today, as in all moments of historical change and because of the drastic economic situation caused by the COVID-19 pandemic, we can steer our future in a better direction to rebuild our economies and societies. To do this, there is a need to build trust in institutions and government engagement, reduce financial concerns, eliminate emotional distress, and prepare new leaders. A new generation will lead the change and introduce a new development model.

7. Blue skills: Development of skills to feed jobs

In line with the EU skills agenda for sustainable competitiveness, social fairness and resilience, and the EU strategy for blue growth, the National Institute of Oceanography and Applied Geophysics (OGS), in partnership with other public and private organisations (universities, research institutions, governmental bodies, and industries), is promoting an articulated training path that aims at overcoming the existing «skill mismatch» in the Mediterranean region between education and training and the labor market. This program has been evolving, and a project has been submitted to the national authority (Italian Ministry of University and Research) and has been positively evaluated and approved. This project, named Blue Skills, is being considered by the Union for the Mediterranean as one of the successful best practices to take part in the Med4Jobs initiative. It is also often included in several initiatives, such as Blue Med, West Med, EUSAIR, and the Western Mediterranean Forum (5+5 Dialogue).

This training offers opportunities for «Blue» careers by developing skills, leveraging innovation, exchanging knowledge, and valorizing research for a more sustainable Mediterranean Sea. It aims to develop new curricula and increase employability in the marine and maritime sectors. By supporting the Euro-Mediterranean communities of the blue economy stakeholders through HE, research, and innovation, the project enhances the shared knowledge of the overall Mediterranean region.

In addition to developing skills and building capacities, the Blue Skills initiative aims to enhance geopolitical dialogue in the Western Mediterranean region through increased international scientific cooperation and science diplomacy.

8. The Italian contribution to the 5+5 Dialogue

To stimulate growth and employment, the 5+5 Dialogue countries are deploying more efforts to promote entrepreneurship—a powerful engine of shared prosperity. The creation and growth of enterprises promotes employment and the development of new skills, reinforces innovation, and increases market potentials.

Many countries are engaged in processes of reforming their political, economic, and social systems to stimulate investment, encourage initiatives, and foster strong economic partnerships that are essential throughout the Western Mediterranean region.

The 5+5 Dialogue member countries need to revitalize their economies to promote smart, sustainable, and inclusive growth to develop disadvantaged regions and enhance job creation in line with international labor market standards. Research, innovation, and HE play a key role in job creation. There is a need for a framework of cooperation and synergies among the 10 countries. Confronted with several challenges, the 5+5 Dialogue member countries are invited to deepen their partnerships to further stimulate economic growth and social stability.

Italy, as a member country of the 5+5 Dialogue, has committed to developing, creating, and maintaining a sustainable blue economy platform for the benefit of Western Mediterranean countries. This initiative has been expanded to all Mediterranean countries and has been strongly supported by the UfM.

The main goal is to create the conditions to promote joint, complementary, and concrete actions to maximize the impact of investing in improving existing skills (upskilling) and training new skills (reskilling) in the identified field throughout HE (university degrees, such as advanced master's programmes, and training-of-trainers, such as summer schools) and VET and to bridge the gap between government–industry–academia in the blue economy sector through building strong partnerships for skills development in the Mediterranean region, with particular focus on youth skills. The specific goals are as follows:

- promoting capacity building and training offers on sustainable blue economy in the Mediterranean;
- transferring knowledge, promoting citizen science, and enhancing the involvement of stakeholders;
- boosting innovation, leveraging new technologies, generating transferable skills, and promoting youth employability;

- raising awareness of ocean governance, climate change and sea level rise, marine biodiversity and ecosystem functioning, sustainable blue economy and ecosystem-based management, maritime spatial planning and all fields related to the marine and maritime sectors; and
- strengthening regional cooperation and promoting dialogue in the Mediterranean (science diplomacy).

To reach these objectives, a tailor-made training offer has been developed, which is articulated as follows:

- a yearly summer school, organized in collaboration with the Euro-Mediterranean University in Portorož (Slovenia), which is addressed to young scientists and researchers (45–50 participants) from the Mediterranean;
- an advanced master's degree in sustainable blue economy jointly organized by OGS and the University of Trieste (25 students per year);
- access to research infrastructures, international mobility programs, and job shadowing (10–12 fellowship grants per year);
- support of 2–3 scientists and researchers for conducting Ph.D. research programs;
- and public outreach, dissemination, and scientific communication for the benefit of local communities.

Young scientists, researchers, and Ph.D. students have benefitted from this training offer; project managers, economists, engineers, and other professionals have updated their skills; policymakers, administrators, and the public have been involved; and young individuals and children have been reached.

Fig. 2. Summer school on blue growth in the Euro-Mediterranean region organized every year by OGS with the financial support of the Italian Ministry of University and Research.

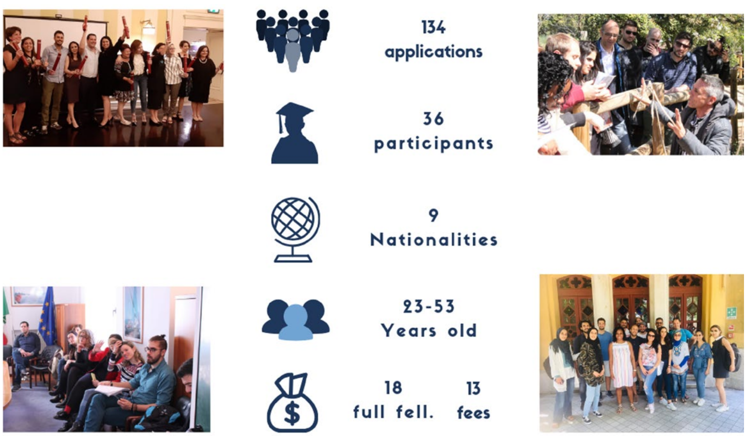

Fig. 3. Master's degree in sustainable blue economy organized every year by OGS with the financial support of the Italian Ministry of University and Research.

9. Conclusions

As a mechanism for regional cooperation and with the aim of strengthening partnership and scientific and technological cooperation among member countries, the 5+5 Dialogue on research, innovation, and HE encourages and supports the link between research, academia and industry in the Mediterranean. Partner countries believe in science diplomacy and in supporting scientific cooperation as a means to boost cross-border alliances in the sustainable blue economy sector and to contribute to the exchange of knowledge, goods, and services and to the circulation of talents between the two shores of the Mediterranean.

Science diplomacy plays an important role in easing dialogue among Mediterranean countries, spreading transboundary cooperation at multi-level governance, supporting policy and decision-making at national levels, and, above all, giving value to each country's specificity, which could be considered as a strength for the Mediterranean region.

In conclusion, establishing strategic partnerships to foster synergies with existing platforms for developing blue skills and making available investment tools and financial services beneficial to all Mediterranean countries is the only key to success for the entire region.

From an African Proverb: «if you want to go fast, walk alone. If you want to go far, walk with others». This is the real meaning of diplomacy and international cooperation.

Science diplomacy through the lens of regional cooperation: the experience of the Central European Initiative

Alessandro Lombardo

Abstract

This chapter will present the activities the Central European Initiative (CEI) has carried out in the field of science diplomacy over the last few years. As the largest intergovernmental forum for regional cooperation in Europe, the CEI's experience at the interface between science, policy and diplomacy could help elaborate preliminary thoughts on the connection between regional cooperation and science diplomacy. Both tools are indeed characterised by a dual purpose: they contribute to the consolidation of multilateral relations; and are instrumental to pursue national interests. Collaboration and competition converge in complex and not always clearly understandable patterns. This holds even more true in the new geopolitical scenario that is emerging both in Europe and globally, and which can only have an impact on how states will make use of regional cooperation and science diplomacy. After a brief historical overview of the development of regional cooperation in Europe, a description of the CEI's science diplomacy action is proposed. Overall, this enables the reader to

observe science diplomacy under the lens of regional cooperation, explore possible synergies between these two tools and identify the most effective science diplomacy activities that could be promoted within the framework of regional organisations.

1. Regional cooperation after the end of the Cold War: origins and evolution of the CEI

The end of the Cold War and the breakdown of the bipolar order opened new spaces for regional cooperation[1] in Europe. Indeed, prior to 1989, the ideological confrontation would have blocked any attempt to support regional cooperation across the Iron Curtain, in areas such as Central Europe, the Baltic, the Balkans and the Black Sea. As Cottey (2009: 4) put it, «the end of the Cold War created both a new strategic context in which sub-regional cooperation became possible and new challenges to which sub-regional cooperation was one response». Regional cooperation emerged, therefore, as a promising tool to promote the re-integration of Central and Eastern Europe and to facilitate the process of political reform and economic transition in post-Soviet countries[2]. Moreover, these groupings seemed to provide for agile platforms where cross-border topics, such as environmental problems, border management issues or transnational crime, could be addressed from a broader perspective.

Scholars have often remarked three specific features of regional cooperation: a) the geographical proximity of participating states; b) the existence of common issues (or challenges) calling for coordinated/integrated responses on a transnational and cross-border scale; c) the need to involve both state and non-state actors at multiple levels (national and sub-national). Hence, regional cooperation has been defined as a «regular process of political and economic interaction between neighbouring countries [involving] national governments, local authorities, private companies and civil society actors on a wide range of issues» (Dwan, 2000). Similarly, Cottey (2009: 5) defines it as a process of «cooperation amongst states (and/or other actors) on the basis of a geographically defined sub-area of the larger region», while Gebhard (2013: 26) as «an intensified or structured relationship between geographically adjacent entities to facilitate both inter-state and sub-state level cooperation in certain selected issue areas».

Regional groupings have proliferated in the last thirty years, with regionalism and regional integration emerging as growing factors on the European political landscape. The first of these cooperative schemes launched in the post-Cold War phase was the Quadrilateral Initiative (or *Quadrangolare*), the initial step of the process that led to the inception of the Central European Initiative (CEI) in 1992. On November 11, 1989, two days after the fall of the Berlin Wall, the foreign ministers of Austria (Alois Mock), Hungary (Gyula Horn), Italy (Gianni De Michelis) and former Yugoslavia (Budimir Lončar) met in Budapest and adopted a Joint Declaration setting the main objectives of their joint diplomatic initiative, among which: «to promote the process of greater unity of Europe, and to strengthen joint responsibility for the future of Europe» (Bonvicini, 1992). The main scope to support the reconstruction of Europe and the re-establishment of East-West relations, in line with the 1975 Helsinki Act and the CSCE (Conference on Security and Cooperation in Europe) process, had to be pursued through manifold cooperation «in different spheres of social and economic life, having in mind the cultural and historical heritages of the four countries» (Bonvicini, 1992). Although representing different positions on the international landscape – Austria was a neutral country, Hungary was still part of the Warsaw Pact, Italy was a member of NATO and former Yugoslavia was one of the leaders of the Non-Aligned Movement – the four countries highlighted their shared views by attaching «great importance to economic and scientific-technical relations as well as co-operation in the fields of energy, industry, environmental protection, transport, tourism, culture, education, information and other fields of common interest».

In an article published in the Italian journal of geopolitics «Limes» in 1993, Ambassador Luigi Vittorio Ferraris, an Italian diplomat, made a comprehensive analysis of the political interests behind Italy's decision to support the establishment of the Quadrilateral Initiative (Ferraris, 1993). According to Ferraris, in De Michelis's view, the Quadrilateral Initiative represented an opportunity for Italy to sustain a renewed projection in the Adriatic-Danube area, which had been precluded until that moment by the ideological confrontation. Such projection could serve two foreign policy objectives, namely: a) to counterbalance the Paris-Bonn axis; and b) to reinforce the geopolitical relevance of Italy, as the end of the Cold War could have diminished it by limiting the country's room for diplomatic manoeuvre to the sole Mediterranean area. For De Michelis, Italy was both a Western *and* a Central European country, a vision that Ferraris deemed as «historically not exact, but politically interesting [...]» because the existence of Italian interests in Central Europe was an «[...] invention [...] intended to oppose an alleged desire for German domination over the Danube and therefore the Adriatic and Balkan areas». This analysis highlights one important aspect behind the political decision to launch an intergovernmental forum such as the Quadrilateral Initiative, i.e., the existing «tension» between one country's national interests and regional/multilateral ones. A similar feature also characterises science diplomacy, which will be discussed later on.

Following the Quadrilateral example, similar diplomatic initiatives were undertaken in other European regions: in 1991, the Visegrad Group (VG) was set up by Czechoslovakia, Hungary and Poland to address two main foreign policy goals: the dissolution of the Soviet-era security system and the accession of central European countries in both the European Community and NATO. While the VG was promoted by a small group of countries of the former Soviet bloc, the much larger memberships of two other regional groupings – the Council of the Baltic Sea States (CBSS)[3] and the Organisation of the Black Sea Economic Cooperation (BSEC)[4] — both established in 1992 — fully demonstrate that the main purpose of post-Cold War regional cooperation, as already mentioned above, was the reconstruction of East-West relations.

After this post-Cold War enthusiasm for regional cooperation, the use of this tool in the European diplomatic practice has been quite irregular. Nevertheless, two phases of development could be identified: first, countries resorted to regional cooperation in the second half of the 90s following the end of the Yugoslav wars. A new round of regional institution-building was promoted in the Balkans, based on the assumption that common political, economic and social challenges required shared (regional) solutions[5]. Organisations such as the Southeast European Cooperative Initiative (SECI, 1996), the South-East European Cooperation Process (SEECP, 1996) and the Stability Pact for Southeastern Europe (1999), the latter replaced by the Regional Cooperation Council (RCC) in 2008, were established during this period. Then, in the first decade of this century, new regional initiatives were promoted by the EU, such as the European Neighbourhood Policy (2004), the Black Sea Synergy (2007) and the Eastern Partnership (2009). These initiatives reflected the need to consolidate the Eastern side of the EU and mitigate the risk of new «diving lines» created by the EU/NATO eastward enlargement[6], while counterbalancing the growing Russian presence in the area. Moreover, starting from 2009, the «EU Macro-Regional Strategies» have been promoted in the Baltic Sea (EUSBSR), Danube (EUSDR), Adriatic-Ionian (EUSAIR) and Alpine (EUSALP) regions[7].

As opposed to the fragmented landscape of regional cooperation in Europe, the evolution of the CEI over the last thirty years has been steady. At the Summit held in Venice (August 1, 1990), the Quadrilateral Initiative was joined by another country, i.e., Czechoslovakia; then, in the aftermath of the dissolution of the Warsaw Pact (July 1, 1991), Poland was welcomed as the sixth member of the forum. Finally renamed «Central European Initiative» in 1992, the CEI has expanded its geographical outreach way beyond the initial focus on Central Europe. The partition of Czechoslovakia, the dissolution of former Yugoslavia and the accession of Albania, Belarus, Bulgaria, Moldova, Romania and Ukraine in 1996 have made the CEI the largest intergovernmental forum for regional cooperation in Europe. Such an extended geographical scope could only represent a challenge in terms of Member States' homogeneity, economic and cultural interdependence and long-term aims, thus complicating the identification of common foreign policy interests and shared goals. To consolidate the governance of the forum, and to ensure administrative/conceptual support to the cooperative actions promoted by the participating countries, an Executive Secretariat was, therefore, seated in Trieste in 1997.

Today the CEI membership includes nine EU countries[8], five accession countries in the Western Balkans[9] and three Eastern Neighbours[10]. This hybrid EU/non-EU membership shares the common mission to promote «regional cooperation for European integration and sustainable development». To this aim, the CEI has developed a specific working methodology: its traditional action fostering policy dialogue and multilateral diplomacy, at both intergovernmental and inter-parliamentary level, is complemented by a strong project-oriented vocation. Supporting and implementing regional projects (transnational, cross-border and interregional ones) has become essential to fulfil the CEI's political mandate, as well as to address the common sector priorities identified by CEI Member States and included in the triennial CEI Plan of Action, ultimately seeking to contribute to enhancing social, economic and territorial cohesion in Central, Eastern and South-Eastern Europe.

2. CEI's action in the field of science diplomacy

The importance of technical and scientific cooperation as useful tools for achieving common political goals was already highlighted in the above mentioned Joint Declaration marking the inception of the Quadrilateral Initiative. Since then, the CEI has promoted regional and cross-border cooperation in the fields of science, research and innovation, and contributed to the development of knowledge societies in its Member States by supporting a combination of intergovernmental actions (i.e., meetings of ministers in charge of science and research) and result-oriented operations (projects funded by its own resources; participation in international projects funded by the EU Framework Programmes for Research and Technological Development).

Against this background, science diplomacy officially became part of the CEI's policy portfolio on December 13, 2019, when the CEI ministers in charge of science and research convened in Trieste under Italy's chairmanship. The main output of this gathering was the unanimous adoption of the Trieste Declaration on Science, which outlined the CEI Member States' common vision on scientific cooperation and science diplomacy: strong emphasis was put on science as an effective vector of soft power. Therefore, it was seen as a useful tool for accomplishing the CEI mission aimed at bridging EU and non-EU countries.

From the viewpoint of an organisation such as the CEI, science diplomacy represents an emerging and promising domain of international relations, as well as an interesting policy tool that, just like regional cooperation, encompasses both a national and a multilateral dimension. As said, an intergovernmental forum provides a valuable platform where multilateral actions can be developed between and among countries sharing common needs and goals. At the same time, also national interests can be pursued through the inception of, or participation in, a regional initiative, thus determining that potential «tension» between cooperation based on converging interests and competition on conflicting ones. The same holds true for science diplomacy, whose multi-faceted character is probably one of the reasons why it has been impossible to agree on a «one-size-fits-all» definition so far.

In the absence of a broadly accepted definition of science diplomacy, an assessment of the CEI's action in this field could be carried out against two taxonomies elaborated in the past to categorise science diplomacy-related actions. The first one was proposed by the Royal Society (RS) and the American Association for the Advancement of Science (AAAS) in their policy report *New frontiers in science diplomacy* (Royal Society and AAAS, 2010), which distinguishes between the following three dimensions: a) diplomacy for science, i.e. a country's diplomatic support to international scientific cooperation, which enables also the promotion of its own national assets in the field of research & innovation; b) science for diplomacy, i.e. using the soft power of science to establish or maintain relations when political tensions hinder the normal diplomatic practice; c) science in diplomacy, i.e. the use and valorisation of scientific expertise in policy- and decision-making processes, particularly in the domain of multilateral negotiations on transboundary grand challenges. Another useful taxonomy is the «pragmatic approach» by Gluckman and his co-authors (Gluckman et al., 2017), which attempts to overcome the above mentioned theoretical RS/AAAS conceptualization by focusing on the concrete reasons that push a government to invest in science diplomacy. Three domains are identified: a) actions designed to directly advance national needs; b) actions designed to address cross-border interests; c) actions primarily designed to meet global needs and challenges.

Going back to the CEI, the Trieste Declaration on Science marked a shift of perspective from supporting international scientific cooperation to developing a broader action in the field of science diplomacy. This shift is acknowledged in the CEI Plan of Action 2021-2023, which was adopted at the end of 2020: CEI Member States agreed to put a stronger accent on the importance of science diplomacy by including objective 2.6 «Furthering Science Diplomacy» as one of the twelve thematic priorities, i.e., one of the main fields on which the Organisation will focus its action in the upcoming years.

By combining the policy orientations included in the Trieste Declaration on Science and the agreed priorities summarised in the CEI Plan of Action 2021-2023, it is possible to assert that the CEI's action in the field of science diplomacy has been mainly directed towards two objectives: firstly, by taking into account the CEI's «hybrid» membership, science diplomacy could represent an effective tool to facilitate dialogue between EU and non-EU countries, thus contributing to identify a common set of interests in the field of scientific cooperation, international research and innovation; secondly, considering its structure and working methodology, the CEI could provide a well-established platform where multi-level and multi-stakeholder science-policy-diplomacy interactions could be initiated and nurtured. All activities promoted by the CEI following the adoption of the Trieste Declaration on Science, thus in the period 2020-2022, were designed bearing these two overarching objectives in mind.

As a first step, in line with the encouragement of the CEI ministers to investigate the concept of science diplomacy «including through the implementation of trainings, capacity building actions, research activities and networking», the CEI-Executive Secretariat started a collaboration with the University of Trieste (Department of Social and Political Sciences) to analyse two relevant topics, namely: a) the science diplomacy cooperative networks across the CEI area - a broad portion of Europe which, until then, had been generally ignored by the socio-political research in the field (Arnaldi, Lombardo e Tessarolo, 2021); b) the global offer of training on science diplomacy vis-à-vis the assets of the Friuli Venezia Giulia Region as a potential competence hub/training centre on science diplomacy - also considering that the «science diplomat» job profile is slowly taking root. These activities have demonstrated that a widespread interest in science diplomacy exists in Central, Eastern and South-Eastern Europe, although a tendency towards fragmentation between the structures involved in foreign policy and those involved in international research may hinder the deployment of this tool's full potential. Therefore, supporting the involvement of accession countries and Eastern neighbours in the debate on science diplomacy, as well as the design and implementation of capacity-building and training activities could match a growing need shared by several CEI Member States. In this regard, the CEI's participation in the EU Science Diplomacy Alliance - a collaborative effort aimed to consolidate a common EU approach on science diplomacy - could help bridge with non-EU countries, and thus mitigate the risk that new dividing lines would emerge between those countries included in a (future) EU science diplomacy strategy and those excluded.

Another aspect emphasised in the Trieste Declaration on Science was «the importance of the CEI as a well-established forum for dialogue and platform for result-oriented cooperation, in which context interactions between scientists, diplomats and policy-makers shall be facilitated with the goal to tackle complex, science-driven issues of common interest». Indeed, one of the main objectives of science diplomacy is to facilitate encounters between the communities of scientists and diplomats, including through the establishment of science-policy-diplomacy interfaces to address complex threats overcoming national borders. On such basis, as a quick reaction to the fast evolution of the COVID-19 pandemic in the countries of Central, Eastern and South-Eastern Europe, the CEI, along with the Regional Office for Europe of the World Health Organisation (WHO), promoted the joint CEI-WHO Task Force in response to COVID-19, comprising key health officials and experts from CEI Member States. Throughout 2020, this transnational platform ensured knowledge circulation, data exchange, sharing of experiences and best practices, which provided CEI governments with robust evidence for their national policymaking[11].

Along similar lines, yet in a different field, the CEI is cooperating with the National Institute of Oceanography and Applied Geophysics (OGS) of Italy towards the establishment of a transnational network aimed to strengthen collaborative research in the fields of seismology and earth science. Again, the Trieste Declaration on Science provides the necessary policy framework: indeed, CEI ministers had encouraged the Organisation to enhance cross-border and transnational cooperation focused on prevention of natural disasters, risk mitigation and adaptation, based on the assumption that research infrastructures in CEI non-EU countries cannot benefit from being part of existing European initiatives in the field, such as the European Plate Observing System (EPOS). Fostering collaboration with those CEI countries currently not participating in EPOS, through the establishment of the CEI-OGS transnational network, is therefore crucial to complement larger EU-led initiatives, enhance the provision of data and services and ultimately increase the number of scientists engaged in collaborative and transnational research. In order for this effort to be successful, the support of diplomatic structures (ministries of foreign affairs), and of those involved in international scientific cooperation (ministries in charge of science and research) is essential. This initiative is a clear example of science-policy-diplomacy interface.

In parallel to the initiatives briefly described above, the CEI has continued to ensure its traditional support (also financial support) to activities favouring international networking, capacity building, knowledge circulation and mobility of researchers. To design and implement these actions, effective collaborations and teamwork between and among state and non-state actors dealing with international relations, scientific cooperation and research is required, in line with the common science diplomacy vision developed by CEI Member States.

3. Conclusions: which synergies between science diplomacy and regional cooperation?

Science diplomacy is a multi-faceted and multidimensional concept that implies the implementation of different activities, which are nonetheless addressing a common objective: to bridge between the communities of scientists and diplomats, thus pooling resources, skills and competences to tackle the most complex challenges of our times in an effective manner.

The experience of the CEI demonstrates that regional cooperation and science diplomacy can be used sinergistically to valorise their outcomes, notwithstanding the fact that both tools are inherently characterised by a dual purpose: they contribute to the consolidation of multilateral relations and could also be instrumental to pursue a country's national interests. By looking at the activities promoted by the CEI during the period 2020-2022, thus following the adoption of the Trieste Declaration on Science, this potential «tension» between collaboration and competition has not occurred. In fact, all such activities could be easily related to categories «b» («actions designed to address cross-border interests») and «c» («actions primarily designed to meet global needs and challenges») of the «pragmatic approach» by Gluckman and his co-authors (Gluckman et al. 2017). Regarding the Royal Society and AAAS (2010) taxonomy, the dimension of «science in diplomacy» seems the most appropriate for defining CEI's action. This is demonstrated by the promotion of collaborative research on scientific topics interlinked with foreign policy objectives - such as the CEI-WHO Joint Task Force in Response to COVID-19 or the CEI-OGS transnational research network in the field of seismology and earth science. Nevertheless, also the dimension of «diplomacy for science»

- yet understood as a collaborative, multilateral effort rather than a single country's strategy to advance its national interests - is well-suited for a diplomatic body such as the CEI.

Indeed, at least so far, science diplomacy within the CEI's portfolio has pursued multilateral goals, such as the translation of scientific research into knowledge to inform the policy-making process; the organisation of an effective dialogue between the world of science and that of diplomacy; the professionalisation of relations between the scientific and the political-diplomatic communities; their collaboration in order to find shared solutions to grand transnational challenges. The same logic will be followed in the future, notwithstanding the changing geopolitical scenario at EU and global levels, which is having, and will also have, an impact on the CEI's constituency. The EU candidate status granted to Bosnia and Herzegovina, Moldova and Ukraine, as well as the opening of accession talks with Albania and North Macedonia put CEI non-EU countries in the Western Balkans and in Eastern Europe on a clearer path towards the European Union. Science diplomacy and regional cooperation can represent useful tools to support these long and complex processes, even more so if innovative combinations and synergies will be found to maximise their impacts.

Endnotes

1 In this chapter, the expressions «regional cooperation» and «sub-regional cooperation» will be used with the same meaning. The latter was mainly used in the past to distinguish between the European integration process, perceived as a regional effort, and other cooperative schemes encompassing a more limited number of countries, thus a sub-region of Europe (e.g., Central Europe). The enlargement process, on one side, and the EU emerging as a global player, on the other side, have made this semantic distinction obsolete. Therefore, although the quoted literature often refers to «sub-regional cooperation», the expression «regional cooperation» will be preferred whenever possible.

2 According to Gebhard (2013), «despite their functional and political differences, most of these formations were created in the framework of the broader aim of «returning to Europe» or «reintegrating to the West» of post-Soviet countries.

3 Including Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia (in March 2022, Russia was suspended from participation in CBSS activities; in May 2022, Russia decided to withdraw from CBSS), Sweden and the European Commission (replaced in 2009 by the European Union).

4 Including Albania, Armenia, Azerbaijan, Bulgaria, Georgia, Greece, Moldova, Romania, Russia, Turkey and Ukraine (later joined by North Macedonia and Serbia).

5 Solioz and Stubbs (2009) assert that this second phase of regional cooperation was «largely engineered from outside and approached as a kind of peace-building project [...]. SEE [South-East Europe] was an emergent sub-regional space, largely ascribed by outside forces rather than achieved from within».

6 Poland, Czech Republic and Hungary joined NATO in 1999; Bulgaria, Romania, Slovakia, Slovenia, Latvia, Lithuania and Estonia in 2004; Albania and Croatia in 2009.

7 In a debate organised by the Committee of the Regions on 13 April 2010, entitled «Europe's Macro-Regions: integration through territorial cooperation», Martin Dangerfield (2010) highlighted that the concept of macro-regional cooperation was any news for Europe, due to a longstanding tradition of «macro-regional style» cooperation, usually referred to as «sub-regional cooperation».

8 Bulgaria, Croatia, Czech Republic, Hungary, Italy, Poland, Romania, Slovakia, Slovenia.

9 Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia.

10 Belarus, Moldova, Ukraine, with Belarus suspended of its rights of representation in the CEI «as a consequence of the country's actions in support of the aggression against Ukraine» (Statement by the Bulgarian CEI Presidency and the CEI-Executive Secretariat on the suspension of the Republic of Belarus from the Central European Initiative, 25 March 2022).

11 This experience of «science diplomacy in practice» was described in the article "*A Regional Approach to Fighting COVID-19 in Central, Eastern and South-Eastern Europe*, published in «Science & Diplomacy», an online publication from the Center of Science Diplomacy of the American Association for the Advancement of Science (AAAS) (Lombardo and Apuzzo, 2021).

The Sustainable Development Goals, science diplomacy and TWAS

Peter F. McGrath

Abstract

To attain the targets of the 17 United Nations Sustainable Development Goals will require not only the input of science, but also the judicious application of science diplomacy. Unfortunately, scientific research, outputs and applications are skewed heavily towards High-income Countries (HICs), whereas many Low- and Middle-income Countries (LMICs) invest much less in training scientists and providing suitable facilities for them to carry out their research. Supporting research in LMICs is critical to reaching the SDGs as not all research outputs from HICs are directly transferrable to lower-resource settings.

Throughout its 40-year history, The World Academy of Sciences (UNESCO-TWAS), headquartered in Trieste, Italy, has been working to build scientific capacity in the Global South, frequently relying on South-South collaboration and exchange to implement its programmes. More recently, since 2014, TWAS has developed activities in the area of science diplomacy – particularly raising awareness among young scientists in LMICs of the necessity to *think of the applications of their research beyond the laboratory, i.e. how their results might be used to tackle the SDGs and how, in turn, they can raise awareness among local policy-makers of the need to engage with scientists within their own countries. Examples based on the actions of alumni from TWAS science diplomacy courses are presented. Also highlighted is the fact that TWAS and other scientific institutions in and around Trieste receive core funding from the Government of Italy, confirming these entities of the so-called Trieste Science System as an instrument of soft power (using science, i.e. science diplomacy) to enhance the credibility and influence of Italy.*

In 2015, Member States of the United Nations agreed to a set of 17 development objectives to be achieved by 2030. Known as the Sustainable Development Goals (SDGs, <http://sdgs.un.org/goals>), they cover a range of issues from eliminating poverty, ensuring adequate nutrition, and tackling climate change and biodiversity loss. Many scientific organizations around the world contributed to discussions during the drafting of the SDGs, in what can be regarded as an example of «science in diplomacy» – one of the three pillars of a widely used definition of science diplomacy[1].

Indeed, it is clear that science must also play a key role in reaching the 169 targets of the 17 SDGs by 2030. How can we ensure food and nutrition security, for example, or the provision of safe drinking water and adequate sanitation, without the application of science and technology? Going further, it is clear that many of the SDGs cannot be attained by individual countries acting alone. The SDGs relating to Climate Action (SDG#13) and – as the COVID-19 pandemic has brought to the centre of our attention – Good Health and Wellbeing (SDG#3), among others, also require the application of science diplomacy. In this case, we can consider the «science for diplomacy» pillar of the tripartite definition referenced above.

Unfortunately, scientific research and outputs are skewed heavily towards High-income Countries (HICs), where investment in necessary personnel and infrastructure is largely adequate. In many Low- and Middle-income Countries (LMICs), however, there is a serious lack of investment in training and retaining scientists and providing those that do remain with suitable facilities for them to carry out their research. Not all research and development carried out in HICs is directly transferrable to LMICs: local context plays a major part in the adaptation and uptake of any technology. To attain the SDGs, therefore, it is imperative that research and development is supported in LMICs. Such support must include sustained efforts in capacity building in science and technology. Only in this way can appropriate local solutions be found for local challenges.

Prior to the 2015-2030 SDGs, the world's nations agreed on another set of targets, the 2000 Millennium Development Goals (MDGs, <http://www.un.org/millenniumgoals/>). It soon became clear that capacity building was an essential requirement. For example, the World Water Development Assessment Programme (2003) noted that: «To fulfil the 2003 requirements of the UN Millennium Development Goals, member countries agreed that Africa would need an estimated 300% increase in the number of trained water professionals, Asia would need a 200% increase, and Latin America and the Caribbean a 50% increase, in all disciplines». And that: «At the 2015 Knowledge Exchange in International Waters conference (Beijing), Asian and African representatives requested capacity building training in international water law and conflict management»[2].

But this is not an issue that arose in 2015 with the introduction of the SDGs, or indeed in 2000 with the introduction of the MDGs. In fact, Abdus Salam, a Pakistani physicist, recognized this issue back in the 1960s. Salam, who went on to win the Nobel Prize for physics in 1979[3], was the driving force behind the establishment of the International Centre for Theoretical Physics (ICTP, <www.ictp.it>) in Trieste, Italy, in 1964. ICTP was created to provide «scientists from developing countries with the continuing education and skills that they need to enjoy long and productive careers. ICTP alumni serve as professors at major universities, chairpersons of academic departments, directors of research centres and ministers of science and technology in nations throughout the developing world. Many of them have been recognized in their own countries and internationally for their contributions to science and science policy» (ICTP - The Abdus Salam International Centre for Theoretical Physics, n.d.)

Recognizing that ICTP dealt with only a limited area of science and that sustainable economic development required the input of all scientific disciplines, Salam followed up the establishment of ICTP with the creation of what was then known as the Third World Academy of Sciences (TWAS). Beginning with just 42 Founding Fellows in 1983, TWAS (now The World Academy of Sciences and acting as a programme unit of UNESCO, <www.twas.org>) recognizes more than 1,200 eminent scientists from around the world as Fellows, with more than 80% from LMICs.

Through four decades, TWAS' mission has remained consistent:

- Recognize, support and promote excellence in scientific research in the developing world;
- Respond to the needs of young scientists in countries that are still developing in science and technology;

- Promote South-South and South-North cooperation in science, technology and innovation; and
- Encourage scientific research and sharing of experiences in solving major challenges facing developing countries.

TWAS uses the credibility of its eminent Fellows from around the world to provide capacity-building programmes aimed largely at young scientists in LMICS, and particularly a sub-set identified as Science and Technology-lagging Countries (STLCs). For example, TWAS and its partners offer over 300 fellowships per year to scientists in the developing world who want to pursue a doctoral degree or postdoctoral research, and also allocates well over USD1 million in research grants every year to individual scientists and research groups in STLCs.

Partners in the TWAS fellowships schemes are typically government agencies in those LMICs that have excellent scientific facilities. These include the Chinese Academy of Sciences (CAS), the Council for Scientific and Industrial Research (CSIR) and the Department of Biotechnology (DBT) of the Ministry of Science and Technology, both in India, the National Research Foundation (NRF) and the Department of Science and Technology (DST) of South Africa, and the Scientific and Technological Research Council of Turkey (TÜBİTAK). Thus, negotiations between TWAS and these partner agencies can be considered as examples of the third pillar in the science diplomacy definition, i.e. «diplomacy for science».

Such fellowship and other exchange schemes were designed to encourage South-South collaboration – one of TWAS' key missions that also has relevance to the SDGs. As mentioned above, research carried out in HICs cannot always be easily transferred to LMICs. In contrast, research performed in a developing country – leading to innovation in a resource-constrained environment – is often more directly applicable in other developing countries. As well as helping to directly build scientific capacity, therefore, such exchange schemes also lay the foundations for technology transfer and the attainment of the SDGs.

The investment contributed to the various TWAS fellowship programmes by the partner governments is not trivial – all costs for hosting the visiting scientists are borne by them. So what do these countries gain from their philanthropy? The answer can be found in the concept of «soft power», defined as «the ability of a country to persuade others to do what it wants without force or coercion» (Nye, 1990). Soft power is often expressed through culture (e.g. art, cuisine), but also sport, political values – and scientific collaboration.

TWAS receives core financial support from the Government of Italy via the Ministry of Foreign Affairs and International Cooperation (MAECI). Indeed, other international scientific institutions in Trieste, including ICTP and the International Centre for Genetic Engineering and Biotechnology (ICGEB, <www.icgeb.org>), also receive such support. Likewise, other institutions in the region, such as the National Institute of Oceanography and Applied Geophysics (OGS, <www.ogs.it/en>) and the Central European Initiative (CEI, <www.cei.int>), are also directly active in science diplomacy activities. These examples amply demonstrate that, through its political and financial support, the Italian government is using its soft power to promote science diplomacy and to build lasting relations with scientists from around the world.

It is fair to say that science diplomacy activities in Trieste began with TWAS. Since 2014, TWAS (in partnership with the American Association for the Advancement of Science (AAAS, <www.aaas.org>), has trained more than 400 young scientists, largely from LMICs, in science diplomacy. These efforts ensure that the scientists carrying out research in their laboratories or through field studies are aware of the wider implications of their work and how it can contribute to informing policy and contributing to the SDGs.

To provide one example, Patrick Ssebugere, an environmental toxicologist at Makerere University, Uganda, attended an AAAS-TWAS science diplomacy course in 2018. He learnt new communication skills, which he is now putting to good use acting as an advisor for policymakers and the Government of Uganda. He has begun to monitor the western Uganda region, where deep oil fields are luring the interest of international oil companies. Drilling, which may start in a near future, could release pollutants such as heavy metals and polycyclic aromatic hydrocarbons into the soil that may eventually leach into lake basins. Ssebugere and his team are carrying out preliminary tests, collecting baseline data to advise the Government when the drilling starts. Another of his projects involves devising new methods to quantify the levels of microplastics in surface waters, sediments, fish and other organisms in Lake Victoria, the shores of which are shared by three nations (Serra, 2022).

It is also clear that policy-makers, diplomats and government officials are often unaware of the importance of science diplomacy and especially the contributions that scientists can provide towards policy options. Indeed, as one expert speaker at an AAAS-TWAS science diplomacy course succinctly put it: «Policy-making without science is just guessing» (Copeland, 2009). For these reasons, science diplomacy training provided by TWAS is targeted not only towards young scientists, but so-called «science diplomacy ambassadors» (including young government officials, perhaps working in a ministry of science or department of energy) are also invited to attend. Testimonials received from such course participants confirm that they are actively using the science diplomacy training they received in their daily work. Recently, ministry officials in Brazil, India and South Africa, for example, have confirmed to TWAS that they are using what they learnt during their science diplomacy training «on a daily basis».

The numbers of individual young scientists who are able to take forward their science diplomacy training and have a positive impact in policy circles are, however, limited. A more effective outcome is the example provided by Grace Abakpa of the National Biotechnology Development Agency (NABDA) and Etim Offiong, African Regional Centre for Space Science and Technology Education – both from Nigeria and who met for the first time in Trieste at a AAAS-TWAS train-the-trainers' science diplomacy course in 2019. On their return to Nigeria, they connected with their Federal Ministry of Science and Technology and provided a 3-day course in science diplomacy to some 35 staff members, officials and policy-makers.

«The Federal Ministry of Science and Technology really welcomed our feedback [from the TWAS course attended], and in 2020 this culminated in an agreement which aims to set up trainings for early career scientists in the Ministry on science diplomacy», informed Abakpa. «It further aims to work in collaboration with other ministries – especially the Ministry of Foreign Affairs – for further work on science diplomacy and broader inclusion and engagement of policy makers. The TWAS training contributed greatly to this outcome».

In summary, it can be said that societies face three kinds of problems that can be classed as simple, complicated or complex. An example of a simple problem would be how to irrigate a field. Introduced from Egypt to Greece by Archimedes, the origins of the so-called Archimedes Screw are said to date back to the third century BCE. A more complicated problem is providing water and sanitation to every household in a city. This requires a combination of facilities and technologies – from reservoirs to pumping stations, to purification and sewage treatment plants. However, it can be done with available technologies. These can also be classed as «tame» problems. In contrast, complex – or «wicked» – challenges require solutions that go beyond the competencies of science and technology. Continuing the above example of providing water to a city – what happens when multiple actors with multiple demands are concerned.

Perhaps the water resource is shared by more than one nation, or the available water must be shared with other sectors such as agriculture and industry, while not forgetting our duty to protect the natural environment (enshrined, for example in SDG#14 – Life Below Water).

«The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature of these problems. They are "wicked" problems, whereas science has developed to deal with "tame" problems» (Rittel and Webber, 1973: 155).

The SDGs – while requiring the input of science to reach the targets – are «wicked»/complex problems. That is, more than just science and technology is required to deal with them. What is required is science diplomacy – a concerted effort to build bridges and understanding between the scientific and the policymaking communities. In many LMICs (and elsewhere!) critical first steps in this process include capacity building in research and development, and capacity building in science diplomacy.

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Endnotes

1 From the definition of science diplomacy provided by the Royal Society and by the American Association for the Advancement of Science, in *New Frontiers in science diplomacy* (Royal Society and AAAS, 2010).
2 Both quotes from Marshall et al. (2017).
3 See <http://en.wikipedia.org/wiki/Abdus_Salam>.

SESAME, a new light for the Middle East

Giorgio Paolucci

Abstract

The chapter describes the genesis and development of SESAME (Syncrotron-light for Experimental Science And Applications in the Middle East), an international multidisciplinary research laboratory based on a synchrotron light source, whose headquarters is in Jordan. The chapter explains the path taken, thanks in part to Italy's support, by this scientific cooperation project and its establishment as an open space for collaboration between countries, especially in the Middle East but not only, that have serious difficulties in meeting on common ground, thus representing both an important resource for science and an opportunity for dialogue between peoples.

1. Introduction[1]

Allan, Jordan. Here, about 40 km from the capital Amman, in the heart of the Middle East and North Africa (MENA) region, SESAME (Syncrotron-light for Experimental Science and Applications in the Middle East) was officially opened on 16 May 2017. SESAME is an international multi-disciplinary research laboratory based on a synchrotron light source, which will enable scientists in the Middle East as well as in other countries, to access a world-class centre in order to carry out their research activities. SESAME is not «just» a laboratory in the region, but a unique development opportunity which could play a wide-ranging, key role in the scientific, technical, and economic development of the region. In fact, synchrotron light research can be applied to a wide range of scientific areas: from atomic physics to life sciences, from materials science to archaeometry. For this reason, researchers from various different areas can work together and develop ideas, methodologies and instruments which in other contexts that focus on specific research topics would not be possible. However, there is another reason why SESAME is so unique and valuable: it serves as an open space, a place where countries that normally struggle to find common ground actually work together. The following countries are members of SESAME: Cyprus, Egypt, Jordan, Iran, Israel, Pakistan, the Palestinian National Authority and Turkey, while the following are observers: Brazil, Canada, China, France, Germany, Japan, Greece, Italy, Kuwait, the United Kingdom, the Russian Federation, Spain, Sweden, Switzerland, and the United States. SESAME is therefore an important scientific resource but also an important project in which different countries work together.

2. A dream, not a utopia

Experience teaches us that the presence of a large laboratory based on particle accelerators is an exceptional stimulus for growth in the region where it is located. This comes from the impact that the research activities carried out have on increasing our understanding, and from the fact that these laboratories use state-of-the-art technology. In other words, scientific, technological and cultural development is the result not only of what is being studied but also of how it is studied. In keeping with this principle, as far back as the 1980s some scientists in the region were recommending that the Middle East should be committed to undertaking large physics projects. In 1983, speaking at a meeting in Bahrain, Nobel Prize laureate Abdus Salam said:

> «We forget that an accelerator like the one at CERN develops sophisticated modern technology at its furthest limit [...]. I cannot but feel envious that a relatively poor country like Greece has joined CERN, paying a subscription [...]. I cannot rejoice that Turkey, or the Gulf countries, or Iran or Pakistan seem to show no ambition to join this fount of science and get their people catapulted into the forefront of the latest technological expertise».

A few years later, in the mid 1990s, some «well meaning» physicists developed the concept further and, as well as supporting the involvement of the countries of the region in existing projects (such as CERN), conceived the idea that an experimental physics centre in the Middle East could bring together countries that would not cooperate in any other areas. The idea that emerged was to try and reproduce, in this troubled region, the same spirit of cooperation that CERN had created in Europe in the period following the Second World War, by enabling researchers from countries that up to a few years before had been fighting each other (such as the French and British along with the Germans and Italians, as well as Soviet and American researchers during the Cold

War period) to meet and work together in an environment that was free from political or ideological influences.

In January 1995, Sergio Fubini, an Italian theoretical physicist at CERN and later professor at the University of Turin, sponsored a meeting between Egyptian and Israeli scientists in Cairo, with the aim of laying the foundations for cooperation between the Arab and Israeli scientific communities. Following the meeting, a memorandum of understanding was signed between the Sub-secretary of State for Egyptian research, Mohamed Mokhtar El Halwagi, the Director of the Recah Institute of Physics in Jerusalem, Eliezer Rabinovici, and Sergio Fubini himself. The memorandum identified condensed matter physics and high-energy physics as areas in which scientific cooperation in the Middle East should be enhanced for «the benefit of human knowledge». Moreover, it recognised that in order to achieve this objective a «significant and sincere cooperation among experts would be needed, regardless of their nationality». Finally, it underlined the importance of training young researchers for these purposes.

This meeting was followed by the Sinai meeting on High Energy Physics, Condensed Matter and Environmental Physics, which was held in Dahab, Egypt, in November of the same year, which was also sponsored by the ICTP (International Center for Theoretical Physics), the Trieste-based centre founded by Abdus Salam, given that the aim of the initiative was in line with the ICTP's objectives. This meeting formalised the MESC (Middle East Scientific Cooperation) group.

In November 1997, the MESC group organised a second conference in Turin, this time on Experimental Techniques in High-Energy and Synchrotron Radiation Physics, which saw the participation of 31 researchers from Israel and various Arab states.

Meanwhile, following the reunification of Germany, it was decided that a new synchrotron light laboratory should be built in Berlin, in the former East Berlin to be precise. It was a third generation source (BESSY 2), and building it would make the existing accelerator (BESSY 1) obsolete. It was understood, therefore, that the long-awaited plan to build a synchrotron-light source accelerator in the Middle East, based on the CERN model, could be achieved by re-installing the decommissioned BESSY 1 accelerator in the Middle East. The proposal was formulated by Gustav Adolf Voss of DESY (Deutsches Elektronen Synchrotron, Hamburg), and by Herman Winick of SLAC (Stanford Linear Accelerator Center, Stanford University), during a meeting in Berlin. Voss presented the proposal at the MESC meeting in 1997. MESC was enthusiastic about the idea of reinstalling BESSY 1 in the Middle East. Consequently, MESC's steering committee organised a meeting in Uppsala, Sweden, in April 1998 in order to study a potential plan to transport the components of BESSY 1 to the Middle East. The researchers who attended the meeting believed it was a good way to initiate an experimental research project with accelerators in the region, and decided that MESC would seek international support in order to carry out the project.

It was also at this time that Said Assaf, of the Palestinian National Authority, coined the acronym SESAME (Synchrotron-light for Experimental Sciences and Applications in the Middle East), which makes an obvious reference to the expression «Open, Sesame!» from the folk tale «A thousand and one nights», clearly emphasising the nature of a research laboratory which would be open to the wider international community.

A planning committee was therefore set up which would be coordinated by Herwig Schopper, who was already the Director General of CERN. Schopper, Fubini and Voss brought the plan to donate the disused components of BESSY 1 to SESAME to the attention of the German government. The plan was approved, on condition that the dismantling and transportation of the components would be carried out by SESAME. The project was subsequently brought to the attention of the then Director General of UNESCO, Federico Mayor, because Schopper was convinced that the only way to complete this international venture would be for it to be carried out under the auspices of UNESCO, as had happened in the case of CERN.

3. Today is already tomorrow

In June 1999, UNESCO organised a meeting with delegates from the Middle East and neighbouring countries, which led to the setting up of an international *ad interim* committee to prepare for the creation and management of an international centre.

At the beginning of 2000, the newly-elected Director General of UNESCO, Kōichirō Matsuura, informed the German government that UNESCO was ready to take the first steps needed in order to create SESAME, as a centre under the auspices of UNESCO. He also announced that the costs of dismantling BESSY 1 would be covered by international funds. These assurances led the German authorities to formally agree to donate the BESSY 1 machine to SESAME, and the components of the machine were subsequently dismantled with the technical support of teams from Armenia and Russia, and with funds provided by UNESCO, as well as members of the international ad interim committee of SESAME, and the US State Department.

During a meeting of the *ad interim* committee in Geneva in April 2000, it was decided that SESAME would be located in Jordan. The main selection criteria required that the host nation would be able to guarantee that scientists from all over the world would be able to access the centre, and in particular researchers from all the other members of SESAME, and that it would provide the site where the laboratory could be built and that it would pay for the building. Other criteria were the presence of adequate service infrastructure (such as water and electricity). Jordan, thanks also to the interest in scientific research shown by King Abdullah II and all the royal family, provided the best guarantees on every front. At the beginning of 2002, after an exchange of correspondence between Jordan's Minister of Education and Germany's Federal Minister for Education and Research in which Jordan's Ministry of Education took responsibility, as a matter of trust, for the appropriate transport, storage and use of the storage ring, the components of BESSY 1 were sent on 7 June 2002 from Berlin, via Hamburg, and delivered to the free port of Zarqa in Jordan, in order to be stored until the SESAME building was completed.

To facilitate its construction, it was decided that the main SESAME building would be based on the design of an existing building: the ANKA-FZK laboratory in Karlsruhe, Germany, which houses a synchrotron with similar characteristics to those of the SESAME machine. At the same time, they decided to appoint as SESAME's Technical Director the head of the German laboratory, Dieter Einfeld, considering his knowledge of the building, whose design plans were made available and translated into Arabic. On 6 January 2003, in the presence of King Adullah II and UNESCO's Director General, Mr Matsuura, as well as representatives of the members of SESAME, the first SESAME stone was laid. Construction of the main building, which was by no means a straightforward undertaking, took five years to complete. And so the main SESAME building was officially opened on 3 November 2008 at a ceremony attended by all the authorities of both members and observers, as well as by King Abdullah II and Mr Matsura. Unfortunately, however, an incident occurred on 14 December 2013 when, following heavy snowfall mixed with rain and hail, the roof of the building collapsed, which took everyone by surprise, given that the building had been designed to withstand the heavy snowfalls encountered in Germany. Fortunately, the components of the machine were not damaged. The SESAME members reacted promptly to this incident, thanks to support from Jordan as well, and they managed to repair the damage relatively quickly by building a new roof. Once the main building had been completed, priority was given to the creation of apartments for residential use to ensure that lodgings were available for the researchers to use as soon as they started working at the centre, since there were no hotel facilities in the area surrounding the laboratory. In this case too, the building work was conducted in a very short period of time and the SESAME community demonstrated their organisational and management skills as well as their capacity to deliver on their commitments.

4. Why synchrotron light

Synchrotron light is an extremely powerful instrument for studying matter. In essence, it uses the property of «ultra-relativistic» electrons (electrons moving at almost the speed of light) to produce electromagnetic radiation with characteristics that cannot be obtained through other sources (such as X-ray sources commonly used in radiology departments or dental surgeries). These characteristics have an extremely wide-ranging spectrum from a few kilometres (infrared) to fractions of Ångstrom (X rays), a very high collimation (fractions of milliradians), and very high intensity (1012 photons/second). These characteristics are obtained by deflecting the ultra-relativistic electrons: each time

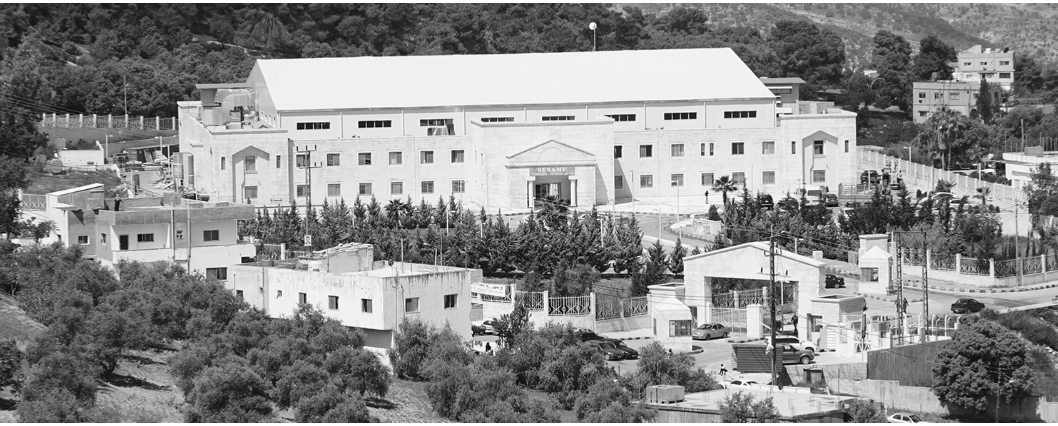

Fig. 1. Panoramic view from a hillside near the main building and the SESAME laboratory complex.

Fig. 2. Group photo of some of the participants at one of SESAME's Users Meeting. An opportunity for researchers planning to carry out their research at SESAME to meet up.

the electrons are deflected, synchrotron light is produced. A synchrotron light laboratory, therefore, consists of a ring with electrons ranging from a few hundred megaelectronvolts (MeV) to a few gigaelectronvolts (GeV), whose speed is therefore only less than the speed of light by some part of a milliard, from which the so-called or beamlines depart tangentially, where experiments are carried out.

The ring has a polygonal shape, and consists of a certain number of «bending magnets», deviating electrons at each angle, and of «straight sections», allowing for the insertion of devices (so-called wigglers and «undulators») which, through a series of alternating-polarity magnets, force the electron to follow a zig-zag trajectory, in other words a series of curves. Bending electrons at these speeds will make them emit synchrotron light. That ultra-relativistic electrons in a curved trajectory would emit radiation with these properties was already known since the first half of the 20th century: the article reporting the first observation of radiation emitted by a synchrotron dates back to 1948, while the theory explaining the phenomenon both qualitatively and quantitatively was published the following year. It is interesting to note that for a decade synchrotron radiation was considered a «nuisance»! The fact that electrons emit energy in the form of electromagnetic radiation implies that the energy lost should be replaced if you wish them to keep circulating inside the accelerator. Therefore, if the plant is intended for different purposes (such as trying to achieve collisions between electrons and positrons), synchrotron light is just a nuisance. It was not until the 1960s that the first pioneering experiments were carried out at the National Bureau of Standards in the United States (which, by using the calculability of the emission of synchrotron light, focused on the absolute calibration for photon detectors), and at the Frascati National Laboratories (LNF) of the National Institute for Nuclear Physics (INFN).

Fig. 3. Overview of the inside of the tunnel of the SESAME storage ring. The devices on the right are three of the four cavities made in Italy with part of Italy's financial contribution to SESAME.

Fig. 4. Installation of a section of the vacuum chamber of the SESAME storage ring.

After this, at the end of the 1960s, accelerators originally designed for other purposes began to be used systematically to produce synchrotron light, creating the beamlines that collect the radiation emitted by the accelerator and select one wavelength at a time, directing it towards a sample. Therefore, by knowing the characteristics of the incident radiation and the effects of its interaction with the sample (such as attenuation, diffusion or emission of electrons) we obtain information on the sample itself. This is the period that the scientific community is referring to when it talks about «first-generation synchrotron radiation», that is when accelerators designed for other purposes were used in order to generate it. The development of «second-generation» of synchrotron light sources began in the 1970s, when accelerators specially designed for the production of radiation were developed. This period saw the creation of laboratories such as the LURE laboratory (Laboratoire pour l'Utilisation du Rayonnement Électromagnétique) in Paris, the SRC (Synchrotron Radiation Center) in Madison, Wisconsin, the SRS (Synchrotron Radiation Source) in Daresbury, in the United Kingdom, and BESSY (Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H.) in Berlin. The latter began operating in 1982: at the time I was a young postdoc researcher in Berlin and I remember vividly how excited I was when the first beamline of electrons circulated in the machine!

Those years saw a gradual expansion of the use of synchrotron light. In fact, in the beginning, experiments were mainly carried out by materials physicists. However, over time, chemists, biologists, doctors, and researchers in other fields gradually came to appreciate the results that synchrotron light provided them with, thereby becoming not only an instrument for enthusiastic and visionary physicists but an extremely useful tool whose applications were certainly worthy of further studies.

The advancements in accelerator technology and in instruments used for experiments as well as the pressure from researchers in other areas led to the development of the so-called «third-generation» synchrotron light. These are accelerators enhanced for «brilliance» (i.e. the photon flux per area per unit time and divergence angle): machines in which certain adaptations are made in order to keep the size of the beamline of electrons down to a few microns, rather than the millimetres of the previous light sources. The first laboratories of this type began operating in the mid 1990s: the European Synchrotron Radiation Facility (ESRF) in Grenoble, France, the Advanced Light Source (ALS) in Berkeley, in the United States and Elettra in Trieste, followed later by other laboratories in Europe, America, Asia, and Oceania.

The extraordinary characteristics of synchrotron light, which have been gradually honed, enable us to obtain information on the physical, chemical and structural properties of many types of materials. A synchrotron light laboratory makes it possible to study matter ranging from isolated atoms to molecules, proteins, nano structures, living cells, biological tissues, industrial materials, archaeological artifacts as well as living organisms such as insects and small mammals, but also human beings. A modern synchrotron light laboratory is therefore a multi- and inter-disciplinary research centre, in which the circulation of ideas and concepts from disciplines that are traditionally far apart makes it possible to develop innovative ideas and methodologies, something which would probably never happen in a different, mono-thematic environment. This combination of basic research, applied research, including industrial research, and sophisticated technology makes these laboratories exceptional drivers for development. «Contamination», as one would say in other disciplines, is one of the reasons behind the global success of synchrotron light: today there are approximately 50 synchrotron light laboratories around the world. And now, with SESAME, the MENA region also has its advanced light laboratory, the first one in the Middle East, which means that it can now compete internationally.

5. A visionary project with ambitious goals

SESAME certainly has a mission which is both scientific and socio-political: to promote excellence in the field of science and technology in the Middle East, to reverse the brain drain, to improve science in the region and its technological infrastructure, and last but not least, to contribute to a better understanding among people from different cultural backgrounds, through peaceful scientific cooperation.

The purpose of the project has been right from the beginning to achieve these socio-political objectives through the development of an ambitious scientific project. It was therefore clear that the simple reinstallation of BESSY 1, an accelerator which had started operating at the beginning of the 1980s and therefore had been designed in the 1970s, would not be capable of carrying out innovative research nor would it have attracted the interest of scientific community that included the top researchers who had gone abroad to work in other laboratories. For this reason, right from the start, it was important to bring the original design up to date. BESSY 1 was a second-generation, low-energy (800 MeV) source which couldn't achieve the short wavelengths of emitted radiation required for competitive applications in the fields of materials science and life sciences. Their first idea was to update the ring in order to achieve the energy of 1 GeV, but the ring would remain a second-generation ring. Under the technical coordination of Dieter Einfeld first, and subsequently Gaetano Vignola, a proposal was recommended, that was approved and then carried out, which consisted of using the main part of the BESSY 1 storage ring as an injector in a much bigger ring, of 2.5 GeV. It is important to note, in fact, that the energy of the photons emitted by a synchrotron light storage ring depends on the square of the energy of the electrons. To go from 1 GeV to 2.5 GeV, therefore, improves performance in the region of shorter wavelengths or so-called «hard» X-rays, opening up the possibility of studying X-ray absorption and crystallography, which are in high demand among the scientific community of the Middle East.

In 2017, SESAME moved on from the construction phase to the operation phase: the first beamline of electrons, in fact, began circulating at the beginning of January and conditions of stored beamlines were quickly achieved. In spring 2017, conditions close to operational conditions were achieved (energy of 2.5 GeV and at least 35 mA power), as well as the installation of the first two beamlines. In March 2017, they had already received 50 research proposals from the international scientific community, which demonstrated the huge amount of interest in the initiative.

6. Italy's involvement in SESAME

Since 2013, the Italian government, through the Ministry of Education, University and Research (MIUR), has contributed to the SESAME project, thus highlighting aspects of inter-governmental dialogue. The decree providing for the distribution of funds intended for research institutes that year had allocated one million euros to the project and contained the following statement: «Through INFN, Italy will participate in the construction and installation of the SESAME synchrotron in the Kingdom of Jordan. The funding in 2013 would help to provide elements of the accelerator, mainly in kind and with the help of qualified staff. The value of the synchrotron project transcends science, without neglecting it, as it is a collaboration among many countries in the Middle East, including Israel». There were more contributions in the following years reaching a total of over 2.4 million euros by 2016. With this contribution, Italy, which in the eyes of its researchers has always played a crucial role in the development of the project, stands out among SESAME's observers as the only country that has allocated ad hoc funds to the project.

The first tranche of funds was allocated to the development of radio-frequency cavities, in collaboration with INFN and Elettra: cavities are essential components for the operation of an accelerator such as SESAME, because they provide the electrons with the energy they have lost in order to generate synchrotron light. The second tranche was used to develop a state-of-the-art X-ray detector by INFN in collaboration with many of Italy's scientific and technological entities and installed on the first SESAME beamline to be completed, the X-ray absorption fine structure (XAFS) / X-ray fluorescence (XRF) beamline. This detector enables scientists to study in detail the chemical bonding of materials in traces, such as soil contaminants. The third tranche was used to develop a support infrastructure for the researchers that carry out their research at SESAME.

Fig. 5. SESAME's research laboratory where the XAFS/XRF beamline and the materials science beamline are installed.

7. A light for many research projects

The basic techniques for using synchrotron light are similar to those used to carry out physical and chemical analyses or analyses of solid and gaseous materials found in many laboratories, research centres or university campuses. However, these analyses depend on the use of radiation sources that are much weaker and limited in their wavelength. The higher irradiance and the collimation of synchrotron light allow for the application of these methods to much smaller or more diluted samples, in order for example to analyse nanostructured materials or devices. A rapidly growing application is the study of the internal structure of most biological materials, grown as crystals measuring only tenths of millimetres.

In the majority of nano-technological applications and in bio-crystallography it is impossible to use a standard laboratory.

The nanometric definition that can be achieved in modern laboratories such as SESAME also allows for more applicative studies such as, for example, understanding the behaviour of steel by analysing the composition of its edges with the definition of certain nanometres, or in forensic applications to detect extremely small percentages of specific elements on a surface.

Taking account of SESAME's characteristics and the needs of the community of its future users, three beamlines were originally identified to be ready in the first operational period: the XAFS/XRF beamline for studying X-ray absorption and X-ray fluorescence, the IR (infrared) beamline to allow infrared microspectroscopy, the materials science beamline for X-ray diffraction on both natural and artificial materials. These beamlines have come into operation between 2018 and 2019. Moreover, thanks to the international cooperation, two more beamlines are coming into operation at the time of this writing (fall 2022):

a. a beamline for soft X-Ray spectroscopy, HESEB (HElmholtz SEsame Beamline), entirely supported by the German Helmholtz Association;
b. a beamline for tomography, BEATS (BEAmline for Tomography at Sesame), supported by the European Commission.

It is important to note that synchrotron radiation centres are there to be used not only by the international scientific community, but also by hi-tech industries. It will be possible to carry out various types of measurements on every beamline. The XAFS/XRF beamline, for instance, can be used to conduct studies on catalysts: even during a chemical reaction it is possible to trace the changes made by reactants, and the «contamination» process of the material itself. The same method can be applied to the study of the contamination of soil samples, making it possible to identify the presence of heavy metals in the surrounding chemical environment.

The infrared beamline is used to study biological samples. The advantage of synchrotron light, in this case, consists of being able to obtain a chemical map: the distribution of molecules within a single cell can be obtained and linked to the development of diseases. Studies on cancer cells or on the presence of prions (such as those that cause bovine spongiform encephalopathy) were successfully carried out using this technique. The beamline is suitable for studies in materials science, it will have a strong impact on the study of geological materials and will enable scientists to simulate extreme conditions: due to the high collimation of the synchrotron radiation beam it will be possible to measure samples in temperature and pressure conditions that can be found at the centre of the Earth. In addition, the same beamline is used to study artificially-produced materials such as ceramics in order to check the quality of industrial manufacturing processes.

HESEB hosts a microfluorescence end station for archaeometric studies and will host a second end station, supported by Turkey, for photoelectron spectroscopy experiments.

BEATS will perform imaging and tomography with applications in archaeology, materials science, and life sciences.

8. Conclusions

The development in the analysis of materials and the basic knowledge that it has generated have supported a more extensive and long-term industrial growth in the 20th century, based on the continuous development of new products and

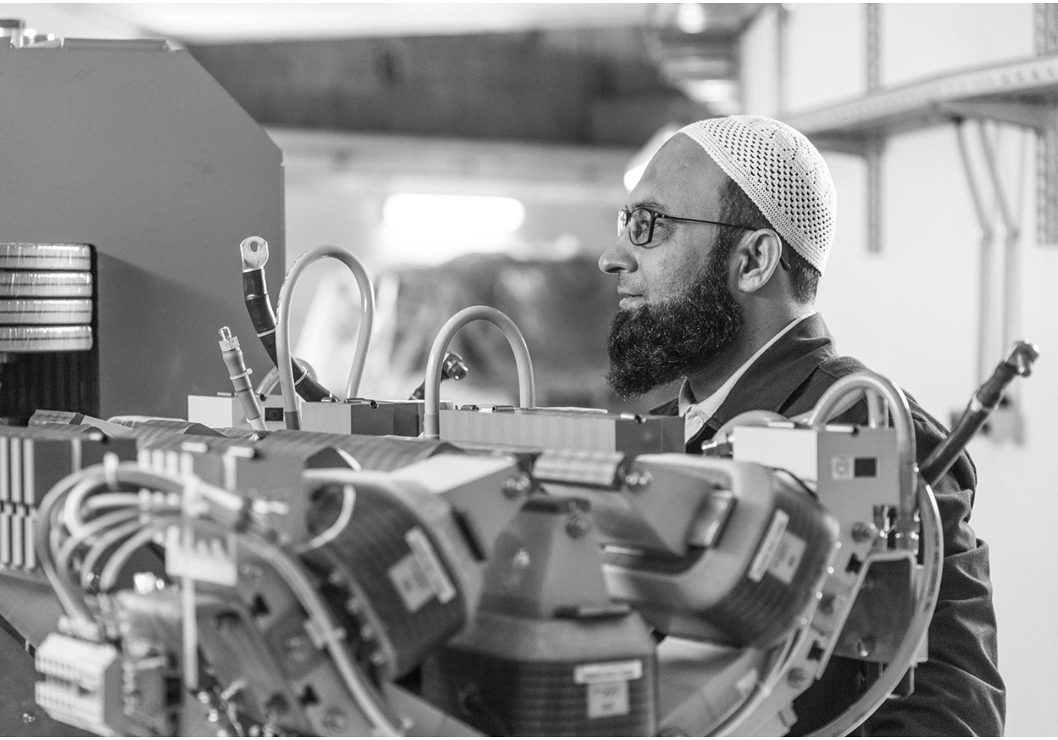

Fig. 6. Installation phase of a magnet by a Pakistani technician.

processes. The majority of these have been generated by new experimental functionalities in the field of advanced materials and biomaterials, with the development of new properties and devices. Even if they are not specifically built with socio-political purposes, laboratories such as SESAME are an international hub where researchers from different countries and fields of expertise interact and exchange opinions, solutions and experiences, in a spirit of both collaboration and healthy scientific competition, developing ideas and acquiring knowledge as well as contributing to the training of a new generation of researchers who, in turn, will adopt an open-minded approach.

Experiences in other countries prove that laboratories of this type represent the backbone of the growing network of international centres of excellence, contributing to the integration and development of research and culture. From an organisational point of view, SESAME has copied the organisation of CERN in Geneva, but has borrowed from CERN also the vision of a laboratory that sees science as an opportunity to contribute to the dialogue amongst researchers from countries that, in other areas, would find it difficult to share common projects. SESAME will provide fantastic occasions for multidisciplinary research in the MENA region. It will enable scientists to work together, giving the region a development opportunity. At the same time, the international nature of SESAME will enable researchers from different cultures, different religions and different experiences to interact with each other.

Achieving a complex project such as SESAME with limited financial resources and in a region of the world which has been so badly affected by intense political tensions and without a strong scientific tradition, is the result of an ambitious and brave vision and has required the determination and unwavering commitment of many people who, over the years and with different levels of responsibility, have succeeded in identifying the most effective solutions in dealing with a long series of issues. It is thanks to them therefore that SESAME is today the achievement of a dream that, from the outset, had seemed to many a utopia.

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Endnotes

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