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REPORTS

August 30th – September 1st 2022 – The WP Ethics in Chemistry at the 8th European Chemistry Congress (ECC8) at Lisbon, Portugal:

- Working Party Meeting
- Panel discussion: Diversity and Inclusion in Chemistry (second section in this Chemistry in Europe Newsletter article)
- Presentations by Guillermo Restrepo (“*The chemical space and some ethical consequences of its uneven growth*”) and Jan Mehlich (“Teaching Responsible Chemistry: A Challenge-Based Learning Framework for the Implementation of RRI Courses in Chemistry Education”)

October 14th 2022 – Thematic Meeting (online): The Chemical Space
Guillermo Restrepo (Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany) introduces his look at the history and contemporary development of chemistry practices and their impact.

December 9th 2022 – Thematic Meeting (online): Chemists’ Contribution to the Sustainability Landscape
Peter Mahaffy (The King’s University, Edmonton) discusses the ethical responsibility of chemists in the context of sustainable development.

February 24th 2023 – Thematic Meeting (online): Teaching Ethics in Chemistry – Latest efforts and developments
Luigi Campanella, Tom Boersen and Jan Mehlich inform about the state-of-the-art of the *Good Chemistry* course.

UPCOMING EVENTS

April 13-15th 2023 – ECTN Annual Meeting and General Assembly in Amsterdam (NL): “*Quality of Teaching and Learning in Higher Education Chemistry: Best Practices, Opportunities and Trends*”

August 20-25th 2023 – IUPAC / CHAINS 2023 in Den Haag / The Hague (NL): World Chemistry Congress “*Connecting Chemical Worlds*”

September 4-6th 2023 – GDCh-Wissenschaftsforum Chemie in Leipzig (DE)

EDITORIAL

“Optimism is our duty. We all are co-responsible for what is coming.” (Karl Popper)

The academic education is dedicated not only to the formation of highly qualified specialists in various fields, but also to the formation of people with a moral and ethical behaviour in their future professional development. Chemistry was always, and today it continues to be, part of our daily life. Moreover, chemists and chemical engineers, through all their activities, are responsible for a sustainable development, a healthy environment, resources economy, new materials, and healthy food, or, generally speaking, to some extent, for a good life for everybody on this planet. It is well-established now that a course on *Professional ethics* is welcome in the curricula of any specialization based on chemistry, such as chemical technologies, food chemistry, environmental sciences, new materials, pharmaceuticals and biology, nuclear energy, scientific research. Usually, such courses are delivered, as expected, by the academic staff, and they include topics which provide to the young specialists valuable skills for writing and publishing, for understanding the benefits of a good research and useful applications, for avoiding a negative impact on environment or the human health. Is this enough? Are we already at the point where academic education is touching the real life? What is happening after graduation, when the former students enter a company with an independent policy, or are engaged in activities not totally friendly for environment and human health, when the interest in financial advantages conflicts with moral and ethical behaviour? For a prosperous future of the human society, we still need not only a theoretical approach, but valuable practical solutions for an ethical professional behaviour.

Your WP EiC Steering Committee

Chemical space and some ethical consequences of its uneven growth

by Guillermo Restrepo (Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany)

Ethical discussions of chemistry normally address the driving forces involved in the social and environmental effects of chemicals and to a lesser extent how social and environmental variables have affected chemical activities. Running across these discussions is the generation of knowledge, which is materialised in the production of substances and which is affected by social and environmental factors. I argue that a *better understanding of knowledge production is key to ethical discussions of chemistry*. How can we understand the role of chemical weapons, the side effects of medicines or the environmental impact of chemicals if we do not know the details of knowledge production? Without understanding the interaction between chemical rules and the social and semiotic factors that allow discovery of new substances, how can ethical questions in chemistry be addressed? All in all, how can we analyse the responsibility of chemists for their knowledge to society and the environment if we do not recognise the responsibility of chemists for their own knowledge?

What is chemical knowledge? It is an emerging property of the interaction of the social, semiotic and material systems of chemistry.^[1] Social system involves scientific institutions and chemists, while the semiotic system spans the theoretical structure of chemistry as well as its language and communication channels. In turn, the material system is made up of substances, reactions and technologies involved in chemical activities.^[1]

An interesting aspect of chemical knowledge is the *chemical space*, upon which theories, semiotic tokens and institutions are based.^[1] Chemical space spans all substances and reactions reported over history.^[2,3] By analysing its temporal unfolding, we found that chemists have expanded this space at an exponential rate such that each 16 years the number of new substances doubles.^[2] That is, by 2039, the number of substances discovered will be twice the number of substances known until today. A similar increase has also been observed in the number of reactions over the course of history.^[4]

The chief method used by chemists to expand the chemical space has primarily been preparative chemistry since the dawn of the 20th century.^[2] This anthropogenic turn on the

discovery of chemicals has led to a space far from diverse.^[5] Chemical space is overpopulated by organic compounds, mainly of substances involving C, H, N and O,^[2] which, in addition, have low structural diversity.^[5] The space we have is the result of self-reinforcing processes in chemistry,^[6] which include a reliance on very few classes of reactions,^[4] amide synthesis from carboxylic acids and amines, and alkylation of alcohols or phenols with primary or secondary halides/O-sulfonyls being the most popular ones. The frequent use of a small set of starting materials, with acetic anhydride and methyl iodide topping the list of most used substrates,^[2] is another evidence of self-reinforcing processes expanding the chemical space. This disciplinary modus operandi has produced a chemical space with many chemically useless substances. This is evidenced by the null number of reactions triggered by most of the substances in the space.^[2]

Is chemists' responsibility to keep adding more or the same substances to the space? In what extent are chemists responsible for maintaining a high diversity of substances and preparation methods? Is the purpose of chemistry to gain a deeper understanding of some particular substances and the methods to produce them? To what extent does the organic bias of the chemical space affect the aims of chemistry? To address the ethical dimensions of chemical activities on society and the environment, chemists need to have a better understanding of these questions. After all, what can chemists say about the effects of their activities if they do not have a clear understanding of those activities and of the factors shaping them?

[1] Restrepo, G.; Jost, J. *The evolution of chemical knowledge: a formal setting for its analysis*, Springer: Berlin, 2022.

[2] Llanos, E. J.; Leal, W.; Luu, D. H.; Jost, J.; Stadler, P. F.; Restrepo, G. Exploration of the chemical space and its three historical regimes. *P. Natl. Acad. Sci. USA* **2019**, *116*, 12660-12665.

[3] Restrepo, G. Chemical space: limits, evolution and modelling of an object bigger than our universal library. *Digital Discovery* **2022**, *1*, 568–585.

[4] Szymkuć, S.; Badowski, T.; Grzybowski, B. A. *Angew. Chem. Int. Ed.* **2021**, *60*, 26226–26232.

[5] Lipkus, A. H.; Watkins, S. P.; Gengras, K.; McBride, M. J.; Wills, T. J. *J. Org. Chem.*, **2019**, *84*, 13948-13956.

[6] Jost, J.; Restrepo, G. Self reinforcing mechanisms driving the evolution of the chemical space. *Perspectives on Science* Accepted.

When I was asked to write my profile as an honorary member of the Working Party on Ethics in Chemistry I hesitated, since I am not a chemist or a scientist. The only experience with chemistry I had (since school) was during my tenure as Director General of the Organization for the Prohibition of Chemical Weapons (OPCW) for two terms (2010-2018). The OPCW that I had the privilege to lead was founded in 1997 to eliminate the threat of chemical weapons forever. The declared stockpiles of such weapons have been destroyed under the verification of the OPCW inspectors and 193 States Parties have declared on multiple occasions their commitment to prevent their re-emergence. In the lines that follow I will go beyond ethics-related issues and share with the readers some experiences I had in my professional life.

Ethics in general is a universal concept. It transcends nations, borders, cultures, and civilizations. The specifics may vary, however, from one era to another. The German scientist, Fritz Haber successfully weaponized toxic chemicals during the World War I and oversaw their uses at the frontline. He was regarded as a loyal citizen who served his country. No widespread criticism was expressed at that time about him, and he was not accused of being “unethical”, using his scientific knowledge to help kill more people, though his wife, also a chemist committed suicide, in reaction to her husband’s war efforts. Haber was awarded the Nobel prize of chemistry after the war, for his invention of synthesizing ammonia from nitrogen and hydrogen. This was important for large scale synthesis of fertilizers which helped enhance food security worldwide. Similarly, the scientists who took part in the Manhattan Project were not accused of being unethical at the time. The atomic bomb they developed was used twice in Japan, in 1945, with devastating humanitarian consequences though the goal of ending the war was accomplished. At the same time, nuclear technology is being widely used since then in energy production, medicine, or other peaceful purposes. Indeed, the dual use of science and technology remains a conundrum.

Developments in life sciences and technology over the past years have been spectacularly impressive. This phenomenon, however, raised concerns about the possible misuse of science by states and non-state actors. Regulating research activities at national and

international levels is difficult and not always desirable. There is a risk of hampering innovation. In the absence of rules and regulations “ethics” come into play. Researchers are expected to act responsibly and avoid actions which may harm people, nature, and environment. Hence, ethics ought to be a dynamic concept. It must adapt to new circumstances and should address not only the present but the future too.

While I was the Director General of the OPCW I spoke on ethics in chemistry on a few occasions. I participated in panel discussions. I also asked my staff to act professionally and objectively, solely based on scientific truth. I reminded them that the International Secretariat of the Organization was accountable to the whole membership as enshrined in the Chemical Weapons Convention (CWC). There was an unwritten code of conduct which we ought to follow. As Director General I paid utmost care to the principle of impartiality while making clear that I wouldn’t remain neutral if the credibility and integrity of the CWC regime were at stake. My position as DG dictated that I should stand up against such risks, which I did numerous times. The OPCW has been a pillar of the rules based international order and it was our collective duty to preserve its credibility and effectiveness. Fortunately, a great majority of States Parties were supportive of my stance. I pushed back attempts to discredit the reports of the OPCW inspectors who investigated the allegations of use of chemical weapons in Syria. The methods and procedures they employed were technically and scientifically proven and their conclusions were irrefutable. I advocated the identification, prosecution, and punishment of those who ordered the use of or actively used chemical weapons. The use of such weapons is a crime and the only way to prevent its recurrence was to deter potential users through a certainty about accountability. Impunity should be rejected. These efforts were successful to a certain extent. Although no individual is yet punished, national courts in some European countries have been seized for certain cases and the OPCW is continuing its investigations. The OPCW was able to adapt itself to meet new challenges and it is now considered as a successful organization of disarmament and non-proliferation which has the necessary capabilities to enforce the prohibitions deriving from the Convention.

The OPCW has also promoted the peaceful uses of chemistry through several capacity building activities and fellowship programs. It has established close cooperation with the chemical industry, the IUPAC and chemical societies. This cooperation with stakeholders gave birth in 2015 to the "Ethical Guidelines in Chemistry" that are being implemented by many chemistry practitioners throughout the world.

My direct acquaintance with ethics in my work life did not commence with the OPCW. It goes back several years. When I joined the Turkish Foreign Service in 1976, during the training program for cadets, we were advised that the diplomatic career was a marathon, and we should not be spoiled by recognitions at an early stage nor demoralized by the lack of them. Most important was to respect each other and not to undermine your peers but rely for success on your own performance and dedication. Meritocracy would ultimately prevail and there was no need to panic if there were some hiccups. I followed these advices throughout my career in the Foreign Service. I worked at the Personnel Department first for two years as the custodian of performance records which were then confidential, later as the Head of Department for three years. During this period, I tried to provide equal opportunity to all, while promoting colleagues who were somewhat underrated and containing those who prematurely overestimated their skills. My recommendations were generally followed by the committee of senior officials which decided upon promotions and assignments. In such positions where you play a role in the fate of fellow humans, one must act objectively and impartially, setting aside personal feelings. I tried to do just that.

Throughout my career at the Turkish Foreign Service as well as at the OPCW, I never used double talk. I didn't give different messages to different audiences in order to please them. Double talk was not only unethical but also futile in a transparent world. Deceiving people has fortunately become harder and those who attempt it are increasingly exposed and pay a price in the end. Diplomacy is conducted on the basis of mutual trust. If you make an effort to empathize with your interlocutor and trust each other, you will have a better chance to achieve a positive outcome. You don't necessarily need to be friends, but honesty is a key factor for accomplishment in diplomatic interactions, and in other fields as well, I suppose. I may have chosen to remain silent in some

instances when I couldn't reveal our real intentions or objectives, but I never lied. The truth would be unveiled anyhow and there was no substitute for trust.

The primary duty of diplomats is to defend and promote the national interests of the country they represent. In bilateral diplomacy your role is to build on the legacy of your predecessors and try to further develop the friendly relations and cooperation between the countries. Increase in the bilateral trade volume, joint projects that you could help initiate are your accomplishments. In dealing with bilateral problems the aim is to find compromises that could be acceptable to both sides. The success in all this is measured by mutual satisfaction.

However, the situation in a multilateral forum is different. When I was assigned to the Turkish Delegation at NATO in 1986, I had no experience in multilateral diplomacy. I had to work more than my colleagues who were already familiar with NATO affairs. Negotiating with several countries at the same time required additional skills and subtleties: lobbying for your position behind the scenes, persuading your interlocutors and being engaged in a give and take. Margin for flexibility should always exist since sticking to your initial position will usually produce no results. Multilateral diplomacy provided me with a different perspective in analysing international affairs. I got involved actively in discussions on different issues even if they were not of direct interest to my country. I tried to help reach a consensus by proposing some formula that could be acceptable to all, since this was the only way to take a decision at NATO. I had a reputation of "consensus builder" and I made extra efforts to maintain it at a higher level when I returned to NATO as Ambassador in 2002.

The real turning point in my professional life was when I switched to the International Secretariat of NATO in 1989. I worked at the Political Division for five years. I was able to follow closely the demise of the Soviet Union (I was in the meeting room when the Soviet Ambassador to NATO announced the end of the USSR in December 1991) and the new relationship between NATO and Russia as well as the other former Soviet republics. I was involved in shaping the cooperative schemes with them. But most importantly, I began to look at issues at hand from an international perspective rather than a narrow national one. This was like a new world for me. I was focusing on what would be in the interest of the whole membership and beyond. How could we effectively address the

problems in a way to protect the interests of all countries and people, simply put for the common good of humankind. I was bewildered to watch that short sighted national positions that overlooked others' interests were sometimes vigorously pursued by individual member countries. Instead, with some tweaks a satisfactory solution for all could be found.

The internationalist perspective I acquired at NATO helped me to design my future career. During my tenure in Geneva as Ambassador to the UN, I had to deal with diverse issues. Human rights, disarmament, public health, refugees, labour were the main areas. I participated in the work of UN organizations dealing with those issues. These institutions were slow in decision making and implementation. There was also a great deal of duplications with other structures in New York. I learned more about another important international player: the civil society. The NGOs reflecting the "people's voice" in different areas play a significant role. During my time in Geneva some NGOs were instrumental in the successful realization of certain initiatives in the fields of disarmament, public health, refugees, and others. Their supranational perspective, that seemed sometimes unrealistic at first glance, produced concrete results since they were able to raise public awareness and influence decision makers at capitals. Although some countries are not entirely happy about the critical approach of NGOs, I believe that their inputs are valuable and are increasingly recognized both at national and international arenas. I listened to them and learned a lot. During my tenure at the OPCW I supported the active participation of NGOs in annual conferences of States Parties.

Despite the increased use of technology in communication, human to human contacts continue to play a significant role in diplomacy. When I arrived in Geneva at the end of 2006, I visited all my colleagues (around 180). I attended all national day receptions or other cultural and social events organized by different missions. Even if I couldn't stay long in many instances, "acte de presence" was appreciated. In diplomacy, reciprocity is a common practice. The national day receptions and cultural activities I hosted were very well attended. My wife and I were frequently invited to dinners by colleagues. My wife was asked to lead the committee for the organization of the annual UN Bazar in 2008, a big charity event. It was very successful.

I always used moderate language in meetings even if there was sometimes harsh criticism against my country. The goal should be to garner the sympathy or support of third parties since these problems will not be solved there. I believe that I was able to achieve it to a certain extent. This attitude also helped me to have a good relationship with many colleagues even when we did not see eye to eye on every issue. Hence, when I decided to apply for the position of Director General of the OPCW in 2009, my colleagues in Geneva were very supportive. I started my campaign in Spring. I visited 26 countries and was received by senior officials in the Ministries of Foreign Affairs. I travelled to The Hague eight times and met with Ambassadors who would vote during the election in October. I shared my thoughts about the organization and sought their views and expectations. We were seven candidates. Five rounds of voting took place. I was the leading candidate in every round. Following the withdrawal of other candidates after each round I was appointed as Director General. I believe that my connections both in Geneva and elsewhere along with the support of my government were instrumental in my election.

One of the happiest days in my life was October 10, 2013, when the Nobel Peace Prize Committee announced its decision to award the OPCW. I vividly remember that Ambassadors and other delegates of member states received the news with applause at the meeting room of the Executive Council. The joy was shared by all. I had the honour to receive the prize in Oslo on behalf of the organization. Several Ambassadors and colleagues from the Secretariat accompanied me. My wife and my daughter were also there. The King and Queen who attended the ceremony and the banquet in the evening received me separately at the Palace. They were very friendly.

This was a unique experience for me, my family and the OPCW staff. This was a morale boost for our inspectors who were about to be deployed to Syria, in very challenging circumstances, in the midst of a civil war.

The Nobel Prize was for the organization I had the privilege to head at that time. But other recognitions, personal ones were also extended. I received honorary doctorate degrees from the Geneva School of Diplomacy, Universities of Buenos Aires and Bologna, University of Surrey in the UK and MGIMO University in Moscow. In my acceptance speeches on these occasions, I emphasized

the importance of ethics in practicing our professions as individuals and the respect for international law by the states.

Again, at a personal level I was decorated by Germany, Austria, France, and the United Kingdom for my efforts to promote international law, peace and stability as Director General of the OPCW. All this was unexpected. I never thought, when I took over my position at the OPCW that the job would be so challenging but abundantly rewarding at the same time. The awards also fuelled the sense of “mission accomplished “ I felt at the end of my tenure in July 2018.

This was my second retirement, the first one being from the Turkish Foreign Service in 2010. We have settled in a coastal town in Turkey. In 2018 and 2019 I was invited to several events to give speeches or to participate in panel discussions. Then the pandemic erupted. Our lives, like others’ have been seriously affected. I wrote an article in April and a scenario in June 2020 proposing the establishment of a new international organization with different capabilities, including a rapid response team of experts who would be ready to act at the onset of an epidemic before it spread elsewhere. I drew from my experience at the OPCW, where I set up a team of first responders to assist member countries which could come under a chemical weapon attack. I have been promoting this rapid response concept for the past two and half years with the support of a think tank in Washington. I have been assuring my audiences that this proposal, if

realized, would not undermine existing institutions, primarily the WHO but complement them.

Furthermore, I was invited to be a senior member of the European Leadership Network based in London and a board member of a think tank in Istanbul. I wrote or co-authored a number of articles on security issues, including on the war in Ukraine. As someone who spent most of his life to contribute to peace efforts worldwide, I find it extremely frustrating and indeed appalling that thousands of people have been killed and millions had to leave their homes. This war is illegal, unethical, and immoral. Nothing similar should have occurred in the twenty first century.

Whether you are a scientist, a diplomat or a politician, an artist or an academic, a businessperson or a shopkeeper, you need a moral compass to guide you throughout your lives. Such a compass cannot simply be innate. The way you are raised by your family, your education, your in-job training, your interaction with your peers and others, in sum the moral values you acquire will help build the compass. Once it is internalized you become a tiny but useful individual for the common good of humankind. Tremendous advances in science and technology will not suffice to achieve a more peaceful, safer world. We need to render the moral compass of values truly universal, transcending borders, cultures, and faiths. I shall try to instil such values in today’s youth during the rest of my life.