# The Three-letter Element Symbols: Meddling Manner or Diplomatic Defusing?

***Lars Öhrström** talks to **Norman E. Holden** about unnilhexium, and other periodic table ghosts of the Cold War*

**When Lars Öhrström started paying real attention to chemistry, during his high school years in the early 1980s, the three-letter symbols then designating any element with atomic number higher than 103 seemed like a permanent fixture to the periodic table in the chemistry classroom. In the following years, he learned that they were only temporary placeholders for elements that fulfilled the criteria of "being discovered" but where, for unclear reasons, a name had not yet been agreed.**

Later, and much to his surprise, he found himself directly involved in approving names and symbols of new elements as National Representative in the IUPAC Division of Inorganic Chemistry in 2009. In subsequent Wikipedia editing he found some rather derogatory remarks concerning IUPAC and these systematic names, both in the main text and on the discussion pages, and started to wonder if these names and symbols really were so "silly" and "ignored", as implied?

Who better to ask than the living memory of IUPAC, Norman E. Holden, who has background knowledge about the old Commission on Nomenclature of Inorganic Chemistry (CNIC), the Commission on Isotopic Abundances and Atomic Weights (CIAAW), and the Inorganic Chemistry Division (Division II), where he still, at 80+, makes significant contributions?

***Lars Öhrström (LÖ):** Let's start at the beginning: Who came up with the three-letter symbols in the first place?*

**Norman E. Holden (NEH):** That has an easy and uncontroversial answer. The systematic element naming scheme was the brainchild of the late Joseph Chatt, who was the chairman of the Inorganic Nomenclature Commission (CNIC) at the time. Subsequently, it was endorsed by the entire commission that included as an Associate member, a fairly young Jan Reedijk (Netherlands), the present President of Division II, which assumed the responsibility for the naming of chemical elements from CNIC, when IUPAC terminated (almost) all IUPAC Commissions after the Brisbane General Assembly in 2001. Other CNIC members from that time period included Yves Jeannin (France), the CNIC Vice-Chairman at the time and later IUPAC President, the Titular members, Jeff Leigh (UK), a later President of Division II, Boris Myasoedov (USSR), and another Associate member, Ekkehardt Fluck (FRG), another President of Division II.

***LÖ:** When was this?*

**NEH:** The recommendations were published in *Pure and Applied Chemistry* in 1979, (see also ref [1] for the complete 1978 Commission membership)

***LÖ:** Can you give us a bit of context in why CNIC and IUPAC felt this scheme was needed?*

**NEH:** This systematic naming scheme was generated at a time when there was still a major, one and a half

## Systematic Nomenclature and Symbols for the New Elements*

Newly discovered elements may be referred to in the scientific literature, but until they have received permanent names and symbols from IUPAC, temporary designators are required. Such elements may be referred to by their atomic numbers, as in 'element 120' for example, but IUPAC has approved a systematic nomenclature and series of three-letter symbols [1].

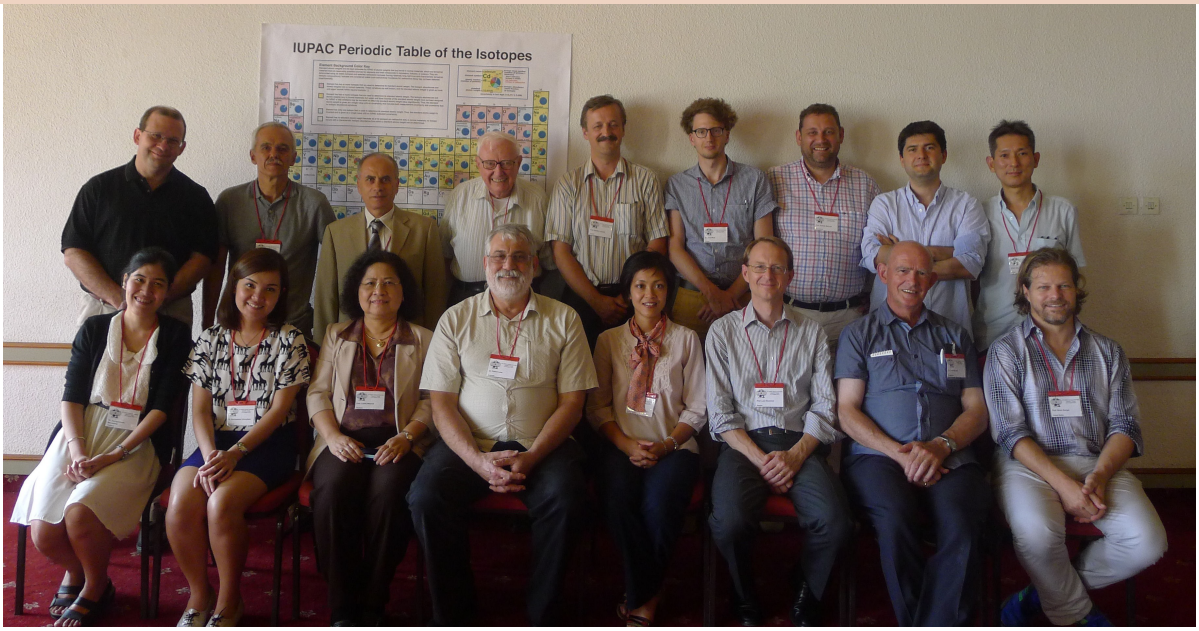
The name is derived directly from the atomic number of the element using the following numerical roots

| | |
|---|---|
| 0 = nil | 5 = pent |
| 1 = un | 6 = hex |
| 2 = bi | 7 = sept |
| 3 = tri | 8 = oct |
| 4 = quad | 9 = enn |

The roots are put together in the order of the digits which make up the atomic number and terminated by 'ium' to spell out the name. The final 'n' of 'enn' is elided when it occurs before 'nil', and the final 'i' of 'bi' and of 'tri' when it occurs before 'ium'.
The symbol for the element is composed of the initials letters of the numerical roots which make up the name.

Examples:
element 113 = ununtrium, symbol Uut
element 106 = unnilhexium, symbol Unh

** reproduced from* Nomenclature of Inorganic Chemistry—IUPAC Recommendations 2005 *(ISBN 0-85404-438-8), also known as the* IUPAC Red Book.




*The Inorganic Chemistry Division at the IUPAC General Assembly in Istanbul, August 2013, gathering members and observers. Left to right, back row: Daniel Rabinovich, Milan Drábik, Adem Kiliç, Norman Holden, Markku Leskelä, Juris Meija, Thomas Walczyk, Javier García-Martínez, Ken Sakai; front row: Duangsamorn Morawong, Udomphan Kemawadee, Ladda Meesuk, Robert (Bob) Loss, Robin Macaluso, Lars Öhrström, Jan Reedijk, and Brian Korgel.*

decade long, controversy between the USA (Glenn Seaborg and Al Ghiorso at the Lawrence Radiation Laboratory, LBL, at Berkeley, California) and the Soviet Union (Georgiy N. Flerov at the Joint Institute for Nuclear Research, JINR, at Dubna, Russia). Both of these laboratories were involved in heavy element research, including claims to the first discovery of the elements numbered 104 and 105, and both groups denied first discovery claims from their rival lab. The major players (nuclear scientists involved in the production and the measurement of nuclides of heavy elements) supported either one camp or the other.

When Yves Jeannin and I wrote an article on the 'Systematic Naming Scheme for the Heavy Elements' in *Nature* during 1985, see [2], we mentioned two reasons for the proposed naming scheme. First, there was the problem of a pair of chemical elements with $Z$ = 104 and $Z$ = 105, whose discovery was claimed by two separate scientific groups. Each of these groups reported different names for each of the two elements. There were multiple articles appearing in the scientific literature with a total of four names for these elements. The experiments of the US group followed the alpha particle decay of reaction products from a given target and projectile. The experiments from the Soviet group followed the spontaneous fission decay of reaction products from a different target and projectile.

***LÖ:*** *What was the initial response of IUPAC?*

**NEH:** The expertise of IUPAC is in chemistry and not in the physics of nuclear reactions, thus IUPAC chose a 'wait and see' attitude to determine if some consensus would form in the scientific community. Unfortunately, this was the period of the Cold War and it eventually became clear that such a resolution would never be forthcoming. In 1974, IUPAC and IUPAP, the International Union of Pure and Applied Physics, appointed a group of experts who were not directly involved in the controversies, three experts from the USA, three from the USSR, and three from other countries. This committee never completed its work, nor issued a report, nor met as a group, until it disbanded. I later attended a meeting of the Interdivisional Committee on Nomenclature and Symbols (IDCNS), a forerunner of the present Interdivisional Committee on Terminology, Nomenclature and Symbols (ICTNS), and I argued for IUPAC to form another group to try to resolve the impasse between the scientists from the USA and the Soviet Union. The proposed IUPAC 1979 naming scheme would provide systematic alternative neutral names for discussion and for use as a periodic table placeholder, until an official discovery was recognized. In 1985, IUPAP and IUPAC established a new joint group, the Transfermium Working Group (TWG). Members would not be drawn from countries of the major labs

concerned with research into heavy elements (USA, USSR, and now including West Germany). The first report of the TWG on establishing criteria that must be satisfied for the discovery of new elements was published in 1991 [3].

***LÖ:*** *But there were two reasons you said?*

**NEH:** The other important reason was to provide users, such as theoreticians, a tool when discussing the properties of 'as yet undiscovered and named elements'. Common or trivial names are not approved before elements are officially discovered. However, names are needed for practicality and for abstracting and retrieval (indexing) purposes. The atomic number would serve for merely referencing the elements, but when discussions of chemical compounds involving these elements begin to appear in the literature, this artificial system would become necessary for the names of compounds and their formulae.

***LÖ:*** *Did the system work then, or were these names and symbols simply ignored?*

**NEH:** The answer would depend upon what one's hopes were for the system. As far as their use as a placeholder in the periodic table, they served their purpose. The IUPAC Periodic Table was copied into numerous textbooks and wall charts with these symbols.

Shortly after the publication of the naming scheme, I had occasion to discuss the matter with Joe Chatt. He had high hopes at the time that this scheme would solve the issue of the two sides promoting their own names for any new elements. However, neither side was interested in the systematic naming scheme in their scientific articles.

***LÖ:*** *But perhaps it was used by other communities, such as theoreticians?*

**NEH:** Certainly Joe Chatt had expectations for a more extensive use than merely as placeholders in the periodic table, but as for the opinions of other members of the CNIC and IUPAC members in general at that time, I cannot answer. At a meeting of the IDCNS in September 1980, Joe did admit that there were various criticisms voiced about the naming scheme, but he stated that a better system has never been proposed and with time he thought that the scheme would emerge with less criticism. It should be noted that there were various classes involved. There were theoretical elements, which had not yet been discovered. There were elements that had been reported in the scientific, refereed, literature but which had not yet been confirmed by an independent source, and there were elements which had been reported, confirmed, but that IUPAC had not yet officially accepted.

However, other than in some IUPAC documents such as the Table of Atomic Weights and the Periodic Table, I have been told that they have been used in only three heavy element scientific articles in more than three decades.

***LÖ:*** *Do you remember any other reactions from people in the field?*

**NEH:** You have to understand the mind-set in those days. I had a conversation with Al Ghiorso (who was the head of the Berkeley heavy element effort after Glenn Seaborg left Berkeley to become the chairman of the United States Atomic Energy Commission) around 1972, before the naming scheme existed. I was working for the General Electric Company at the time and publishing the GE Wall Chart of the Nuclides,

**Joseph (Joe) Chatt (1914-1994)** was a British inorganic and organometallic chemist at the University of Sussex, recipient of the 1981 Wolf prize, Fellow of the Royal Society (FRS), and a Commander of the Order of the British Empire (CBE).

**Georgiy N. Flerov (1913-1990)** was a Russian nuclear physicist, discoverer of spontaneous fission of uranium in 1940, initiator of the Soviet nuclear weapons program, and director of what is now the Flerov Laboratory of Nuclear Reactions in Dubna. Flerovium, formerly Uuq, element 114, is named after this laboratory.

**Albert (Al) Ghiorso (1915-2010)** was a US electrical engineer and nuclear scientist. He co-discovered 12 new elements at what is now the Lawrence Berkeley National Laboratory in California.

**Glenn Seaborg (1912-1999)** was a US chemist involved in and leading the discovery of 10 new elements. He served 10 years as Chairman of the United States Atomic Energy Commission and received the 1951 Noble Prize in Chemistry. Element 106, formerly unnilhexium, is named seaborgium after him.

which depicted the properties of all of the thousands of nuclides of the known chemical elements. When Al asked me if I would assign the Berkeley names for elements 104 and 105 on the chart, I told him that I would not use the Berkeley names. At that point, Al pleaded with me not to use the Dubna-proposed names either. Since there was no internationally official name for these elements, I would use neither of the proposed set of names. This adversarial attitude continued until the element naming controversy was finally resolved in the late 1990s.

During this time period, I also discussed the scheme with Professor Darleane Hoffman of the Nuclear Chemistry Division at Los Alamos Scientific Lab, who would become chairman of the IUPAC Commission on Radiochemistry and Nuclear Techniques of the Analytical Chemistry Division in the late 1980s and early 1990s. She indicated to me that the USA heavy element scientists considered the naming scheme as silly and that they would never use it.

I also had two meetings with Flerov. The first was at the time of the Munich IUPAC General Assembly in 1973, which was followed by an IUPAP Nuclear Physics Conference. This occurred at a time long before the scheme came to be. In 1989, Flerov attended a talk I gave on spontaneous fission at the US National Academy of Sciences in Washington, but the subject of the IUPAC element naming scheme never came up in our discussion. Flerov and I were both members of the Atomic Weights Commission at the same time but he was never allowed to attend these Commission meetings. As a result, I never learned of his personal views on the subject of the systematic naming scheme.

In their 1991 report, the TWG noted that the IUPAC proposed systematic names were only intended for use in the period when no "official" names were yet available, but they had not met with favour among nuclear chemists nor among physicists and would not be discussed by the TWG in its work. [3]

***LÖ:*** *Was there at any time an idea of IUPAC as meddling bureaucrats?*

**NEH:** I was not familiar with the term "meddling bureaucrats" either at the time or until very recently (less than six months ago). If that term was the private opinion of some of the leading scientists of the time, it was never expressed to me in those terms.

Note that IUPAC is a member of the International Council for Science, ICSU, originally known as the International Research Council and later called the International Council of Scientific Unions, which is comprised of 17 such unions, including IUPAP and the International Union of Biological Sciences (IUBS), among others. These unions have only very small groups of permanent administrators, who sustain these organizations. The naming scheme did not come from IUPAC administrators, but from scientific and technical members of the organization, which was comprised entirely of volunteer scientists.

***LÖ:*** *Was there ever a notion that these symbols and names would become permanent?*

**NEH:** It is very clear that there was never any intention of these systematic names depriving discoverers of the right to name a new element after their discovery of that new element was officially accepted.

***LÖ:*** *When we have discussed this earlier I remember you mentioning that the whole controversy needs to be "seen in the context of the cold war", when indeed a simple game of chess could invoke reactions from the US state department and the propaganda war was fought on all fronts. Do you think the prospect of having the entire row of super heavies, from Seaborgium to the yet unnamed element 118, named after Soviet scientist, or vice versa, displayed in classrooms and textbooks all over the world, gave rise to any (official or unofficial) pressure on the scientists in question not to give in?*

**NEH:** I do not think that any of the scientists were concerned about future discoveries. Their concern was about who would receive credit for the discoveries at hand. In this 'Cold War', one of your strongest weapons in the public relations battle was the name you proposed for 'your' element, and you wanted to see it being mentioned in the scientific literature to bolster your claim of discovery. You would never give up your strongest weapon and then accept a 'neutral' name. This would indicate that you really did not believe strongly in your scientific case for the right to discovery and the name you proposed for your element.

As far as fame and vanity go, the major public relations effort to change the IUPAC rule on naming an element after a living person would indicate that, no matter how great any of us might be, none of us should be considered entirely immune to fame and vanity.

***LÖ:*** *What was your initial reaction to these names and symbols?*

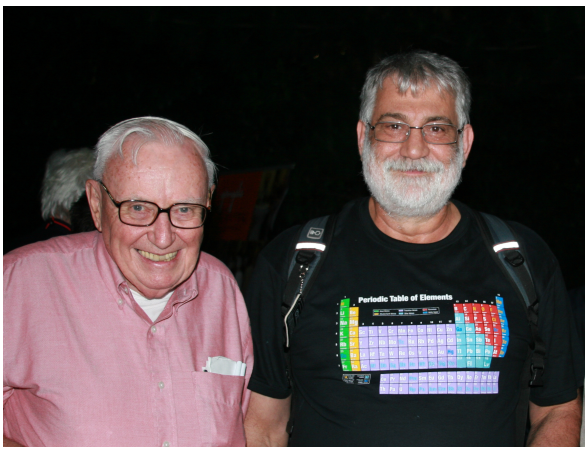
**NEH:** I was probably one of the first persons to use the IUPAC names in the scientific publication of the 1977 Atomic Weights report, published in the very same issue of *Pure and Applied Chemistry* in 1979, see [4]. I will admit that, as I looked at the names and the three-letter symbols in that table, they did look rather strange to me. However, I understood that these names and symbols were only temporary until an official decision on a trivial name was made by IUPAC, and it also provided a mechanism to report these elements in the table.

One final note to this story: two of the most recent elements that were accepted by IUPAC (flerovium, element 114, and livermorium, element 116), are the direct result of a joint collaboration between scientists from the US and Russia.

***LÖ:*** *Finally on the lighter side of things, there is probably one or two anecdotes about these famous and colourful scientists you could share with us?*

**NEH:** Since I began with a Joe Chatt story, let me end with one, but with a different context. During the ICTNS meeting at Emmanuel College in Cambridge, September 8-12, 1980, I was invited to the meeting to discuss the new definition of atomic weight. During breaks in the meeting, Joe Chatt gave me a tour of Emmanuel College, which had been founded in 1584 and where he had been a student more than four decades before. The physician and natural philosopher, Thomas Young, was enrolled there in 1797. He developed a wave theory of light and sound. Joe showed me the college pond where Young got his ideas on the interference of light by observing the ripples set up by the swans on the pond. It was a very interesting story.

Unfortunately for Joe, a short time later I read a paper by Bernice Weldon (B.W.) Sargent of the Queen's University, Canada. He had received an Exhibition of 1851 Science Research Scholarship and became a student at Rutherford's Cavendish Lab during 1928-30 and stayed at Emmanuel College. Sargent mentioned that in 1929 a group of undergraduate and research students at Emmanuel College, founded the Thomas Young Science Club and they began to spread a story about how Young got his ideas about wave interference from watching swans in the pond at Emmanuel College. I am not sure whether or not Joe appreciated it, when I later explained the source of his great story.




*Normal Holden (left) happily considers the two new homemade additions to the periodic table T-shirt of then Division II President Bob Loss, who has just reported on the final replacement of ununquadium and ununhexium to the Division meeting in Istanbul in August 2013.*

## Acknowledgments

The authors thank Jan Reedijk for his review and Fabienne Meyers for help searching the IUPAC archives.

## References

1. J. Chatt, Recommendations for the Naming of Elements of Atomic Numbers Greater than 100, *Pure Appl. Chem.* **51**(2):381–384 (1979).
2. Y. Jeannin, N.E. Holden, The Nomenclature of the Heavy Elements, *Nature* **313**:44 (28 February 1985).
3. D. H. Wilkinson, A. H. Wapstra, I. Uhelea, R. C. Barber, N. N. Greenwood, A. Hrynkiewicz, Y. P. Jeannin, M. Lefort, M. Sakai, Criteria That Must Be Satisfied for the Discovery of a New Chemical Element to Be Recognised, *Pure Appl. Chem.* **63**(6):879–886 (1991).
4. N.E. Holden, Atomic Weights of the Elements 1977, *Pure Appl. Chem.* **51**(2):405-433 (1979).

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**Norman E. Holden <holden@bnl.gov> has been involved with IUPAC for over 40 years and is today an emeritus member of the Inorganic Chemistry Division. In 1979-1983 he was chairman of the Commission on Atomic Weights and Isotopic Abundances (known now as the Commission on Isotopic Abundances and Atomic Weights, CIAAW). Since 1974, he has been at the National Nuclear Data Center of the Brookhaven National Laboratory, in Upton, New York, USA.**