Pierre Avenas
with the collaboration of Minh-Thu Dinh-Audouin
Preface by Professor Jacques Livage

The amazing history of element names

Société Chimique de France

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translated from *La prodigieuse histoire du nom des éléments*

with the collaboration of Alan Rodney

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By the same author

On polymers:

- *Mise en forme des polymères. Approche thermomécanique de la plasturgie*, with J.-F. Agassant, J-Ph. Sergent, B. Vergnes and M. Vincent, Lavoisier, 4th ed. 2014 (1st ed.1982), preface by Pierre-Gilles De Gennes.
- *Polymer processing. Principles and modeling*, with J.-F. Agassant, P.-J. Carreau, B. Vergnes and M. Vincent, Hanser Publishers, 2nd ed. 2017 (1st ed. 1991).
- Etymology of main polysaccharide names, Chap. 2 of T*he European Polysaccharide Network of Excellence (EPNOE)*, *Research initiatives and results*, P. Navard (ed.), Springer, 2012.

Etymology books:

With Henriette Walter, published by Robert-Laffont:

- ***L'étonnante histoire des noms des mammifères.*** *De la musaraigne étrusque à la baleine bleue*, 2nd ed. 2018 (1st ed. 2003), republished in 2 vol., « Le goût des mots », Points: Chihuahua, zébu et Cie, 2007, and Bonobo, gazelle et Cie, 2008.
- ***La mystérieuse histoire du nom des oiseaux.*** *Du minuscule roitelet à l'albatros géant*, 2007.
- ***La fabuleuse histoire du nom des poissons.*** *Du tout petit poisson-clown au très grand requin blanc*, 2011.
- ***La majestueuse histoire du nom des arbres.*** *Du modeste noisetier au séquoia géant*, 2017.

With the collaboration of Minh-Thu Dinh-Audouin, published by EDP Sciences/SCF:

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"La prodigieuse histoire du nom des éléments" was originally published in French in 2018 by EDP Sciences.

Ce n’est point en resserrant la sphère de la nature et en la renfermant dans un cercle étroit qu’on pourra la connaître ; ce n’est point en la faisant agir par des vues particulières qu’on saura la juger ni qu’on pourra la deviner ; ce n’est point en lui prêtant nos idées qu’on approfondira les desseins de son auteur. Au lieu de resserrer les limites de sa puissance, il faudra les reculer, les étendre jusque dans l’immensité ; il ne faut rien voir d’impossible, s’attendre à tout, et supposer que tout ce qui peut être, est.

Buffon, *Histoire naturelle*

It is not by tightening the sphere of nature and enclosing it in a narrow circle that we will be able to know it; it is not by making it act by particular views that we will be able to judge it nor guess it; it is not by lending it our own ideas that we will be able to deepen the designs of its author. Instead of tightening the limits of its power, we must push them back, extending them into the immensity; we must not see anything as impossible, we must expect everything, and suppose that everything that can be, is.

Buffon, *Histoire naturelle*

Preface

THE AMAZING HISTORY OF ELEMENT NAMES

Year 2019 was declared as the *International Year of the Periodic Table of the Chemical Elements* by UNESCO. It was indeed 150 years ago that Mendeleev published his famous Periodic Table bringing together the 63 chemical elements already known at that time. The 118 elements known today perfectly fit together, including the empty spaces left by Mendeleev. It was therefore useful to recall the history of this table and the origin of the names of the chemical elements. This is what Pierre Avenas has done, already well-known for the etymological articles he published in *L'Actualité Chimique*, the journal of the French Chemical Society. *A priori*, such an opus could have been a simple enumeration of the elements classified according to their alphabetical order or by the date of their discovery. But actually this book, based as it is on the etymological origin of the names, takes us through a real odyssey of mineral, living and even thinking matter. He shows us how the whole history of Humanity lies behind the simple denomination of the chemical elements, from the four elements of Empedocles to the recently discovered radioactive elements. Moreover, the term *element* does not apply only to the atoms of the Periodic Table. It also applies to the molecules that build living matter. The names of the chemical elements come from very diverse origins. They most often do not come from the simple field of chemistry and are inspired by other scientific or cultural fields.

The Periodic Table of elements reveals Mendeleev's genius. It is undoubtedly one of the most beautiful manifestations of the human spirit. At that time, only 63 elements were known, characterized by their mass and chemical properties. Atoms, each with its nucleus and electronic layers, had not yet been discovered by Niels Bohr. How was it then possible to classify the known chemical elements, leaving empty spaces for those which would be discovered later?

The book naturally starts with the four elements suggested by Empedocles (fire, air, water and earth) on which the description of matter was based until the 18th century. It reminds us of the basic role of metals in the history of mankind, from the Bronze Age to the Iron Age! The book then takes us to other horizons, such as mythology, history or geography. It shows us which people, beliefs or circumstances inspired the name of each element. We thus cover the entire history of mankind, from the pigments used in parietal wall paintings to very recently discovered radioactive elements. The elements, which in fact constitute all the living and inanimate matter of the Universe, play a basic role in our history. Far beyond simple chemistry, Pierre Avenas opens up a vast horizon in which sciences, history and humanities are closely intertwined.

Jacques Livage
Professor at the Collège de France
Member of the French Académie des Sciences

Foreword

THE AMAZING HISTORY OF ELEMENT NAMES

Year 2019 was proclaimed by UNESCO the

"*International Year of the Periodic Table of Chemical Elements*".

This theme is more familiar than it sounds in scientific terms, since we use the names of chemical elements every day, such as the **oxygen** we breathe or the **helium** we use to inflate balloons. **Gold** and **silver** are also chemical elements, as are **copper** or **iron** and numerous other metals. Some elements are known to be beneficial to health, such as **phosphorus** for the brain functions, **fluorine** for our teeth, **sulphur** for our hair... and others are known as trace elements, such as **iodine** or **selenium**. And everyone knows that table salt is sodium chloride, where two elements, **chlorine** and **sodium**, combine. Finally, let's mention the field of energy, where we are constantly talking about **carbon**, but also photovoltaic **silicon** and **uranium** as used in nuclear power plants. We can see that a great many chemical elements are no strangers to us.

Today, 118 of them have been identified, 90 of which are natural on Earth, where they make up the totality of matter, *i.e.*, including the mineral or living kingdoms. The elements combine in the countless substances and compounds that surround us, many of which are part of daily life.

• An approach based on etymology...

This book is a collection of articles, known as "clins d'œil étymologiques" ("etymological winks"), published since 2012 in *L'Actualité Chimique*, a journal of the *Société Chimique de France* (SCF[1]), French Chemical Society. The basic, underlying idea is to present the etymological

1. www.societechimiquedefrance.fr

origin of the names of substances, whether they be chemical elements or compounds such as starch, brass or plexiglas.

But that's not all, the aim of the book goes far beyond that.

● ... and that leads to worlds that are sometimes unsuspected

Indeed, the etymology of a name often tells us a great deal about the discovery of the substance evoked, about the research scientists involved, and even about the state of science at the time of discovery. A whole history that quickly led us on to other scientific or cultural fields such as botany and zoology, astronomy, history and mythology, medicine and biology, technology and industry...

Names that make people travel, if only because they are given in English, French and often in Spanish and German. Both the chapter titles and the illustrations give free rein to the reader's imagination.

But the aim of the book is also to make the Periodic Table more familiar, as highlighted in the theme of the year 2019.

● From the list of elements to the Periodic Table

In 1789, Lavoisier established the concept of the chemical element and his *Traité élémentaire de chimie* listed 23 elements known at that time.

Later on, other elements were discovered, classified by mass from the lightest, hydrogen, to the heaviest, uranium. And, taking into account their properties, they were arranged in a table with several columns.

And it was a graduate from the French engineering school École Polytechnique, Alexandre de Chancourtois (1820-1886), who was the first to introduce periodicity in this classification, in 1862, in the original form of a helix traced on a cylinder, the so-called *Telluric screw* still visible at the *École des Mines de Paris*. Then, in the following few years, other researchers, *a priori* independently of each other, presented this periodicity in a double-entry table. This was notably the case in Germany by Lothar Meyer and in Russia by Dmitri Mendeleev, who first used this table as a predictive tool.

● Mendeleev's table, which is certainly periodic and above all predictive

Mendeleev (1834-1907), professor of chemistry at the Institute of Technology and at the University of St. Petersburg, Russia, marked the history of chemistry with his publication in 1869[2], not so much by the concept of periodicity of the elements, already well understood by others, but above all by predicting the subsequent discovery of missing elements in slots that remained empty in his table of the 63 elements known at that time. He also predicted certain properties of these future elements, several of which were actually discovered during his lifetime, which caused a real sensation.
These historical elements can be found in *The amazing history of element names* and many other references to the Periodic Table, the construction of which can be followed throughout the book.

But for the Ancient scholars, the elements were *fire*, *air*, *water* and *earth*, offering an excellent place to start Chapter 1.

2. E. Scerri, *Le tableau périodique, Son histoire et sa signification*, EDP Sciences, Paris, 2011, 349 pp, p. 64 (1st ed. *The Periodic Table, its story and its significance*, Oxford, 2006).

To make the reading easier

Typographical conventions

in italics	the word itself
« »	the meaning of the word
< >	graphical form
[ ]	pronunciation
*(in front of a word)	reconstructed form, non-attested in writing

With a few exceptions, Greek words are transliterated according to the usual standards:

α → a *β* → b *η* → ê *θ* → th *φ* → ph *ψ* → ps *ω* → ô
χ → kh (becomes <ch> pronounced [k], in Latin and in English, French…),

υ → u (becomes <y> in Latin and in English, French…)

Example :

Greek *ἐτυμολογια* → *etumologia* > Latin *etymologia* > English *etymology*

Words written in specific alphabets (Cyrillic, Arabic...) are also transliterated

Some keywords

– ***Indo-European***: refers to a reconstructed language, believed to have been spoken 5 000 years before our era in a region near the Black Sea, and from which the languages of the so-called *Indo-European* family originate, consisting mainly of Sanskrit, Asian languages (Persian, Hindi...), and most European languages: Greek, Latin and the Romance languages from which they come (Italian, Spanish, French...), Slavic languages (Russian...), Germanic languages (English, German...), Celtic languages (Breton...)...

– ***atom***: from the Greek *atomos*, ‘indivisible’, already describing an indivisible particle in Democritus or Aristotle. It was around 1900 that the structure of the atom was understood: a positive nucleus surrounded by negative electrons. Since then, as in this book, we can say *chemical elements* as well as *atoms*.

– ***ion***: an atom that has either captured one or more electrons (*viz.*, an anion, negative) or has lost one or more electrons (*viz.*, a cation, positive). First coined by the English physicist Faraday in 1834, this word comes from the Greek *ion*, a present participle of the verb “to go”, therefore “going, that goes”, either towards the anode (the + pole), or towards the cathode (the - pole).

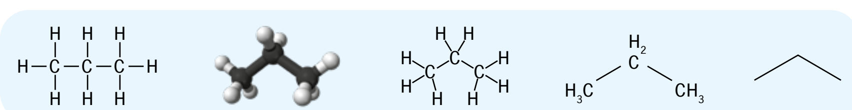
– ***isotope***: from the Greek *iso*, “the same”, and *topos*, “place”, created in 1913 by the English physicist Soddy to designate atoms in the same slot of the Periodic Table, *i.e.*, sharing the same atomic number (same number of electrons) but different masses. Example: for carbon (atomic number 6) we know carbon 14, which is a radioactive isotope, whereas the most common isotope, carbon 12, is not.

• IUPAC (International Union of Pure and Applied Chemistry)

The International Union of Pure and Applied Chemistry is a non-governmental organization based in Zurich. Founded in 1919, it is interested in the progress of chemistry, physical chemistry, biochemistry, *etc.* Its members are n ational chemical societies. It is IUPAC that validates the chemical nomenclature, including the names of chemical elements (or atoms), their chemical symbols, isotopes, *etc.* Example: IUPAC recently (June 8, 2016) validated the name of the latest element identified to date, *oganesson* (Og), atomic number 118.

Depending upon the context, the same molecule can be represented by different sorts of formulae or drawings. Example of propane:

$$C_3H_8 \quad CH_3CH_2CH_3 \quad CH_3\text{-}CH_2\text{-}CH_3$$



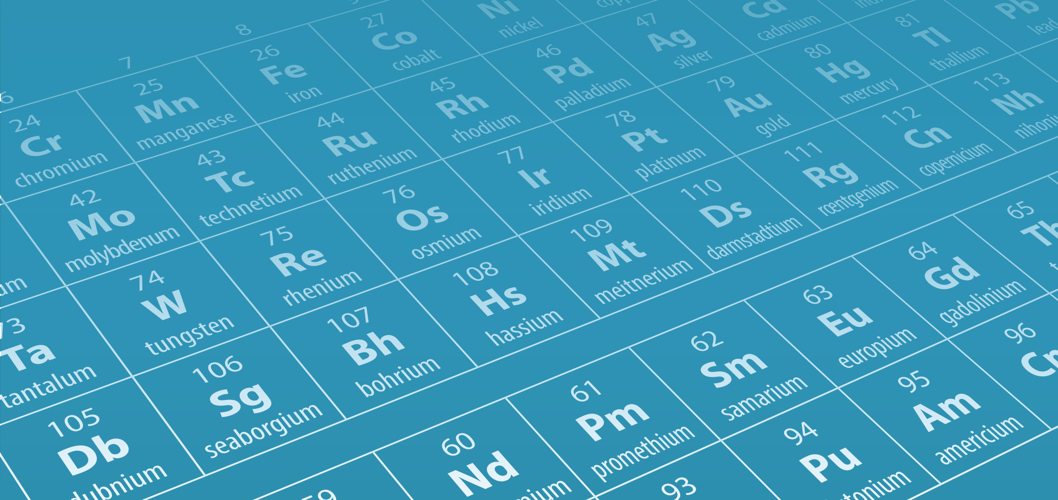
Summary

CHAPTER

1

Fire, air, water, earth… and the 5th element?

Where we see how Lavoisier ushered in modern chemistry



ELEMENTS OF THE ANCIENTS AND ALCHEMISTS

Ancient Greek philosophers first thought that one element lay at the origin of everything, ***fire*** for some, ***water*** for others, until Empedocles, in the 5th century BC, asserted the existence of four primitive elements: ***fire***, ***air***, ***water*** and ***earth***, not the *Earth* our planet, nor *earth* in which plants grow, but ***earth*** in the sense of all solid matter, considered as one single element.

The description of **Empedocles**, born in the Greek city of Agrigento in Sicily, was both poetic and mythological: thus the luminous *fire* was that of Zeus, and the *water* came from the tears of Nestis, a Sicilian deity.

Later on, **Plato** (c. 427-347 BC), born in Athens, adopted a more mathematical concept. He assumed that the four elements were made of very small, invisible particles in the form of regular polyhedra, as previously studied by the Pythagoreans:

Tetrahedron **FIRE** — Octahedron **AIR** — Icosahedron **WATER** — Hexahedron **EARTH**

The cube (hexahedron) has the most stable appearance of *earth*, while the tetrahedron appears more mobile and "sharp", aggressive as fire.

The octahedron represents *air* and the icosahedron rolls easily, like flowing *water*.

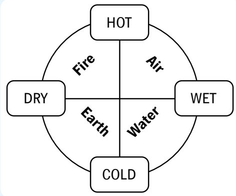
Now there is a fifth, regular convex polyhedron, the dodecahedron, and according to Plato: "*the God used it for the Whole, when he drew the final arrangement*"[1].

This dodecahedron prefigured the notion of the fifth element, as made explicit later on by Aristotle.

Dodecahedron

1. Plato, *Timée Critias*, Timée, 55 c, Les Belles Lettres, Paris, 2011, text by Albert Rivaud.

Aristotle (384-322 BC), born in Stagira in Macedonia, favoured the sensations derived from the elements, their primary qualities being hot and cold on one hand and wet and dry on the other. According to Aristotle, the four elements stem from these basic qualities combined in pairs.



But the question remains: were there only four elements in the Universe?

The fifth element: *ether*

In Greek mythology, Æther (Greek *Aithêr*) is one of the primordial gods associated with the creation of the world. He personifies the brightest, purest and highest part of the atmosphere, called in Greek *aithêr*, a name related to the Greek *aithein*, *"to burn, to be luminous",* and the origin of the English word *ether*.

For Aristotle[2], the *ether* was this fifth element in which the stars above us in the sky laid, rotating around the Earth.

The alchemists, heirs of the Ancients

The principle of the four elements remained predominant throughout the Middle Ages and until the beginning of the 18th century. In regard to the concept of the fifth element, it inspired the alchemists to use the term *quinte essence*, from the Latin *quintus*, "fifth", and *essentia*, "nature of things", to designate the final stage of any distillation, hence the more general notion today of *quintessence*.

In the 2nd edition (1778) of Macquer's *Dictionnaire de chymie* the word in French *éther* already had its modern meaning of a highly volatile liquid, but we still find the four elements: *fire*, *air* and *water*, which cannot be decomposed, and *earth*, purest emanation of which is quartz, instead of the diamond set out in the 1st edition (1766).

Lavoisier's revolutionary theory

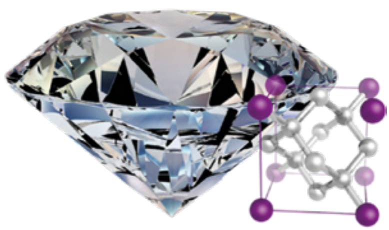
In 1789, in his *Traité élémentaire de chimie*, Lavoisier published the first table of chemical elements in the modern sense of the term, including hydrogen and oxygen from the decomposition of water, nitrogen from the decomposition of air and with carbon recognized as the sole constituent of diamond… and this definitively shattered the old four-element theory.

Within a decade, a giant leap forward had been taken, as we shall see…

2. Aristotle, *Du Ciel*, Livre I, 270 b, Les Belles Lettres, Paris, 2003, text by Paul Moraux.

1 Earth, a precious diamond mine!

carbon* (C), *coal*, *diamond*, *graphite*, *graphene* and *fullerenes



➜ Diamond, emanating from a pure element?

Diamond, as a chemical product?

Why not, in the article *Earth* (*Terre* in French) of the 1st edition of his *Dictionnaire de chymie* (1766), Macquer wrote about diamonds: "*it is the very matter of this stone that we consider to be the simplest, purest & most elementary earth that we know*".

This text was prophetic because diamond is indeed the emanation of a pure element, certainly not from the *earth*, in the ancient meaning of the term *element*, but from carbon, a chemical element in the modern sense.

Diamonds are eternal, but only in the cinema

All very hard matter, including metallic materials, and more specifically diamonds in Theophrastus' work, were called in Greek *adamas*, *adamantos*, formed by the privative *a-* and the verb *damnêmi*, "to tame". The diamond, with its exceptional properties, was therefore described as "untamable" in Greek, which Latin then took over as in the form of *adamas*, later evolving to *diamas*, *diamantis*, hence in French *diamant*, Italian and Spanish *diamante*, English *diamond* and German *Diamant*. The privative *a-* was dropped during this evolution, even in Modern Greek, *diamanti*, as if the diamond was no longer "untamable". A premonitory step, we might say.

From diamond to coal, light shed on carbon

In 1773, Lavoisier, with the help of Macquer, showed that, far from being eternal, diamonds raised to very high temperatures burned, giving the same combustion gas as coal. From there, he identified the element he called "*coal substance*" in 1781, and Guyton de Morveau, in 1787, named it in French *carbone*, which readily abbreviated to *carbon* in English. And then it was proven that diamonds are carbon crystals. They are made up only of carbon atoms, which form cubes stacked on top of each other, a little like Plato imagined the structure of the *earth* element!

The French word *carbone* was formed on the Latin *carbo*, *carbonis*, probably related to the verb *cremare*, "burn" (*cf. cremation*). The word *carbo* first referred to charcoal and later on, especially earth coal. In French, *charbon*, "coal", and *carbone* are etymological doublets, which also exist in other Romance languages, but not in Germanic languages: *coal* in English and *Kohle* in German have the same origin, not Latin but Germanic.

English	French	Italian	Spanish	German
coal	*charbon*	*carbone (m.)*	*carbón*	*Kohle (f.)*
carbon	*carbone*	*carbonio*	*carbono*	*Kohlenstoff (m.)*

German is somewhat different, with *Kohlenstoff* translating Lavoisier's "coal substance". CO_2, for example, is called *Kohlenstoffdioxid*, but also and even more commonly *Kohlendioxid*. And the radical *Karbon-*, today *Carbon-*, is also used, in particular, for *Carbonate*, *Carbonyl*...

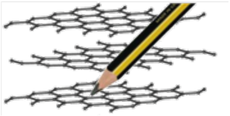
● Black lead, pencil writing and graphite

Charcoal has been used as a black pencil since the beginning of time, used primitively for rock paintings, and this makes it possible to date them, thanks to the so-called *carbon 14* dating process. Even today, charcoal is still used to draw: in French, it is *fusain* (or artists' charcoal, the result of burning wooden sticks in a kiln without air), called *carboncino* in Italian for example.

In ancient times, people also wrote with a lead-based metal tip, or later with a stone called *plumbago* (its Latin name, from *plumbum*, "lead"), *plombagine* in French, because of its similarity to lead. This stone was also called *black lead*, in French *mine de plomb*, where *mine* meant "ore".

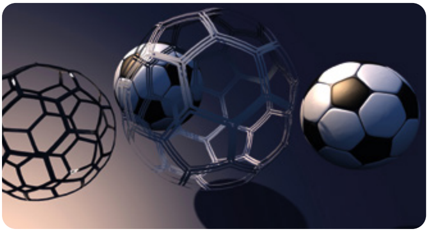
But the Swedish chemist Scheele showed, at the end of the 18th century, that this black lead had nothing to do with lead, and that it was actually a particular form of carbon, even better than charcoal for writing.

In 1790, the German mineralogist Werner gave for black lead a more satisfactory name, *graphite*, from the Greek *graphein*, "to write". However, the term *mine de plomb* pencil is still sometimes used in French, hence the common name, *lead* pencil in general in English. In German, the traditional name of the black pencil is *Bleistift*, from *Blei*, "lead", and *Stift*, "tip, pencil".



➜ Graphite molecular sheets.

More recently: fullerenes… and graphene

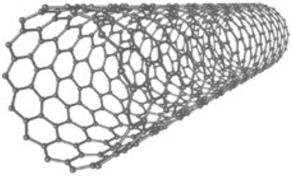


➜ Fullerenes or, aka, "*footballenes*" for the C_{60}.

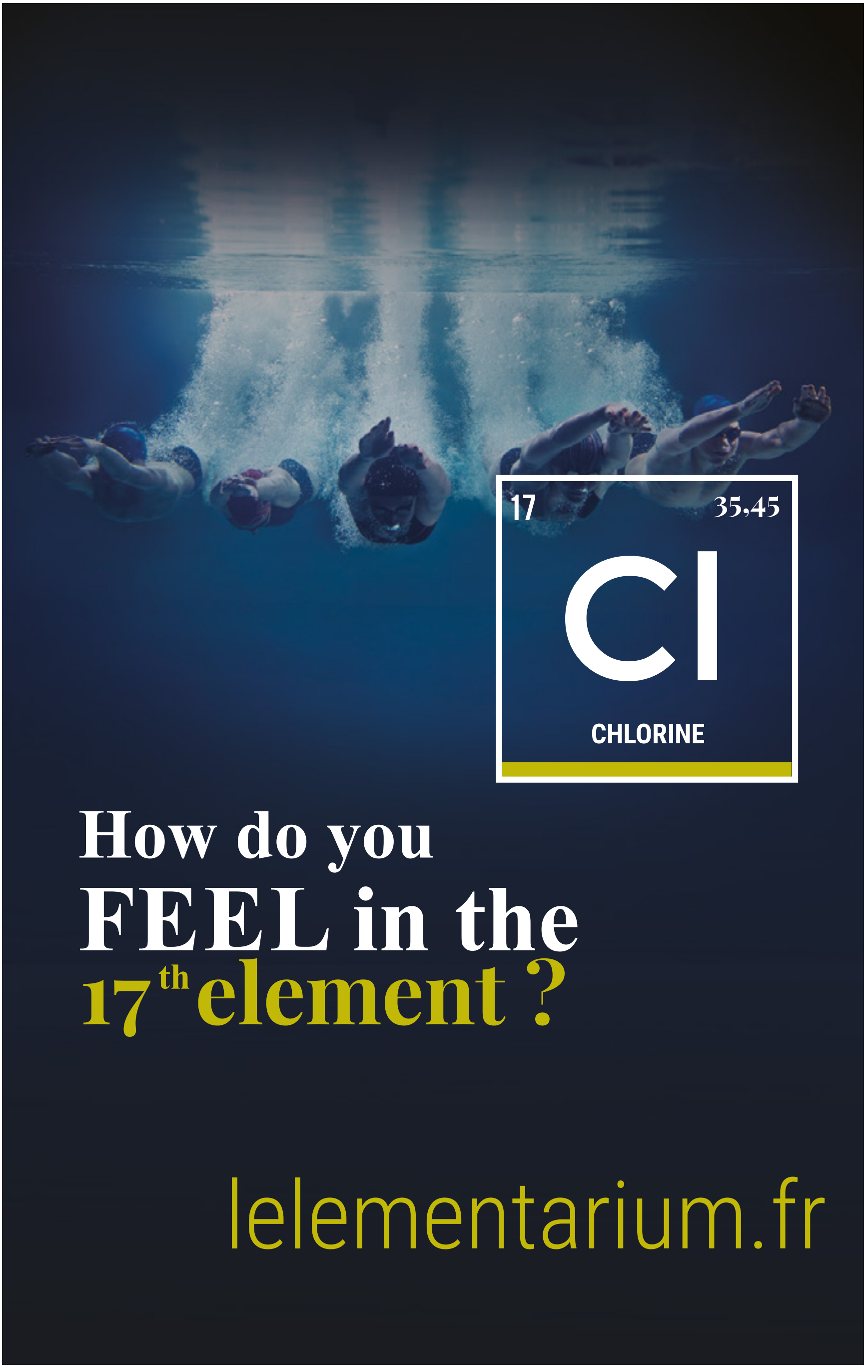
An unexpected event in 1985 was the discovery of a completely new form of carbon, the archetype of which is the C_{60} spherical set of 60 carbon atoms forming 20 hexagons and 12 pentagons, like a microscopic football.

Plato would surely have adored knowing this amazing molecule, he who imagined elementary particles in the shape of polyhedra, even if his own were regular, therefore composed of only one kind of polygon, whereas C_{60} is a semi-regular, so-called *Archimedean* polyhedron, because it is composed of two kinds of polygons.

This structure was also reminiscent of the geodesic domes (*i.e.*, recalling the shape of the Earth) of the American architect Richard Buckminster Fuller (1895-1983), known as *Fuller*. From there, the derivative name *fullerene* was given in 1992 to C_{60} and other related molecules, including the nanotubes discovered a little earlier.



➜ Carbon nanotube.


17
35,45
Cl
CHLORINE
How do you
FEEL in the
17th element ?
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