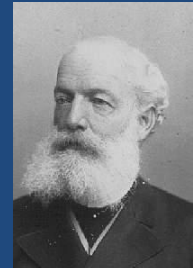
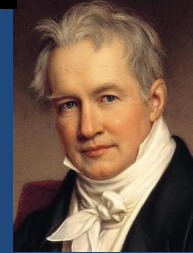


# ΙΥC 2011

## Η εξέλιξη του Περιοδικού Πίνακα

Αθανάσιος Ζαρκαδούλας  
4<sup>ο</sup> Έτος



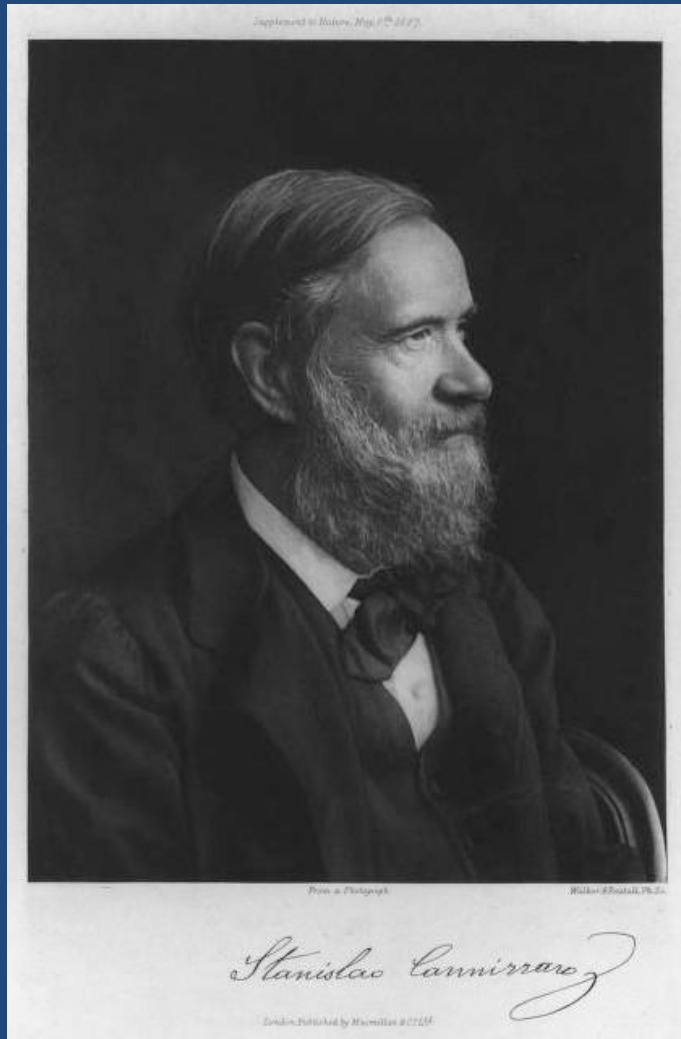
# Συνέδριο στην Karlsruhe

## 3 – 5/09/1860

- Πρώτο διεθνές συνέδριο Χημείας
- Ξεκαθαρίστηκαν κάπως οι έννοιες άτομο και μόριο
- Ορίσθηκαν τα a.w. και e.w.

# Stanislao Cannizzaro

## 1826 – 1910



- Συγκέντρωσε την εργασία του Avogadro
- “...The different quantities of the same element contained in different molecules are all whole multiples of one and the same quantity, which always being entire, has the right to be called an atom . . . .”

# Alexandre-Emile Béguyer de Chancourtois

## 1820 –1886



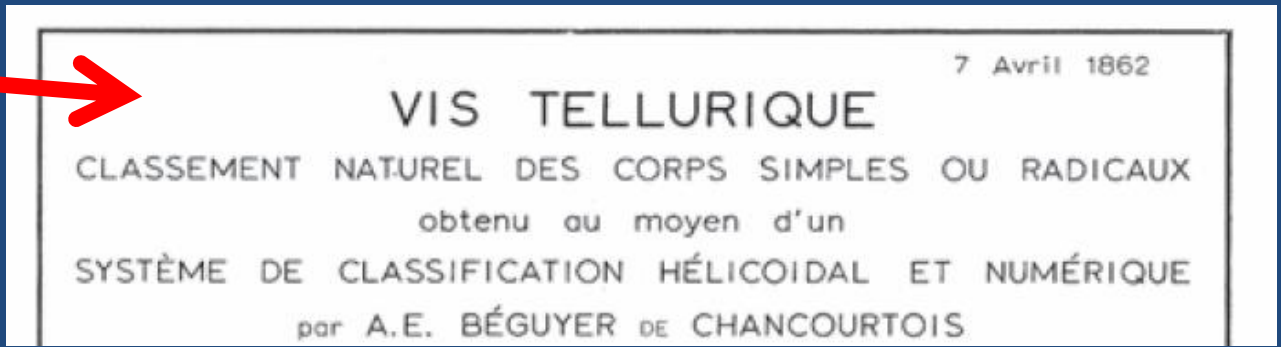
- 1862: οι ιδιότητες των στοιχείων είναι περιοδική συνάρτηση του a.w.
- Μικρή αναγνώριση
- Πρώτη σχηματική κατάταξη, “Vis Tellurique”
- Δεν έλαβε υπόψιν χημικές ομοιότητες
- Συμπεριέλαβε ρίζες

7 Avril 1862

### VIS TELLURIQUE

CLASSEMENT NATUREL DES CORPS SIMPLES OU RADICAUX  
obtenu au moyen d'un  
SYSTÈME DE CLASSIFICATION HÉLICOÏDAL ET NUMÉRIQUE  
par A.E. BÉGUYER DE CHANCOURTOIS

		Tableau des Caractères Géométriques														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hydrogène	H	1														
Lithium	Li	7														
Silicium	Si	9														
Bore	B	11														
Carbone	C	12														
Azote	N	14														
Oxygène	O	16														
Fluor	F	19														
Sodium	Na	23														
Magnésium	Mg	24														
Aluminium	Al	27														
Silicium	Si	28														
Phosphore	P	31														
Soufre	S	32														
Chlore	Cl	35														
Potassium	K	39														
Calcium	Ca	40														
Titane	Ti	48														
Chrome	Cr	52														
Manganèse	Mn	55														
Fer	Fe	56														
Nickel	Ni	59														
Cobalt	Co	59														
Cuivre	Cu	63														
Yttrium	Y	88														
Zinc	Zn	65														
Zirconium	Zr	91														
Arsenic	As	75														
Brome	Br	79														
Selenium	Se	80														
Rubidium	Rb	85														
Strontium	Sr	87														
Lanthane	La	91														
Cerium	Ce	92														
Molybdène	Mo	96														
Diymane	Di	96														
Yttrium	Y	100														
Thallium	Tl	103														
Rhodium	Rh	107														
Platidium	Pt	107														
Argent	Ag	108														
Cadmium	Cd	111														
Etain	Sn	115														
Thorium	Th	119														
Uran	U	120														
Antimoine	Sb	121														
Cæsium	Cs	132														
Iode	I	127														
Tellure	Te	128														
Tantale	Ta	184														
Tungstène	W	185														
Iridium	Ir	197														
Platine	Pt	199														
Or	Au	200														
Mercur	Hg	204														
Ruthenium	Ru	205														
Csimum	Cs	206														
Bismuth	Bi	209														

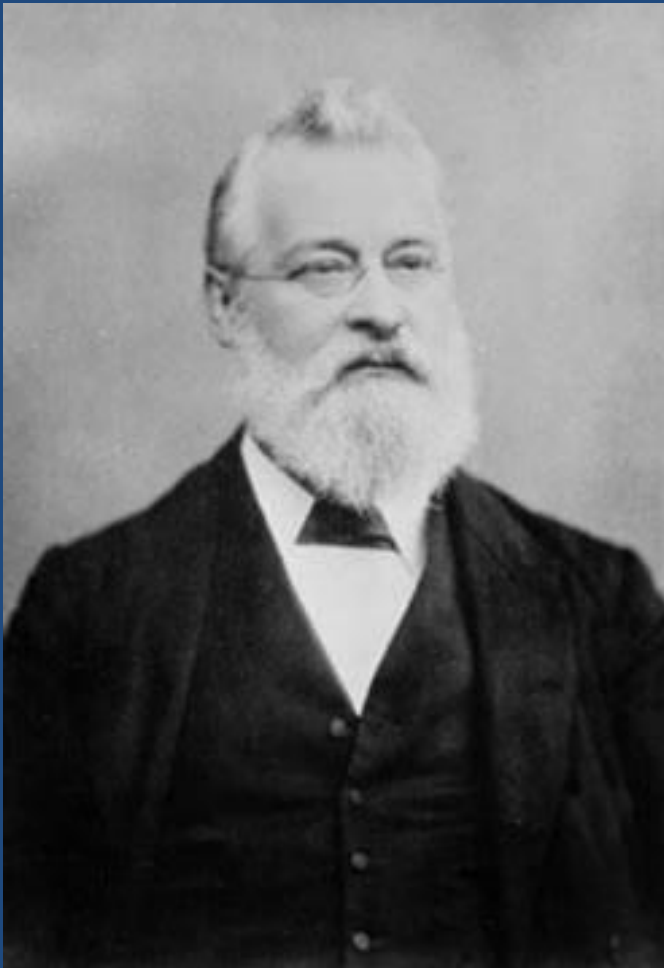


Δίνοντας Faraday Lecture το 1889, ο Mendeleev σχολίασε αρνητικά αυτό το περιοδικό σύστημα.

A.E. Béguyer De Chancourtois,  
 Vis Tellurique: Classement naturel des corps simples ou radicaux, obtenu au moyen d'un système de classification hélicoïdale et numérique,  
*Comptes Rendus de L'Academie*, 54, 757–761, 840–843, 967–971, 1862.

# John Alexander Reina Newlands

1837 – 1898



- Δεν συμμετείχε στην Karlsruhe
- 1863: πρόβλεψη αλκαλίου με a.w. 163, στοιχείο ενδιάμεσο των Ir, Rh
- 1864: δημοσίευση δεύτερου συστήματος

Group I. Metals of the alkalis:—Lithium, 7; sodium, 23; potassium, 39; rubidium, 85; caesium, 123; thallium, 204.

The relation among the equivalents of this group (see *CHEMICAL NEWS*, January 10, 1863) may, perhaps, be most simply stated as follows:—

1 of lithium + 1 of potassium = 2 of sodium.  
 1 " + 2 " = 1 of rubidium.  
 1 " + 3 " = 1 of caesium.  
 1 " + 4 " = 163, the equivalent of a metal not yet discovered.  
 1 " + 5 " = 1 of thallium.

Group II. Metals of the alkaline earths:—Magnesium, 12; calcium, 20; strontium, 43.8; barium, 68.5.

In this group, strontium is the mean of calcium and barium.

Group III. Metals of the earths:—Beryllium, 6.9; aluminium, 13.7; zirconium, 33.6; cerium, 47; lanthanum, 47; didymium, 48; thorium, 59.6.

Aluminium equals two of beryllium, or one-third of the sum of beryllium and zirconium. (Aluminium also is one-half of manganese, which, with iron and chromium, forms sesquioxides, isomorphous, with alumina.)

1 of zirconium + 1 of aluminium = 1 of cerium.

1 " + 2 " = 1 of thorium.

Lanthanum and didymium are identical with cerium, or nearly so.

Group IV. Metals whose protoxides are isomorphous with magnesia:—Magnesium, 12; chromium, 26.7; manganese, 27.6; iron, 28; cobalt, 29.5; nickel, 29.5; copper, 31.7; zinc, 32.6; cadmium, 56.

Between magnesium and cadmium, the extremities of this group, zinc is the mean. Cobalt and nickel are identical. Between cobalt and zinc, copper is the mean. Iron is one-half of cadmium. Between iron and chromium, manganese is the mean.

Group V.—Fluorine, 19; chlorine, 35.5; bromine, 80; iodine, 127.

In this group bromine is the mean between chlorine and iodine.

Group VI.—Oxygen, 8; sulphur, 16; selenium, 39.5; tellurium, 64.2.

In this group selenium is the mean between sulphur and tellurium.

Group VII.—Nitrogen, 14; phosphorus, 31; arsenic, 75; osmium, 99.6; antimony, 120.3; bismuth, 213.

Member of a group having lowest equivalent		One element immediately above the preceding one		Difference	
				H = 1	O = 16
Magnesium	24	Calcium	40	16	1
Oxygen	16	Sulphur	32	16	1
Lithium	7	Sodium	23	16	1
Carbon	12	Silicon	28	16	1
Fluorine	19	Chlorine	35.5	16.5	1.031
Nitrogen	14	Phosphorus	31	17	1.062

		Triad					
		Lowest Term		Mean	Highest Term		
I.	Li 7	+17 =	Mg 24	Zn 65	Cd 112		
II.	B 11						Au 196
III.	C 12	+16 =	Si 28		Sn 118		
IV.	N 14	+17 =	P 31	As 75	Sb 122		+88 = Bi 210
V.	O 16	+16 =	S 32	Se 79.5	Te 129		+70 = Os 199
VI.	F 19	+16.5 =	Cl 35.5	Er 80	I 127		
VII.	Li 7	+16 =	Na 23	Rb 85	Cs 133		+70 = Tl 203
VIII.	Li 7	+17 =	Mg 24	Sr 87.5	Ba 137		+70 = Pb 207
IX.			Mo 96	V 137	W 184		
X.			Pd 106.5		Pt 197		

## Relations Between Equivalents, *Chemical News*, 10, 59–60, 1864

Group	a	No.	b	No.	c	No.	d	No.	e	No.
	N	6	P	13	As	26	Sb	40	Bi	54
	O	7	S	14	Se	27	Te	42	Os	50
	Fl	8	Cl	15	Br	28	I	41	—	—
	Na	9	K	16	Rb	29	Cs	43	Tl	52
	Mg	10	Ca	17	Sr	30	Ba	44	Pb	53

## On Relations among Equivalents, *Chemical News*, 10, 94–95, 1864

Ανώθυμα, On Relations among the

Equivalents, *Chemical News*, 7, 70–72, 1863

No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.				
H	1	F	8	Cl	15	Co & Ni	22	Br & Ni	22	Pd	36	I	42	Pt & Ir	50
Li	2	Na	9	K	16	Cu	23	Rb	30	Ag	37	Cs	44	Os	51
G	3	Mg	10	Ca	17	Zn	24	Sr	31	Cd	38	Ba & V	45	Hg	52
Bo	4	Al	11	Cr	19	Y	25	Ce & La	33	U	40	Ta	46	Tl	53
C	5	Si	12	Ti	18	In	26	Zr	32	Sn	39	W	47	Pb	54
N	6	P	23	Mn	20	As	27	Di & Mo	34	Sb	41	Nb	48	Bi	55
O	7	S	14	Fe	21	Se	28	Ro & Ru	35	Te	43	Au	49	Th	56

*Chemical News, 13, 113–114, 1866*

- 65 στοιχεία, αρίθμηση κατά αύξον a.w.
- δεν έτυχε καλής αποδοχής
- η ανακάλυψη των ευγενών αερίων τον δικαίωσε
- ο Mendeleev θεώρησε τη συνεισφορά του μεγαλύτερη από του Lothar Meyer
- βραβείο Davy 1887



# William Odling

1829 – 1921



- 1864: δημοσίευση με 57 από τα 60 γνωστά στοιχεία
- Δούλεψε ανεξάρτητα από τον Newlands
- Διαπίστωσε περιοδικότητα με διαφορά a.w. 16
- Διαχωρισμός ορισμένων στοιχείων με βάση τις διαφορές στα a.w. (Zn, Cd μαζί, χωριστά το Mg)

			Ro 104	Pt 197
			Ru 104	Ir 197
			Pd 106.5	Os 199
.....H 1	"	"	Ag 108	Au 196.5
"	"	Zn 65	Cd 112	Hg 200 .....
.....L 7	"	"	"	Tl 203
G 9	"	"	"	Pb 207 .....
...B 11	Al 27.5	"	U 120	"
C 12	Si 28	"	Sn 118 .....	" .....
...N 14	P 31	As 75	Sb 122	Bi 210
O 16	S 32	Se 79.5	Te 129 .....	"
.....F 19	Cl 35.5	Br 80	I 127	"
.....Na 23	K 39	Rb 85	Cs 133	"
Mg 24	Ca 40	Sr 87.5	Ba 137 .....	" .....
	Ti 50	Zr 89.5	Ta 138	Th 231.5
	"	Ce 92	"	"
	Cr 52.5	Mo 96	{ V 137 .....	"
	{ Mn 55		{ W 184	"
	{ Fe 56			"
	{ Co 59			"
	{ Ni 59			"
	{ Cu 63.5			"

“With what ease this purely arithmetical seriation may be made to accord with a horizontal arrangement of the elements according to their usually received groupings, is shown in the following table, in the first three columns of which the numerical sequence is perfect, while in the other two the irregularities are but few and trivial.”

On the Proportional Numbers of the Elements,  
*Quarterly Journal of Science, 1, 642–648, 1864*

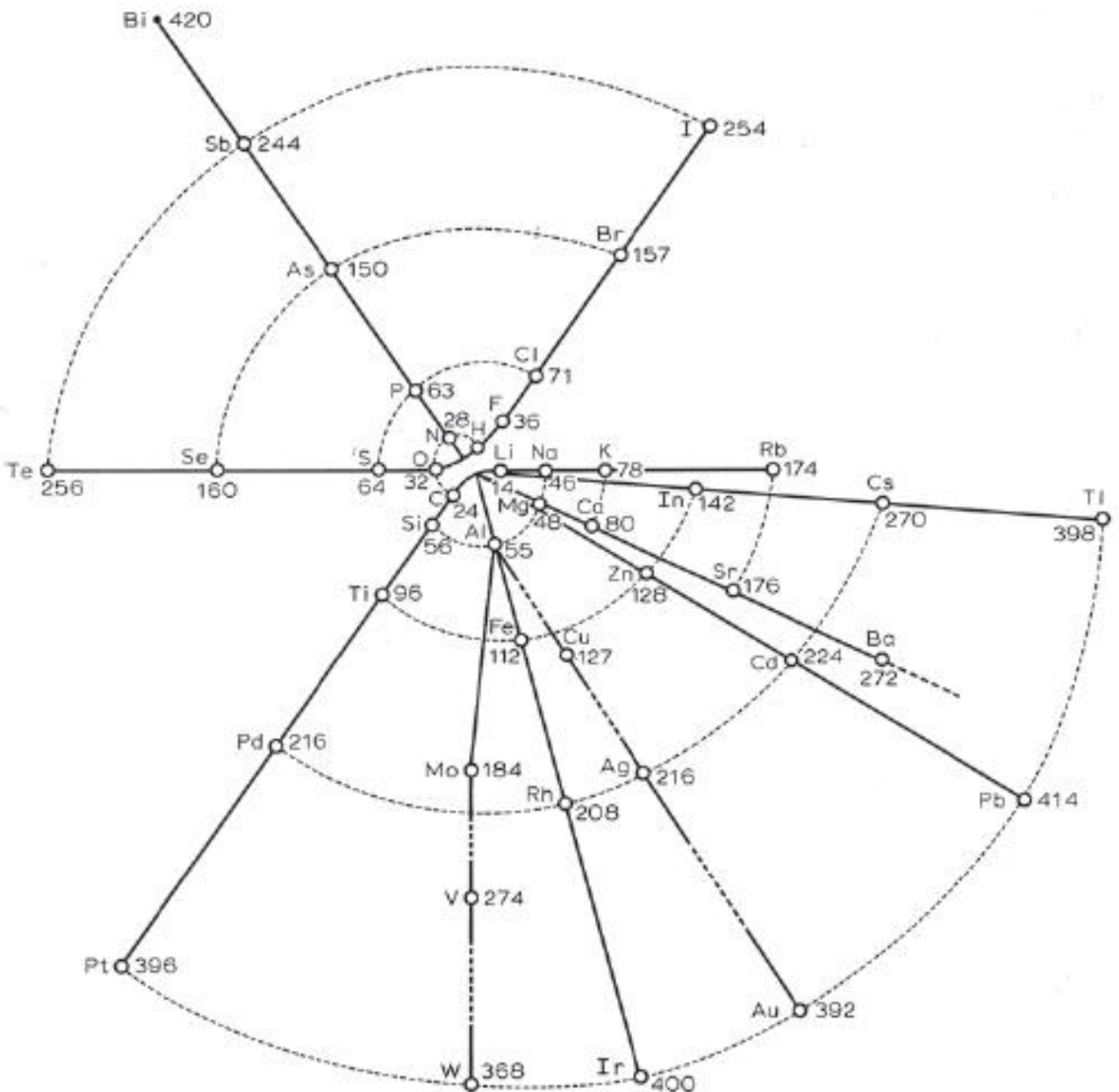
# Gustavus Detlef Hinrichs

## 1836 – 1923



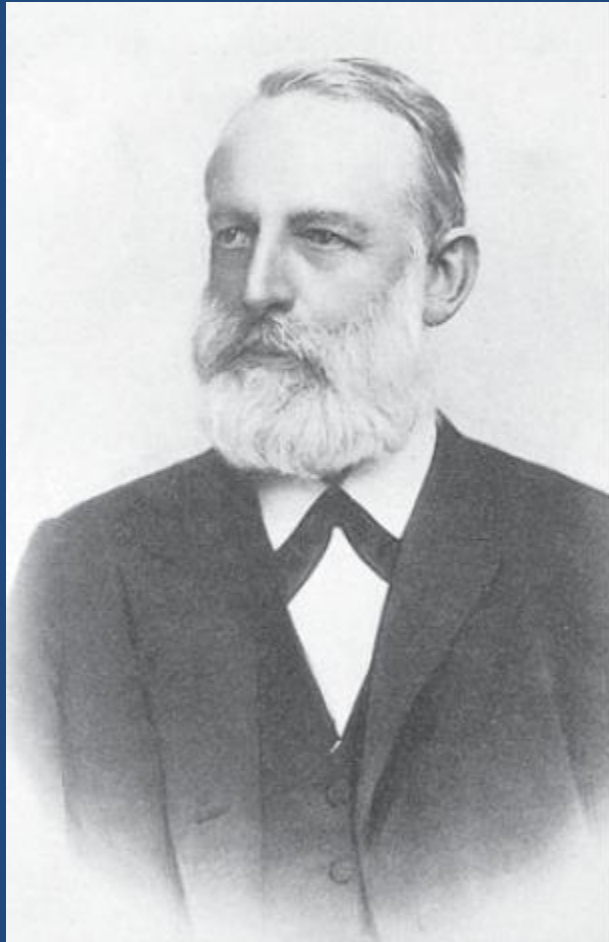
- Μελέτησε τα αποτελέσματα των Kirchoff και Bunsen
- Συνέδεσε τις μαύρες γραμμές στα φάσματα με το a.w.
- Σύνδεση a.w. με τις διαστάσεις:  $A = a \times b \times c$
- H/2 ως βασική μονάδα

G.D. Hinrichs,  
*Programm der  
 Atomechanik oder  
 die Chemie eine  
 Mechanik de  
 Pantome, Augustus  
 Hageboek, Iowa  
 City, IA,  
 1867*



# Julius Lothar Meyer

1830 – 1895

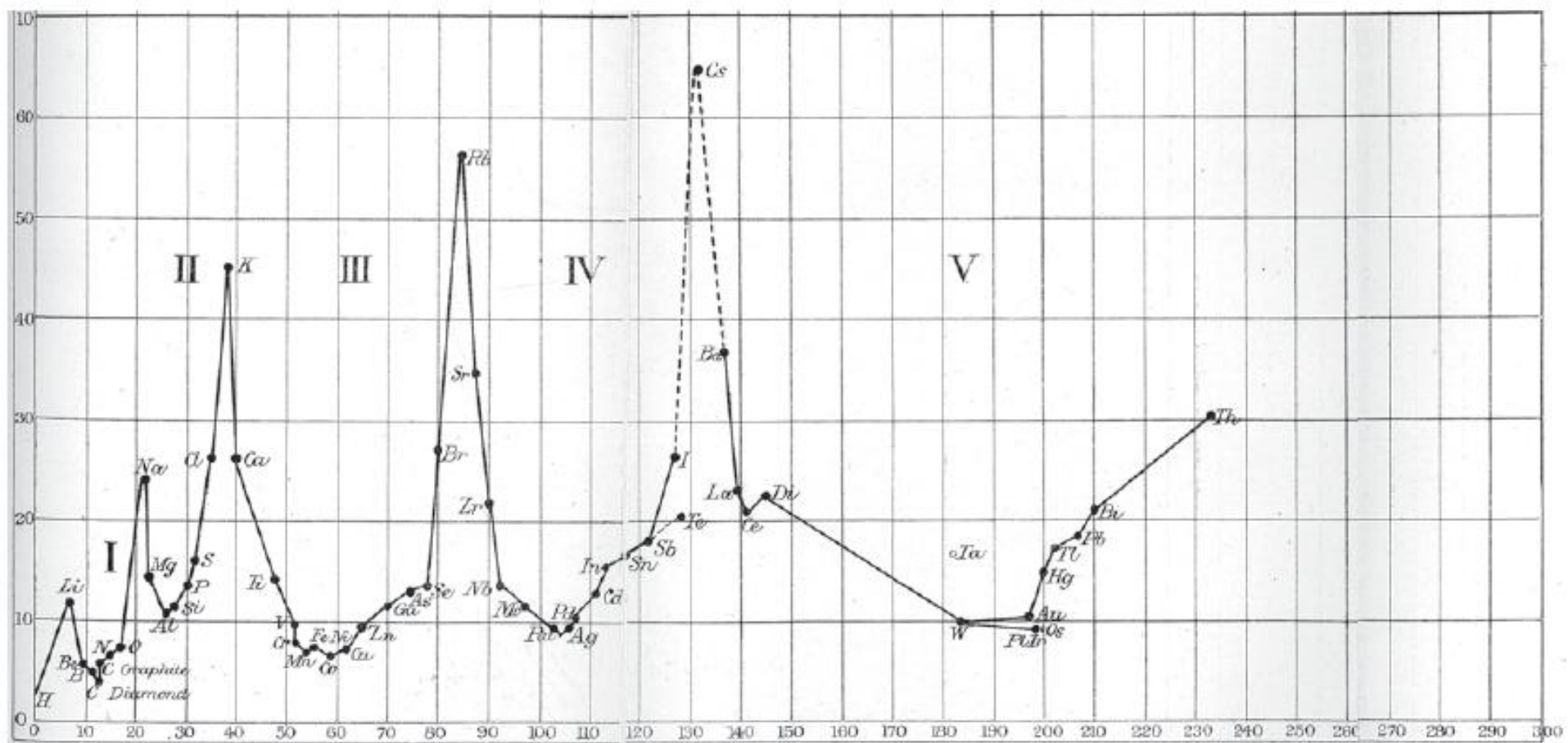


- Επηρεάστηκε από τον Cannizzaro: “The scales fell from my eyes and my doubts disappeared and were replaced by a feeling of quiet certainty.”
- 1862: στο βιβλίο του, 28 στοιχεία κατά αύξον α.ω.
- 1864: δημοσίευση άρθρου με 28 στοιχεία (οριζόντιες σχέσεις)

	4 werthig	3 werthig	2 werthig	1 werthig	1 werthig	2 werthig
	---	---	---	---	Li = 7.03	(Be = 9.3?)
Differenz =	---	---	---	---	16.02	(14.7)
	C = 12.0	N = 14.04	O = 16.00	Fl = 19.0	Na = 23.05	Mg = 24.0
Differenz =	16.5	16.96	16.07	16.46	16.08	16.0
	Si = 28.5	P = 31.0	S = 32.07	Cl = 35.46	K = 39.13	Ca = 40.0
Differenz =	$\frac{89.1}{2} = 44.55$	44.0	46.7	44.51	46.3	47.6
	---	As = 75.0	Se = 78.8	Br = 79.97	Rb = 85.4	Sr = 87.6
Differenz =	$\frac{89.1}{2} = 44.55$	45.6	49.5	46.8	47.6	49.5
	Sn = 117.6	Sb = 120.6	Te = 128.3	I = 126.8	Cs = 133.0	Ba = 137.1
Differenz =	89.4 = 2 x 44.7	87.4 = 2 x 43.7	---	---	(71 = 2 x 35.5)	---
	Pb = 207.0	Bi = 208.0	---	---	(Tl = 204?)	---

- Κατάταξη με βάση το σθένος
- Χημικές και φυσικές ιδιότητες (π.χ. Te, I)
- Πρόβλεψη Ge

J. Lothar Meyer, *Die modernen Theorien und ihre Bedeutung für die chemische Statistik, Breslau (Wroclaw), 1864*



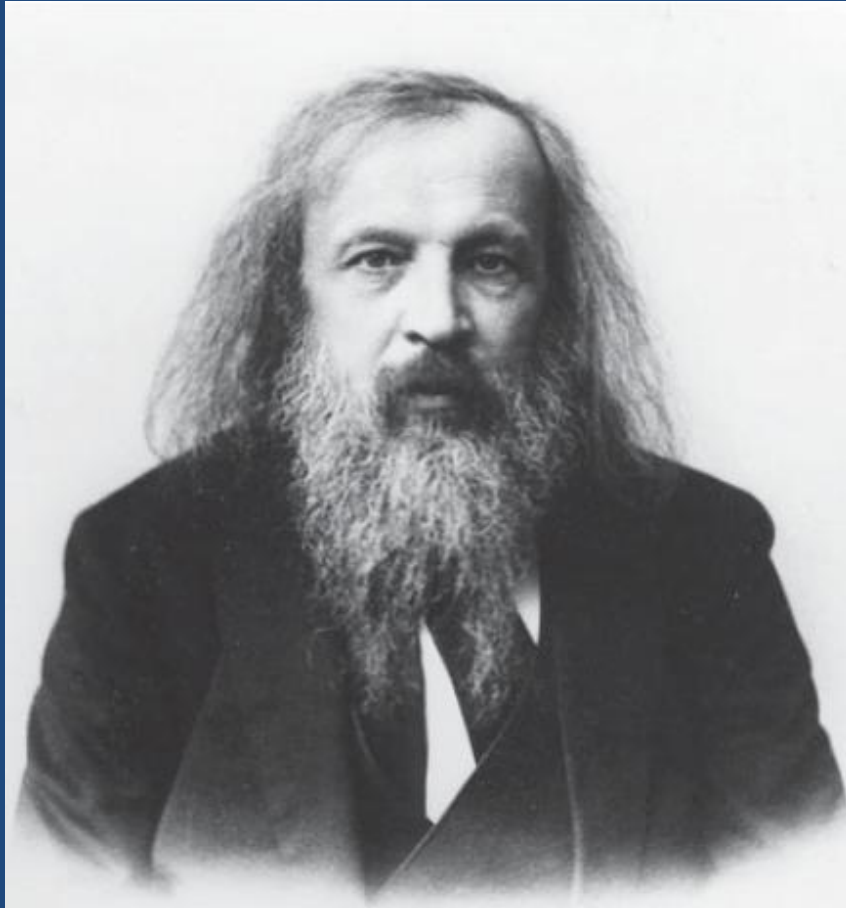
## Διάγραμμα ατομικού όγκου – ατομικού βάρους

J. Lothar Meyer, *Die Natur der Chemischen Elemente als Function ihrer Atomgewichte*, *Annalen der Chemie, Supplementband*, 7, 354–364, 1870. Redrawn by T. Bayley, *Philosophical Magazine*, 13, 26–37, 1882

Дмíтрий Ивáнович Менделéев

Dmitri Ivanovich Mendeleev

1834 – 1907



- Αρχικά ταξινόμησε τα στοιχεία με βάση το σθένος
- Ενάντιος στις τριάδες
- F, (Rb, Cs, Tm)
- Χρησιμοποίησε τα a.w. του Cannizzaro
- Δεν είναι ξεκάθαρο το πώς ξεκίνησε να σκέφτεται



Lanthanides, Gadolinium	
$\frac{42.5}{17.5}$ <hr/> 33	$E_n = 56.3$ $Z_n = 59.9 \quad Z' = 0$ $n = 72.25$ $\Sigma_n = 100$
2.707	$Li = 0.01$
4.401	$Be = 0.02$
6.941	$B = 0.04$
9.012	$C = 0.08$
12.011	$N = 0.14$
16.000	$O = 0.24$
19.003	$F = 0.32$
23.006	$Ne = 0.48$
27.023	$Na = 0.70$
30.974	$Mg = 1.00$
35.463	$Al = 1.40$
39.948	$Si = 2.00$
44.956	$P = 2.70$
49.987	$S = 3.50$
55.937	$Cl = 4.50$
62.940	$Ar = 6.00$
68.933	$K = 8.00$
72.640	$Ca = 10.00$
78.940	$Sc = 14.00$
85.468	$Ti = 18.00$
91.224	$V = 24.00$
98.043	$Cr = 32.00$
106.42	$Mn = 42.00$
114.41	$Fe = 54.00$
120.409	$Ni = 70.00$
127.305	$Cu = 90.00$
134.467	$Zn = 120.00$
140.908	$Ga = 160.00$
147.06	$Ge = 210.00$
153.938	$As = 280.00$
160.928	$Se = 370.00$
167.927	$Br = 490.00$
174.967	$Kr = 660.00$
181.938	$Rb = 880.00$
188.906	$Sr = 1200.00$
196.967	$Y = 1600.00$
204.038	$Zr = 2100.00$
210.986	$Nb = 2800.00$
218.975	$Mo = 3700.00$
226.045	$Ta = 4900.00$
233.039	$W = 6600.00$
241.037	$Re = 8800.00$
248.077	$Os = 12000.00$
256.086	$Ir = 16000.00$
264.101	$Pt = 21000.00$
272.107	$Au = 28000.00$
280.127	$Hg = 37000.00$
288.107	$Tl = 49000.00$
296.159	$Pb = 66000.00$
304.064	$Bi = 88000.00$
312.044	$Po = 120000.00$
320.076	$At = 160000.00$
328.069	$Ac = 210000.00$
336.153	$Th = 280000.00$
344.215	$Pa = 370000.00$
352.084	$U = 490000.00$
360.054	$Np = 660000.00$
368.042	$Pu = 880000.00$
376.047	$Am = 1200000.00$
384.063	$Cm = 1600000.00$
392.091	$Bk = 2100000.00$
400.122	$Cf = 2800000.00$
408.156	$Es = 3700000.00$
416.153	$Fm = 4900000.00$
424.103	$Md = 6600000.00$
432.077	$Nu = 8800000.00$
440.065	$Pm = 12000000.00$
448.066	$Lr = 16000000.00$

- 17 Φεβρουαρίου 1869
- Τύπωσε και διένειμε 200 αντίτυπα του συστήματός του
- Προέβλεψε “many yet unknown elements e.g. elements analogous to aluminum and silicon with a.w. 65 – 75”

Typische Elemente

H = 1	Li = 7
	Be = 9,4
	B = 11
	C = 12
	N = 14
	O = 16
	F = 19

Na = 23
Mg = 24
Al = 27,3
Si = 28
P = 31
S = 32
Cl = 35,5

K = 39	Rb = 85	Cs = 133	—	—
Ca = 40	Sr = 87	Ba = 137	—	—
—	? Yt = 88?	? Di = 138?	Er = 178?	—
Ti = 48?	Zr = 90	Co = 140?	? La = 180?	Tb = 231
V = 51	Nb = 94	—	Ta = 182	—
Cr = 52	Mo = 96	—	W = 184	U = 240
Mn = 55	—	—	—	—
Fe = 56	Ru = 104	—	Os = 195?	—
Co = 59	Rh = 104	—	Ir = 197	—
Ni = 59	Pd = 106	—	Pt = 198?	—
Cu = 63	Ag = 108	—	Au = 199?	—
Zn = 65	Cd = 112	—	Hg = 200	—
—	In = 113	—	Tl = 204	—
—	Sn = 118	—	Pb = 207	—
As = 75	Sb = 122	—	Bi = 208	—
Se = 78	Te = 125?	—	—	—
Br = 80	J = 127	—	—	—

D.I. Mendeleev, Sootnoshenie svoistv s atomnym vesom elementov,  
*Zhurnal Russkeo Fiziko-Khimicheskoe Obshchestv*, 1, 60–77, 1869

### Mendeleev's Spiral Table of 1869

Li	Na	K	Cu	Rb	Ag	Cs	—	Tl
7	23	39	63.4	85.4	108	133	—	204
Be	Mg	Ca	Zn	Sr	Cd	Ba	—	Pb
B	Al	—	—	—	Ur	—	—	Bi?
C	Si	Ti	—	Zr	Sn	—	—	—
N	P	V	As	Nb	Sb	—	Ta	—
O	Si	—	Se	—	Te	—	W	—
F	Cl	—	Br	—	J	—	—	—
19	35.5	58	80	100	127	160	190	220

23 Αυγούστου 1869

D.I. Mendeleev, *Zhurnal Russkeo Fiziko-Khimicheskoe  
Obshchestvo*, 1, 60–77, 1869

MENDELÉEFF'S TABLE I.—1871.

Series.	GROUP I. R <sub>2</sub> O.	GROUP II. RO.	GROUP III. R <sub>2</sub> O <sub>3</sub> .	GROUP IV. RH <sub>4</sub> . RO <sub>2</sub> .	GROUP V. RH <sub>3</sub> . R <sub>2</sub> O <sub>5</sub> .	GROUP VI. RH <sub>2</sub> . RO <sub>3</sub> .	GROUP VII. RH. R <sub>2</sub> O <sub>7</sub> .	GROUP VIII. RO <sub>4</sub> .
I .....	H=1							
2 .....	Li=7	Be=9.4	B=11	C=12	N=14	O=16	F=19	
3 .....	Na=23	Mg=24	Al=27.3	Si=28	P=31	S=32	Cl=35.5	
4 .....	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Ce=59 Ni=59, Cu=63
5 .....	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6 .....	Rb=85	Sr=87	? Y=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104 Pd=106, Ag=108
7 .....	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	I=127	
8 .....	Cs=133	Ba=137	? Di=138	? Ce=140	....	....	....	....
9 .....	....	....	....	....	....	....	....	....
10 .....	....	....	? Er=178	? La=180	Ta=182	W=184	....	Os=195, In=197 Pt=198, Au=199
11 .....	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	....	....	
12 .....	....	....	....	Th=231	....	U=240	....	....

Estestvennaya sistema elementov i primenie ee k ukazaniyu svoistv neotkrytykh elementov, *Zhurnal Russkeo Fiziko-Khimicheskoe Obshchestvo*, 3, 25–56, 1871.

										even elements						
										I	II	III	IV	V	VI	VII
										H						
										Li	Be	B	C	N	O	F
										Na						
even elements								odd elements								
I	II	III	IV	V	VI	VII	VIII	I	II	III	IV	V	VI	VII		
—	—	—	—	—	—	—		—	—	—	—	—	—	—		
K	Ca	—	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	—	—	—	—
Rb	Sr	Yt	Zr	Nb	Mo	—	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	J
Cs	Ba	La	Ce	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	Er	Di?	Ta	W	—	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	—	—
—	—	—	Th	—	U	—	—	—	—	—	—	—	—	—	—	—

Redrawn from D.I. Mendeleev, *Chemical News*, 40, 231–232, 231

# Antonius van den Broek

1870 – 1926



1913: πρότεινε τα  
στοιχεία να  
κατατάσσονται με  
βάση το πυρηνικό  
τους φορτίο

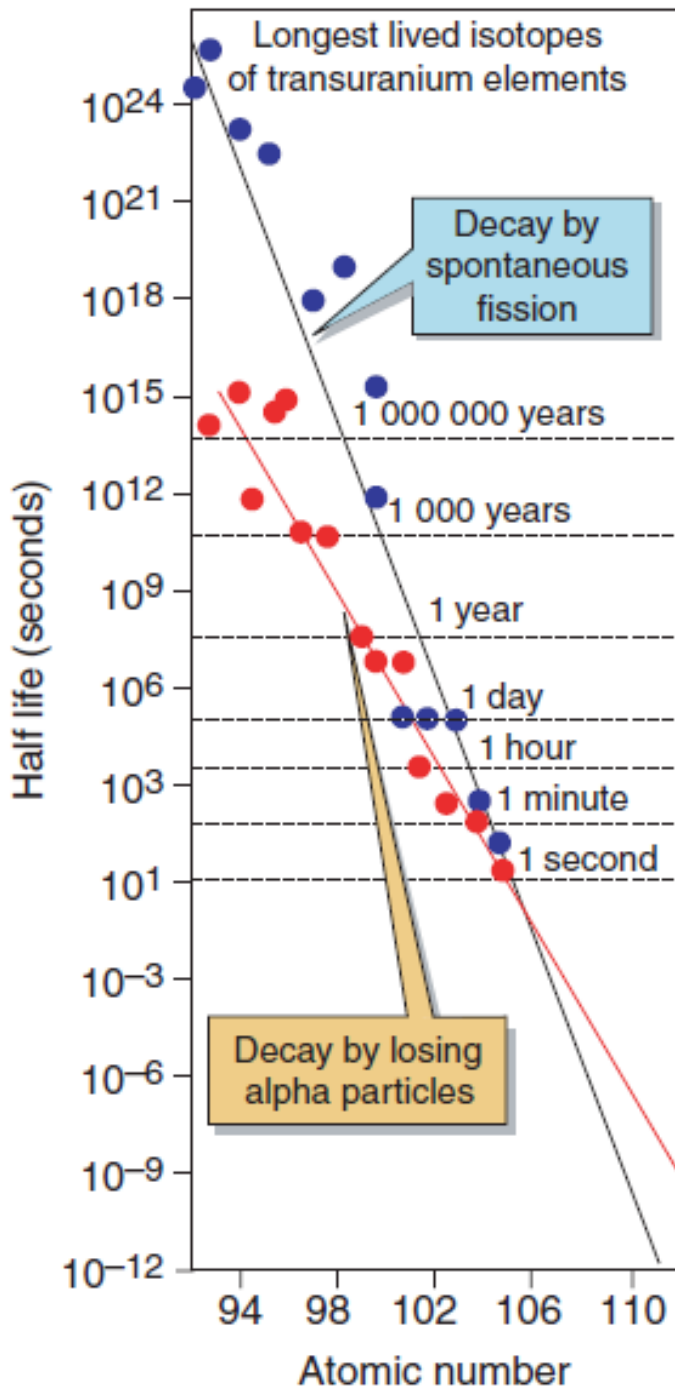
# Henry Gwyn Jeffreys Moseley

## 1887 – 1915



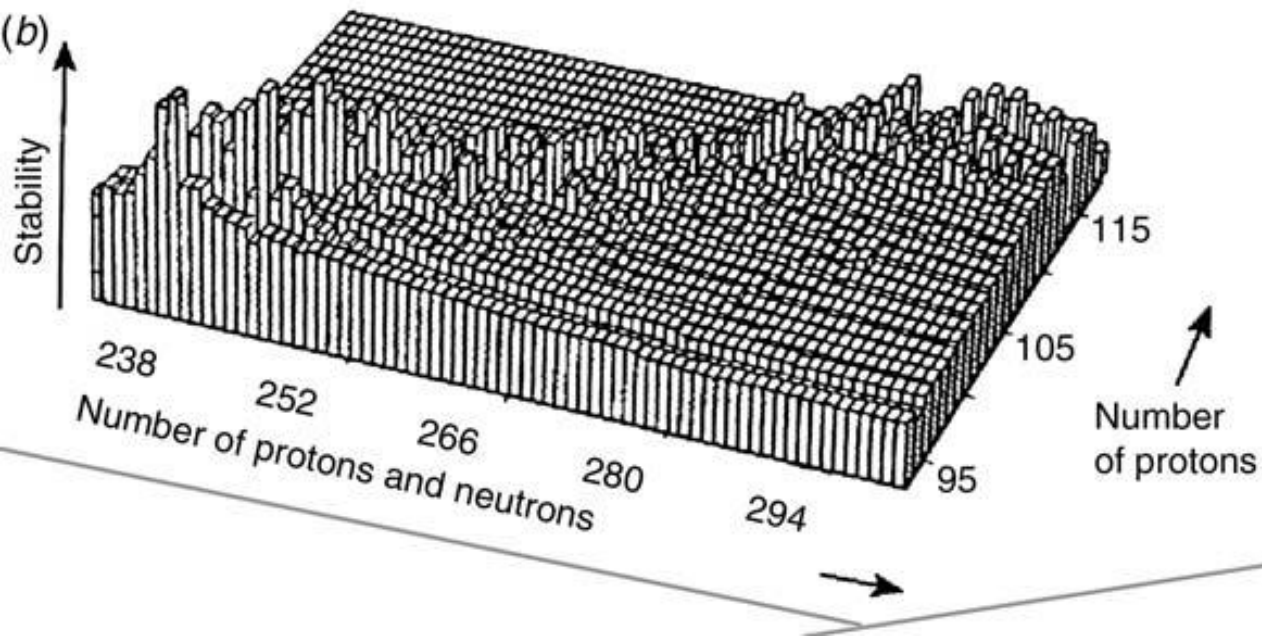
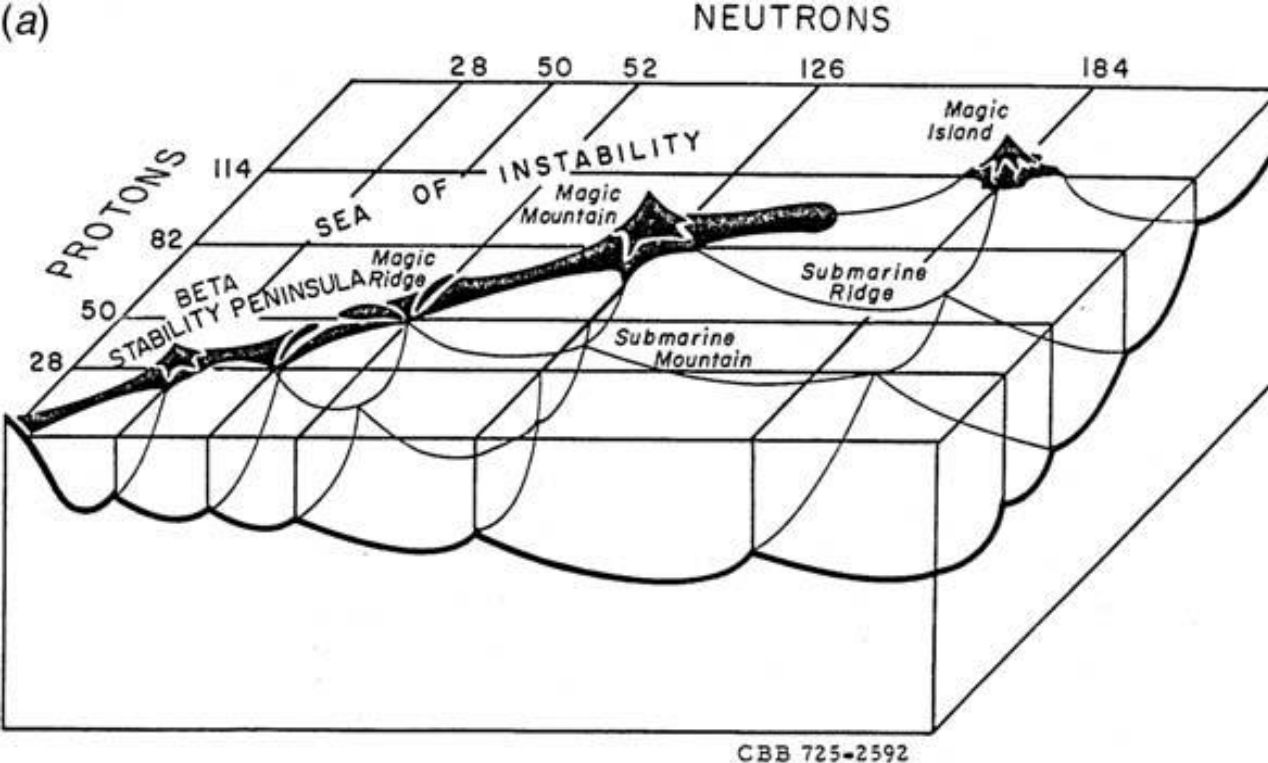
Η συχνότητα των Κ-  
γραμμών στο φάσμα  
κάθε στοιχείου  
ανάλογη με το  
τετράγωνο του  
ακεραίου που  
αντιστοιχεί στη θέση  
του στοιχείου στον  
Π.Π.

# Μέλλον (;)



- Ως το 1970:  $Z_{\max.}=108$
- Αρχές 1970: προβλέφθηκε σταθερότητα για  $Z=114$  και  $N=184$
- Superheavy elements:  
 $t_{1/2} \approx$  ηλικία του σύμπαντος





# Νήσος Σταθερότητας

- g-block
- Δεν υπάρχουν στη φύση
- Όχι νήσος
- Πιο σταθερός:  $Z=112$ ,  $N \sim 184$ ,  $\alpha$ -decay με  $t_{1/2} \approx 20$  d
- Δυσκολίες στη σύνθεση

1	1 H	2																13	14	15	16	17	2 He	1s
2	3 Li	4 Be																5 B	6 C	7 N	8 O	9 F	10 Ne	2s2p
3	11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	3s3p					
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	4s3d4p					
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	5s4d5p					
6	55 Cs	56 Ba	57- 71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	6s5d6p					
7	87 Fr	88 Ra	89- 103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113	114	115	116	117	118	7s6d7p					
8	119	120	121-	156	157	158	159	160	161	162	163	164	139	140	169	170	171	172	8s7d8p					
9	165	166											167	168					9s9p					

6	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	4f
7	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	5f
8	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	6f

8	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	5g
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