With the Compliments and best Respects

of the Author.

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XII.

GEOMETRICAL ILLUSTRATIONS OF NEWLANDS' AND MENDELEJEFF'S PERIODIC LAW OF THE ATOMIC WEIGHTS OF THE CHEMICAL ELEMENTS. By REV. SAMUEL HAUGHTON, M.D. (Plates IV.–VIII.)

[**Abstract.**]

PART I.—THE FIRST AND SECOND PERIODS OF SEVEN ELEMENTS FOLLOWING HYDROGEN; OR, *THE CARBON-SILICON DOUBLE PERIOD.*

[Read April 28, 1888.]

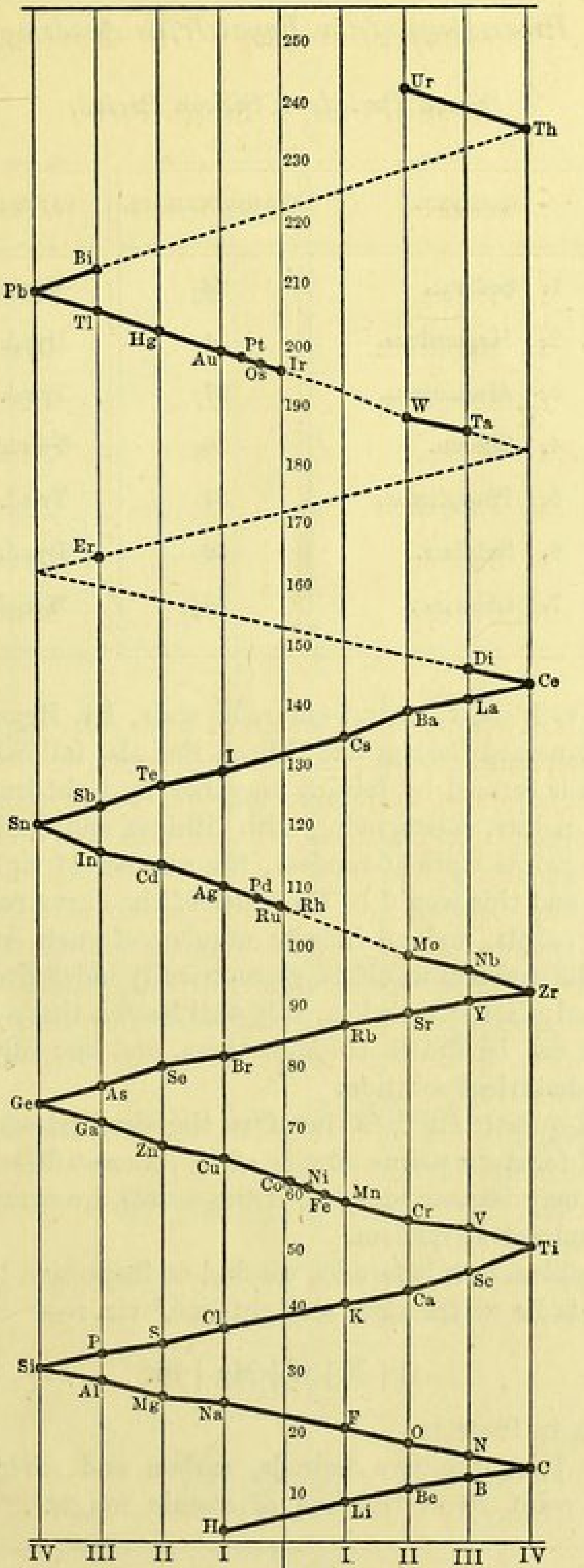
I assume on the part of my readers a general knowledge of Newlands' *Law of Octaves*, of Mendelejeff's *Periodic Law*, and of Reynolds' graphic representation of the results arrived at by their successors on this remarkable subject.

I reproduce, in Plate IV., with Dr. Reynolds' permission, the most recent graphic representation of the Periodic Law.

In this diagram the elements are plotted according to their atomic weights and valencies; the vertical co-ordinates being atomic weights, and the horizontal co-ordinates being valencies, counted (for convenience of plotting) positive or negative, according as the element belongs to an odd or even period of seven.

First Period, or Carbon Period.

ELEMENT.	ATOMIC WEIGHT.	VALENCY.
1. Lithium.	7	Monad.
2. Beryllium.	9	Dyad.
3. Boron.	11	Triad.
4. Carbon.	12	Tetrad.
5. Nitrogen.	14	Triad.
6. Oxygen.	16	Dyad.
7. Fluorine.	19	Monad.



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Cr
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Ti
Sc
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K
Cl
S
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Si
Al
Mg
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F
O
N
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B
Be
Li
H
IV III II I I II III IV
DIAMAGNETIC PARAMAGNETIC

Second Period, or Silicon Period.

ELEMENT.	ATOMIC WEIGHT.	VALENCY.
1. Sodium.	23	Monad.
2. Magnesium.	24	Dyad.
3. Aluminium.	27	Triad.
4. Silicon.	28	Tetrad.
5. Phosphorus.	31	Triad.
6. Sulphur.	32	Dyad.
7. Chlorine.	$35\frac{1}{2}$	Monad.

In Plate v. I show, on an enlarged scale, Dr. Reynolds' diagram for the above-named Carbon and Silicon Periods, following hydrogen. This diagram is formed by joining together by right lines the successive fourteen points, commencing with lithium and ending with chlorine. If the points were at random, the number of right lines would be thirteen; and this would be the order of the curve passing through the fourteen points, and an infinite number of such curves could be drawn, and the problem would be geometrically indefinite. The points being supposed placed at random, it is well known that a single general quartic curve can be drawn through them, and one only, thus giving an unique geometrical solution.

A general quartic curve is therefore the simplest solution that the collocation of fourteen points admits of in its most difficult form; but this solution may become simpler, if the points are arranged by a law or method, and not at random.

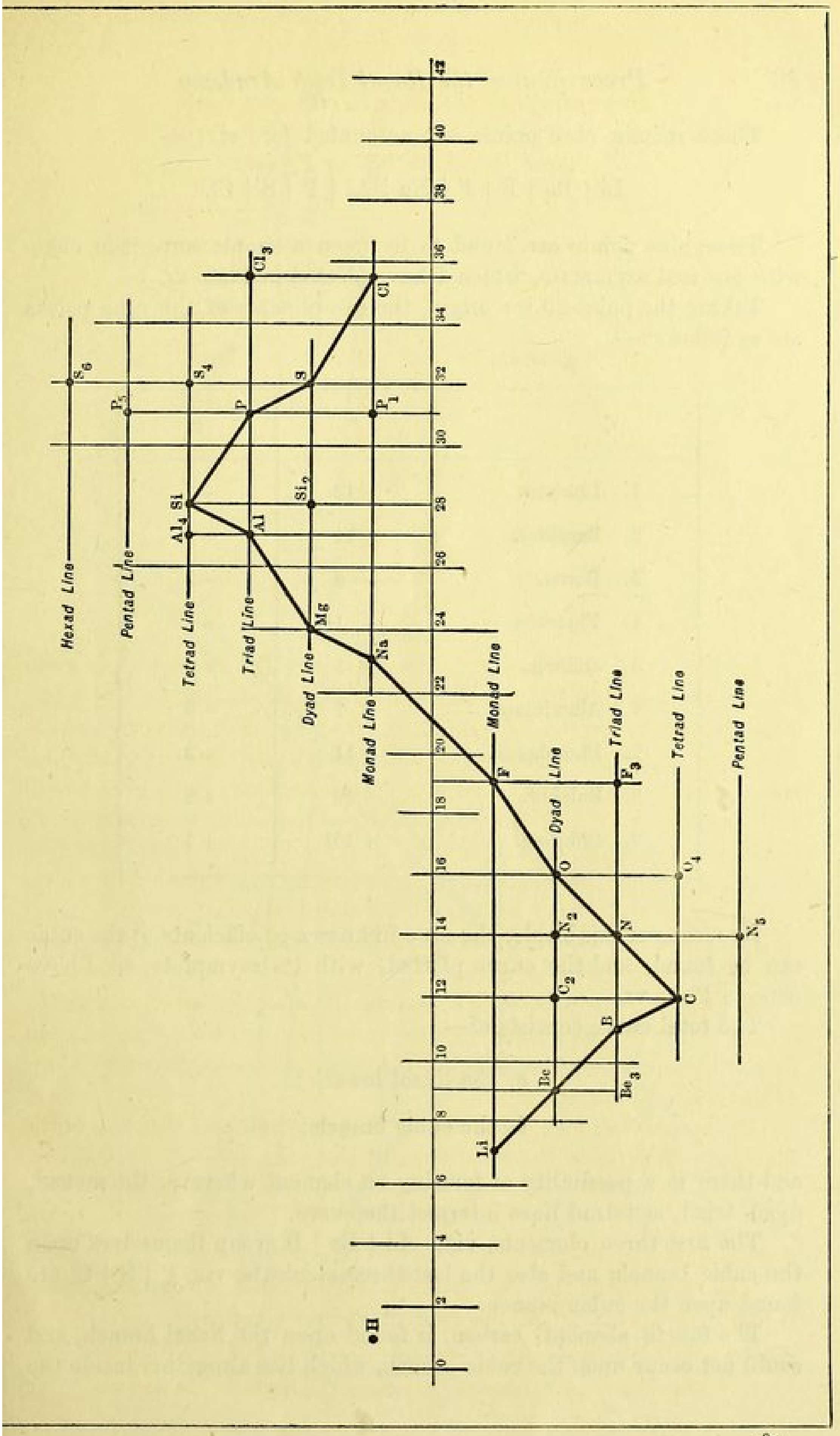
In the problem now before us, we find on inspection that five of the fourteen points lie on the same straight line,[1] viz.:—

C | N | O | Mg | Si.

This is shown in Plate vi.

This line joins the two tedrads, carbon and silicon, and passes through the point 20 of the line of atomic weights.

[1] The chances are millions to one against this happening at random.


Hexad Line
Pentad Line
Tetrad Line
Triad Line
Dyad Line
Monad Line
Monad Line
Dyad Line
Triad Line
Tetrad Line
Pentad Line
H
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Be_3
B
C
C_2
C_4
N
N_2
N_5
O
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F_3
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Mg
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Al_4
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There remain nine points not accounted for, viz.:—

Li | Be | B | F | Na | Al | P | S | Cl.

These nine points are found to lie upon a simple serpentine cubic with one real asymptote, which I have plotted in Plate VI.

Taking the point 20 for origin, the co-ordinates of the nine points are as follows:—

	x	y
1. Lithium.	− 13	− 1
2. Beryllium.	− 11	− 2
3. Boron.	− 9	− 3
4. Fluorine.	− 1	− 1
5. Sodium.	+ 3	+ 1
6. Aluminium.	+ 7	+ 3
7. Phosphorus.	+ 11	+ 3
8. Sulphur.	+ 12	+ 2
9. Chlorine.	+ 15½	+ 1

By means of this Table, the nine unknown co-efficients of the cubic can be found, and the curve plotted, with its asymptote, as I have done in Plate VI.

The total curve consists of—

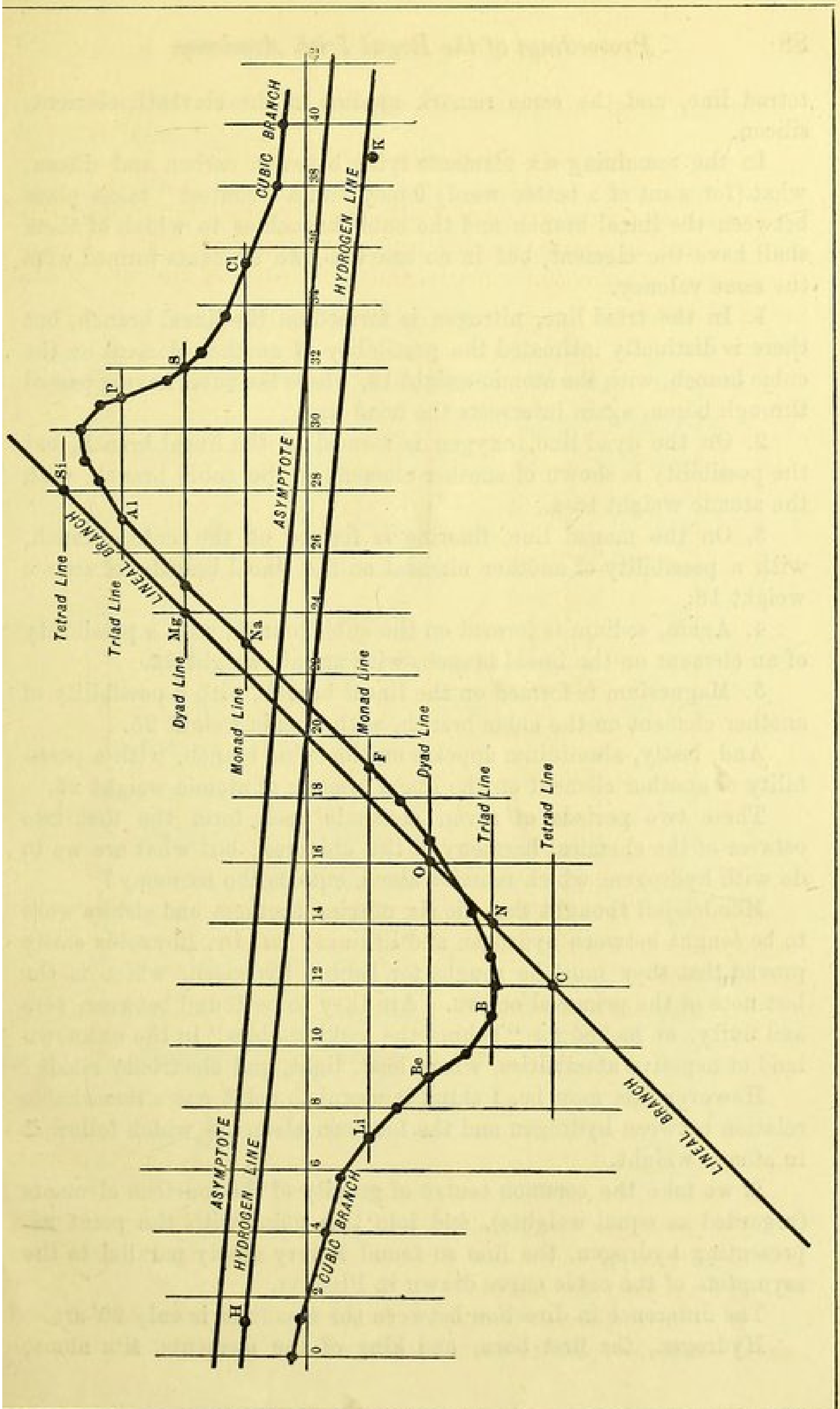
a. the lineal branch;

b. the cubic branch;

and there is a possibility of forming an element wherever the monad, dyad, triad, or tetrad lines intersect the curve.

The first three elements, viz.—Li | Be | B group themselves upon the cubic branch, and also the last three elements, viz. P | S | Cl are found upon the cubic branch.

The fourth element, carbon, is found upon the lineal branch, and could not occur upon the cubic branch, which lies altogether inside the


CUBIC BRANCH
HYDROGEN LINE
ASYMPTOTE
LINEAL BRANCH
Tetrad Line
Triad Line
Dyad Line
Monad Line
H
Li
Be
B
C
N
O
F
Na
Mg
Al
Si
P
S
Cl
K
0
2
4
6
8
10
12
14
16
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22
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tetrad line, and the same remark applies to the eleventh element, silicon.

In the remaining six elements lying between carbon and silicon, what (for want of a better word) I may call a "contest" takes place between the lineal branch and the cubic branch as to which of them shall have the element, but in no case are two elements formed with the same valency.

1. In the triad line, nitrogen is formed on the lineal branch, but there is distinctly intimated the possibility of another element on the cubic branch, with the atomic weight 13, where the cubic having passed through boron, again intersects the triad line.

2. On the dyad line, oxygen is formed on the lineal branch, but the possibility is shown of another element on the cubic branch, with the atomic weight 16·4.

3. On the monad line, fluorine is formed on the cubic branch, with a possibility of another element on the lineal branch, of atomic weight 18.

4. Again, sodium is formed on the cubic branch, with a possibility of an element on the lineal branch, with atomic weight 22.

5. Magnesium is formed on the lineal branch, with a possibility of another element on the cubic branch, with atomic weight 25.

And, lastly, aluminium appears on the cubic branch, with a possibility of another element on the lineal branch, of atomic weight 26.

These two periods of seven elements each form the first two octaves of the chemical harmony of the universe; but what are we to do with hydrogen, which remains alone, outside the harmony?

Mendelejeff thought that his six missing brothers and sisters were to be sought between hydrogen and lithium; but Dr. Reynolds easily proved that they must be sought for behind hydrogen, which is the last note of the primeval octave. Are they to be found between zero and unity, or looked for "behind the looking-glass" in the unknown land of negative atomicities, where heat, light, and electricity reside?

However this may be, I think it useful to point out a remarkable relation between hydrogen and the fourteen elements which follow it in atomic weight.

If we take the common centre of gravity of the fourteen elements (regarded as equal weights), and join this point with the point representing hydrogen, the line so found is very nearly parallel to the asymptote of the cubic curve drawn in Plate VI.

The difference in direction between the two lines is only 20′ arc.

Hydrogen, the first born, and king of the elements, sits alone, without brothers or sisters, and seems to resemble the fabled Isis of Egyptian mythology—

Ἐγώ εἰμι πᾶν τὸ γεγονός, καὶ ὄν, και 'εσόμενον, καὶ τὸν ἐμὸν πέπλον οὐδείς πω θνητὸς ἀπεκάλυψε.

NOTE.

TABLE OF *Fifteen Elements, with Name of Discoverer and Date.*

ELEMENT.	NAME.	DATE.
1. Hydrogen.	Cavendish.	1781
2. Lithium.	Arfwedson.	1817
3. Beryllium.	Wohler.	1828
4. Boron.	Gay Lussac and Thenard.	1808
5. Carbon.	——	Prehistoric.
6. Nitrogen.	Rutherford.	1772
7. Oxygen.	Priestly.	1774
8. Fluorine.	Moissan.	1886
9. Sodium.	Davy.	1807
10. Magnesium.	Davy.	1808
11. Aluminium.	Wohler.	1828
12. Silicon.	Berzelius.	1823
13. Phosphorus.	Brandt.	1669
14. Sulphur.	——	Prehistoric.
15. Chlorine.	Scheele.	1774

PART II.—THE THIRD AND FOURTH PERIODS OF SEVEN ELEMENTS FOLLOWING CHLORINE; OR, *THE TITANIUM-GERMANIUM DOUBLE PERIOD.*

[Read May 14, 1888.]

I now proceed to the discussion of the third and fourth periods of seven elements each.

Third Period, or Titanium Period.

ELEMENT.	ATOMIC WEIGHT.	VALENCY.
1. Potassium.	39	Monad.
2. Calcium.	40	Dyad.
3. Scandium.[1]	44–45	Triad.
4. Titanium.	48	Tetrad.
5. Vanadium.	51	Triad.
6. Chromium.	52	Dyad.
7. Manganese.	55	Monad.

Fourth Period, or Germanium Period.

ELEMENT.	ATOMIC WEIGHT.	VALENCY.
1. Copper.	63	Monad.
2. Zinc.	65	Dyad.
3. Gallium (*Ekaluminium*).	69	Triad.
4. Germanium (*Eka Silicium*).	72	Tetrad.
5. Arsenic.	75	Triad.
6. Selenium.	79	Dyad.
7. Bromine.	80	Monad.

[1] The atomic weight of scandium lies between 44 and 45, but nearer to 44.

At the commencement of the year 1875 there were three unknown elements of this Table, viz. :—

Gallium, found in 1875;

Scandium, found in 1879;

Germanium, found in 1886.

And it is the glory of the Periodic Law of Modern Chemistry that it predicted (approximately) the atomic weights of these three unknown elements and their valencies, which predictions were fulfilled by the successive discovery of the unknown elements.

In Plate VII., which is a representation of the third and fourth periods of Dr. Reynolds' curve, we can see that a triad element is wanting between calcium and titanium, and both a triad and tetrad element wanting between zinc and arsenic. These missing elements were predicted and found.

It is quite true that there were three well-known elements lying between manganese and copper, viz. iron, nickel, and cobalt; but these three elements did not conform to the rules of the Periodic Law, and their places have been taken in that law by scandium, gallium, and germanium.

They were like the "three children in the oven" described by Daniel (Shadrach, Meshach, and Abednego), who refused to worship the Golden Image or Periodic Law set up by Nebuchadnezzar and the modern chemists.

I hope to show in the present Paper that iron, nickel, and cobalt are not so refractory as they appear at first sight; but, on the contrary, ready to take their proper places on the chemical curve when rightly interpreted.

An inspection of Plate VII. shows (just as we found in the former curve in the case of the tetrad elements, carbon and silicon) that the line joining the tetrad elements, titanium and germanium, contains five elements, viz.:

Ti | Va | Ca | Ga | Ge,

leaving nine elements free, which sit upon a general cubic—

K | Ca | Sc | Cr | Mn | Zn | As | Se | Br.

If we use the atomic weights and valencies of these nine elements (taking scandium = 44·3), we can find the equation of the cubic passing through these points, the form of which I have plotted in Plate VIII., and which has one real asymptote like the former cubic, but has a much more complex shape.[1] The dyad lines, both positive and negative, have a remarkable relation to the cubic curve. They are both very near the position of the horizontal tangent.

In fact, the positive dyad line intersects the cubic in three real points, viz.:—

79, 65·064, 65.

The first of these is the element selenium, and the third the element zinc, with another element almost identical with zinc in atomic weight, both points being nearly on the horizontal tangent.

The negative dyad line intersects the cubic in three real points also, viz.:—

40, 52, 56;

which represent exactly the atomic weights of the three elements—calcium, chromium, and iron.

Now, we must remember that the cubic curve was constructed without any reference to iron, or its atomic weight, and it is very remarkable to find it taking its place on the curve after chromium, and near nickel and cobalt, which are not far off the dyad line.

In fact, the cubic curve points out, by clinging to the dyad line, from 52 to 59, the possibility of forming, in that interval, a number of elements similar to each other in physical and chemical properties. These elements have been actually formed, and are—

Chromium, Iron, Nickel, Cobalt.

Excepting these four elements formed on the cubic branch of the curve, the distribution of the remaining elements, between the lineal and cubic branches, is similar to that found in the curve described in Part I.

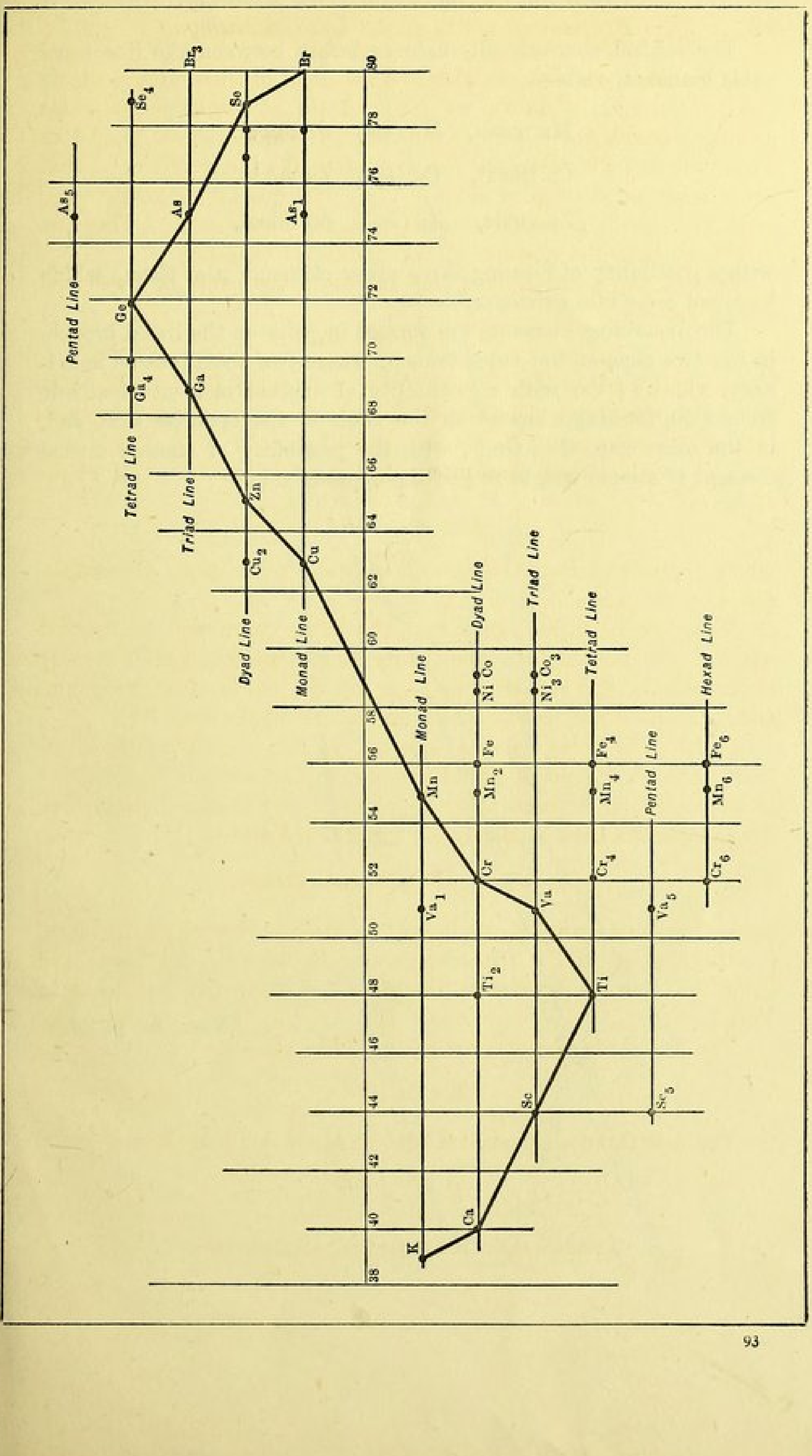
The first three elements are on the cubic, viz.—

K | Ca | Sc.

The last three elements are also on the cubic branch, viz.—

As | Se | Br.

[1] I venture to call it a serpentine 'whiplash' cubic.


Pentad Line
Tetrad Line
Triad Line
Dyad Line
Monad Line
Hexad Line
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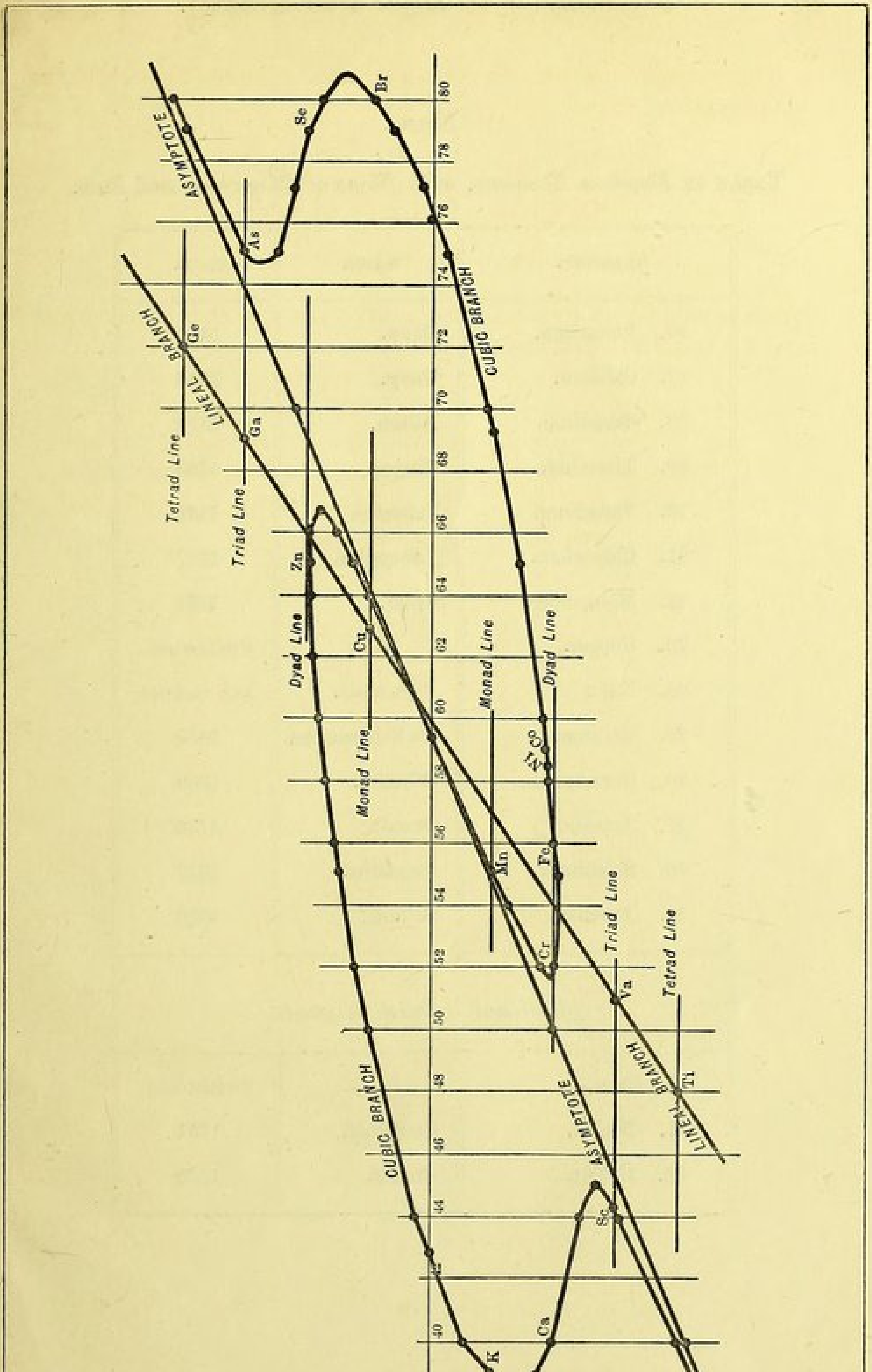
The central elements alternate as before between the lineal and cubic branches, viz.—

Mn cubic,	Mn (*bis*)	57 lineal,
Cu lineal,	Cu (*bis*)	64 cubic,
Zn cubic,	Zn (*bis*)	66 lineal,

with a possibility of forming three other elements near them, which have not come into existence.

The remaining elements are formed in pairs on the lineal branch, in the two gaps of the cubic branch, where two roots become imaginary, viz. Ti | Va, with a possibility of another element of atomic weight 50, forming a monad on the cubic at the opposite side, and, in the other gap, Ga | Ge | , with the possibility of another monad element of atomic weight 69½ at the opposite side.

[Note, see p. 96.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Note.

Table of *Fourteen Elements, with Name of Discoverer and Date.*

ELEMENT.	NAME.	DATE.
16. Potassium.	Davy.	1807
17. Calcium.	Davy.	1808
18. Scandium.	Nilson.	1879
19. Titanium.	Gregor.	1789
20. Vanadium.	Sefstrom.	1831
21. Chromium.	Vanquelin.	1797
22. Manganese.	Gahn.	1774
23. Copper.	——	Prehistoric.
24. Zinc.	Paracelsus.	xvi. century.
25. Gallium.	De Boisbaudran.	1875
26. Germanium.	Winkler.	1886
27. Arsenic.	Brandt.	1733
28. Selenium.	Berzelius.	1817
29. Bromine.	Balard.	1826
Additional Isolated Elements.		
30. Iron.	——	Prehistoric.
31. Nickel.	Cronstedt.	1751
32. Cobalt.	Brandt.	1735