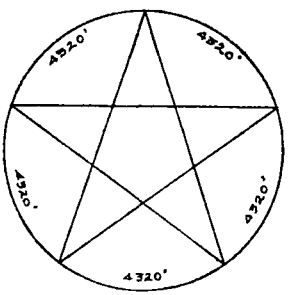
IDEAL METROLOGY

IN

NATURE, ART, RELIGION AND HISTORY,

BY

H. G. WOOD.



SYMBOL OF CONSECRATION.

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INTRODUCTION.

A DECISION based on circumstantial evidence may be confirmed, modified or wholly rejected. The court of inquiry feels its way through a tangle of facts without being able to forecast the outcome; but at the close of its investigation a judgment is reached that depends upon coincidences, which taken separately would be of little value but taken together clearly determine the result. The judgment of the court is its interpretation of the facts.

When the inquiry relates to the symbolic use of numerals many men show great distrust of any conclusion that is based on numerical coincidences. One says he can take the measures of a table and a bookcase and find any amount of such coincidences; another says these things are of no practical value; another declares that they are accidental and signify nothing, and still another says there is no historical record that the coincidences were designed.

In answer to this distrust I may frankly state that I attach no importance to a mere coincidence, taken

apart by itself, but if it belongs to a system of activities I cannot rightly interpret its meaning and purpose without duly considering the system of which it is a part. The grades, curves, sidings and signals of a railway system are as they are because they were designed so to be; they represent a business ideal of transportation. A passenger may not know the significance of a train whistle, but his life depends upon the quick action of the brakeman who understands the warning. To be of real value and mean something, coincidences must singly and collectively belong to a comprehensive system of facts which are specific revelations of homogeneous activity. Such coincidences appear in the laws of nature, the growth of plants, animals, man and human history, and in the Divine inspirations that have come to us through past ages. Numerical coincidences abound in all these departments. They are the necessary product of God's conception of what creation must be to satisfy His ideal of finite being and action, and cannot be classed as unimportant or of no practical value. What God does means something, whether it be in material or spiritual things. Every detail of His work is a necessary part of the progressive manifestation of His wisdom and love. Creation is a finite revelation of Divine ideals.

By a careful study of physical relations and the systematic coincidences that are displayed in the laws of nature we may come to understand more fully the handiwork of the Master Builder. Much of this is an open book which all may read and reverence; but to trace back to the fountain of being, the veins, arteries

and nerves of this vast system of Divinely ordered activities is a life long work of love and faith. The facts herein presented will not be questioned, but the reader will decide for himself whether to accept, modify or reject the author's interpretation; we seek only truth and right judgment.

CHAPTER I.

IDEALS IN NATURE.

THE processes of Divine activity are perfect; there is no afterthought to correct disturbed relations. Every possibility is foreseen from the beginning, and the processes continue in their appointed cycles without a fault. It is God's workmanship, the mode or way of Divine activity, to which we give the name Natural Law.

The opening chapter of the Hebrew Scriptures, or Book of Beginnings, presents a philosophy of creation and enunciates the processes, or cycles of Divine activity. The unproduced intelligent being is God. The formula of Divine activity is given in the words, Let there be light. Ages of evolution followed, and the earth, with its manifold forms of life, set in one of many solar systems, was made habitable for man. It was a product of Divine energy, thought and love, a finite exhibit of His perfection. He is its life, the life of physical relations, the all-pervading FORCE, the living Energy that inheres in the nature of things. "In Him we live and move and have our being." The study of physical laws is a study of the order and way in which God works.

Creation, as God's work, is supremely accurate in its physical relations; but as God's ideal of relations necessary to universal order and living harmony, it is supremely spiritual, a sacramental veiling of His omni-

presence. These physical relations are expressed in mathematical terms. The last analysis of natural processes reveals a mathematical law, it may be in the elliptical orbit of a planet, the pentagonal division of an apple core, the spiral growth of a vine, the form of a honey-bee's cell, or the structure of the bones, nerves, muscles, ligaments and tissues of the human body.

Ages long ago men reckoned the cycles of nature by numbers, and numbers became symbols of natural law and of spiritual ideals manifested in nature. Ancient students had a double grasp of the Divine order of things, — it was physical and spiritual. As then so now, the true study of nature is a search for Divine thought, the Divine ideal that is veiled in material forms and relations. Do the mathematical terms that express these relations reveal the ideal? The threads of a woven fabric may not separately exhibit the ideal of its design, but taken together in their orderly relation they do. If we discover intelligible relations in one department of the activities of nature we may well believe that we have touched the ideal of design; but if we find the same ideal in many departments, though modified like the instrumental variations played by the artist in executing a score of music, we may rationally believe in a unity of design coupled with a manifold purpose. The harmony is one throughout.

MUSIC.

For this study of nature we take first the harmony of music, as perhaps the most easily apprehended in numeric form. In music middle C is taken for the

standard of musical pitch. It is defined by the number of its vibrations per second. For many years that number was 256. Haydn's pitch was not so high. Music masters have found the pitch of 256 too high for the average human voice; it had been adopted to secure greater brilliancy in operatic work. The strain was too severe, and now 240 is made the international standard. Harmony in music is based on natural law; it is a mathematical law and no human power can change it. The steps from note to note are mathematical steps. Beginning with 240 for middle C, the scale is without fractions, and runs, D, 270; E, 300; F, 320; G, 360; A, 400; B, 450; C, 480. Any other scale within reach of the human voice involves fractional vibrations. We may therefore say that 240 is the natural pitch, and best suited to vocal purposes. It will be observed that all these vibration numbers are multiples of one or more of the cardinal numbers except 7 which as a numeric symbol signifies rest and in music is silent. The strong note G has 360 vibrations per second, which is a multiple of all the cardinal numbers except 7; tunes in the key of G have great vigor, but lose vitality when transposed to another key. Each key has its own effective ideal. The pathos or solemnity of a tune depends much upon the key in which it is written, while its richness depends upon the choral combination of its tones. The number of vibrations in a chord of the natural scale is a multiple of 3, as C 240, E 300, G 360, total 900. Three, the numeric symbol of harmony, was used by the ancient Greeks as the symbol of divine perfection.

A note with its octaves expresses absolute unity, for the chord is a unison. Two notes, as C and E, make a harmony, but it is by a repetition of the conjunction of sound waves. Three notes, as C, E and G, are a full chord and express the fundamental ideal of harmony. Upon this basis many chords may be produced and even the entire gamut may be comprised in one, though some of the tones will be in different octaves. Under the natural law of harmony music represents ideal harmonies of life and speaks to the responsive soul in a language full of Divine ideals. It is the voice of numbers interwoven by the law of nature to express the deepest and loftiest emotions. It comes from the rhythmic flow of the sea, the winds and the falling waters. The conscious stir of animal life enters into the chorus of song; even amidst the noise of the city's confusion its undertone is felt, in which all sounds are blended and subdued with ever changing cadences. Voices beyond the reach of human ears announce, like a breath of the Infinite, the transformation of cloud-mist into snowflakes, water and earth into growing plants, bud and flower into luscious fruit, food and water into human flesh, and star-dust into suns and worlds. There is no silence in nature save the mystic "half hour" in which the creature reverently awaits the revealed presence of the Most Holy.

COLORS.

Light is recognized as a force in nature, a necessity to reproductive life, but what it is in itself we may let faith answer. In ancient times men reverently asso-

ciated it with, or called it, Divine energy. It is the swiftest of all activities that have come within the reach of human measurement. It has a velocity of nearly 200,000 miles in a second, with a vibratory action of 30,000 to 70,000 waves in the space of one inch. In the music scale one vibration of middle C requires $\frac{1}{240}$ of a second, but the time of one wave-vibration in red is $\frac{1}{400000000000000}$ of a second. We cannot think of light as a material substance, but rather as an immaterial activity.

The solar spectrum shows that light is a compound of wave motions of different lengths, the longest waves giving the darkest shade of red, the shortest giving a grey effect. The number of waves in one inch is for red 36,000, orange 40,000, yellow 46,000, green 49,000, blue 56,000, violet 60,000, grey 70,000. If these numbers be divided by 150 we have a scale nearly identical with the numeric scale of music:

Red	36,000 ÷ 150 = 240;	C is 240	vibrations per second.
Orange	40,000 ÷ 150 = 266;	D is 270	" "
Yellow	46,000 ÷ 150 = 306;	E is 300	" "
Green	49,000 ÷ 150 = 326;	F is 320	" "
Blue	56,000 ÷ 150 = 373;	G is 360	" "
Violet	60,000 ÷ 150 = 400;	A is 400	" "
Grey	70,000 ÷ 150 = 466;	B is 450	" "

The color standards here given are the result of a practicable adjustment for commercial and artistic use. A softer shade of green, say 48,000, would make its 326 coincide with 320 in the music scale, as red 240 and violet 400 coincide with C and A. From these coincidences we infer that the ideal numeric basis of

color relations is the same as the ideal basis of musical harmony.

The relationship of color and music has other marks. Grey merges into black at the upper end of the scale, and red into darkness at the lower end. So the tones in the higher flight of octaves become silent to the human ear, as also do those of the lower octaves in their descent. Between these extremes the blending of color shades as of music-tones is unlimited except by nature's law of harmony. The greens and yellows are never misplaced in Divine workmanship. The fundamental pitch of nature's choral is 160, the sub-octave of F 320, whose twin sister in color is the softer shade of green, the topaz of pure sunlight, the regal jewel of the tribe of Judah in the Breastplate of Judgment. Color harmony is best secured by the juxtaposition of alternates in the color scale, as musical harmony is by the combination of alternate tones in the music scale. The psychological effect of color is quite analogous to that of music, so that we call the latter bright, fiery, pale, blue or somber. There is chemical activity in one as in the other. The initial gathering of a storm does not resound in our ears, and we know not the existence of the far-away stars till we see their image in the photographic touch of light, the Divine fire of the universe.

As to the characteristic motion of sound and light activity we may safely call it elliptical. If a lower note of the piano be struck from beneath the string, a distinct repetition of taps can be felt above or below, and at a less distance on the sides. The motion of the string is not purely oscillating but elliptical. As the

sound dies away the range of the vibration diminishes, and the motion of a given point on the string is a spiral. The spiral may be the ideal form of all motions in nature, for God's work is progressive, and there is no need that He ever retrace His steps. The chemistry of light may yet bring confirmation of this as a fundamental truth.

MOLECULES.

The ideal of harmony, numerically displayed in music and color, is also found in the molecular relations which chemical elements bear to one another. So far as we know they are seventy in number and are rarely found pure in nature. The law of combination is as fixed with them as it is in musical chords, every element has its unit of combination, which is called its molecular weight or equivalent. In the ascending scale of music a note's octave has double its number of vibrations. The molecular weights of the seventy elements, being arranged on the geometric scale of doubles, exhibit a remarkable likeness to the numeric octaves of music. In the table on the opposite page note vibrations are given by tenths, thus 24 represents middle C 240.

The close coincidences there displayed indicate that harmony, quite like that found in color and music, exists in the relations which chemical elements bear to one another. Since the molecular weight of one element is the proportion in which it combines with another, we may say that the activities which effect a chemical union are akin to those which make a chord in music: sometimes elements mix without union, as

COMPARATIVE TABLE

OF NOTE NUMBERS AND MOLECULAR WEIGHTS.

⅒ C equals....24	⅒ E equals....30	⅒ G♯ equals...38.4
Car. 12 12	Pho. 31 30	Flu. 19 .....19.2
Mag. 24.3.....24	Nic. 58.7.....60	—— ——.....38.4
Tit. 48.1.....48	Cob. 59	Ar. 75 .....76.8
Mol. 96 96	Tin 119 120	Gad. 156 ....153.6
Os. 191 192	Ant. 120	
Irid. 193	Ur. 239.0....240	⅒ A.....40
Plat. 194.8.....		Pot. 39.1.....40
Gold 197.2.....	⅒ F equals.....32	Arg. 39.9.....
	Hy. 1 1	Cal. 40 .....
⅒ C♯ equals...25.6	—— ——.....2	Sele. 79.1.....80
Van. 51 .....51.2	Hel. 4 4	Bro. 79.9.....
Chr. 52	Lith. 7 8	Kry. 81.8.....
Ruth. 101.7....103.2	Ox. 16 16	
Rho. 103	Sul. 32 32	⅒ A♯ equals...42.6
Pal. 106	Cop. 63.6.....64	Rub. 85.4.....85.2
Mer. 200.3....206.4	Zinc 65.4.....	Thu. 170.7....170.4
Thal. 204	Iod. 126.8....128	Yter. 173 .....
Lead 206.9.....	Xen. 128	
Bis. 208.5.....		⅒ B equals....45
	⅒ F♯ equals...34.1	Bor. 11 .....11.2
⅒ D equals....27	Caes. 133 ....136.4	Nat. 23 .....22.5
Al. 27.1.....27	Bar. 137	Scan. 44 45
Mang. 55 54	Lan. 138	Yttri. 89 90
Silver 108 108		Zir. 90.7.....
	⅒ G equals....36	Col. 94 .....
⅒ D♯ equals...28.8	Chl. 35.4.....36	Tan. 183 180
Nit. 14 .....14.4	Gal. 70 72	Tung. 184 .....
Silic. 28.4.....28.8	Ger. 72	
Iron 56 .....57.6	Ceri. 140 144	
Cad. 112.4....115.2	Neo. 140.5.....	
Ind. 114	Pras. 143.6.....	
Tho. 232 ....230.4		

discordant notes mix without harmony, and sometimes two elements require a third for a solvent, as two discordant notes become harmonious in union with another.

When two or more elements combine, it can be seen by the table that generally the notes that correspond to those elements constitute a musical chord. If the human ear could discern the sounds produced by chemical action, we might perceive a musical harmony in all forms of living growth.

The sum of the vibrations that make a chord in music is a multiple of three. In like manner the sum of the molecular weights in a chemical combination is a multiple of three; thus water is two parts hydrogen, and sixteen parts oxygen, and the molecular weight is $2 + 16 = 18$; the notes corresponding to hydrogen and oxygen in the table are sub-octaves of F. Phosphate of soda is phosphorus, oxygen and sodium; the weight is 163.8 which is a multiple of three. The molecular weight of a chemical compound of two or more elements is often a multiple of three or even nine. It is found in this way that eighty per cent. of the simple compounds are multiples of three, and correspond to musical chords. Long before the Christian era philosophers and students of nature assigned to the number three ideal perfection and harmony, and used it as a numeric symbol to represent divine perfection in the cycles of natural law.

I have traced a parallelism of activities in musical vibrations, color waves and molecular actions. In these departments of nature systematic coincidences

are unveiled which exhibit not only internal harmony in each department, but a persistent harmony between the departments, harmonies that are correctly expressed in the language of numbers. In doing this I have described and measured the movements and relations of things, not the things themselves. I do not know what hydrogen or oxygen is, — they are called gases, but in changed conditions they become liquids or solids. All gases may become liquid or solid, and all solids may become gases. To my sense and intelligence chemical elements exhibit in their manifold forms and combinations a *resident* force, the results of whose activity I can measure and define, while the force itself escapes my grasp. There is only one way in which I can postulate a satisfactory explanation of the harmony I find in the natural relations of physical phenomena: It is of God the Almighty. He is the intelligent and persistent FORCE, the LIFE of the physical universe whose manifold forms of activity we describe as Laws of Nature.

The supreme stimulant to a persistent study of nature is, not that we may see God face to face, or discover the final analysis of His activity, a feat quite beyond the reach of finite intelligence, but that we may attain to a rational knowledge of Divine ideals, and lovingly adjust our own life and action to the harmony of Divine workmanship. I would say however that the numerical correlations I have traced in physical things are but single aspects of ideals veiled in the perfection of Divine handiwork deeper and more comprehensive than we can grasp. The ideals are of God's own being

and, like Himself eternal, the imperishable thought of Divine Intelligence, of which the universe is a living manifestation.

CRYSTALS.

The physical products of nature are defined as organic and inorganic. This is not a faultless definition, for all things in nature are organized, some by generation, others by accretion. To the former belong activities involving fertility, growth, reproduction, parentage, etc.; to the latter belong concretive forces involving elemental additions according to fixed laws; minerals are of this class; nevertheless they are constantly used by life activities in the production and growth of plants and animals.

"Each mineral, with few exceptions, has its definite form, by which it may be known as truly as a dog or a cat. These forms are cubes, prisms, double pyramids and the like, called crystals, with faces arranged in symmetrical order according to mathematical law." *Dana.*

The dimensions of a fully developed crystal may be several feet or only the small fraction of an inch. A good specimen is measured by the length of its axes, of which there are three, the vertical and two others in angular relation to it and to each other. The point of their intersection is the centre of the crystal; its measurement is along the axial lines. If the crystal is a cube the axes are of equal length and perpendicular to one another. As crystals differ in form the axes may differ in length and angular relation. The innumerable forms of crystallization chiefly due to these differences may be reduced to six groups or systems.

Group.	Axis angle.	Axis length.	System.
I	90°	All equal.	Isometric.
II	90°	Two equal.	Tetragonal.
III	90°	All unequal.	Orthorhombic.
IV	90° and 90°+	All unequal.	Monoclinic.
V	90° ±	All unequal.	Triclinic.
VI	60° and 90°	Two equal.	Hexagonal.

The vibratory action of tones in the musical gamut is in close numerical relation to the action that belongs to crystal formation. This is shown by taking 24, that is, one-tenth of middle C, for a unit in the axial proportions of a crystal. In the following table the first line of each section gives the axial proportions, the second line gives the corresponding multiples of 24, and the third line gives the corresponding letters of the gamut.

AXIAL RATIOS OF CRYSTALS AND MUSICAL CHORDS.

1	1	1	1	5/3	5	1	3/2	3/2
24	24	24	24	40	120	24	36	36
C	C	C	C	A	E″	C	G	G
1	1	2	1	5/4		1	5	5
24	24	48	24	30		24	120	120
C	C	C′	C	E		C	E″	E″
1	2	4	1	2	2	1	4/3	4
24	48	96	24	48	48	24	32	96
C	C′	C″	C	C′	C′	C	F	C″
1	3/2	3	1	1	3			
24	36	72	24	24	72			
C	G	G′	C	C	G′			
1	4	4	1	3	3			
24	96	96	24	72	72			
C	C″	C″	C	G′	G′			

It is obvious that in each of the foregoing cases the letters of the musical scale are a chord. Since a crystal grows by molecular increments it is evident that it is the product of two or more forces bringing the molecules together and holding them in compact relation. When two such forces work in the same plane the crystal is sheet-like in form, but if a third force enters into the structural process the result is a solid. If all these forces are of the same kind and degree and in rectangular relation the product is a cube or some form analogous to the cube, and the crystal is isometric. If the relative activity of these forces be changed the axes become more or less unequal or inclined, and the crystal does not conform to the cubic base. From this preliminary point of view we may say that a crystal is the product of forces acting in different planes and with or without different degrees and kinds of activity, but always in accord with mathematical law.

It will be seen in the foregoing table that the axial relations of a crystal are rational and can be expressed in numeric integers. To secure such relations the forces engaged must work together harmoniously. The fundamental ideal of this harmony appears to be exhibited in the numeric proportions which the axial lengths bear to one another. The table shows that the axes of a crystal stand numerically not only in a rational but in a musical relation. Crystallization therefore is one of the many processes in the physical world which reveal the Divine ideal of harmony.

GRAVITATION.

Passing now from earth to the great solar system in which it moves, we find the numeric ideal of harmony still in force. The form of energy by which the planets are balanced in their courses is gravitation: its work can be accurately measured, but mechanical science is unable to determine what it is in itself. It is incessant and omnipresent. Like heat and light it may be termed one of the forms of Divine activity. It is the simplest of the forces of nature. No interval of time is required for the gravitating force that belongs to one body to reach another however distant. Sound does not pass through a vacuum, light is checked and heat is easily obstructed, but the force of gravitation admits of no suspension. Better than any other form of activity in the physical creation it represents the absolute unity and omnipresence of God.

In the solar system it stands in harmonious relation to another activity by which the planets are safely carried on their way. The nearer a planet is to the sun the swifter must be its motion. By diligent observation of their times and positions, the law of planetary adjustment has been discovered. It is this: — The square of the number of mean earth-solar-days in which a planet makes one revolution around the sun, divided by the cube of its mean solar distance in earth miles yields the same quotient whether the planet be more or less remote from the sun. It is Kepler's third law of motion $\frac{t^2}{d^3}$ equal to one million million millionth of .17456.

The speed of planetary motion ranges from 3 to 25 miles per second, the slowest being Neptune, the most remote from the sun, and the swiftest, Mercury. The place which a planet holds in this vast system of moving bodies is well expressed by the square root of its solar distance; for the gravitation that belongs to the sun decreases in proportion to the square of its distance from the planet. Now the space covered by the radius-vector in a given time, being the result of the balancing of the centripetal and centrifugal forces, is a constant quantity wherever a planet may be in its orbit. The radius-vector spaces for a given time determine most accurately the numerical relation which the several planets bear to one another. The given time then being one day of twenty-four hours, the spaces covered by the radius-vectors of the several planets are in the ratio of the square root of the solar distances; hence the relation which a planet bears to the solar system in its orbital motion is correctly expressed by the square root of its mean solar distance. In this way we find that the planets bear a remarkable rhythmic relation to one another. The square root of solar distances in miles, according to Lockyear, is as follows: —

Mercury	35,390,000 ;	square root =		5.95	thousand.
Venus	66,130,000 ;	"	"	8.1	"
Earth	91,430,000 ;	"	"	9.6	"
Mars	139,310,000 ;	"	"	11.8	"
Asteroids	250,000,000 ;	"	"	16.	"
Jupiter	475,690,000 ;	"	"	21.8	"
Saturn	872,130,000 ;	"	"	29.5	"
Uranus	1,753,850,000 ;	"	"	41.9	"
Neptune	2,746,210,000 ;	"	"	52.	"

Now comparing these square root numbers with the vibration numbers of the music scale by tenths, we have the following remarkably close coincidences:

Mercury.....	5.95	; C	2d	octave	below..... 6.0
		D	"	"	" 6.5
		E	"	"	" 7.5
Venus.....	8.1	; F	"	"	" 8.0
		G	"	"	" 9.0
Earth	9.6	; G♯	"	"	" 9.6
		A	"	"	" 10.0
		B	"	"	" 11.2
Mars 11.8		; C	1st	"	" 12.0
		D	"	"	" 13.5
		E	"	"	" 15.9
Asteroids.....16.		; F	"	"	" 16.0
		G	"	"	" 18.0
		A	"	"	" 20.0
Jupiter.....21.8		; A♯	"	"	" 21.3
		B	"	"	" 22.5
		C	middle		.....24.0
		D	"		.....27.0
Saturn.....29.5		; E	"		.....30.0
		F	"		.....32.0
		G	"		.....36.0
Uranus.....41.9		; A♯	"		.....42.6
		B	"		.....45.0
Neptune.....52.		; C♯	"		.....51.2

Thus the earth and its celestial companions are set in numerical harmony like that displayed in notes, colors, molecules and crystals. The activities that determine the stability of our solar system truly present an ideal harmony that belongs to creation. The accomplished singer, according to the perfection of his musical nature, does his work easily without taking count of the number of vibrations necessary to produce each

note; so God's creative work in all its physical relations is the necessary product of His perfection. That work stands before us an accomplished fact, its laws are open to human investigation, and it is in them that we may discern the Divine ideals of harmony.

The earth holds a unique place in the solar system. Its orbit is not midway between Neptune and the sun, for Neptune is more than thirty times as far as the earth from the sun; but the force of gravity diminishes so rapidly that the sun's attraction of Neptune is only $\frac{1}{900}$ of its force on the earth. By the law of gravitation it is found that the circle of mean solar gravitation is nearly coincident with the earth's orbit, so we may say that this orbit is the balancing line of the solar system, — as G is close to the mean of the vibrations that comprise the musical octave. Perhaps this is why Kepler's third law is a music numbering only when its units of measure are earth days and earth miles. We cannot regard God's work as in any way accidental. The solar system is as it is because He designed it so to be; but why He has given the earth its unique place in that system we may let faith answer.