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An Introduction to the Foundations of Chemical Information Theory. Tarski–Lesniewski Logical Structures and the Organization of Natural Sorts and Kinds

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Abstract: Organic mathematics is an applied mathematics of philosophical atomism. The order of the chemical elements in the table of elements is the source of order for the logical operations of addition and subtraction of atomic numbers. The inverse square laws of physics are the source of organization of subatomic structures of chemical atoms (atomic and molecular structures). These facts are foundational to the logic of the chemical sciences and are therefore the scientific basis for chemical information theory. The theories and facts of the chemical sciences are so perplex that several forms of symbolic representations are necessary to communicate the broad range of scientific concepts used to inquire into the nature of natural sorts and kinds. The logics proposed by Tarski, Lesniewski and Malatesta are applied to the construction of a numerical “spine” of perplex numbers representing atomic numbers as meta-symbols in meta-languages. The orbital angular momenta of certain collections of electrical particles (also known as “handedness”) are critical components in constructing the logical propositions of the perplex number “spine”. Biological communication channels can function if and only if the natural sorts and kinds are consistent with the matching patterns of the optical isomers. The terms spinners and twisters are introduced to express the electro-mechanical torques necessary for encoding chemical information. This hypothesis can be tested by several categories of experiments, including clinical pharmaco-dynamics and clinical toxico-dynamics of dissymmetric isomers of different sorts and kinds.

Keywords: chemical information; perplex numbers; communication; natural kinds; constructionism; hybrid logic; Tarski logic; Lesniewski logic; semiosis; emergence

1. Introduction

The foundational philosophical principles of the natural sciences are vigorously debated among philosophers and metaphysicians. Each scientific discipline offers foundational principles consistent with its logical development, as well as its relation to other scientific disciplines, generating a manifold of interrelated, intertwined, and interlaced, but nevertheless, plausible conjectures. However, the phenomenological facts of the sciences are logically interrelated into perplex patterns of natural sorts and kinds [1,2]. Occasionally, the facts of nature are simply and superficially related by simple “linear” geometric concepts that relate physical units to mathematical functions. Examples of the natural simplicity of nature are such classical physical equations as $F = MA$, $V = IR$, and $PV = nRT$. These simple symbolic representations of physical geometries of artificial phenomena are extraordinary powerful and economically fecund. However, such mathematical regularity in nature is relatively rare and sharply constrained to a narrow range of scale that limits the meanings of the logic to a natural granularity bounded by Pythagoreanism. Natural systems, such as chemical and biological

systems, exhibit highly irregular patterns, dissymmetries not addressed by the prevailing “symmetric” theories of physics. Organic mathematics, the applied mathematics of abstract semiology, will be used to introduce a formal view of chemical information theory that embraces the ampliative logic of the natural dissymmetries of animate forms, including isomerism, handedness and other physical phenomena.

This paper is an inquiry into the ampliative logic necessary for the emergence of irregularity of perplex systems from the regularity of mathematical–physical principles. In order to pursue this objective of relating the inanimate to the animate, a synthesis of logical forms (from the very small to the very large) as pragmatically used in the natural sciences, is essential. The emergent synthesis to be described in this paper draws on the formal and informal logics of multiple disciplines. The acute focus is on the re-conceptualization of scientific knowledge within the logical meanings of scientific notations as relatives of one-another, rather than the Pythagorean hegemony of geometric forms and physical laws. Malatesta, in a simple and consistent manner, articulates the historical development of the meanings of logical notations from ancient to modern times [3]. More recently, Beziau has summarized some of the operational constraints on the categorical meaning of logic itself [4]. Molecular biology invokes a form of hybrid logic of Brauner [5]. The historical linkages between logical and geometric diagrams are clearly summarized by Greaves [6]. The synthesis of the physical logic of electrical number theory is developed from electromagnetic structures first proposed by Rutherford and Moseley [7]. Chemical signs and chemical semiosis are interpreted in terms of an elaborate semantic framework developed by C. S. Peirce in the late 19th Century and the logic of several forms of mathematical graphs, including the labelled bipartite graph theory of Chandler [1]. The reader should be aware of the earlier lengthy discussion of aspects of the chemical constraints on algebraic biology and the algebraic constraints on chemical logic [2]. A relevant philosophical/historical analysis of emergence is described by Blachowicz [8].

This novel form of the logical consistency of organic mathematics among multiple disciplines is generated from the concepts of two early twentieth century Polish logicians, Alfred Tarski (1901–1983) and Stanislaw Lesniewski (1886–1939). In “The Primary Logics”, Malatesta concisely frames the semantic threads linking the logical symbol systems of the natural sciences to the meta-languages of Tarski [3]. Lesniewski’s part-whole relations between intra-disciplinary terminologies bridges the emergent gap between the meta-languages and the emergent meta-symbol systems of the chemical and biomedical sciences. By combining formal concepts from number theory and biochemical theory, I seek a synthesis of the forms of symbolic logics with forms of scientific symbols to generate a theory of chemical information that can construct the forms of the animate from the inanimate.

One ur-concept of this proposed ampliative logic is the synthesis of logical diagrams from the counts of sub-atomic particles. Relations between the magnitudes of electromagnetic particles are counted in terms of the perplex number system, a graphic logic inspired by biochemical facts [9]. The physical conservation laws for mass and electricity and the inverse square laws severely constrain the organization of the forms of these novel algebraic objects. Operationally, the numerical constraints of chemical valences, operating on the counts of perplex numbers, generate the emergent diagrammatic forms of perplex numbers. The nodes of these labelled bipartite graphs are composed from symbols representing the ordinal and cardinal, the electromagnetic particles of the atomic numbers. This duality of the kinds of magnitudes for counting sub-atomic particles sharply constrains the forms of logical propositions of chemical information theory.

This form of applied mathematics is called organic mathematics. The intended sense of meaning of the adjective “organic” is to focus the mathematical operations to illations among electromagnetic precursors of organic matter. Within the Tarski–Lesniewski hypotheses, the formative operators acting on electro-magnetic particles are ampliative by virtue of the additivity of electrical particles and the multiplication of electrical forces. Thus, in organic mathematics, the counts of the parts of the whole are organized into logical diagrams of illations among electro-magnetic particles (labelled bipartite graphs). The organic forms of the discrete counts unambiguously represent parts of the whole in

Tarskian meta-languages, the propositional terms that name the multitudinous forms of sorts and kinds. For example, the specific pattern of organization of electro-magnetic particles can represent the names of organic chemicals (such as amino acids, sugars, fats, vitamins . . .), organelles (such as mitochondria, nuclei, chloroplasts . . .), organs (such as heart, lungs, liver . . .) and organisms (bacteria, yeast, insects, mammals, man . . .). Consequently, the perplex number system maps to a novel physical notation for the chemical sciences based on electrical units. In this writer's judgment, the simpler view of traditional mathematical logic based on our intuitive notions of geometry, e.g., space and time, is too simple to generate an exact description of natural irregularities of animate forms because the numerical representation of polarity of electromagnetic particles requires both ordinal and cardinal numbers. Natural irregularities require an overt notation that crisply distinguishes the logical adjacency relations between electrical species from the logical relations among corporeal masses.

2. Scientific Units

The two basic premises of chemical information theory are beguilingly simple:

"The union of units unifies the unity."

"The disunion of the unity separates the units."

The grammatical simplicity of these two sentences should not obscure the perplex logical meanings that are to be associated with them in the context of Tarski–Lesniewski inferences. Logically, the two propositional sentences can express the meanings of both Tarskian meta-languages and the meanings of Lesniewski's part-whole illations as well as the converse, the whole-part illations of perplex organic systems. A "Lesniewskian" union of units can specify polynomials, that is, a name composed from the names of the units. For example, the names "oxygen" and "hydrogen" are sub-units of the unified name, dihydrogen oxide. The disunion of the polynomial, "sodium chloride" separates into two elemental names, "Sodium" and "Chlorine". The meaning of the term "polynomial" varies with the meta-linguistic context of the sentence.

The grammatical structure of these two abstract sentences express two antecedent terms and a consequent term. The subjects of the two sentences (union and disunion) express the concepts of transforming parts to wholes and wholes to parts. The two logical terms of the genitive case of each sentence are the objects of other sentence. The "predicates" of the sentences are unity and units respectively, but neither are logically contained in the subjects of the sentences (in the sense of Leibniz). The concrete scientific meaning of the term "units" is not specified beyond the grammatical notion of a plurality. During recent centuries, several systems of scientific units have emerged that can be used to express logical inferences. All of these systems of units are either directly or indirectly connected to one-another. In this sense, a logical unit can specify both existence and magnitude. In this pair of sentences, the natures of the scientific units are not specified; the physical meaning of the sentence varies with the selection of the names for the units and for the names of the unities. Similarly, the physical meaning of the two verbs varies with the physical formation operator selected for relating the subjects to the predicates. The verbs of these two propositions can express formative and deformative operations among the parts of the whole. *The sentences are synonymous with the composition of parts into an emergent whole and the decomposition of a whole into distinctive parts.* Logically, the two sentences are congruent with the mathematical operations of addition and subtraction of numbers. Thus, these two propositions have the potential to describe coherently the nouns, verbs, and predicates of the meta-languages of scientific discourses by counting the relations between the identities of units. In addition to the common sensory experiences of everyone, scientific inquiry extends to the colossal galaxies of the heavens as well as to the infinitesimally small electro-magnetic quanta, such as orbital angular momentum. This paper hypothesizes that ampliative logics grounded in both Tarski's conceptualization of meta-languages and Lesniewski's conceptualization of part-whole mereologies can unite the logics of the natural sciences into a coherent unity that span physical scales

of human scientific thought. This hypothesis infers that the quantitative symbol systems of the natural sciences are related by compositions of logical meanings such that natural sorts and kinds emerge.

3. Units of Conceptual Change in Abstract Meta-Languages

Each meta-language expresses scientific propositions in logical terms appropriate to phenomena of the scientific discipline with its associated cultural competencies. The logical scales of the organic disciplines range from sub-atomic electrical charges to the populations of biological species of eco-systems. The intrinsic nature of the concept of change is expressed in different terms as the language of causality progresses from the behavior of corporeal but invisible subatomic particles to the reproduction of life and the genesis of new species. The differences between the causal antecedent and the resultant consequences express the logical change(s) as a function of the meanings of the logical units of the discipline or disciplines. Causality may be either denoted or connoted depending on the empirical observations, the logical terms, the nature of the propositions and the nature of the scientific disciplines. One purpose of organic mathematics is to arrange the logical terms of the meta-languages of multiple disciplines in such a manner that numerical calculations are meaningful. Often, numerical measurements of initial (antecedent) and final (consequential) forms are necessary to establish scientific causal illations.

The forms of change within a set of terms of meta-languages may infer reasoning between antecedents in one discipline and between the consequences in another discipline. Such inferential calculations depend on coherent understandings of the measured quantities in multiple symbol systems. For example, the mathematical, chemical, and genetic symbol systems are integrated in calculations of mutation rates. The comparison of the therapeutic efficacies of chemical isomers is another. These forms of interdisciplinary inference are seldom necessary for the domains of mathematical physics which are constrained by the abstract mathematical meanings of physical units, such as mass, distance, time, and temperature.

The concept of measurement of change is interwoven with the concepts of units of meaning within a scientific theory. Physical dynamics is often grounded in the units of time and space, the Kantian a priori. Often, each physical term (unit) is hypothesized to correspond with a geometric distance within one dimension. Often, differential equations are used to represent the n-dimensional relations between units of measurements and units of numerical distances. The success of this method has been fecund, both conceptually and economically. Part of this success in such a hype-simplistic scheme of causality emerges from the use of mathematical logic to transform simple independent eigenforms into mutually dependent terms in eigenvectors. Consequently, the Kantian stance on the intuitive meaning of scientific categorization plays a strong role in the public interpretations of these scientific theories as merely Pythagoreanism.

Biological change is perplex; it lacks the simple inferences among physical variables. The inquiry into biological change is a function of Lesniewski's part-whole illations. Spontaneous biological change entails logically multiple forms of representations, multiple abstract symbol systems (mathematical, physical, chemical, genetic . . .) and multiple meta-languages. The simplistic causal hypothesis of one variable, one dimension, one distance is problematic for organic systems because it does not entail the perplexity of biological changes (except in rare circumstances). Some aspects of biological perplexity are expressed by recognizing three clear and distinct forms of biological change—genetic changes entailing the genesis of new intergenerational forms, developmental changes entailing changes that span the time between a fertilized egg and a mature organism and metabolic changes that entail the genesis of the animate forms from inanimate matter. *Clearly, an ampliative logic is necessary for all three forms of perplex organic changes.* A genetic mutation entails a perplex change in one, or two or all three of the organic changes of form. All forms of biological change are constrained by the organism's home, the local eco-system. These fact constrains the formation operators for many propositional functions of organic mathematics.

Chemical change entails only three abstract symbol systems; mathematical, physical, and chemical units are essential to expressing logical changes of chemical form. Thus, its perplexity ranks between physically simple points, lines, planes, and spaces and the rich dynamics of biological forms of change. Chemical change entails conservation of parts (units), whether viewed as mass particles or electrical particles, a constraint imposed by nature. Lesniewski's propositional functions are necessary to represent the part-whole relations of chemical and biological forms. Furthermore, Lesniewski operators are necessary to generate the nascent logical terms of the sublative meta-languages that connect the construction of living systems to the inanimate physical precursors of life (electrical particles). Such nascent terms are linguistically necessary to generate the nascent concepts that bind the units into unities. For example, several linguistic terms must be coined in order to arrange the symbols for electrical particles into the symbols for organic DNA molecules and its extension to the symbolic meta-language of genetics and the simple language of semiology. Lesniewski's novel propositions can create the generative language of the ampliative logic necessary for the genesis of the languages of the life sciences.

Three distinct forms of chemical change can be described. The first and easiest to understand is simple physical transformation between solids, liquids and gases. A phenomenological example of great scientific and engineering importance is the dynamic physical transitions of water between ice, liquid and steam. The nature of water itself, its eigenform, remains unaltered, despite the dramatic changes of its attributes, its physically measurable predicates. Lesniewski's part-whole logic can be applied to physical forms. In ice, each part, that is, water molecule, is adjacent to other water molecules in a fixed pattern of relations because an ice crystal is a stationary pattern among the parts of the whole. In liquid form, each water molecule is changing positions relative to all other molecules because it is a fluid. Motion is un-seething as the individual molecules bump into one another. In the form of steam, each molecule is free to move within the volume and shape of the container. Steam pressure is interpreted in terms of forces generated by water molecules colliding with the walls of the container. Thus, phase changes express relative freedom of motion of particles in space. The physical science of thermodynamics was constructed to relate the dynamic transitions of matter (such as water and other chemical forms) to the physical transitions that leave the chemical identity unchanged.

Central to the discipline of chemistry are the changes of the units of identity of matter. The antecedent units of identity are changed to the consequential units of identity. The logic of changes of identity are proposition functions that express the disappearance of one or more identities and the appearance of one or more identities. The consequential forms of identity are new names that that incorporate all the parts of the antecedent names. Lesniewski part-whole relations are meaningful for all the identities of the chemical sciences. The inferences (propositional functions) among the identity relations form the perplex logic for the essential consistency of the chemical sciences across the fields of meta-symbols and meta-languages, biology, ecology, and the biomedical sciences. Chemical thermodynamics differs from physical thermodynamics because additional logical premises are necessary to express the illations of changes in the units of chemical identity.

Two forms of representation (symbol systems) exist to express the change in the identity of matter. One form uses the traditional form of chemical symbols in the sense of Dalton. The second form uses the relations among enumerable electrical parts [1]. The nature of the chemical change transforms matter into alternative forms of representation, expressed as chemical symbols in either notation. The consequential forms of identity are new names that that incorporate all the parts of the antecedent names in either notation. Logically, these changes can be described by bi-conditional formative operators in either notation.

4. Atomic Units

The construction of the atomic units from electro-magnetic theory was the major logical bifurcative point in the history of the theory of the natural sciences. With the elaboration of the regularity of the order of the electrical forms of atoms, Rutherford and Moseley initiated the union of the units of the

natural sciences, the union of physical units with chemical units. While the logical composition of bipolar units into non-polar units was empirical, the philosophical concept of a non-divisible logical atom as an independent mathematical object was replaced by the demonstrations of the separability of all chemical atoms into distinctive and countable electrical sub-units, nuclei and electrons. The class of all chemical atoms became a class of structurally interdependent mereological objects, of logical and mathematical relatives subject to the rules of arithmetic.

The a priori of Kantian logic was transformed into the a priori of number. The linguistic and phenomenological opportunities to interlace the nouns, verbs, objects, predicates and adjectives of physics and chemistry was opened. During the subsequent century, these opportunities have profoundly altered the scientific theory of the units and the unity of nature. The antecedence of the table of elements infers organic mathematics and perplex systems theory as its logical and arithmetic consequences.

In the twenty-first century, it is now logically easy to hypothesize propositions that link the regularity of physical order with the irregularity of molecular organization and the handedness of isomers necessary to denote bio-dynamics. By extension, the molecular organizations, highly irregular in natural sorts and kinds, are related to the irregular forms of living organisms. The direct testing of hypotheses that relate regularity of physics to the irregularity of natural structures became facile through the common causal agency of electromagnetism. The language of electromagnetism became the common bond that associated the units of physics with the *unity* of chemical objects. However, the language of chemistry demands that the relations between units (of atoms) and unity (of molecules) be expressed as contiguities of parts within wholes. However, this necessitates a diagrammatic logic that demonstrates the contiguity of parts. *Consequently, the union of the units from physics to chemistry requires novel notions about the meaning of names, of numbers, of relations, of illations and the logic of the conjunctions that form molecules from atoms. The form of the irregular electric illations of molecules are expressed in terms of diagrams, the logics of the irregular illations are expressed in terms of electrical counts and measurements of the irregular illations expressed in terms of physical units, most often by electro-magnetic spectra.* This infers the ampliative logic of compositional mathematics of labelled bipartite graphs for the representation of natural sorts and kinds.

Today, the ur-theory of the natural sciences is grounded in the regular ordering of atomic numbers of the table of chemical elements. On one hand, these mathematical objects are decomposed into parts represented in the physical units of mass and electricity; on the other hand, the same mathematical objects are composed into objects of unbounded size and unbounded variety that generate unbounded irregularities of natural objects (perplex predicates). The irregular ampliative logic that connects physical units to biological emergence and evolution requires the composition of terms within the integrative meta-languages of science by arithmetic operations. In this paper, this novel ampliative logic follows the logical principles of Alfred Tarski and Stanislaw Lesniewski. *Emergence and evolution are framed phenomenologically by the mutation of logical diagrams rather than the Kantian presuppositions of space and time.* The structural diagrams of the labelled bipartite graphs of organic mathematics are necessary logical antecedents to the predicate logic of quanta of motion within atomic units and the mechanics of motion within molecular unities. In traditional physics, both forms of motion (quantum mechanics and molecular mechanics) are referenced in the Kantian philosophy of space and time, not atomic numbers. *The ordinal and cardinal numbers are the a priori of organic mathematics.* This perplex theory of the natural sciences gives precedence to the logic of chemical causality over the phenomenology of motion, that is, the mutation of graphs of the arrangements of the parts demonstrates reproducible facts about sorts and kinds. The phenomenological denotation of motion of the parts of the whole is a consequence of the antecedent denotation of the illations among the atomic relatives. The inferences of the mereological dynamics are a consequence of the priority of the physical concept of electricity as it manifests itself in orbital angular momenta of the parts of the whole. Handedness, a necessary predicate for denotation of perplex illations of life, is a consequence of the pentadic apodicity of

chirality of orbital angular momenta. This example illustrates the union of mathematical, physical and biological units necessary to denote perplex systems theory.

5. Logical Units—Physical Atomism and Tarski–Lesniewski Propositional Functions

A tipping point in the history of science was the construction of the atomic numbers in the second decade of the 20th Century. The crucial experiments of Rutherford and Moseley unconcealed one of the deepest and least understood secrets of nature, the direct one to one to one correspondences between order of numbers and the order of the electrical parts of chemical elements and the order of the chemical table of elements. The concept of the order of numbers became a basic fact of nature, not merely a human linguistic invention for counting magnitudes. This natural order of natural kinds was demonstrated by matching the chemical identities of all known chemical elements with the count of electrical particles (electrons and nuclei) and with the physical attributes of each. (The triadic nature of this matching is a radix for the perplexity of ampliative logic of the chemical sciences.) The semantics of the natural order of natural kinds became grounded on the identity of each of the nouns, the quantities of the parts of the whole, e.g., nuclei and electrons) and the observable causal relations among these terms, the electro-magnetic forces generating the organic unity of the mathematical object.

The complete set of matchings the semantic names with their chemical properties and with their physical properties and with the logical ordering of the counts of the parts of the whole re-conceptualized the physical radix of the chemical table of elements (TOE). In a few short decades, the TOE became the de facto central thesis of the natural sciences. Today, TOE is the core hypothesis of the sciences of the invisible subatomic physics, atomic physics, chemistry, biochemistry, and the other sciences that seek to infer relations between invisible particles and visible events. Logically, the TOE satisfies Hilbert's criteria for mathematics, it is consistent with the order of numbers, it is complete with respect to all the chemical elements and compositions of relations among symbols and symbol systems are decidable. In this paper, the TOE is the radix of Tarski–Lesniewski propositional functions that denote the corporeal and countable abstract mathematical objects that are the material sources of the necessary constituents of the visible irregularities of natural sorts and kinds that compose the unity of life.

The logical inferences from the Rutherford–Moseley type of experiments are of two forms—extension to objects smaller than members of the TOE and extension to objects larger than members of the TOE. In the former class, are electrons, nuclei and yet smaller sub-atomic particles. In the latter class are the corporeal forms of molecules, organelles, cells, tissues, organs, individuals, and larger classes of compositions of units of the TOE. The extension of TOE units to smaller objects uses the meta-language of physics and is symbolized in the formal physical units of electricity, distance, wavelength, temperature, and so forth. The extension of TOE units to larger objects uses the meta-languages of chemistry and biology and medicine and is symbolized by several Lesniewskian notations, including the notations for inheritance. The ampliative logic of chemical information theory connects the smaller corporeal forms to the larger corporeal forms. A propositional functions of formative operators connects parts into wholes under the constraints of the conservation of mass, electricity and number. The mathematical operation of organic addition connects TOE units into larger forms and networks of larger organic forms. Both the formative operators acting on TOE constituents and mathematical arithmetic are sharply constrained by conservation of number rule of perplex graph theory. The logical inferences from the Rutherford–Moseley types of experiments are necessary to beget the physical facts of emergence, development, and evolution of the individual forms of natural sorts and kinds.

Traditionally, the logic of chemistry was grounded in the ratiocinations of John Dalton (1766–1844). Multiple comparisons of relative weights of atoms in multiple compounds were used to hypothesize the relative ratios of each sort of atom in a compound. Icons (graphic diagrams) of molecules were images specifying the adjacencies of all the atoms of the molecule. The local positions of iconic

components were determined by assembling the weights of molecular fragments into an organized whole. An ad hoc logic of perplex chemical information theory does not use the relative weights as the primary logical reference system for assembly of unities from TOE units. Rather, the ordinal and cardinal numbers are used as representations of identities of sub-atomic corporeal quantities.

The numerical connections between physical atomism and the scientific meta-languages (including the meta-language of chemistry) will be constructed by Tarski–Lesniewski propositional functions grounded in the physical units of electricity. The scientific radix for this construction is the physical concept of electricity. The polarity of electricity manifests itself in structural forms of relations among individual identities, that is, the mereological nature of the electrical operands and operators as numerical units (members of TOE).

The two electrical propositions for logical illations on electrical terms are simple:

Like poles repel one another.

Opposite poles attract one another.

In the language of atoms, this infers the basic relations of electrical quanta are nearly as simple:

All nuclei repel one another.

All electrons repel one another.

All nuclei attract all electrons.

All electrons attract all nuclei.

These six propositions are phenomenological assertions. These phenomenological assertions are the radix of the meta-languages of quantum mechanics and chemistry. The scientific concept of “poles” is ancient. The concepts of nuclei and electrons interdependent electrical components of subatomic particles was formulated by Rutherford and Moseley [7].

The mathematical implications of these six assertions in the chemical meta-language are also simple. Within the antecedent phenomenology of the natural order of the TOE, each chemical name is associated with two forms of physical representations, one form for the units of mass and another form for the units of electricity. (Although it is seldom recognized or stated, this dualism of symbolic representations is intrinsic to the role of formal logic in the natural sciences.) Consequently, the triadic association of the name of the chemical element with the atomic number and the physical attributes of itself infers five *interdependent* types of numbers.

These are (1) the atomic number itself; (2) the number representing the count of the charge on the nucleus; (3) the number representing the count of the electrons; (4) the number representing the mass of the nuclei; and (5) the number representing the mass of electrons. The antecedent role of physical rules requires that these five numbers be represented in all organic formative operators working on TOE members. Consequently, in all higher order objects, the meta-languages of science must necessarily give an exact accounting of these five numbers. More abstractly, the apodicity of organic mathematics is a pentadic form of perplex numerals.

Within the meta-language of physics, two forms of physical units are necessary to represent the physical attributes of electricity and mass. These five types of numbers form the logical spine for all Tarski–Lesniewski compositions of TOE members, regardless of the physical units of the unity. The forms of the forces of attraction and repulsion differ among these five numbers. Newtonian forces of attraction are a general form of attraction working on all mass numbers. (No Newtonian force as repulsion is defined.) Coulombic relations are more perplex than simple Newtonian forces. Both attractive and repulsive relations are necessary to quantify Coulombic forces. These forces are defined in the propositional terms of poles. Such poles are both a conceptual and causal source of electro-magnetic fields and radiation. Two numerically distinct classes of electrical repulsion exist. One class of repulsion exists between the unitary charges of electrons. The second class of repulsive forces exist between the integer-valued classes of nuclear charges. Only one primary class of attractive

electrical coulombic relations exist, that between nuclei and electrons. Since the counts of positive and negative charges are enumerated in the TOE, the count of the classes of forces between the individual parts of simple unities is direct. This capacity to count the order of the ordinal and cardinal numbers and the contiguity relations among the units provides a mathematical foundation for the design, conduct and interpretations of chemical phenomenology within the meta-languages of physics, chemistry and biochemistry (molecular biology). These counts of relations among parts of the whole, under the constraint of electro-neutrality, as the units of a unity entail the mathematical basis for emergence of perplex systems. In summary, one critical distinction between organic mathematics and traditional mathematics is this economy of relations.

Tarski–Lesniewski propositional functions bind the TOE units into unities. Specific TOE units are composed logically into specific patterns of contiguity, thereby generating the nature forms we experience. All such compositions are ampliative with respect to size (mass and electrical units). Chemical knowledge includes designing specific formation operators to generate specific forms of matter. These sentential propositions ground the sortal, ampliative logic of electrical particles and are subject to verification or falsification. These simple polar electrical propositions, when applied to the ordinal and cardinal numbers, can unite the mathematical, physical and chemical concepts of number and entail the forms of natural kinds [1]. The grammatical propositions are quantifiable for the electrical parts of the atomic numbers by applying Coulomb’s law of electrical forces to the size and/or count of numbers as parts of the whole within the context suggested by related experiences. These electrical relatives are necessary predecessors of ratiocinations of physical theories of matter, such as Schrodinger’s theory of motion for sub-atomic parts of atoms (quantum mechanics) and Lewis’s theory of chemical conjunctions (valence bond theory). In summary, electricity becomes the Aristotelian “*demonstratio a priori*” of the order, organization, and logic of organic mathematics, thus entailing the perplex patterns of organic forms of life, the natural sorts and kinds we experience in everyday life.

6. Terms of Reference for Integrative Scientific Meta-Languages

I propose that the integrative meta-languages can be systematically constructed around five integrative concepts: identity, quantity, grammar, logic and genesis (or emergence).

Each of these referential terms plays a critical role in the meanings of the organic terms of the scientific meta-languages and the composition of scientific symbol systems. Conceptually, interiority and exteriority are distinguishable in terms of part-whole relations. The electromagnetic structure of every atomic number creates a space for an interiority of meaning. Each electrical particle necessarily generates illations with other electrical particles. *Electromagnetic quanta of information expose the meanings of perplex interiorities. This fact stands in stark contrast to the lack of interiority of a geometric point and to members of sets.* The interior identity of organic identities exhibit measurable quantities. The grammar of electromagnetism is different from the grammar of mass. The interior logic of organic terms as attractors and repellers differs from the simplistic constraint of the exterior logic of points as representations of magnitudes of mass. The genesis of organic Lesniewski objects requires copulative relations as well as predicates. The grammatical copula works to bind mereological contiguities. These contiguities mark the crisp distinction between the interiority or exteriority of an abstract thought, e.g., a thought of a point without interiority or a thought of an individual sort or kind with a rich articulation of interior parts. Each of the five integrative concepts connotes a linguistic ur-meaning and denotes a particular meaning in a particular meta-language of mereology. Invoking Tarski–Lesniewski modal logics enables a crisp logical organization of natural phenomena, such as molecular handedness, within these five integrative reference terms.

In order to create integrative metalanguages, a common logical thread must be present to bind the meanings of the propositional terms of the languages together, to bridge the gaps, say, between the meta-languages of sub-atomic physics and genetics. In other words, integrative metalanguages presuppose a notion of common logical terms that link meta-languages to one another. In even

simpler terms, common logical terms are necessary for integrative meta-languages. The terms of the meta-languages must form meaningful forms of correspondence between the nouns, copula, predicates and other grammatical forms of the metalanguages such that the connotations and denotations of the measurements of each of the individual meta-languages cohere. For example, if quantitative thought is common to all scientific meta-languages, then number symbols are common logical terms in these metalanguages. If the concepts of mass and electricity are common terms in the metalanguage of physics, then the symbols for mass and electricity are common logical terms in related metalanguages. If the names of atoms are common terms of the meta-language of chemistry, then the symbols for atoms are common terms in the related meta-languages. From these examples, an inductive inference about scientific metalanguages was drawn. The genesis of integrative metalanguages is expressed in the meanings of scientific symbols. The scientific symbol systems developed out of precursor signs in order to express novel ideas and concepts not explicated in other symbols. Thus, today's scientific symbol systems have co-emerged from patterns of natural observations and relations. A scientific meta-language infers unique symbolic meanings for its propositional terms. The converse is also true. A scientific symbol system entails the unique facts that led to the co-emergence of the meanings of scientific symbols.

The following approach is suitable for the purposes of integrative meta-languages and generative logics. The over-arching logical concept is a concept of the unity of nature that is separable into natural units. Within a set of integrative meta-languages, this concept becomes a foundational premise for symbolic logics of extensions by connotation and denotation between the names of the terms of the disciplines. Within the symbol system of organic mathematics, the union of integer units necessarily increases the number of parts of the whole. Within the symbol system of physics, the union of electrical parts generate chemical atoms (atomic numbers). Within the symbol system of chemistry, a union of atomic numbers generates molecular numbers. Within the symbol system of biology, the union of organic parts generate the living whole. Within the context of organic mathematics and chemical information theory, the philosophy of atomism and the phenomenology of electro-magnetism generate a prior of meta-languages that entails the construction of the animate from the inanimate. This semantic construction starts with the prior order of the names of the electromagnetic parts and organizes the successive wholes (unities) of the terms of representing the composite structures of natural kinds.

In the context of chemical information theory, these five propositions are to be interpreted within the integrative meta-languages of science. Within the context of organic mathematics, these five propositions connect the scientific symbol systems with the magnitudes of quantities that are composed into the corporeal identities. The nature of logical rules of associativity varies with the generating functions of the grammar of the meta-languages. The grammars of the symbol systems connect the inanimate terms with the animate terms. The generative logics of the formation operators working on electromagnetic particles fuel the associations among the meta-languages. The natural forms originate in the distribution of attractive and repulsive forces among the electrical charges. The extensions from the invisible to the visible are cumulative additions of electromagnetic parts to atomic numbers, atomic numbers to molecular numbers, molecular numbers to cellular numbers and the cellular numbers to the number of parts of a visible organism. The identities of these numbers can be arranged to create a "number spine" for the quantities defined for the identity terms of each meta-language. That is, an identity term connotes a unit in a specific meta-language such that the prior identities denote a specific quantity in the emergent identity. In simpler terms, this represents a many-to-one mapping from a collection of identities to a new identity (with its emergent properties. The denotation of an identity is a name and a quantity within a meta-language). The notion of a union of identities connotes logical associativity in the Lesniewski's sense of part-whole relations. The nature of logical associativity (formative operators) varies with the generating functions of the grammar of the meta-languages.

7. Units of Meaning: Atoms of Logic and Logic of Atoms

The very nature of integrative meta-languages necessitates the arrangement of logical terms of propositions expressing meaning of qualities and quantities in multiple logics and multiple languages. The first challenge is to arrange scientific propositions such that the meanings are exact and extendable in one language. The second step is to arrange the meanings of the scientific propositions in the adjacent meta-languages such that there are consistent paths of sublations across multiple meta-languages. Phenomenologically, a consistent path across scientific meta-languages invokes the logic of atoms (perplex number theory). Clearly, this is essential for the numerical propositions in each of the relatable meta-languages, otherwise logical propositions between measurements in meta-languages could not be confirmed or denied in terms of the unity of the units. The second challenge is to ensure that the threads of logical meaning are meaningful across multiple meta-languages and satisfy Hilbert's criteria of consistency and completeness. (This is a very delicate linguistic task for several cultural reasons that go beyond the scope of this paper.)

Here, we focus on scientific symbol systems and the usage of scientific symbolic units to express related identities and quantities in meta-languages. In chemical information theory, the principle disciplinary components of units are mathematics, physics, chemistry, genetics, names of biological species and social identities. The development of the meanings of basic scientific symbol systems are united by the logical terms describing the method of measurements. A meta-language is characterized by the units of measurements used to express its units of thought, semantically and syntactically in its units of propositional logic, "atoms of logic". Intrinsic to the goal of chemical information theory is the enablement of communications about scientific propositions among logics of the chemical sciences among knowledgeable scientists with the essential cultural competencies. Such propositional terms must link in such ways that exact communications across the sublative cultural boundaries are possible. That is, the goal is to construct a set of interdependent scientific symbol systems that have well defined syntactical and semantic boundaries. If one thinks of the use of scientific terms in practice, this is a challenging task because of the role of individual experience in defining both denotations within a parent symbol system and connotations within adjacent symbol systems. This requires an interiorly and exteriorly for giving accounts of magnitudes that are dependent on the cultural competencies of the inquirer.

The concept of an integrative system of scientific meta-languages necessitates a common system of reference that serves all the meta-languages. This common system of reference must serve the vital functional role of representing the names and the magnitudes of all the mathematical objects that relate the scientific facts of physics, chemistry, biology and medicine within the framework of Tarski-Lesniewski propositions and associated modal logics. The chemical table of elements is the ur-reference system for this systematic logic of the integrative meta-languages for the following reasons.

1. The regular order of the atomic numbers is the same regular order of the natural integers. This enables construction of a relational number line that spans the sciences and the catalogue of natural sorts and kinds.
2. All chemical atoms have a common structural form; the individuals differ by the count of the electrical charges and associated predicates. This enables common electrical terms in formative operators used to compose chemical meta-languages.
3. The atomic numbers satisfy Hilbert's criteria for mathematical objects—consistency, completeness and decidability. This enables abstract scientific extensions of meaning of terms.
4. The arithmetic operations of addition and subtraction, under the constraints of conservations of mass, electricity and number, are applicable to the atomic numbers. This phenomenological fact is the logical basis for chemical concepts of molecular number, molecular formula, molecular weight and Tarski-Lesniewski formation operators.

5. Each atomic number is a distinctive logical term that entails a particular grammatical subject and a set of particular physical predicates that are necessary for the logical description of the irregularities of nature. This enables the perplex grammar of organic sentences.
6. Each atomic number stands in one to one correspondence with its electrical parts in terms of an ordinal number and (a) cardinal(s) numbers.
7. The table of elements is an abstract source of terms for the names and the numbers describing the abstract forms of physics, chemistry, biology, biomedical sciences as well as, articles of commerce. Compositions of atomic forms generate perplex forms that are named by relations between parts and wholes. The names of material objects are one of three categories: the names of the subatomic parts formed by decomposing atoms, the names of the individual atomic forms, and names of compositions of atoms (molecules, organelles, cells, tissues, organs, individuals and higher order categories).
8. Causal association of TOE components is countable in terms of relations between ordinal and cardinal numbers.
9. The names of chemical elements are linguistically stable; many of them are in use for centuries and, for many metals, millennia. This enables a consistent history of the emergence of scientific notations.
10. The mathematical operations of composition of chemical atoms are consistent with logical operations of formation operators.
11. The mathematics of quantum mechanics and quantum chemistry originates in the TOE. This enables a quantitative logical linking of abstract physical and chemical propositions. However, the mathematics of thermodynamics is problematic for chemical and biological meta-languages because of the thermodynamic philosophy of units and unity.

These attributes of TOE are the common predicaments of the chemical sciences. They manifest themselves directly in scientific experiments and in human experience (units of thought, symbols). In other words, they manifest themselves in the natural forms of matter, the natural forms of addition, the natural forms of chemical logic, the natural forms of formative operators and the natural forms of anticipation intrinsic to biological reproduction [9]. The chemical symbol system records the natural forms of unity into logical diagrams as composites of TOE identities such that parts relate to wholes, consistently, completely and with decisiveness. Thus, chemical information theory entails the catalogues and categories of natural sorts and kinds.

8. Disunion of Perplex Entities

The disunion of a unity necessarily separates natural sorts and kinds as wholes into parts, decreasing the number of internal relations and thus increasing the number of parts. The disunion of atoms separates the nucleus from the electrons. The disunion of organic molecules separates the whole into atoms. The disunion of a cell separates the molecular constituents from one-another. In this sequence of propositional sentences, the disunion terms reference the nouns of electrical parts, atoms, molecules, organic parts and living whole. The grammatical examples of the disunion of water and salt were given earlier. The converse relations between the perplex unions and disunions are a consequence of physical constraints, that is, the conservation of mass, electricity and number in the mereological compositions.

These sentences are examples of the basic compatibility of compositions of propositional terms from different scientific symbol systems into meaningful sentences. Within the symbol systems used by the bio-chemical community, the meta-languages of the disciplines are coherently intertwined because of the facts of nature are used to compose and validate the emergent logical terms and symbols [10].

9. Units of Quantal Chemistry in Meta-Languages

The phenomenological relations between quantum mechanics and quantum chemistry are related through the electro-magnetic properties of matter. The TOE is the common reference for the mathematics operations of these two meta-languages. The TOE is necessary for the consistency, completeness and decidability of both.

However, the differential mathematical terminology for angular momentum (spin) is confusing to both logicians and non-mathematicians. This is important because the pairings of angular momenta in quantum terminology entails the synductive logical operations of perplex conjunctions necessary to form molecules from atoms [11]. This can be termed spinner formation and implies the formation of the pairing of atoms electrically [12]. In the chemical and biological meta-languages, the concatenation of four different chemical radicals around a central atom (usually a carbon atom) generates rotational forces on electric fields, resulting in two different compounds with the same physical attributes except for different mirror images (handedness). Handedness expresses the dissymmetry of polarities of parts of the whole, resulting in torque in the electrical fields. In almost all cases, the presence of handedness differentiates living matter from non-living matter. Phenomenologically, handedness is common property of almost all biochemical monomers. These novel asymmetric rotational forces can be termed “twisters”, in semantic parallel to Penrose’s mathematical concept of quantum mechanical “twistors.” The dynamics of biochemical networks are regulated by these electrical forms because only the natural enantiomers support the physical transformations of metabolism. Hence, the logic of third-order bio-cybernetics invokes a dissymmetric twister logic for the dynamic propositions asserted for the “electrical metabolism” necessary for life. The role of torques (angular momenta) generated by twisters sharply constrains biochemical information theory to the enantiomers of optical isomers by constraining the rate constants, in simple cases, to either zero or non-zero. (It is conceivable that the logic of twisters as manifested in the interior attributes of biochemical terms, is a direct observable biological consequence of the quantum notion of “internal measurements”.)

10. Conclusions

The electro-mechanical theory of communication proposed by Shannon uses a binary number system to develop communications channels between senders and receivers. It functions by encoding communicable messages (also known as “information”) into a binary symbol system of “bits”. The term “bit” is polysemic. It serves several functions in the mechanical processes of transmitting propositional functions as encoded messages between separate locations followed by decoding the transmitted form back into the original message. The vast utility of Shannon information theory is a direct consequence of symbolic abstractions and logical Boolean operations on numbers. Many biologists assert that the thermodynamic concept of “entropy” functions as biological information because a simple mathematical formula for entropy and information have the same form. The logical grounding for this “linear” generalization of the thermodynamic concept is vague and lacks persuasiveness because it seeks to substitute directly terms of one meta-language for meanings in another meta-language without regard to sublations between metalanguages. M. Eigen expresses an alternative view, suggesting that the entropy concept is not consistent with statistical thermodynamics [10]. In sharp contrast to the artificial “bits” of Shannon information theory, the binary number system for organic mathematics uses two forms of logical entities, integer numbers and simple indivisible units. The union of these two forms of units unite to entail the logical unity of perplex numerals and perplex numbers. In the meta-language of physics, an atom emerges from the union of the polar opposites, a nucleus and an equipollent count of electrons. The TOE is the union of all known sorts of units of perplex numerals as corporeal—physical entities that entail well-defined units of physical predicates. All molecules are unions of combinations of perplex numerals in the meta-language of chemistry. Consequently, the meaning of the TOE expresses logical predicates in both the meta-language of physics and the meta-language of chemistry.

Biochemical information theory originated from the discover of molecular transmitters (hormones, neural transmitters, immunoglobulins, and other dynamic signal carriers) within organisms. During the past century, the emergent terminology of molecular biologists has slowly constructed parts of a chemical language for describing the organization and operations of living systems in terms of the chemical elements. This emergent meta-language is now in its logical and mathematical infancy. Chemical information is internalized within chemical symbols because of the polarity of the parts of the whole organized into diagrams (labeled bipartite graphs) of ordinal and cardinal numbers. This interiority of organic entities separates the phenomenology of chemical sciences from phenomenology of meta-languages based on the premises of space and time as continuous geometric variables composed of invisible and incorporeal objects. The symbolic language of the grammar of chemical diagrams complements the symbolic anatomy of genetics and medicine. The meta-languages of chemistry, of genetics, and of medicine are more than philosophical concepts, they are more than complementary concepts; together, they establish causal relations that are essential to the practical aspects of biological emergence that extend directly to human health and well-being. The challenge to chemical information theorists is to extend the scientific logic that spans the yawning gap between mathematical and physical truths and the facts of life.

One purpose of this introduction to chemical information theory is to argue that the phenomenological union of the symbolic units of scientific notations can be unified to a scientific unity within the phenomenological constraints of matter. This perspective embraces the mechanical theories of physics as foundational to the performative operations on the elements of TOE [11]. The composition of physical symbols, under the mereological constraints of the conservation of mass, electricity and number, generate higher order symbol systems along the finite extension of the number spine. The hybrid formative operators entailed by the polarity of matter are extended along the integer number spine to natural sorts and kinds by mathematical addition of (perplex) numbers, augmented by the internal electrical illations of the emergent unity. The union of spinners is necessary to unite natural atoms into material wholes. The union of twisters generate the handedness of natural sorts and kinds that compose the dynamics of the identities of life forms. The essential role of spinners and twisters in a physical theory of evolution should not escape the attention of analysts seeking to extrapolate illations among meta-languages that connect the inanimate to the animate.

The open logic of organic mathematics is entailed by the apodicity of the corporeal sciences. The motivation for forming this abductive logic was to express formally the coherency of the multiple logics of the natural sciences. The emergence of the formality accrues from the pentadicity of the magnitudes entailed by atomic numbers, the pentadicity of the grammatical structure of the propositional functions of the formation operators and the pentadicity of the torques of handed molecules. I believe that these pentadicities infer, formally, the synductive logic of the identities of natural sorts and kinds. An introductory glimpse of this open logic was published in 2009 (Chandler, [1]).

The present paper completes the 15-year inquiry into the logical foundations of organic mathematics. The further development of the organic mathematical structures used to calculate the catalogue of categories is in progress. It entails novel diagrammatic logics from pentadicity of atomic numbers to the spatial forms of the algebraic graphs of electrical particles. The constraining principles of conservation of mass, electricity and number form the generating functions that specify the identities of natural sorts and kinds. The central hypothesis that the logical apodicity of the pentadicities of matter and language form an innovative and integrative system of bio-mereology can now be formally addressed.

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