THE LINGUISTICS OF FOOD AND DRINK LANGUAGE

I. THE PARTS OF SPEECH AND WHAT THEY STAND FOR

DESCRIPTION AND CLASSIFICATION

Of the two primary uses of food language – description and evaluation – description is easier to explain. Another name for description is *classification*. Classification, obviously, consists of assigning things to classes. It is an activity we do all the time, but like many things that puzzle philosophers it is much more complicated that it seems. Exactly what is a thing? What is a class? How do we decide what class to put a thing into?

ONTOLOGY

Philosophers and logicians explain classification as follows. First it is necessary to distinguish between a thing and a class. What makes them different? Philosophers address this question in the discipline called *ontology*, which is the branch of philosophy that studies the fundamental divisions of reality. Reality consists of those things that "exist." Another name for a thing that exists is an *entity.* Traditionally, ontologists divide entities into three fundamental kinds or *categories*: individuals, universals, and classes.

INDIVIDUALS

An *individual* is an entity that exists as singular thing. It is the sort of entity that we can point to or indicate, and that we can count. Individuals are entities that are elements of classes, have properties, and that other individuals stand in relations to. Individuals include people, tables, horses, trees, rocks, mountains. Though an individual exists as a singular thing, it may be causally dependent on others individual, it may be a part of a larger individual, and it may have parts of its own that are individuals. In traditional philosophy individuals are also called *substances*. An individual is marked linguistically by the fact that it is the sort of entity that we refer to by a proper name or a demonstrative pronoun like *this* or *that*.

UNIVERSALS, PROPERTIES

A *universal* is something that individuals or pairs of individuals share but that does not exist by itself. Universals fall into two varieties: properties and relations. A *property*, which is also called a *quality*, is an entity that does not exist on its own the way an individual does, but rather "exists in" or *inheres* in multiple single individuals at the same time. Properties are often referred to in English by abstract nouns ending in *ness* or *ity*, for example, *redness* and *humanity*. If a property inheres in an individual the individual is said to *possess* that property. Some properties, called *sensible properties*, are such that we can sense whether an individual possesses it. Examples include colors, tastes, and smells. Other properties cannon be directly senses and are are said to be abstract, like *humanity* and *tax deductible*. Properties are marked linguistically by the fact that we refer to them with adjectives. For example, the adjective *red* stands for the property of redness, and *human* for the property humanity. The sentence *Socrates is human* is true because Socrates is human. That is, the sentence *Socrates is human* is true because the property named by the adjective *human* inheres in the individual named by the proper name *Socrates.*

THE PROBLEM OF UNIVERSALS

Properties are what philosophers call explanatory entities. An *explanatory entity* is one that theorists (philosophers or scientists) assert exist because if they do they can use them to explain some basic fact of nature. The explanatory role of properties in philosophy is to solve the so-called *problem of universals*: how is it that two distinct individuals can be "the same?" The standard explanation (called *realism*) posits the existence of properties: two distinct individuals are the same because there exists some property that inheres in both. Two red things are similar, for example, because redness inheres in both, and two humans are similar because humanity inheres in both. The sentences *Socrates is human* and *Plato is human* are both true because though the proper names *Socrates* and *Plato* stand for distinct individuals, the adjective *human* stands for a single property, namely humanity, and humanity inheres simultaneously in both individuals. Properties, to be sure, are rather strange, non-commonsensical entities. A property (as explained by Boethius, 480-537 A.D.) has the odd feature that one and the same property can "wholly and completely" exist in multiple distinct individuals at the same time. Ontologists who believe in properties (they are called *realists*) accept this odd feature of properties because if properties of this sort exist; they provide an answer to the problem of universals. In these notes it will be assumed that realism is true, and that it is a basic fact of reality that odd entities like properties exist.

Given properties, it is also possible to explain "what is common" in food and drink. Food and drink properties come in many forms. They include sensory properties like color, taste and smell; physical properties like acidity and density; metaphorical properties like strength and weakness; and aesthetic properties like excellence and disgustingness.

CLASSES AND SETS

Classes are groups of individuals that share some property in common. They are "similarity groups." Classes are also called *sets*. Some classes are familiar, like the class of cows and tables. But a class can be formed from an arbitrary collection, for example, the class that contains just President Obama, my grandmother, and the tallest tree in Montana. Normally a class has multiple individuals in it, but there are cases in which a class contains only one individual, like the set the contains just the number 2, or no individuals at all (*the empty set*), like the set of humans that are fifty feet tall.

Classes have the special feature that they stand one-to-one to properties. Every property *P* determines a class *C* and *vice versa*. Given property *P,* a class *C* can be *defined* as the class of all entities that possess the property *P*. Conversely, every class *C* determines a property *P.* Given the class *C,* the property *P* can be defined as that property that all and only the elements of *C* have in common. Linguistically, classes are marked by the fact that they are named by *common* or *collective nouns,* nouns that stand for groups. Accordingly, just as there is a 1-1 correlation between properties and sets, there is, in principle, a 1-1 correlation between adjectives and common nouns, though sometimes a given language does not possess both words. In English, for example, corresponding to the common noun *cow,* there is the adjective *bovine*. In English the very same word, *human,* functions as both a common noun naming the set of humans and an adjective standing for the property of humanity. On the other hand, though English has an adjective *red* that name redness, it does not possess a common noun that stands for the class of red things.[1]

To say two individuals have something in common, then, is just another way of saying that they are in the same class. The explanatory role of properties, then, is to explain classification. The explanation appeals to properties: two individuals fall in the same class because they both possess the property that defines that class.

RELATIONS

A second variety of universal is what philosophers call relations. A *relation* is universal that inheres in pairs or triples of individuals. For example, all pairs (*a,b*) in which *a* is the father of *b* have in common that they stand in the father-of relation. The pairs (Adam,Able), (Priam,Aeneas), (Philip,Alexander) share the fact that, in philosophical jargon, the first stands in the father-of relation to the second. All pairs (*a,b,c*) such that *b* is between *a* and *c* stand in the between-ness relation. The triples (Sycamore St,Main St.,Walnut St.), (Dayton,Cincinnati,Lexinton), (South Dakota,Nebraska,Kansas) share the fact that the middle element is between the other two. Language has a variety of different phrases used to refer to relations, but these all share the feature that the words in the phrase link individual terms (like proper nouns) that refer to the individuals that stand in the relation. The simplest, and by far the most common type of relation is a two-relations. A relation is *two-place* or *dyadic* are relations that hold between pairs of individuals. Transitive verbs typically stand for a relation that holds between the individuals named by the sentence's subject and object terms. For example, in the sentence *John loves Mary*, *John* stands for John, *Mary* stands for Mary,

[1] Other parts of speech are also used to classify, especially transitive verbs and verb phrases. Semantically, an intransitive verb like *to run* or *to sleep* describes an "action" or "state" of individuals. Viewed abstractly, however, these descriptions are simply ways to classify. They presuppose that the individuals to which the verb applies share a characteristic property. Something that runs or sleeps has the property characteristic of running or sleeping things. The sentence *Socrates runs* is true if the individual named by *Socrates* possesses the property named by *runs*. Semantically, then, transitive verbs and verb phrases function like adjectives; they stand for properties.

loves stands for the "loves" relation, and if the sentence is true, then the loves relation inheres in the pair (John,Mary). Comparative adjectives are also used to stand for relations. In *John is taller than Bill*, *John* stands for John, *Bill* for Bill, *is taller than* for the taller-than relation. The sentence is true if the taller-than relation inheres in the pair (John,Bill). Food and drink language, especially evaluative language, is rich in comparative adjectives describing relations that rank food and drink samples into some order, e.g. *is sweeter than, is chewier than, is more brilliant than*. Below we shall use the notation *aRb* to represent the fact that *a bears the relation R to b.*

NATRUAL KINDS

The first way to explain natural kinds by their role in the laws of nature. Some properties and relations are what may be called *natural*. These are property in occurs in the natural world and are used to define classes. Although there are many properties that in ordinary life we ascribe to things in nature, in serious science and philosophy the term *nature* is understood to refer to nature as it is understood in the natural sciences, and *natural property* is understood to be restricted to the properties that actually occur in some law of nature. A law of nature is some general principle that describes how the world works. It is one of the main goals of the natural sciences to discover what these laws are. These laws talk about how classes in the world relate to each other. Good examples are Kepler's laws of planetary motion. The First Law says, *All planets travel in ellipses around its sun*. The second says, which says, *All planets sweep our equal areas in equal times*. Both laws talks about the class "planets". Classes that figure in scientific laws are special and are called *natural kinds*; the properties that define them are natural properties. They are used, it is said, "to carve nature at its joint." For example, species in biology are natural kinds because species are classes that are referred to the natural laws of biology that explain propagation in animals and plants. Likewise, elements in chemistry are natural kinds because they figure in explanations of chemical composition. *Non-natural* or *arbitrary* properties, and the classes defined by them, are those play no part in any law of nature. Though such a class may be of practical interest, for example, the class of objects sitting on my desk, this class is non-natural because it has no explanatory role in natural science – it is not of "scientific interest."

A second and related way to explain natural kinds is by their role in "inductions," the generalizations scientists make about the world when they discover a natural law. A natural kind stands apart from an arbitrary class is that it is justifiable to make scientific generalizations about a natural kind in a way it is not justifiable to do so about an arbitrary class. A generalization in science is inference researchers make when they conclude from the inspection of a limited number of samples that a regularity holds for an entire set. The inferential process is called by philosophers *induction* – the inference from *some elements of the class A have P* to the conclusion that *every element of the class A has P*. Because it is usually impossible for a scientist to investigate all the elements of a class, they are forced to make inductions to discover the laws of nature, which are usually generalizations an entire set. For example, Kepler's Second Law talks about *all* planets. This generalization holds not only for the limited number of planets Kepler was actually able to inspect but for any planet anywhere.

Philosophers have devised an example to illustrate this point. The set of emeralds is a well defined in geology, it is a mineral with the composition $Be_3Al_2(SiO_3)_6$. This set is a natural kind because it is mentioned in geological generalizations like *every emerald has a hexagonal crystalline structure 6/m2/m2/m.* For the sake of illustration we define an arbitrary set, the set of emroses. An *emrose* is defined as anything that is an emerald before *t* and a rose after *t.* Let us set *t* for tomorrow midnight. (So, an emrose would be just like an emerald until tomorrow midnight and then instantly change into a rose.) It is clear that induction functions reliably in the case of emeralds. After inspecting a suitable number of samples emeralds researchers correctly generalize to the fact that every emerald has a crystalline structure 6/m2/m2/m. However, induction does not work for emroses. No matter how many emroses we have inspected, all of which have a crystalline structure 6/m2/m2/m, the inference to the pseudo-law every emrose has a crystalline structure 6/m2/m2/m is illegitimate. It is just silly to think that tomorrow at midnight an emerald is going to change into a rose. The difference in the two cases is that emeralds unlike emroses caves nature at its joints. The fact that the inference is legitimate in the one case but not the other is expressed by saying that the class emeralds is a natural kind but that of emroses is not.

Yet a third way to explain a natural kind, one related to both natural kinds as classes mentioned in scientific laws and as sets for which generalization is appropriate, is by their role in explanation. In standard cases explanation takes a set form. A particular event is explained by citing both a law of nature that governs that even and the evidence that the causal conditions necessary for the application of that law are satisfied.

Law:	*Every A is B*	*Planets travel in ellipses.*	*Emeralds are hexagonal.*
Causal Condition:	*This is an A*	*Mars is a planet.*	*This rock is an emerald.*
Event Explained:	*This is a B*	*Mars travels in an ellipses.*	*This rock is hexagonal.*

You ask, *Why does Mars travel in an ellipse?* The explanation is, *It is a planet*. *Why is this rock hexagonal? Because it is an emerald.* Implicit but unexpressed in each explanation is an appeal to a law of nature. A natural kind, then, is a class that can be invoked in an explanation. Because this kind is also mentioned in a scientific law and that law is arrived at by a generalization about that kind, a natural kind in this sense is the same as that previously described.

One of the important questions in food science and appreciation is what exactly are the natural kinds appropriate to these fields. While it is clear that the chemistry that forms a part of food science makes use of genuine natural laws, which mention natural kinds, it is far from clear whether ordinary food categories, like varieties of food and drink – milk chocolate, Pinot noir, sour dough bread – form natural kinds in a strict sense. Are there natural laws about Pinot noir or sour dough bread?

OPERATIONAL DEFINITIONS

In science natural properties and kinds are often given what are called operational definitions. A set is *operationally defined* if membership in the set is determined by a decision procedure that consist of an experimental process that terminates in sensible mark open to empirical observation that indicates "yes" if an individual is in the set or "no" if it is not. For example, *acid* has an operational definition: a liquid is an acid if it has a pH less than 7 as measured by the visible color of litmus paper, and is not an acid otherwise. In Ohio *legally intoxicate* has an operational definition: you are intoxicated if a cop's observes that the digits on his breathalyzer are .08 or higher.

Whether food or drink terms have operational definitions is a major issue in the fields of food science and appreciation. While it is clear that some food and drink adjectives are operationally defined, like *acidic* and *dense*, there is a good deal of dispute about whether so-called sensory properties like *sweet* and *red* or evaluative properties like *noble* and *crude* correspond to operationally defined physical properties.

FIGURATIVE LANGUAGE

Most words in English do not possess rigorous operational definitions. Even worse, it is often difficult to know exactly what physical properties, if any, a word is supposed to correspond to. This problem is exacerbated by the fact that there are entire classes of words that are either not descriptive of the physical world, or at least not straightforwardly so. An important case is figurative language. A word is used *metaphorically* or *figuratively* if it is used to refer not to its usually referent but to something similar in some way to its usual referent. If we say a girl is *sweet* or a wine is *feminine,* the girl is not literally sweet but rather possesses some property similar to sweetness in food, nor is the wine literally feminine, but possesses some property similar to femininity among humans. Normally, the reason we resort to figurative language is that we lack adequate words to describe the subject's properties directly. This inability to describe a property directly, then, makes it especially hard explain what we intend when we use a metaphor. Exactly what property of the girl do we mean to pick out when we say she is sweet? If we had a word for that property in the first place, we would not have needed to resort to a metaphor. We shall see that large parts of food and drink vocabulary are figurative precisely because we lack a large store of words that directly describe the physical properties of food and drink. This figurative vocabulary is very hard to define clearly precisely because it is figurative. We shall find that often when we use an adjective figuratively about food and drink, we are not so much trying to pick out a particular property as we are attempting to locate the particular food sample at a place that is similar to the structure that holds among metaphorical entities.

"QUALIA" AND MENTAL PROPERTIES

Some adjectives and nouns are not intended to describe the physical world at all, or at least not directly. What we may call *mental terms* are words that stand for subjective experiences, their properties and classes. The "world" of consciousness is difficult to describe, but let us assume it consists of a series of "subjective states" or "experiences" -- a category of entity that we will not try to define here, but will assume that we all understand from our own experience. These conscious states and experiences, then, are the "atomic parts" or "individuals" that make up our conscious mental life, and that we talk about using appropriate vocabulary. Over the years philosophers and psychologists have used a wide variety of synonyms for these "subjective experience." They have been called *feelings, sensations, phenomena* and *sense data,.* Like physical individuals, conscious experiences have things in common and some differ. Two experiences of seeing red , for example, seeing the red of an apple and of fire engine, are the same, but the experience of seeing the red apple is different for that of seeing the blue sky. Feeling hot is different from feeling cold. Accordingly, to the standard explanation in ontology, what makes conscious states the same and others different are the properties of these states. A property of a conscious experience is called a *mental property* or *quale* (plural *qualia*)[2]. Though the view is controversial, it is commonly held in philosophy that a mental property in not a physical properties of an object "outside the mind." In particular, according to this view, a mental property is not a property of the physical object that causes the sensation of the property. For example, the properties of an object outside the mind that causes us to see it as red are the physical properties of its surface that determine the way it reflects light. Redness, on the other hand, is a property that we experience when light is reflected from that surface in a certain way. Though it is possible to explain to a blind man the light reflective properties of the physical object – all he needs to do is learn the right branch of physics – it is not possible to explain to him what is like to see red. It follows, it is argued, that redness and similar "qualia" cannot be physical properties of the objects "outside the mind" or "outside consciousness."

If, in fact, qualia are properties not of the physical objects we perceive but of our selves, of our mental experience, the question arises whether qualia can be explained scientifically. Ideally, scientific concepts have operational definitions, and this definition, moreover, must be physical because it specifies a physical operation for testing whether something falls under the term being defined. To be operationally defined, therefore,

[2] Strictly speaking in Latin, both ancient and medieval, *quale* is a singular neuter adjective that when used as a substantive means *thing with a quality*. The word in Latin for quality (property) is *qualitas*. Another use in Latin of *quale* is as the interrogative meaning *what quality is it?* Thus, *quale est?* means *what qualitity does it have?* Aristotle, and the medieval tradition following him, explains that a quality (*qualitas*) is the sort of entity that inheres in an individual that provides an answer to the question *what quality does it have?* (*quale est?*). The usage of *quale* (as neuter singular substantive, with the plural form *qualia*) to mean *a quality of conscious experience* is a non-historical neologism of modern philosophy.

qualia have to be either physical properties themselves or experimentally related to physical properties. But if qualia are properties not of the physical objects we perceive but of our conscious experience, what physical objects are qualia experimentally related to? Unfortunately, science is long way from reducing "consciousness" to physical entities or explaining it in physical terms. Whether mental properties relate to physical properties and whether they can be explained scientifically are major open questions in philosophy and psychology.

These issues are central to the fields of food science and appreciation because these fields make frequent reference to sensations of taste, smell, texture, and color – all properties of conscious experience. One of the major issues in food science and appreciation is the nature of the relation that holds, if any, between, on the one hand, the subjective properties we sense when eating and drinking and, on the other hand, the operationally defined physical properties of the food and drink itself.

EVALUATIVE LANGUAGE

Philosophers in ethics and aesthetics make a distinction between descriptive and prescriptive vocabulary, and between language that describe "facts" and "values." By a *value* or *evaluative property* we shall mean one that entails or justifies a moral obligation or an aesthetic judgment, and by an *evaluative* adjective we shall mean one that describes an evaluative property. One of the open questions of ethics and aesthetics is the precise relation between evaluative properties, on the one hand, and physical properties of things described in science, on the other. Can values be defined in terms of facts? Are evaluative properties a special subset of physical properties? In food science and appreciation this questions takes a special form. Is it possible to explicate or analyze the aesthetic and evaluative properties of food and drink in terms of operationally definable physical properties of food and drink?

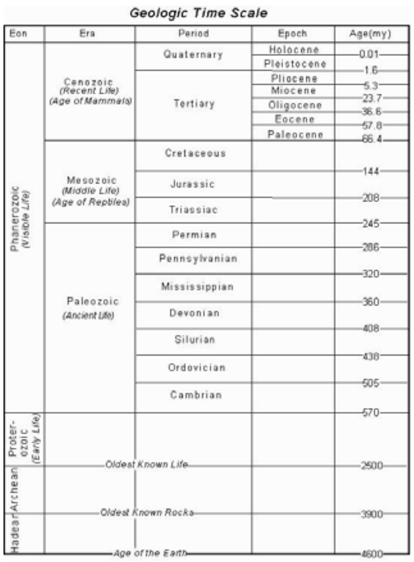
II. SEMANTIC FIELDS

DEFINITION AND EXAMPLES

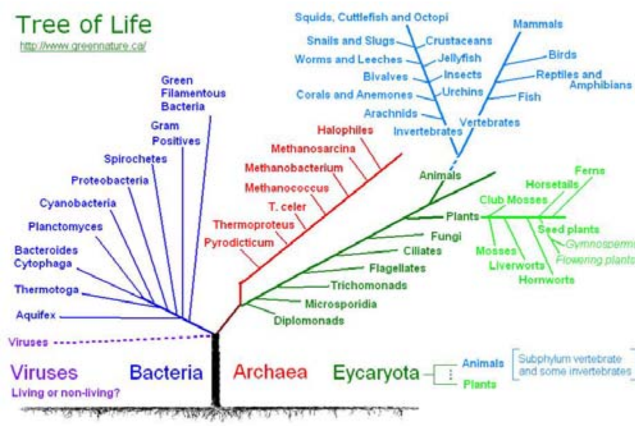
The technical term in logic for the entity that a word stands for is its *referent*, *denotation* or *extension*. For example, the referent of a proper noun is an individual; the referent of an adjective is a property; the referent of a common noun is a set; and the referent of a transitive verb phrase is a relation. Of special interest to linguists, however, are not the referents themselves but the structures that these referents form. These structures have recognizable patterns: they form lines, nested hierarchies, trees, and many other "shapes." Linguists call these the structure assumed by the referents of a word group a *semantic field*.[3] Though linguists themselves do not normally attempt to give precise mathematical definition of *semantic field*, it is clear that a field is a special type of what mathematicians call an *algebraic structure*, i.e. a series of distinguished

[3] The distinction is due to Saussure and Trier. See Lyons, *Semantics,* 1977, 250-261.

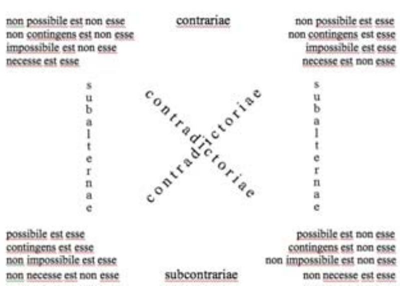
individuals, sets, and relations that obey some characteristic structural "axioms." It is helpful to introduce semantic fields by reviewing the structural diagrams of four examples:

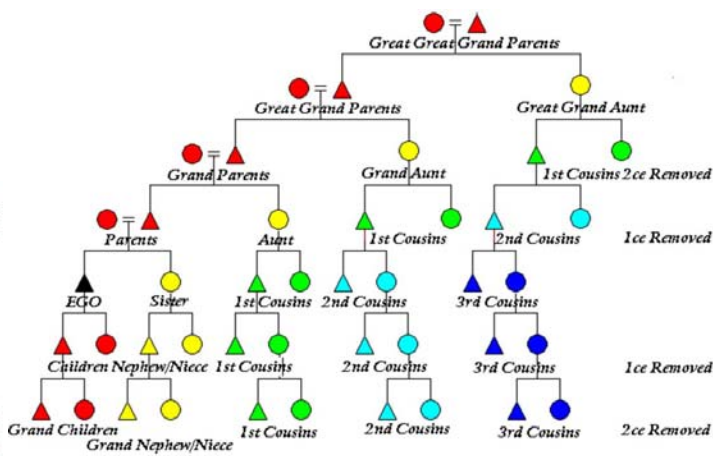

Geologic Time Scale

Eon	Era	Period	Epoch	Age(my)
Phanerozoic (Visible Life)	Cenozoic (Recent Life) (Age of Mammals)	Quaternary	Holocene	0.01
			Pleistocene	1.6
		Tertiary	Pliocene	5.3
			Miocene	23.7
			Oligocene	36.6
			Eocene	57.8
			Paleocene	66.4
	Mesozoic (Middle Life) (Age of Reptiles)	Cretaceous		144
		Jurassic		208
		Triassiac		245
	Paleozoic (Ancient Life)	Permian		286
		Pennsylvanian		320
		Mississippian		360
		Devonian		408
		Silurian		438
		Ordovician		505
		Cambrian		570
Proterozoic (Early Life)	Oldest Known Life			2500
Archean	Oldest Known Rocks			3900
Hadean	Age of the Earth			4600



Geological Timeline Orders of Biological Taxonomy





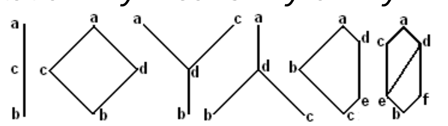
The Modal Square of Opposition Kinship Chart of U.S. Cousin Terminology

In each of these example words are assigned to "nodes" that represent their referents. These referents, moreover, form a structure represented by the diagram. Though word groups are assigned to structures of many different types, three structures are particularly relevant to the language used in the fields of food science and appreciation: lines, trees and what are called "squares of opposition."

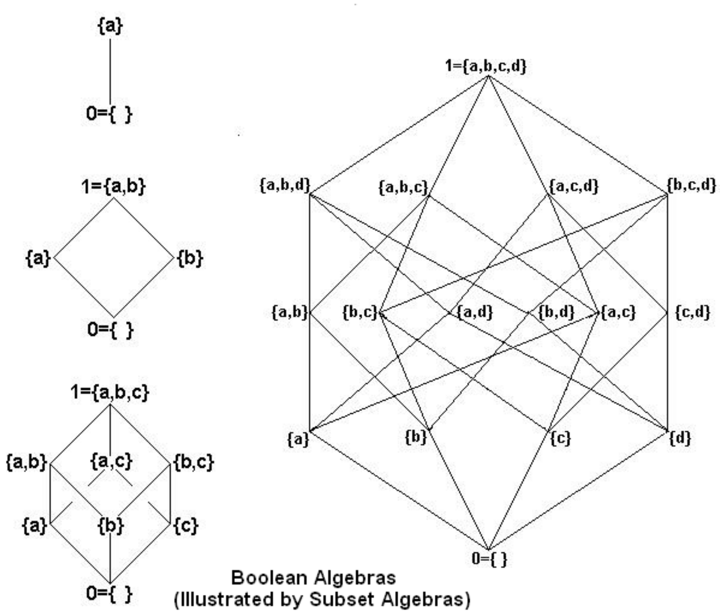
Though it is possible to understand a structure intuitively by diagrams, it is fairly straightforward to define structure precisely using elementary concepts from algebra and logic. Doing so precisely, moreover, makes it possible to explain quite clearly the sort of "world" that food and drink language describes.

ALGEBRAIC STRUCTURES AND ORDERING RELATIONS

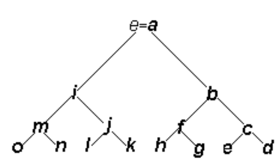
This section explains how to specify a structure by placing restrictions of a relation ≤ that "orders" the elements (nodes) in the structure. By imposing enough conditions, a relation *R* it takes the form of what is called an ordering relation ≤ and forces the elements in the order to assume a specific structure or form. The particular structures relevant to food science and appraisal are five: partial orders, Boolean Algebras, trees, and lines. The diagrams below illustrate these structures. In the diagrams if a point *x* is connects to higher point *y* by an ascending line, then *x* "is below" *y,* or in symbols *x*<*y*. The notation *x*≤*y* means *x*<*y* or *x*=*y.*



Partial Orderings (Reflexive, Transitive & Antisymmetric)



Boolean Algebras
(Illustrated by Subset Algebras)



A Tree

Line
(Reflexive, Transitive, Antisymmetric, Connected)

To specify the relevant conditions on relations, we first define several basic structural properties on relations. Let *R* be any relation.

Definitions of Relational Properties

> *R* is *reflexive* iff for any *x*, *xRx*;
> *R* is *transitive* iff for any *x,y*, and *z*, if *xRy* and *yRz*, then *xRz*;
> *R* is *symmetric* iff for any *x* and *y*, if *xRy* then *yRx*;
> *R* is *asymmetric* iff for any *x* and *y*, if *xRy* then not *yRx*;
> *R* is *anti-symmetric* iff for any *x* and *y*, if *xRy* and *yRx*, then *x*=*y*;
> *R* is *connected* iff for any *x* and *y*, either *xRy* or *yRx*;

The conditions necessary to define a partial ordering and a line are straightforward:

> *R* is *partial ordering* iff *R* is reflexive, transitive, and anti-symmetric.

It is customary to refer to a partial ordering by the symbol ≤. A line is a special partial ordering:

> A partial ordering ≤ determines a *line* iff ≤ is connected.

The conditions necessary to force ≤ into a Boolean algebra are more complicated. It is not necessary to remember all these conditions for practical purposes when studying food and drink science, but it is theoretically interesting that it is actually possible to define such a structure precisely. For its theoretical interest, then, we will state the definition of a Boolean algebra.

A Boolean algebra, is defined by imposing structural conditions on a partial ordering ≤. First we define five preliminary notions: $x \vee y$ (*the least upper bound* of *x and y*), $x \wedge y$ (*the greatest lower bound of x and y*), 1 (*the ≤ maximal element*); 0 (*the ≤ minimal element*); and $-x$ (*the complement of x*).

> $x \vee y$ is the ≤-least *z* such that $x \leq z$ and $y \leq z$, if such a *z* exists;
> $x \wedge y$ is the ≤-greatest *z* such that $x \leq z$ and $y \leq z$, if such a *z* exists;
> 1 is the unique *x* such that for every *y*, $y \leq x$, if such an *x* exists;
> 0 is the unique *x* such that for every *y*, $x \leq y$, if such an *x* exists;
> $-x$ is the unique *y* such that $x \wedge y = 0$ and $x \vee y = 1$, if such a *y* exists.

A Boolean algebra then is any partial ordering in which these notions apply. In algebraic terms a Boolean algebra is a partial order in which the operations of least upper bound, greatest lower bound, and complement are well defined; there is a maximal and minimal element; the operations $\wedge$ and $\vee$ are associative, commutative, and distributive; and complementation is dual. More formally, A partial ordering $\leq$ determines a *Boolean algebra* iff the following conditions are met: $x \wedge y$, $x \vee y$, and $-x$ are defined and exist for any x and y; 1 and 0 exist; for any x and y, $x \wedge y = y \wedge x$; $x \vee y = y \vee x$; $(x \wedge y) \wedge z = x \wedge (y \wedge z)$; $(x \vee y) \vee z = x \vee (y \vee z)$; $x \vee (y \wedge z) = (x \vee y) \wedge (x \vee z)$; $x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z)$; $x \vee -x = 1$; $x \wedge -x = 0$; $1 \wedge x = x$; $0 \vee x = x$.

The final structure to define is that of a "tree." Like a Boolean algebra a tree is a special form of partial order. Let us define a *branch* in a partial order as a maximal connected set, i.e. as a connected set (line) that is not a subset of any larger connected set. In a tree if branches ever intersect at a node, then they coincide for all higher nodes.

A partial ordering $\leq$ determines a *tree* iff:

1. there is a $\leq$-maximal element 1, and
2. if x is an element of branches A and B, then for any y, if $x \leq y$, then y is in both A and B.

LINEAR STRUCTURES AND SCALAR FAMILIES

Lines are typically described by a group of words called a scalar family. To introduce the notion of a scalar family, it is useful to consider an example. Scalar families are collections of words that are used to describe how individuals in the world can be put into a line according to how much of a certain "stuff" they are made of. This "stuff" could be any measurable "mass" quantity. Sometimes it is very concrete like water. In the case of water the relevant mass is referred to by the "mass noun" *wetness.* In addition to using the mass noun to refer to wetness, we also refer to degrees of wetness using a special set of adjectives that rank individuals according to how much water they posses. Such adjectives are said to be scalar or gradable. In the case of wetness these include the series *saturated, wet, damp, dry*, and *desiccated*. Beside the mass noun and the scalar adjectives, three is a third part of speech we can use to rank individuals according to how wet they are or how much "wetness" they possess. This is the comparative adjective expression *is wetter than*. Clearly, the scalar adjectives and the comparative expression are systematically related. Anything that is wet is wetter than anything that is merely damp.

The mass in question may be quite abstract. For example happiness is a mass substance referred to by the mass noun *happiness*. Individuals are ranked by the comparative adjective phrase *is happier than*, and there is a related series of scalar adjectives that rank individuals according to how much happiness they posses: *ecstatic*, *happy, content, so-do, low, sad,* and *miserable.*

In sum, a scalar family is composed of a mass noun, a comparative adjective phrase, and a series of scalar adjectives. To specify its definition more precisely, we must clearly distinguish between the words involved and their referents. A mass noun refers to a mass substance, a comparative adjective refers to a relation, and the scalar adjectives refer to sets that are defined by properties.

Before stating the definition of *scalar family*, however, we should explain what a mass noun is. In grammar a *mass noun* is defined as one that stands for some mass substance, which may be either physical or abstract. The mark of a mass noun, like *water* or *air*, as opposed to a *count noun* like *cow* or *apple*, is that it a mass noun can be modified by *more* or *less*, but not by numbers, but a count noun can be modified by numbers. For example, *more water* and *more air* are grammatical, but although *five cows* and *six apples* are grammatical, *five waters* and *six airs* are ungrammatical.

Thus a *scalar family* is defined as consisting of a mass noun *m,* comparative adjective *C*, and an ordered set of $A_{1,\ldots,}A_n$, of scalar adjectives with the following properties:

- The comparative adjective *C* stands for an ordering relation *R* that ranks individuals according to how much of the mass *m* they possess. That is, if *aRb,* then *a* possesses more *m* than *b.*
- The individuals are ranked in a series of sets $S_{1,\ldots,}S_n$ of decreasing mass. That is, for any S_i in the series, any individual in S_i possesses the more *m* than any individual in S_{i+1}. The same condition can be expressed in terms of the subset relation $\subseteq$: for any S_i *in the series,* $S_{i+1} \subseteq S_i$.

Thus, individuals in S_1 possess the most *m*, and those in S_n the least. The adjectives $A_{1,\ldots,}A_n$, name the sets in the series $S_{1,\ldots,}S_n$. That is, for each S_i in the series, A_i refers to S_i. They are called *gradable* and *scalar* because a gradation and a scale are a kind of ranking.

An example is the scalar family determined by heat. Heat, a mass substance, is named by the mass noun *heat*; the comparative adjective *is hotter than* names an ordering relation that ranks objects according to how much heat they have. The ranked objects are nested into sets defined. These sets have as their defining property how much heat individuals possess, and nested sets are named by the scalar adjective series *boiling, hot, warm, neutral, cool, cold, freezing.* The corresponding sets form name a linear series of progressively more restrictive sets. If something is boiling, it is hot, and if it is hot, it is warm, etc. In terms of the associated mass, a boiling object possesses more heat that those that are just hot, and those that are hot more heat than those that are just warm. In terms of sets, the set of objects with heat to be hot is a subset of the set of objects with enough heat to boil, and the set of objects that have enough heat to be warm is a subset of the set of objects that are hot, etc.

It is now possible to see what sort of “structure” a scalar family “articulates” for its “content domain.” The series of sets $C_{1,\ldots,}C_n$ described by a scalar family forms a “line.” It does so because $C_{1,\ldots,}C_n$ is ordered by the subset relation $\subseteq$, which is reflexive, transitive, anti-symmetric, and connected. Thus, $C_{1,\ldots,}C_n$ ordered by $\subseteq$ forms a linear structure in the algebraic sense. In a precise sense, then, a scalar family is a semantic field that describes a linear structure.

In the fields of food science and appreciation there are many examples of scalar families. In wine appreciation, for example, there is the field determined by sweetness vocabulary. This is the family that consists of the mass noun *sweetness*, the comparative *is sweeter than,* and associated scalar adjectives *syrupy, sweet, bland, flat.* There is also a family that describes astringency consisting of the mass noun *smoothness*, the comparative *is smoother than,* and the adjectives *velvety, gentle, smooth, firm, grating.*

Particularly important to issues of food and drink appreciation is that fact that the ordering underlying a scalar family frequently has an evaluative direction marked by linguistic criteria. One pole of the comparative order is marked as having positive value and its opposite negative value. Though there are various linguistic markers that indicate the direction of this evaluative order, one is perhaps easiest to use. It is found in a use of negation. The relevant negation is often expressed in English by the affixes *un, less,* and *dis*. When this negation is grammatically acceptable, it presumes that the scalar order possesses a distinguished pivot or midpoint. The role of the negative marker is to convert an adjective standing for a mass of positive rank *n* into a marked variant standing for a quantity of rank -*n*. For example, the happiness scale possesses a midpoint between the extremes of ecstasy and misery. It may be referred to by an adjective like *so-so.* The quantity of happiness referred to by *unhappy* falls at the rank as many steps below this midpoint as that referred to by *happy* stands above it. This negation marks the evaluative direction of the underlying comparative order because as a general rule it is ungrammatical to affix a negation to an adjective in the negative half of the scale. For example, *happy* stands for a property as many degrees above the midpoint as *sad* does for a property below the midpoint. But though *unhappy* is grammatical, *unsad* is ungrammatical. Thus, the positive pole of the happiness scale is marked by *happy* and its negative pole by *sad*. Likewise, on the politeness scale, one can be *impolite* but not *unrude*. Therefore *polite* is positive, and *rude* is negative. In food vocabulary, *pleasant* is positive, *unpleasant* negative; *tasty* positive, *detestable* negative; *satisfying* positive, *unsatisfying* negative; and *colored* positive, *discolored* negative.

It turns out, however, that sometimes this form of negation is not defined for food scalars, and in these cases it is implausible to hold that the ordering is evaluative. Which pole of the sweetness ordering for wine is positive? It seems that being both too sweet and too acidic are defects. This fact about values is reflected in the fact that the relevant negation is ungrammatical for both poles. Neither *unsweet* nor *unsour* are grammatical.

TREES AND TAXONOMIC SYSTEMS

Another type of semantic field important to food science and appreciation are those that describe tree structures. Almost every science makes use of some so-called taxonomic system that devides the objects it studies in to a tree structure of subordinate classes. In the earlier examples geology divides geological époques and biology the hierarchy of living things.

Such hierarchical divisions are also common in food research and appreciation. Wine, for example, in the classified in hierarchies of geographical region, plant variety, taste and aroma.[4]

"ANALYSIS IN PARTS" AND BOOLEAN ALGEBRAS

A large part of science, including food science, is "analysis." But what does "analysis" actually mean? Literally, *to analyze* means *to break into parts*. There are two kinds of analysis that are particularly relevant to food science and appreciation.

The first important kind of analysis found in food science in found in the sciences of taste and olfaction. It is common in these fields of research for theories to be advances that analyze complex sensations into a set of fundamental or "atomic" sensations. Tastes are broken typically into four or five basic taste (salty, sweet, acidic, bitter, and umami) and smells into a large but basic set of fundamental olfactory triggers. If it is true that all "smells" are combinations of a limited set of basic odors, or if all tastes are combinations of a limited set of basic tastes, then these combinations form a structure. [5]

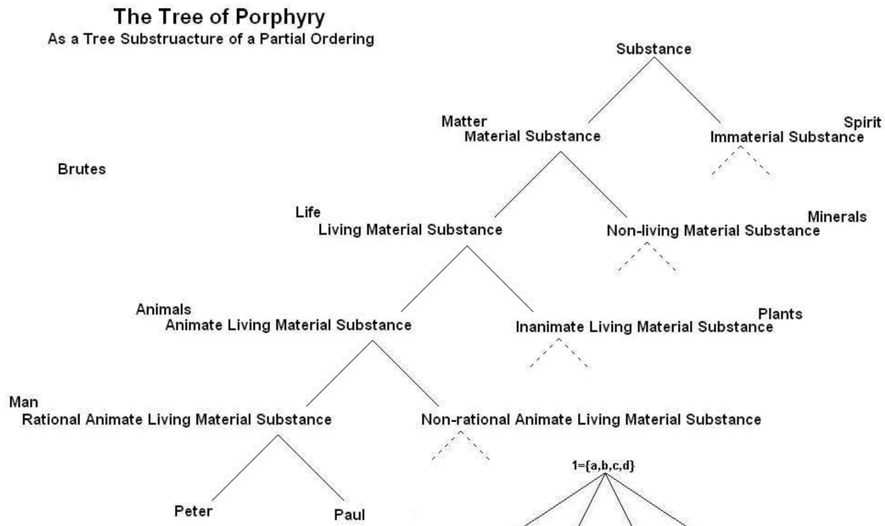
The second type of analysis relevant to food science and appreciation is what philosophers call *conceptual analysis*, the definition of word or concept in terms of more basic words or concepts. Here again, the basic concepts describe atoms that may be combined in a pattern that fits within some partially ordered structure. A famous example from philosophy is the so-called Tree of Porphyry in which progressively narrower species are defined by listing their defining properties. Using a set of basic properties that includes *substantial, material* and *spiritual (immaterial), living* and *mineral (non-living), animate* and *vegetable (inanimate), rational* and *brutish (non-rational)*, various species with their definitions are arrayed on the nodes of the tree in such a way that the tree displays how progressively narrower species (lower on the tree) are defined by a progressively longer list of basic properties. The species *matter* is defined by the two basic properties named by the two adjectives *material* and *substantial*, while the narrower species man is defined by the basic properties named by *rational, animate, living, material,* and *substantial*.

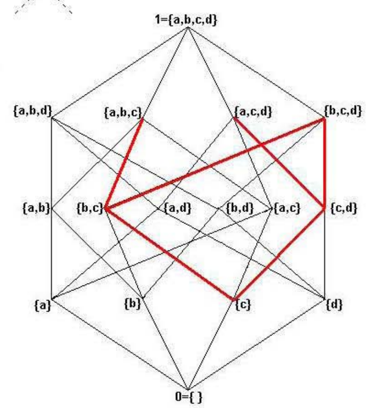
Analyses of both these types are represented by Boolean algebras. Let the 0-element (the least element) be deleted from a Boolean algebra, for example, from those depicted earlier. In the structure that remains the lowest nodes can be understood to be *atoms* from which all higher nodes are "formed." The Boolean algebra of listing

[4] In Lehrer, *Wine and Conversation* (2009) see the the Mouthfeel Wheel, p. 49, and the Aroma Wine Wheel, p. 190.

[5] See Alex Byrne and David Hilbert, "Basic Sensible Qualities and the Structure of Appearance," *Philosophical Issues 18, Interdisciplinary Core Philosophy*, 2008, pp. 385-405; and Richard J Stevenson and Donald A Wilson, "Odour perception: An Object-Recognition Approach," *Perception*, 36 (2007), 1821-1833.

subsets illustrates this point. As the labeling on the examples illustrates – the node {ab} is "composed of" {a} and {b}, etc. Any break down of sensation vocabulary into terms that describe atomic sensations describes a structure of this type.





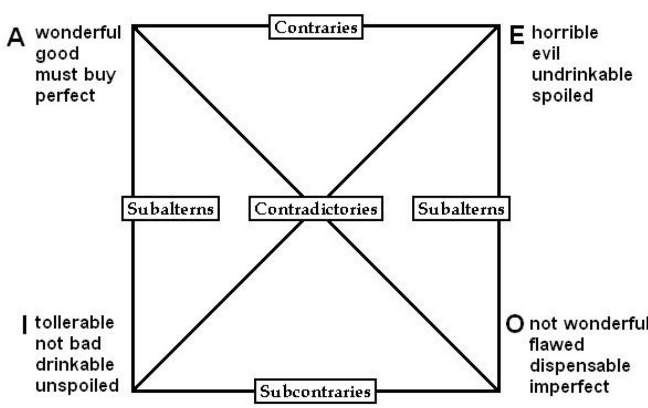
At times writers on food science and appreciation seem to be engaging in what they think of as conceptual analysis because they claim that important evaluative terms for food or drink can be defined by or analyzed into some list of basic sensory properties.

CONTRARIES, PARTITIONS, AND "SQUARES OF OPPOSITION"

Often properties and their corresponding sets are compared or contrasted. They are "opposed" to one another. But, as Aristotle pointed out long ago, there are various senses of "opposition." Perhaps the simplest way to contrast elements is by a *dichotomy*, a division of elements into two mutually exclusive but exhaustive parts. The *complement* of a set *C,* written –*C,* is defined as the set of all elements that are not in *C*. It follows that *C* and its complement –*C* form a dichotomy. The properties defining these sets said to be *contradictory* because a double implication holds: if something is in one, it is not in the other, and if it is not in one, it is in the other. For example, because everything is either round or not round, the set of round things and set of not round things are complements and the properties of roundness and non-roundness are contradictories. Contradictoriness is Aristotle's first sense of opposition.

Often, however, it is useful to divide things into multiple disjoint but exhaustive sets. A family of sets $C_{1,\ldots,}C_n$ is called a *partition* if everything is in some C_i, but nothing is in more than one. It follows that if there are more than two sets in a partition, the sets are not complements, and their defining properties are not contradictories. Just because an element is not in C_1 does not mean that it must be in C_2 because it might be in C_3. On the other hand, a single element cannot be in more than one set of a partition. This feature has a special name. If an element cannot be in more than one set of a group of sets, the properties defining those sets are said to be *contrary*. For example redness, blueness, and greenness are contrary but not contradictory. They are not contradictory because if something is not red, it does not follow that it is blue. One the other hand, color properties are contrary because nothing can be (all over at the same time) more than one color. Contrariety is Aristotle's second sense of opposition.

Often two contrary properties, usually ones that are extreme opposites, are contrasted. For example, the property pairs named by the adjectives *wonderful* and *horrible*, or *good* and *evil* are extreme contraries. Such contrasts are common in food and drink appreciation, as in the contrast in wine appreciation between *must buy* and *undrinkable*, or between *perfect* and *spoiled*. In such cases the pair describes a structure called a *square of opposition*.[6] Properties are assigned to node of the square as follows. The top two nodes are occupied by the properties that are contrary opposites. Traditionally, the upper right node is called *A* and the upper left *E.* Properties diagonal across the square are the contradictory opposites of each other. That is, the lower left is occupied by the property that defines the complement of *E.* Traditionally this node is labeled *I*. The lower right is occupied by the property that defines the complement of *E.* Traditionally, this node is labeled *O.*[7]



[6] The first occurrence of the square is found in Apuleius (1st century A.D.), and the illustration earlier of the square formed from the modal properties *necessary* and *possible* is from the logic of John Buridan (14th century).

[7] The labels for the left nodes, which are affirmative, come from the Latin verb ***a**f**i**rmo* (*I affirm*) and the labels for the right nodes, which are negative, from the Latin verb ***n**eg**o*** (*I deny*).

It follows that these properties stand in several logical relations to one another. One property *Q* is said to *follow from* or be *subaltern to* a property *P* if anything that has *P* *must* also have *Q.* It follows that *E* is subaltern *A*, and *O* is subaltern to *E.* Every wine that is a must buy is drinkable, and every wine that is undrinkable is dispensable. Two properties are said to be *subcontrary* to another if something must instantiate at least one of the two. It follows that *I* and *O* are subcontaries. Every wine is either drinkable or dispensable.