Universal Terminology

Chapter 2: Basic objects

This chapter examines the fundamental objects of Universal Terminology and presents their textual and formal definitions. Terminology is the linguistic part of an ontology, itself supposed to be independent of the representation of its content. It will be demonstrated that any modern and scientific terminology should preferably be independent of language in order to guarantee its universality. This is of course the case for the $\mathbf{T}_{logy}$, which makes all languages perfectly equivalent and protects them from the idiomatic divergences specific to a particular vernacular.

Definitions of what $\mathbf{T}_{logy}$is are presented formally. While many authors develop lists of terms and other classifications, often without formal foundation, a rigorous approach becomes necessary to enable the exchange of information both between human actors and between computer applications. This new framework for terminology development must be made explicit.

Moreover, scientific literature is clearly tending to take on an international status, where it is written in several languages and machine translation ensures its availability around the world. All languages will now be at the same level and the dominance of English will disappear. Universal Terminology constitutes the pillar of the field of anatomy, linking all linguistic or traditional variants to a common identifier.

This document constitutes Chapter 2 of the book on Universal Terminology, which is the original documentation of the $\mathbf{T}_{logy}$.

Contents

2.1 Introduction

This document aims to define the basic objects constituting the $\mathbf{T}_{logy}$, the types of entities included in the TAH hierarchy, certain elementary properties and the relationships governing the hierarchical trees.

In the first part, definitions are developed for objects such as terminology or entity. This exercise is challenging and does not claim to provide a definitive solution. However, it introduces the formalism inherent in ontology, which is a science in itself. Interested readers can find additional and in-depth information elsewhere (see the bibliography).

The second part deals with significant properties in the field of anatomy. Formal definitions must be created to enable communication between computer applications.

The third part deals with physical entity types, based on three fundamental properties: materiality, composition, and symmetry. Entity types strictly regulate the TAH partonomic hierarchy, as hierarchical relationships depend on the types of the parent and child entities.

The fourth part concerns the unit types used in the $\mathbf{T}_{logy}$.

Partonomic links are all specializations of the *part_of* relationship. This complex relationship will be studied in detail. It depends in particular on the types of the parent and child entities: each possible co-occurrence must be considered in turn. For example,

LA:*ossa carpalia* *LA:PairSubsetOf* LA:*ossa manus*

is a relationship between two paired set entities. The relationship

LA:*PairSubsetOf* *LA:isa* LA:*PartOf*

is verified and contributes to the specialization of the *part_of* relationship. Partonomic links are studied in detail in *chapter 13*.

2.2 Basic definitions

In this section, all formal definitions of importance in TAH are explicitly established and briefly discussed.

2.2.1 Class, instance, entity and unit.

A first definition cannot rely on other definitions, because it is the first. It therefore necessarily constitutes a kind of axiom or initial statement by the authors of the terminology:

Entity
`An entity (definition) is a universal ontological term encompassing objects, processes, functions, structures, time, and places, depending on the underlying domain concerned. An entity refers to an object in the domain and designates all of its occurrences.`

This definition will be revisited below under the name anatomical entity.

An entity is an abstract object that allows us to represent a real object in the domain under consideration. There are two types of entities. First, there are entities referencing an object existing in reality. These will be defined as Def:**specific entities**. The EN:*stomach* is a specific unit. Then there are entities linked to representational artifacts, necessary for the correct description of these objects. These will be defined as Def:**generic entities**. The EN:*organ with cavity* is a generic unit, the taxonomic parent of the stomach above. These two types of entities will be defined below, but first, we must define physical entities, either material or immaterial, and non-physical entities.

Physical Entity
`A physical entity (definition) is an entity that has one dimension and exists in reality.`

The physical entities are divided into material and immaterial entities. Only physical entities are included in the formation of the different TAH partonomies.

This property of dimension of the physical entity is true for any entity of dimensions 0 to 3. A 0-dimensional entity is a boundary entity for a 1-dimensional entity: it is an anatomical point.

In human anatomy, physical entities are primarily related to parts of the human body, whether material objects or their boundaries: LA:*manus* is a material object and LA:*sulcus nasolabialis* is a boundary.

Material Entity
`A material entity (definition) is a physical entity possessing mass.`

It is made of matter, whether solid, liquid, or gas. It is the most common entity in $\mathbf{T}_{logy}$. Examples of a material entity are the EN:*sternum*, the EN:*vertebral column* or the EN:*urinary system*.

Immaterial Entity
`An immaterial entity (definition) is a massless physical entity possessing 0 to 3 dimensions.`

It is devoid of matter and can be a space, a surface, a line, or a point. Therefore, it has 3, 2, 1, or 0 dimensions, respectively. In $\mathbf{T}_{logy}$, approximately 10 % of entities are of this type.

For example, an immaterial entity can have a volume like the EN:*laryngeal cavity* or be a two-dimensional surface like the EN:*costal surface of the scapula*, which is obviously not planar, or a line like the EN:*gluteal fold*. A zero-dimensional entity is a point, like the EN:*bregma*.

Non-physical entity
`A non-physical entity (definition) is a dimensionless entity that represents an abstract concept used to represent terminology`

Non-physical entities were infrequent in TA98: they were linked to the expression of directions and relationships and played only a secondary role. In TAH, non-physical entities are defined exclusively in the taxonomy.

Non-physical entities are vocabulary words, relationships between entities, entity types, and other representational objects. An example is EN:*distal*. Another example is EN:*abduction*. An example of a vocabulary word is the word EN:*scapula*. All relationships must also be considered non-physical entities, such as EN:*PairInPair or PIP*, which connects two immaterial paired entities. A complete description of the domain of anatomy requires many non-physical entities.

Class
`A class (or universal, type, genus) (definition) is a representation of all possible occurrences of an object, distributed in space and time.`

Classes share a common essence. Each class definition specifies the essence shared by the corresponding instances through the specification of (i) a Def:**genus**, which is a broader class to which the given class belongs, and (ii) a Def:**differentia** that distinguishes its instances within the broader class, in accordance with the Aristotelian principle of *genus et differentia*.

A class belongs to the domain of representation and not to reality. A class is an abstract concept representing reality.

Genus
`A genus (definition) is any class from which a subclass is defined that shares all its properties.`

Differentia
`A differentia (definition) is a set of properties that distinguishes a child class of a genus from among all its children.`

The very principle of differentia is to propose for each child entity of the same genus a set of one or more properties of that entity, such that these sets of properties are all different by at least one value. The set of properties of a differentia does not need to be extended beyond what is necessary for the above condition to be satisfied. But it can sometimes be succinctly extended to make reading more comfortable or natural for human operators. Typically, the differentia of the EN:*heart* with respect to the genus *organ with cavitated parts* can be limited to its location in the thoracic cavity, but a functional property on the role of the heart would be welcome, but not necessary.

In another part of this documentation, it will be shown that the Aristotelian principle of *genus and differentia* is the basis of the Def:**taxonomic definitions** that have been adapted in the $\mathbf{T}_{logy}$(see *chapter 14*).

We are now able to define an anatomical entity, in order to clarify the initial attempt at the beginning of this section:

Anatomical Entity
`An anatomical entity (definition) is a class in the field of gross anatomy, possibly extended to subfields of anatomy.`

$\mathbf{T}_{logy}$is primarily concerned with the field of gross anatomy, but is not limited to it. Indeed, extensions are possible in many subfields of anatomy such as histology or embryology, as well as in general fields such as physics, chemistry, and molecular biology. Such extensions are based solely on pragmatic criteria.

Instance
`An instance (definition) is a specific occurrence of an object of a class.`

An instance is an individual (a particular, a token) of a specified class, located in space and time. Classes exist in their respective instances.

The instances of the same class differ in size, shape, material, and occurrence in time, but they all share the set of properties that define and distinguish the class from which they originate.

Instances are widely distributed across space and time. The class EN:*sternum* includes not only the more than 9,000,000,000 sternums currently available on Earth as instances, but also past and future sternums over a period when the human species *homo sapiens* is considered stable.

In the TAH documentation, an entity class or an entity instance is often referred to as an entity, and the difference must be inferred from the context.

In a taxonomy, two types of classes can be distinguished based on their position in the hierarchical tree, thus giving rise to different types of instances. True instances correspond to classes directly instantiated in reality; other instances are called indirect instances.

True Instance
`A true instance (definition) is exclusively an instance of the entity itself, but not an instance of one of its ancestors.`

Indirect Instance
`An indirect instance (definition) is an instance of a descendant class.`

Indirect instances correspond to the classes inherited by the terminal entities of the taxonomic tree, but which are themselves partial differentiations in the definition of the terminal entities. An indirect instance does not exist in reality. For example, there is no real scapula, nor is there any representation of it, such as a drawing or an X-ray. But there is a EN:*left scapula* or a EN:*right scapula*. Therefore, a EN:*left scapula* is an indirect instance of a EN:*scapula* as well as an indirect instance of a EN:*flat bone*, or even an indirect instance of an EN:*organ*.

Unit
`A unit (definition) is a collection of entities with one to five elements, linked to a Def:generic entity.`

A typical example of a unit is a Def:**pair unit** such as LA:*clavicula*. This is the collection made of the generic entity *clavicula* and the three specific entities *clavicula (pair)*, *clavicula sinistra*, and *clavicula dextra*.

Only units receive a term as a name in the $\mathbf{T}_{logy}$. The entities constituting a unit have their respective terms automatically generated from the term unit. This feature is valid for all languages of the $\mathbf{T}_{logy}$.

2.2.2 ISA link, taxonomy

The ISA relationship
`An ISA relationship (definition) is the relationship between two classes that preserves all specifications and properties.`

The ISA relationship is the only relationship used when building the taxonomy. In the $\mathbf{T}_{logy}$, no ISA link can exist outside the taxonomy.

Taxonomy
`A taxonomy (definition) is a mathematical tree whose root (a top class or genus) is connected to all other classes by finite chains of ISA relationships satisfying the principle of single inheritance.`

The Fundamental Model of Anatomy (FMA) contains a taxonomy, which is adopted for the TAH. However, this taxonomy had to be partially adapted or updated to take into account the new features present in this edition of the TAH.

The principle of *single inheritance* has been adopted, in accordance with the FMA taxonomy. This means that every entity has a single parent in the taxonomy, without exception (except for the top-level entity, which has no parent). Other authors have developed taxonomies based on the principle of multiple inheritance, but this is a different approach to reality and is not considered here.

TAH Reference Taxonomy
`The TAH Reference Taxonomy (definition) is a partially revised subset of the FMA taxonomy, either expanded or limited to entities present in the TAH taxonomy.`

This TAH taxonomy was initially copied from the FMA taxonomy. However, some discrepancies were noted and corrected.

The TAH taxonomy is published in Latin, in accordance with the rules in force for the entire TAH taxonomy. Furthermore, thanks to the $\mathbf{T}_{logy}$ multilingual capabilities, it can be viewed in any interface language. This means that this version of the FMA is finally available in several languages.

2.2.3 Specific and generic entities

Entities play different roles depending on their position in the partonomy or in the taxonomy.

Specific Entity
`A specific entity (definition) is an entity that has only true instances.`

About half of the entities in the taxonomy are specific entities, called terminal or leaf entities of this hierarchy. The set of specific entities constitutes a global partonomy under the superordinate entity LA: *corpus humanum*. Specific entities, and only these, can always be found in the dissection room, in the sense that they exist in reality. Any entity physically present in a human body, isolated and placed on the dissection table, is a specific entity.

It should be noted that this definition of a specific entity as a terminal entity of the taxonomy is only valid in a complete taxonomy of the domain. For example, LA:*humerus* is not a specific entity, because a complete taxonomy would necessarily add LA:*humerus sinister* as a child of the previous entity, making it a non-terminal entity.

Following the previous example, another specific entity should be mentioned: the LA:*humerus (par)*, which is in fact the partonomic parent of the *humerus sinister* and the *humerus dexter*. The pair of humeri is the Def:**pair entity** consisting of the two humeri in the human body.

The partonomy (to be defined later) consists exclusively of specific entities.

Generic Entity
`A generic entity (definition) is an entity in the taxonomy that cannot have true instances.`

The taxonomy consists exclusively of generic entities, with the exception of terminal entities, which are always specific entities.

2.2.4 The part_of relationship and partonomy

In this book, we use the term partonomy as a synonym for meronomy, a term favored by some authors. Wikipedia recognizes both terms.

Anatomy is particularly concerned with partonomic relationships. This is due to the fact that a natural presentation of the anatomy of the human body is achieved in the form of an anatomical atlas. The anatomical atlas presents a subject (the whole) with all its constituent entities (the parts) in the form of drawings. This paradigm is natural and universally widespread: it constitutes a fundamental approach for teaching anatomy.

When we relate an entity to one of its constituent parts, we encounter a relationship called part_of. This is a well-known relationship, frequently encountered in various fields and extensively documented. However, unlike the predominant ISA relationship in taxonomy, this relationship is somewhat more complex and difficult to formalize. Furthermore, it receives different meanings depending on the context, so the secure exchange of information containing this relationship is questionable. And how many authors have claimed that *blood part_of artery*? An obvious error, illustrating the difficulty in properly understanding the part_of relationship!

part_of relation
`A part_of relation (definition) is a relation between an entity and one of its constituent parts, valid for physical entities. It states that any matter or space of the part is also matter or space of the whole and that there exists matter or space of the whole that is neither matter nor space of the part.`

The part_of relation applies to both material and immaterial entities. In the latter case, a space can be the child entity of a larger cavity; or a face can be the child entity of a volume.

This textual definition is useful for communication between human readers, but it is not sufficiently precise. In the following section, this definition will be reformulated in mathematical language.

Partonomy
`A partonomy (definition) is a partial ordering of entities linked by part_of relationships.`

Global Partonomy
`The global partonomy (definition) is a partonomic hierarchy under a top entity, including all specific entities via part_of link chains.`

A global partonomy includes all specific entities, except generic entities, and this top entity is either LA:*corpus humanum masculinum* or LA:*corpus humanum femininum*. A global partonomy necessarily contains all specific entities of the taxonomy. All their instances are true instances.

It is an essential characteristic of the field of anatomy to have two top entities. There are indeed two human bodies in the representation of this domain, which despite more than 90 % of common parts, are distinct. It is not possible to speak of two genital systems in the partonomy of the human body. It is obviously necessary to speak of a single genital system in each top entity, namely in each human body, male or female.

In the presentation of the partonomy, for practical reasons, we choose to present the common parts only once. This is merely a communication artifact. As soon as we discuss the non-common parts specific to a gender, a typographical mark is systematically present. See for example EN:*external female genitalia*.

Generic Partonomy
`A generic partonomy (definition) is a partonomic hierarchy underlying a generic entity, serving as a model for its descendants in the taxonomy.`

The number of generic partonomies is not limited. They are defined around generic entities, for example, LA:*thoracic vertebrae* or LA:*retinal cones*. By definition, the partonomic links of a generic partonomy are inherited throughout the taxonomy. But the importance of generic partonomies is increased when considering microscopic entities located below the tissue level.

Generic partonomies are generally small. They are always embedded in a global partonomy or one of its sublists, below the corresponding generic entity. In this case, they begin with the character # and continue exclusively in the indented part that follows. A generic partonomy is not part of the list in which it is included, and is positioned there for convenience. One can directly see the generic partonomy of the cones of the retina or the generic partonomy of the thoracic vertebrae.

2.2.5 Terminology

It is now possible, based on what has already been defined, to propose the important definition, that of terminology:

Terminology
`A terminology (definition) is a representational artifact providing language-independent terms for all relevant entities in a domain, with an emphasis on identification, definition, and naming.`

This definition establishes a direct link between a Def:**term** (defined below) and an Def:**entity**. It also explains the three facets of terminology: identifiers (see *chapter 03*), definitions (see *chapter 14*), and linguistic aspects (see *chapter 08* and *chapter 09*).

This definition can be compared to the one presented in [Smith et al., 2006]. It states: *A TERMINOLOGY is a representational artifact consisting of representation units which are the general terms of a natural language used to designate entities in a specific domain.* The idea of representational artifacts was first introduced by this article. However, the author was not aware at the time of the need for language independence, or at least did not mention it.

[Smith et al., 2006]
This article provides a basic introduction to the ontology of the anatomical domain. It emphasizes the separation between reality and its representation. It defines several fundamental objects, such as universals and instances, continuants and occurrents, as well as more complex objects, such as ontology and terminology.

Indeed, the strong claim of this definition is linguistic independence. It will be ignored in the early stages of the discussion, only to be reiterated later.

The TAH terminology focuses on the field of gross anatomy, including some developments in histology. In the original 1998 version of the TA, it contains approximately 7,500 independent entities, which corresponds to the level of knowledge of general medicine, but is generally insufficient for specialties. The TAH was initially published in 1998 as a sequential list in a book. TA objects were identified by an 11-character code defining an order of presentation, but this code, too restrictive and insufficiently neutral, was quickly abandoned in the TAH. The official name is in Latin, and English equivalents are provided. Important synonyms are included, as well as links to eponyms. The TAH is initially produced in Latin, English, French, and Spanish; it is intended to be translated into several languages. The size of the TAH in 2025 is more than double that of the TA, or over 15,000 units. This increase in size is mainly due to the inclusion of taxonomy in the terminology, in addition to the presence of 20 percent more units compared to the 1998 TA.

Paradoxically, a terminology cannot achieve its goal of naming entities if they are not precisely delimited or identified. A precise term must correspond to a perfectly defined entity, allowing it to be distinguished from any other entity at a minimum. In 1998, TA assumed the existence of general anatomical knowledge shared by human beings, which, at first glance, replaced the definitions of anatomical entities. Such a situation suffers from the absence of explicit formulation: it is therefore sometimes vague and often ambiguous. From the implementation of TAH, a concept of entity definitions was established: TAH is committed to a predominant effort aimed at formulating definitions for all the entities it deals with (see *chapter 14*). A system of textual definitions based on taxonomy, called taxonomic definitions, was established. It is also planned to make these definitions machine-readable, at the cost of complex formalization.

The 11-character TA98 code suggested a partonomy of the field of gross anatomy. However, the lack of a formal basis in the 1998 source version complicates harmonization with other ontologies. This was considered a major obstacle to widespread acceptance of this initial version of anatomical terminology. One of the goals of the revised version of anatomical terminology is to resolve this problem.

A more detailed analysis of term definition will be addressed in Chapters 8 and 9, respectively titled Anatomy of a Term and Grammar of Terms.

Let now consider the problem of dependency to one or more languages. A terminology is a representation of the reality, in our situation a representation of the human body. Is a human body more Latin or more Mongolian than it is English or French? Is the reality more important in one language than another? Evidently not, because anatomy itself is universal. But the terminologies have always preferred some languages to others. The reason is simple, the authors of the terminologies did not had the knowledge and/or the tools and/or the manpower for the management of multilingual terminologies, or better for the development of a universal terminology.

In this context, with this essential problem being clear to some terminology authors, Latin was presented as a relatively neutral language, independent of countries and political considerations. Thus, Latin was proposed as a universal language. This is the basis of Terminologia Anatomica. The disadvantage of Latin lies in the fact that it is not sufficiently taught in many countries and that many anatomists do not feel comfortable with it. This is a fact, not an opinion! A recent referendum among the National Societies of the IFAA revealed a narrow majority unfavorable to Latin.

Faced with this dilemma during the development of TNA terminology, it quickly became apparent that developing an abstract, language-independent representation was feasible. Several reasons justify this assertion:

- Necessity: There is a compelling need for a solution.
- Feasibility: Computational tools exist to enable abstract representation.
- Cost or Time: The field of anatomy, from a linguistic point of view, is of a reasonable size.

On this basis, the TAH was implemented according to the concept of Universal Terminology, which means that it is language-independent. To demonstrate its feasibility, the TAH was partially created in five languages: Latin, English, French, Spanish, and Russian. Other languages can be added relatively easily with moderate labor effort. The translation was automated and validated by native speakers. The final quality is at least as good as that of manually prepared term lists.

The adaptation of this Universal Terminology to the entire TA was implemented and finally completed in 2025. This success in a relatively short timeframe (mainly by two part-time employees) is definitive proof that the underlying computer tool is an essential requirement for any future anatomical terminology.

This book constitutes a scientific documentation of the Universal Terminology. The programs necessary to support it will be made available in due course in the public domain on GitHub.

2.2.6 Vocabulary

In general, vocabulary is a set of words from a specific language. However, since we are building a language-independent terminology, we must define vocabulary at an abstract level. We can then associate this abstract level with the vocabulary of any vernacular language.

Lexeme
`A lexeme (definition) is an abstract lexical representation of a word, used to name the objects of the terminology. The types of lexemes are noun, adjective, prefix, or invariant.`

The abstract vocabulary of anatomy is composed of lexemes, which can be of four different types for each entry: noun, adjective, prefix, and invariant. Each entry can contain from zero to four lexemes for each language. The absence of lexemes in a language is possible, as some languages are less extensive than others.

The vocabulary itself is a set of entries, each linked to an abstract language unit corresponding to the words in the different languages where the terminology will be expressed, These entries are primarily specific to the field of anatomy, although common words are also required.

Vocabulary
`A vocabulary (definition) is a set of lexemes necessary for the textual expression of terminology. These lexemes can be associated with words specific to any language.`

In practice, $\mathbf{T}_{logy}$defines lexemes language-independently, without regard to the target vernacular languages of their representation issues, such as syntax, synonyms, homonyms, traditional preferences, etc. In a separate subsequent process, completely independent in terms of time and labor, undertaken for each candidate target language, the universal representation is associated with a specific language. There is no imposed link between one language and another. This strategy guarantees the independence of $\mathbf{T}_{logy}$from any language.

However, one language plays a special role in the terminology: Latin. This ensures two major aspects: 1) a Latin example is provided for each term in the terminology and demonstrates the feasibility of the universal model; 2) it preserves the traditional role of Latin in anatomical terminology and ensures an efficient transition with previous terminologies. However, this Latin correspondence is in no way necessary to perform a correspondence with another language: at most, it acts as a model.

2.2.7 Term

Term
`A term (definition) is an ordered sequence of lexemes, controlled by a universal grammar, which can be automatically transposed into an equivalent term in any language for which its own grammar has been created.`

This definition concerns a universal term and establishes the principle of machine translation in any vernacular language. To do this, for a specific language, it is necessary to establish the transposition links between the universal grammar and the grammar of the language. In general, the transposition rules must solve different problems:

- Sequence of lexemes: The order of lexemes in a term in a given language may differ from the order specified by the universal order. For example, adjectives follow the noun in the universal grammar, as well as in French and Spanish grammars, but precede it in English and Russian.
- Genitive: The formation of the genitive case differs in declined languages. For example, Latin and Russian have a decline, but English, French, and Spanish form the genitive case with a preposition.
- Variability of adjectives: Adjectives can vary in gender, number, and/or case depending on the target language.
- Linguistic exceptions: Here and there, some languages require atypical rules. For example, traditional Latin can place a genitive phrase within the noun phrase on which it depends.
- Prepositions: The use of prepositions can govern different cases depending on the language. However, prepositions are optional, at the discretion of each language.

The full description of the machine translation process is given in *chapter 10*.

2.2.8 List

Lists play an important role in terminology and are not just a presentational artifact. A list is precisely defined by three parameters:

- content: A list is composed of a top-level entity, serving as an identifier, followed by a hierarchical expansion according to a hierarchy defined in the terminology, with an indentation process generated from the hierarchy.
- time: Any list is valid precisely at the time of its creation and can be potentially different from any previous or subsequent version, depending on updates to the anatomical entities it contains.
- language: A list resulting from a mapping process from the universal representation of terminology to a target language, unsynchronized with another language, depends on the quality of the actual implementation of the target language.

List

`A list (definition) is an ordered and sequential set of entities generally represented by their terms, a set that depends on a terminological hierarchy. Every list is valid at a specific time and is expressed in a specific language.`

Every list bears its creation date in the bottom right-hand corner. Obviously, any updates after this date will not be visible in the list.

Lists are particularly sensitive to the terminology update process, especially long lists with more than one hundred items. Updates are necessary for at least three reasons: error correction; ongoing validation of content by experts; and improvements in the medical field. It is certainly inconvenient for a casual user of terminology to find a specific list of interest, whose size varies depending on the access date. To minimize this problem, the concept of published lists was created: these are lists frozen at specific times.

Another process concerns lists: a signature can be calculated based on the item identifiers, hierarchical indentation, and the overall size of the list. However, this signature is completely independent of the language used. When the list is created, the signature is calculated and stored in the database. Later, when the list is regenerated, possibly in a different language, the signature is recalculated and compared to the original value. A signature match guarantees the integrity of the list.

Lists resulting from hierarchies can be very long. For example, the entire taxonomy list exceeds 10,000 lines. Lists that are too long are not easy to consult. This is why the concept of *sublists* was created, which present parts of lists. There are four levels of partonomic sublists: P1, P2, P3, and P4. There are four levels of taxonomic sublists: T1, T2, T3, and T4. It is relatively easy to navigate between list levels, moving from general to specific and vice versa, as needed.

A partonomic list at level P1 is the digestive system, which has 10 sublists at level P2. The one concerning the small intestine contains at level P3 the duodenum.

2.3 Formal part_of

To manage the complexity of the part_of relationship, it is necessary to develop a formal approach. The above definition is perfectly valid, but it is in text form. It is therefore difficult to transfer to a computer. A more formal context is required, which will also be useful for later defining properties or relationships.

To do this, we follow an approach similar to infinitesimal calculus. We consider any material entity to consist of fine grains of matter that are adjacent and continuous, regardless of the shape of the entity under consideration. The size of the grains is small enough relative to the entire entity to ensure that it does not interfere with the entity's properties. In this approach, any entity A can be defined as the sum of its constituent grains δA giving:

$$A = \sum \delta A$$

It is clear that the grains in our formula have nothing to do with human tissues or cells: they constitute a pure mathematical model external to the real world.

We can now reconsider our initial definition and reformulate it in mathematical language:

A part_of B if

$$\text{given } A = \sum \delta A \text{ and } B = \sum \delta B$$

$$1)\ \forall \delta A \exists \delta B : \delta A = \delta B$$

$$2)\ \exists \delta B : (\forall \delta A \text{ then } \delta B \neq \delta A)$$

It is clear from this definition that the part_of relation is transitive:

if A is part_of B and B is part_of C then A is part_of C

2.4 Properties

Several properties are important because they are involved in the definition of all variants of the part_of relationships. In particular, some of these properties, physical, material, generic, composite, and pair, are involved in the definition of entity types.

2.4.1 Symmetric Property

Symmetric Property
`The symmetric property A Sym B (definition) is true when A is symmetric to B about the central sagittal plane.`

Let's prepare the formal definition of this property. We first define a horizontal X axis and a vertical Y axis in the central sagittal plane. Then, we define a Z axis perpendicular to the previous ones. Based on this, any point in space has coordinates on all three axes. The definition can now be expanded:

A Sym B if

$$\text{if } A = \sum \delta A \text{ and } B = \sum \delta B$$

$$\forall \delta A \exists \delta B : \delta A_X = \delta B_X \text{ and } \delta A_Y = \delta B_Y \text{ and } \delta A_Z = -\delta B_Z \text{ and } \delta A_Z > 0$$

2.4.2 Midline Property

Midline Property
`The midline property Mid ( A ) (definition) is true when A is a midline entity with respect to the central sagittal plane.`

Mid(A) if

$$\text{if } A = \sum \delta A$$

$$\forall \delta Ai \exists \delta Aj : \delta Ai_X = \delta Aj_X \text{ and } \delta Ai_Y = \delta Aj_Y \text{ and } \delta Ai_Z = -\delta Aj_Z$$

In fact, a midline entity is like two symmetrical entities joined in the central sagittal plane.

2.5 Entity type

The objective of this section is to analyze the entities of the $\mathbf{T}_{logy}$, in other words, what types of entities they are. One of the hierarchies of the $\mathbf{T}_{logy}$is global partonomy, whose implicit objective is to express global entities and all subordinate entities that are part of the first and enter into its anatomical structure. This procedure arises from the natural way of presenting gross anatomy in atlases, from the general to the particular.

Partonomy is the complement to the taxonomic hierarchy, such as that proposed by the Fundamental Model of Anatomy (FMA).

The Def:**part_of** relationship may be intuitive to humans, but a formal definition is not easy to formulate to control its presence or absence. There are numerous examples in the hierarchy where this relationship is not intuitive in the presence of certain types of entities. In other words, a formal extension of the strict part_of relation is necessary to deal with all anatomical situations.

Entity types govern the hierarchical relationships of the partonomy and vice versa. Several constraints on relationships arise from the entity types at both ends of the relationship. Therefore, for rigorous control of hierarchical relationships, it is necessary to formally define entity types.

The partonomy applies only to Def:**physical entities**. In the following discussion, Def:**non-physical entities** are not included, although they exist in the partonomy. They are part of the taxonomy, but are absent from the partonomy.

Physical entity types are based on three independent properties: materiality, parity, and composition. Each of these properties has two values: materiality separates entities into Def:**material entities** and Def:**immaterial entities**; composition separates entities into Def:**simple entities** and Def:**composite entities**; and parity separates entities into Def:**pair entities** and non-pair entities. This diagram defines eight entity types and can be clearly represented as a cube (see figure 2.1).

In addition, three alternative entity types are documented below. They are necessary for a universal and secure presentation of the $\mathbf{T}_{logy}$: Def:**lexical entities**, Def:**vocabulary entities**, and Def:**interface entities**.

2.5.1 Simple Entity

Simple Entity

`A simple entity (definition) is a physical entity consisting of a continuous assembly of matter or spaces that constitute it.`

$$A = \sum \delta A$$

Examples: sternum, stomach, atlas.

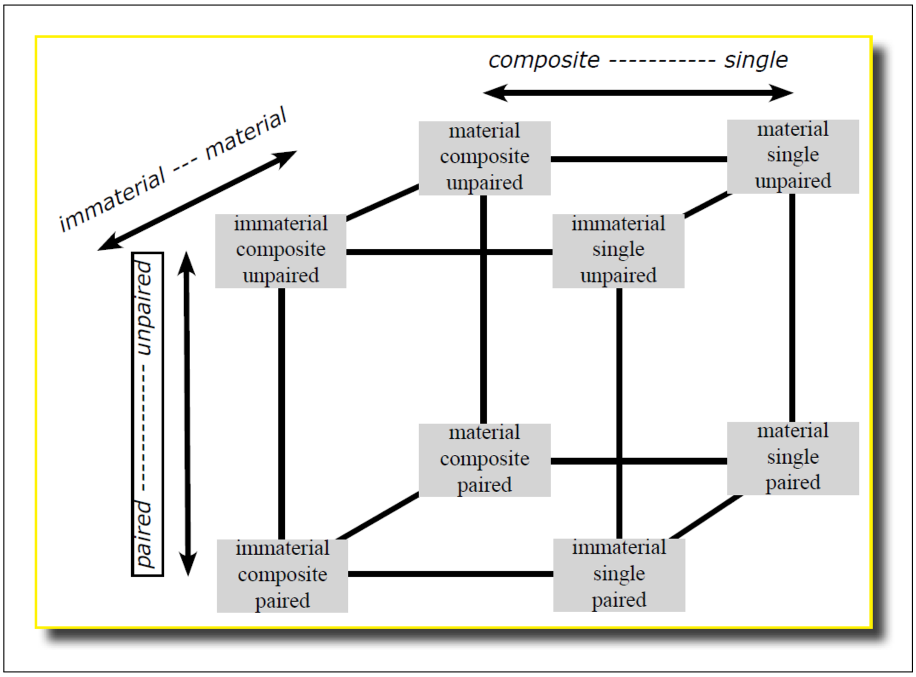

Figure 2.1: The entity type cube, presenting the 8 physical entity types.

2.5.2 Composite Entity

Composite Entity

`A composite entity (definition) is an entity consisting of several distinct components, all corresponding to different occurrences of a generating entity. This generating entity is a generic entity that is the taxonomic parent of all distinct components.`

$$A = \sum \delta A_1 + \sum \delta A_2 + ... + \sum \delta A_N$$

Composite entities are sets often found in terminology to designate objects that appear multiple times in the human body.

Example: cervical vertebrae, interphalangeal joints of the foot.

The two composite material and immaterial entities described above are not sufficient to represent reality. Indeed, some composite entities are made up of a mixture of material and immaterial entities. In general, the entity LA:*morphologia externa telencephali* contains both material and immaterial entities. Such a composite entity is called a mixed composite entity.

Mixed Composite Entity

`A mixed composite entity (definition) is a composite entity whose generator has both paired and unpaired children.`

According to this definition, a mixed set can consist of both paired and unpaired entities. A typical example is the LA:*cisternae subarachnoideae craniales*:

some child cisternae are median simple unpaired entities, others are paired entities.

2.5.3 Simple pair entity

Simple pair entity

`A simple pair entity (definition) is a pair of simple entities symmetrical about the central sagittal plane.`

$$A = \sum \delta A^L + \sum \delta A^R$$

This type represents all pairs of entities symmetrical about the central sagittal plane, which represent approximately 50 % of the $\mathbf{T}_{logy}$. Each pair necessarily has two members, called the left member and the right member.

A pair entity can in no way be considered a composite entity of cardinality 2, because its partonomic descendants are of different natures according to different applicable links. In a pair, each member can be subdivided into smaller constituents; in a composite entity, any partition of a member of the set is forbidden and the partition is performed uniquely by a distribution of the members into subsets or individual members.

Example: radius (pair) or pair of radii.

2.5.4 Composite Pair Entity

Composite Pair Entity

`A composite pair entity (definition) is a pair of composite entities symmetrical about the central sagittal plane.`

$$A = \sum \delta A^L_1 + \sum \delta A^R_1 + ... + \sum \delta A^L_N + \sum \delta A^R_N$$

For example, LA:*costae (par)* is a specific entity composed of 12 occurrences of the pair entity ribs.

The composite pair entity is often referred to in this documentation as *pset*.

2.5.5 Lexical entity

Lexical entity

`A lexical entity (definition) is an entity with a synonym term for another entity.`

During expansion of terms from one entity to another, the main term is used. The expansion on a lexical entity allows the usage of a synonym term.

An example is the LA:*telencephalon* which is often called *cerebrum* thanks to a lexical entity.

2.5.6 Vocabulary Entity

Vocabulary Entity
`A vocabulary entity (definition) is an entity instantiating a lexeme in a given language, in the form of a noun, adjective, prefix, and/or invariant.`

Any lexeme used in the composition of a universal term must be available in any language where a term is to be transposed. Depending on the universal term, different word categories may be proposed.

For example, the word pancreas is defined by LA:*nomen pancreas*. We can see that the $\mathbf{T}_{logy}$includes more than 50 occurrences of this entity, either the noun *pancreas*, or the adjective *pancreatic*, or the prefix *pancreatico*.

The corpus of all vocabulary entities defines a vocabulary in each modern language used for the presentation of terminology. This corpus is accessible on the $\mathbf{T}_{logy}$website.

2.5.7 Interface Entity

Interface Entity
`An interface entity (definition) is an entity that provides standard interface texts, captions, and tooltips for use in materials where terminology is displayed.`

As with any entity, the texts are available in all languages offered for presentation.

2.5.8 Reference Entity

Reference Entity
`A reference entity (definition) is a pseudo-entity in the form of a link to another entity.`

A reference entity is used in hierarchical lists when, at a specific point in the list, the presence of that reference is relevant, but is not part of the list. A reference means "see also." References are in no way part of the hierarchy in which they appear, but are merely additional information inserted for convenience.

In the description of the white matter of certain parts of the central nervous system, there are numerous references that naturally point somewhere in the section LA:*tractus systematis nervosi centralis*. This stems from the fact that in the $\mathbf{T}_{logy}$, white matter is described separately from the parts of the nervous system that give rise to it, for reasons documented elsewhere.

2.6 Unit type

Units, defined as an assemblage of entities corresponding to the same object in the domain, are the only objects explicitly named in the $\mathbf{T}_{logy}$. Entities that always belong to a unit are named based on the unit name, using an appropriate generating process.

Typically, a Def:**paired unit** such as the EN:*pinna* is composed of a generic entity *pinna*, as well as three specific entities *pinna (pair)*, *left pinna*, and *right pinna*, whose terms are generated automatically. The same applies to a Def:**unit of set** such as EN:*typical cervical vertebra* composed of the generic entity *typical cervical vertebra* and the specific entity *typical cervical vertebrae* in the plural as appropriate.

A detailed description of the units is available in *chapter 05*.

2.6.1 Single Unit

Single Unit
`A single unit (definition) is a unit consisting of a single generic entity.`

Indeed, such an entity is both generic and specific. An example is the EN:*sternum*.

2.6.2 Pair Unit

Pair Unit
`An pair unit (definition) is a unit composed of a generic entity and three specific entities representing an pair object in the field of anatomy.`

The specific entities are the pair of two symmetrical lateral members, the left member and the right member.

In $\mathbf{T}_{logy}$, more than one in two units is a pair unit. An example is the EN:*scapula*.

2.6.3 Pair Set Unit

pair Set Unit
`An pair set unit (definition) is a unit composed of two generic entities and three specific entities representing an even set of objects in the field of anatomy.`

The even set unit is often referred to as *pset* in this documentation.

The two generic entities are the parent entity of all the components of the set and the set entity of all these components. The three specific entities are the pair of two symmetrical lateral sets, the set of left-hand members, and the set of right-hand members.

An example is the EN:*ribs*.

2.6.4 Set Unit

Set Unit
`A set unit (definition) is a unit consisting of a generic entity and a specific entity representing a non-pair set in the domain of anatomy.`

The unique specific entity is the set of child entities of the generic entity. An example is the EN:*gastric glands*.

2.6.5 Mixed Set Unit

Mixed Set Unit
`A mixed set unit (definition) is a unit composed of a generic entity and a specific entity representing a mixed set of objects in the domain of anatomy.`

The objects in the mixed set can be a mixture of pair and non-pair entities or a mixture of material and immaterial entities. An example is the EN:*male internal genitalia*, where all daughter entities are even except the EN:*prostate*.

Bibliography

[Smith et al., 2006] Smith, B., Kusniercyk, W., Schober, D., and Ceusters, W. (2006). Towards a reference terminology for ontology research and development in the biomedical domain. *In Proceedings of KR-MED 2006*. PDF.

2.7 Log of updates

05 Jul 2025 Completely revised version. From now on, this document is the translation of the French original document.

18 May 2024 Full revision of the chapter with introduction of formal definitions.

26 Dec 2023 Extension of definitions for the units.

30 Mar 2022 Standardisation of the file as a chapter.

10 Mar 2021 Creation of the file.

2.8 Credentials

This document is part of the book "Universal Terminology," which accompanies the website Terminologia Anatomica, sponsored by the University of Fribourg, Switzerland. It expresses the authors' view of the $\mathbf{T}_{logy}$on the foundations of the science of ontology, supporting the terminology presented here. Although it is as accurate as possible, close to the reality of the terminology database and the software that supports it, approximations, errors, and ambiguities are possible and should be considered beyond their control and intentions.

Any comments regarding the content of this document, the website, and its presentation are welcome. An appropriate response will be provided if necessary.

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