Universal Terminology

Chapter 13: Partonomy

The partonomy - also named mereology - is the preferred hierarchy of the anatomists, because it looks similar to the atlas of anatomy where each figure shows some body part and all its subparts. But the partonomy is formally complex and difficult to implement. Several common relations applicable to the domain of anatomy are similar to the *part_of* relation, but are indeed false friends and are inducing errors of representation.
This chapter will clearly define what is the *part_of* relation and will show how the partonomy lists are built. The reader will discover the multiple specializations of the *part_of* relation, with formal definitions and adequate examples.
This document is the chapter 13 of the book Universal Terminology which presents a global documentation on the $\mathbf{T}_{logy}$.

Contents

13.1 Introduction to the partonomy

The partonomic hierarchy is governed by the part_of relation, which is relatively familiar to the educated human beings: we clearly are able to identify an object and to distinguish several parts of this object. But this a priori simple approach is an illusion, because we will have rapidly to face uncomfortable situations as examplified by the following questions:

- Is a retinal artery part of the eye?
- Is the blood part of the artery?
- Is the surface of a tooth material or immaterial?
- Are the LA:*arteriae digitales plantares part_of* the LA:*arteriae metatarsales plantares*?
- How to define a branch of an artery as a part_of this artery?

A casual user of the $\mathbf{T}_{logy}$cannot necessarily be sure of the answers.

13.1.1 Past terminologies

In 1998 was published the first version of Terminologiy Anatomica (TA98) with the following indication: *The order in which the terms are set out follows the anatomy naturally through each system. Indentation and heading styles are used to indicate the relationship of one term to another.* The part_of relation is not even mentioned. However, a simple walk through the TA98 edition gives immediate evidence that the presentation is mainly oriented around the partonomic hierarchy. But a closer examination will soon or later make visible numerous problems. These problems must be solved in a modern terminology.

Anyway, to do justice to the authors of the TA98 and in particular the chairman of its working committee Professor Ian Whitmore [Whitmore, 1999], it must clearly be said that this version of an anatomical terminology was a major step forward at the time of its publication. It has presented a new modern classification of the anatomical terms, it has open the scope of the anatomical terminology to an international level, and it has made evident the need of a quality reference for the terms of anatomy. We can claim at evidence that the here presented Universal Terminology is grounded on the initial work done under the umbrella of TA98.

However, it is time to make the next steps. The initial concept was valid at the time of its publication, but is not sufficient in a digitized society of the 21st century. The science of ontology as emerged and is no more an option, it must be the core of the present and future terminologies. The formal linguistic is another necessary tool for the management of 50000 terms in multiple languages. The storage and the support of the terminology today is a structured database and the related software to validate it. The time of working lists in 6 columns under the form of spreadsheet is over. The new terminology is founded on formal principles and definitions.

The present chapter is one of the several chapters of the book on Universal terminology. This book is an initiative to provide an answer to the above condition. It aims at setting the basic principles of the new terminology. It provides

numerous definitions in order to justify and to constrain the development into strict scientific limits. The main contribution is to make the terminology independent of any language, and consequently to restore the expression of each individual language on a equal level. The new terminology is neither dependent on Latin, nor on English. This goal has never been stated before, nevertheless, the actual implementation has demonstrated its feasibility in several languages, including the Latin.

Beside the partonomy, we always have to consider the taxonomy: these two hierarchies are complementary and only their parallel presentations would give a complete view on the domain of anatomy: each hierarchy taken alone is unable to show the essential of anatomy: the taxonomy classify the entities by type and the partonomy provides a spatial distribution of these entities. Hopefully, when the TA98 partonomy was published, another initiative was able to build and to publish a taxonomy, call the Foundational Model of Anatomy (FMA)[Rosse, 2001]. These quasi simultaneous efforts were able to give us comparable corpus of significant data. Any further developments must by presented following the same lines.

13.1.2 Around the part_of relation

Several authors have studied the part_of relation and have described it in different domains. This is not our role to present these developments and they are largely documented in the scientific literature. However, in the domain of anatomy, we have a specific context. At first we exclude the temporal relations, that do not exist if gross anatomy as well as most sub disciplines of anatomy, with the exception of embryology for which an extension would be necessary. Then we proceed principally with physical entity, either material or immaterial. Our working context is the material objects outside of temporal constraints: this is a much simpler situation that the general situation.

Our approach will be in three steps, which are sufficient for the $\mathbf{T}_{logy}$:

- To define the part_of relation in the context of material entities.
- To extend this definition to immaterial entities.
- To extend this definition to the branch_of relation.

13.1.3 Material part_of

The relation material part_of concerns the partonomic link between a father material entity and a child material entity, typically LA:*acromion* part_of LA:*scapula*. Basically, we define the relation by the matter that is present in both the father and the child entities.

material part_of relation
`The material part_of relation is a link between entities A and B of the form A part_of B, where all the matter of A is matter of B, and there is some matter of B distinct of A. The term matter has to be understood depending on the actual granularity, from a tissue to a biological cell and to a molecule.`

Under this definition A and B cannot be equal: A is strictly a part of B. An immediate property of this relation is the transitivity. If A part_of B and B part_of C, then A part_of C.

This definition is a generic definition: it defines at large what are all the specializations to be presented thereafter.

13.1.4 Immaterial part_of

The relation immaterial part_of concerns the partonomic link between any father entity and an immaterial child entity, typically LA:*facies sternocostalis* part_of LA:*cor*. Basically, we define the relation with an immaterial child which is a space, a surface, a line or a point defined in relation to a material entity.

immaterial part_of relation
`The immaterial part_of relation is a link between entities A and B of the form A immpart_of B, where there is an entity A' in the relation A' part_of B or A' = B, such that A is some space occupied by A', a surface, an edge or a point in A'.`

13.1.5 Branch_of

The relation branch_of concerns the partonomic link between a father and a child in a subdomain of anatomy with a dendritic hierarchy (vessels or nerves), typically LA:*arteria thyroidea superior* branch_of LA:*arteria carotis externa*. In this situation, we consider each entity as the entire subtree of which it is the trunk, this means that any entity recursively includes the trunk and all its branches. As a consequence, any branch being part of the tree, we join the former part_of definition.

branch_of relation
`The branch_of relation is a link between entities A and B of the form A branch_of B, where B' is the entire tree of which B is the trunk and A part_of B'.`

The branch_of relation applies only to material entity.

13.2 Fundation of the partonomy

The partonomic hierarchy in a domain is in general made of two sets of partonomic lists. First, there is a set of global lists based on the top objects forming the domain; the number of top object is quite variable depending on the domain, from one to several objects. Second, there is an undefined number of generic lists, necessary in presence of set of entities in one object of the domain; one does not want to explicitly make the hierarchy of each member of the set; instead of that we define a generic partonomy applicable to all members. Formally, any of the above partonomic lists is independent of any other lists.

13.2.1 Duality of the domain

In the domain of anatomy, we have two top objects and a few hundreds of generic partonomic lists. Indeed, we have to face two top objects: the *corpus humanum femininum* ♀and the *corpus humanum masculinum* ♂. They are evidently different despite more than 95 percent of their parts are common and essentially not differentiated, at least at the level of the terminology. The difference is the 23rd chromosome: where this chromosome is expressed, the body parts are possibly different. A male body part necessarily belongs to a male individual and a female body part necessarily belongs to a female individual. The terminology must be exact and explicit to this respect. Any body part specific to a given sex must be flagged as such wherever it appears. This was not so clear in past terminologies.

Because 95 percent of all body parts are common to both sexes, it has been long advocated to use a single representation and to flag only the exceptions: this is clearly a pragmatic approach. But it must be driven with precision. To do that we distinguish three types of entities regarding the sex chromosome:

- Ordinary entities are simply represented without any sex flag. This means that such a form represents the two entities for each sex. A typical example is LA:*stomach*, which represents both the *stomach* ♂and the *stomach* ♀. It is not necessary to distinguish these two entities, therefore the representation without any sex flag is adequate.
- Exclusive male entities are flagged with the male sign ♂. Their fathers and children are necessarily of the same sex, but they can be represented as ordinary entities. A typical example is LA:*musculus vesicoprostaticus* ♂. In the $\mathbf{T}_{logy}$, any exclusively male entity must be flagged with ♂.
- Exclusive female entities are flagged with the female sign ♀. Their fathers and children are necessarily of the same sex, but they can be represented as ordinary entities. A typical example is LA:*urethra feminina* ♀. In the $\mathbf{T}_{logy}$, any exclusively female entity must be flagged with ♀.

A strict discipline is advocated in consideration to the above three types. This was not true of TA98, for example LA:*clitoris* ♀ was not flagged.

13.2.2 Top of global partonomy

There are two global partonomies in the domain of anatomy, depending on the gender. For each hierarchy, let examine the top entities and their articulation

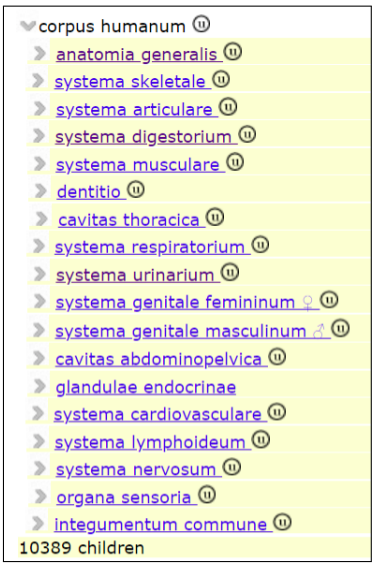

Figure 13.1: This is the representation of the global top partonomy for the domain of anatomy, as it is presented on the website of $\mathbf{T}_{logy}$.

with the children entities immediately below. The top entity is LA:*corpus humanum* and the list of its immediate children is given in figure 13.1.

The representation of the figure is to be understood as either the female representation or the male representation. The result is illustrated for the *corpus humanun femininum* ♀, a similar representation existing for the *corpus humanum masculinum* ♂:

- LA:*corpus humanun femininum* ♀
  - LA:*anatomia generalis* ♀
  - LA:*systema skeletale* ♀
  - LA:*systema articulare* ♀
  - LA:*systema musculare* ♀
  - LA:*systema digestorium* ♀
  - LA:*dentitio* ♀
  - LA:*cavitas thoracica* ♀
  - LA:*systema respiratorium* ♀
  - LA:*systema urinarium* ♀
  - LA:*systema genitale femininum* ♀
  - LA:*cavitas abdominopelvica* ♀
  - LA:*glandulae endocrinae* ♀
  - LA:*systema cardiovasculare* ♀
  - LA:*systema limphoideum* ♀
  - LA:*systema nervosum* ♀
  - LA:*organa sensoria* ♀
  - LA:*integumentum commune* ♀

Figure 13.2: This figure shows the descendant partonomy of the arteria pudenda interna.

13.2.3 Example of list with sex symbols

The following partial partonomy corresponds to LA: *arteria pudenda interna* from which the figure 13.2 is extracted:

It represents two different partonomies, the female presentation:

arteria pudenda interna ♀
- arteria rectalis inferior ♀
- arteria perinealis ♀
- rami labiales posteriores ♀
- arteria urethralis ♀
- arteria bulbi vestibuli ♀
- arteria dorsalis clitoridis ♀
- arteria profunda clitoridis ♀

and the male presentation:

arteria pudenda interna ♂
- arteria rectalis inferior ♂
- arteria perinealis ♂
- rami scotales posteriores ♂
- arteria urethralis ♂
- arteria bulbi penis ♂
- arteria dorsalis penis ♂
- arteria profunda penis ♂
- arteria perforans penis ♂

		15777	valvulae semilunares pulmonales	pulmonary semilunar valvules
		15777	# valvula semilunaris pulmonalis	# pulmonary semilunar valvule
76530		3673	nodulus valvulae semilunaris	nodule of semilunar leaflet
76531		3674	lunulae valvulae semilunaris	lunulae of semilunar leaflet of
7249		3670	valvula semilunaris dextra valvae trunci pulmonalis	right semilunar leaflet of pulmonary valve; right semilunar cusp of pulmonary valve
7250		3671	valvula semilunaris sinistra valvae trunci pulmonalis	left adjacent leaflet of pulmonary valve; left semilunar cusp of pulmonary valve
7247		3672	valvula semilunaris anterior valvae trunci pulmonalis	anterior semilunar leaflet of pulmonary valve; anterior semilunar cusp of pulmonary valve

Figure 13.3: The here presented list is extracted from LA:*radix trunci pulmonalis* at level P4. The valvulae semilunares are three in total. The set of valvulae appears at the first line as a plural term. The explicit three valvulae are listed as the three last lines in this figure. In between is inserted the generic list, started by the number sign #. The length of the generic list is defined by the indentation, here it is long by three lines.

13.2.4 Generic partonomy

The generic partonomies are numerous and can be found in any other partonomic list. A typical example is about the rod cells: they are a few millions present in each retina. In the top partonomy, we discover the eye, within each eye the retina, and as part of the retina the rod cells, represented as a set (plural term). But this hierarchy evidently does not enumerate these cells: nowhere appears an individual rod cell. In order to describe the partonomy of a rod cell, it is necessary to create a generic partonomy with the rod cell (at singular) as top entity. Such a partonomic hierarchy is totally independent of the top partonomy. But for pragmatic reasons of presentation, it is convenient to display it embedded within the top list.

Let review a detailled example with a generic partonomy, about the *valvulae semilunares*. The presentation including the generic partonomy is shown on figure 13.3. One can clearly see the generic partonomic list, headed by # valvula semilunaris pulmonalis at singular and of a length of three lines. This generic list must be considered as independent of the current list visible above and below. It can be displayed alone, out of the present context. It is presented here only for pragmatic reason, after the plural term.

13.3 Bibliography about partonomy

We present here a review of a few articles, considered as relevant to introduce the partonomy and to formally document the basic hierarchy of the $\mathbf{T}_{logy}$. Most of these articles are cited in this chapter.

[**Whitmore, 1999**]
This paper is by the author of Terminologia Anatomica of 1998 and must be a first reading, before discussions and criticisms. It sets the decor in which this terminology appears.

[**Rosse and Mejino, 2003**]
The Foundational Model of Anatomy was first introduced by this important article. It encompasses the material objects from the molecular to the macroscopic levels that constitute the body and associates with them non-material entities (spaces, surfaces, lines, and points) required for describing structural relationships.

[**Rosse and Mejino, 2007**]
A formal review of the FMA, how it is built.

[**Schulz et al., 2006**]
Partonomic relations such as part-of and its inverse has-part are fundamental to the description of the structure of living organisms. Whereas classical partonomy focuses on individual entities, partonomic relations in biomedical ontologies are generally asserted between classes of individuals. This paper makes suggestions for a standardization of partonomic relations in biomedical ontologies.

[**Wacholder et al., 1998**]
A section of this paper is about the structure of an anatomical semantic network. Considerations are given about the ISA relation as well as the part_of relation.

[**Winston et al., 1987**]
A taxonomy of part-whole or meronymic relations is developed. The resulting classification yields six types of partonomic relations, that are described. Partonomic relations are further distinguished from other inclusion relations, such as spatial inclusion, and class inclusion, and from several other semantic relations: attribution, attachment. and ownership. This is a basic introduction to the partonomies.

[Neuhaus and Smith, 2000]
This paper discusses what must be an ontology, the goal being it is simultaneously readable by humans and interpretable by computers. An ontology is made of types (anatomical entities) and relations like isa, part_of or contained_in.

[Mejino and Rosse, 2001]
The role of definition in the FMA is considered.

[Mejino and Rosse, 2003]
Part-whole relationships play a particularly important role in this representation. In order to assure that knowledge-based applications relying on the FMA as a resource can reason about anatomy, we have modified and enhanced currently available schemes of partonomic relationships.

[Smith et al., 2005]
About the relation ontology.

13.4 Naming the part_of relations

There are numerous variants or specializations of the part_of relation, to be documented thereafter. A naming convention is necessary in order to be able to understand their meaning from their name or their acronym. In this section, we develop the imperative way to name the partonomic relations and to define their acronyms in three or more characters.

Any relation is defined by three criteria, plus one or two optional values of dimension. This results in names and acronyms made of three concatenated parts, the value of dimension coming interspersed. The three parts, defined from left to right, are the following:

- **child type**: values are for material entities 'Single' S, Set T, 'Mixed' X, 'Pair' U, 'Pset' V, and for immaterial entities 'Vol' 'Sur' 'Lin' Ptn' M3 M2 M1 M0, 'Vols' 'Surs' 'Lins' Ptns' N3 N2 N1 N0, 'Voly' 'Sury' 'Liny' Ptny' Y3 Y2 Y1 Y0, 'Pvol' 'Psur' 'Plin' 'Pptn' P3 P2 P1 P0, 'Pvols' 'Psurs' 'Plins' Pptns' Q3 Q2 Q1 Q0
- **materiality transition and dendronomy**: values are 'Of' O for child/parent equal to material/material, 'Br' B for equivalent dendronomy, 'Ex' E for immaterial/material and 'In' J for immaterial/immaterial
- **parent type**: values as the child type

According to these specifications a transition between a pset material child from a single material parent would be named PsetOfSingle VOS. And a tran-

sition between a pair immaterial child that is a surface from a pair material parent would be named PsurExPset P2EU, as for LA:*facies lateralis testis (par)*.

The dimension values are the number of dimensions of the concerned entities for volume 3, surface 2, line 1 and point 0. These values are optional.

Finally the inverse of a relation is named with the same name preceded by an underscore, like _SOU.

13.5 Specialization of the part_of relation

Entity types govern the hierarchical links of the partonomy. Several constraints on links arises from the types of entities in the partonomic relations. For that reason - a thigh control of hierarchical links - it is necessary to formally define the entity types: this was done in chapter 2. Let give a summary of physical entity types below:

- *single S*: single material entity
- *set T*: material set
- *mixed set X*: mixed set
- *pair U*: pair material entity
- *pset V*: pair material set
- *single M*: single immaterial entity
- *set N*: immaterial set
- *pair P*: pair immaterial entity
- *pset Q*: pair immaterial set

The $\mathbf{T}_{logy}$applies to dimensional entities only or so call physical entities. In the following discussion, non physical entities are not included, though they exist in the $\mathbf{T}_{logy}$. They are part of the taxonomy, but absent of the partonomy, and consequently are not subject to the part_of relation.

Entity types for physical entities are based on three independent properties: materiality, parity and composition. Each of these property is bi-valued: materiality separates entities in material and immaterial entities; composition separates entities in single and composite entities; parity separates entities in paired and unpaired entities. This schema defined 8 entity types and can be nicely represented under the form of a cube.

The partonomic links have to be differentiated according to their origin and destination entity types. At a global level we can consider two origins and destinations: material and immaterial. The possible links are shown in figure 13.4. Because there are 8 physical types of entities either as origin or destination, there are at least 8 x 8 = 64 possible origin/destination pairs which are feasible in the $\mathbf{T}_{logy}$. But not all of them occur in reality. In particular, pairs with immaterial origin and material destination are vorbidden because they never occur in reality, giving a rest of 48 possible origin/destination pairs. Furthermore, the immaterial children from material fathers are restricted single entities, removing 12 pairs and giving 36 possible origin/destination pairs.

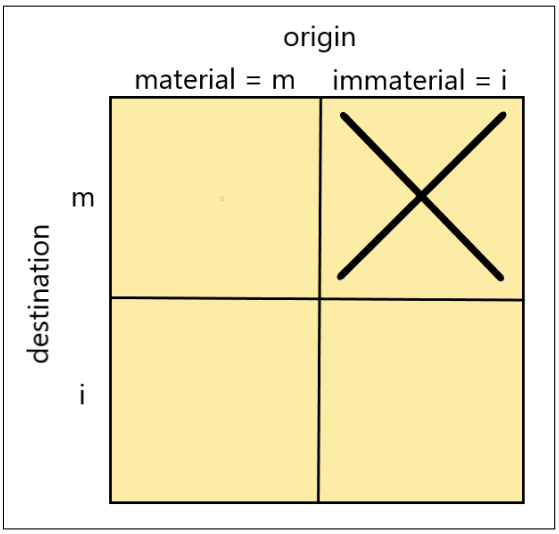

Figure 13.4: The allowed partonomic relations according to material and immaterial entities. The transition from a father immaterial entity to a child material entity does not exist in reality: a material entity cannot be a part of an immaterial entity! The total of allowed partonomic relations is by this evidence reduced to 3/4 of the whole.

In addition, there are a few situations where two to four relations are defined for a given origin-destination pair. Not all possible links are present.

All links express the fact that the destination entity (starting point of the arrow) is a part of the source entity (where the arrow stands). In the partononic tree, which root is at the top and leaves at the bottom, all links are considered from bottom (the part) to top (the container).

The links are themselves entities; they are considered as nonphysical entities of the taxonomy. Therefore, they are part of the $\mathbf{T}_{logy}$and have dedicated Entity Pages.

All links are now explicitly detailed. In the following descriptions of partonomic links, all links are considered as part_of or an extension of part_of link. Consequently, because the part_of link is transitive, any composition of part_of links is itself a part_of link.

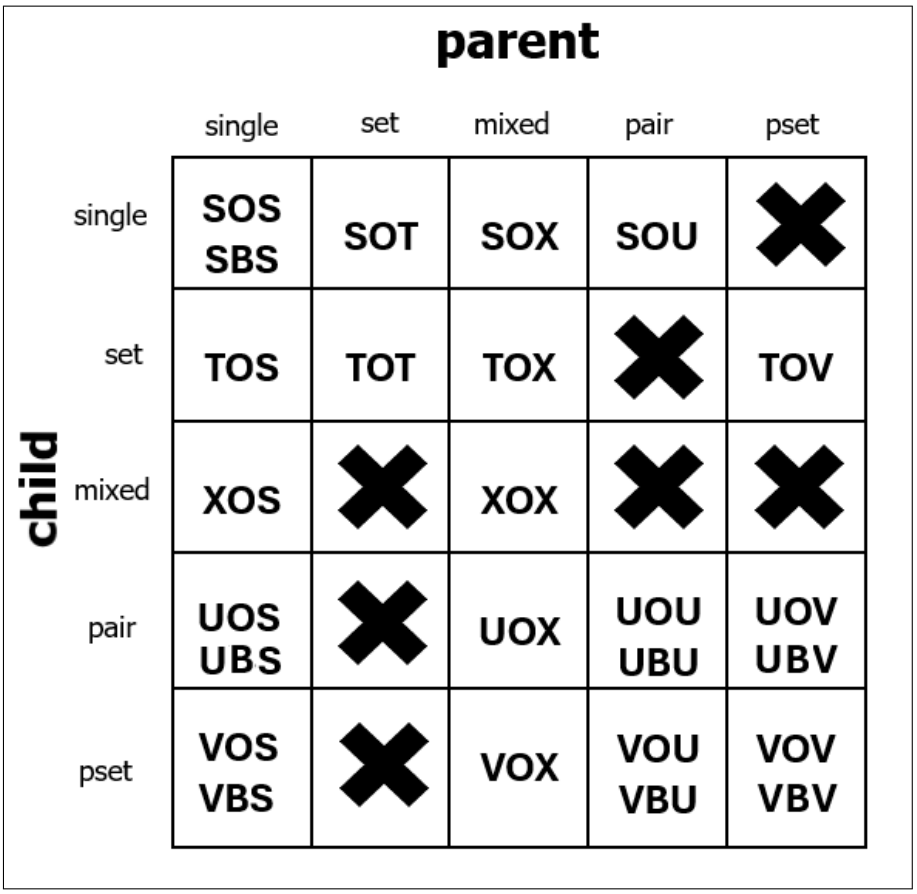

Figure 13.5: This figure presents all partonomic links from a father material entity to a child material entity. On a total of 25 possible situations, 25 links are instantiated in the $\mathbf{T}_{logy}$. They are represented by their acronym given with each definition. Read this table as: **child rel parent** giving for the lower left corner **pset VOS single**

13.6 Material child from material father

This section enumerates the partonomic links occurring between a father entity and a child material entity. In this situation, the number of links is constrained by the 5 x 5 = 25 possible origin/destination pairs as it is apparent on figure 13.5. But not all pairs are active in reality and some pairs present two links. The exact number of links is 25, all of them to be explicitly detailed thereafter.

There are three reasons for the supplement links in the the present context. The first reason is the existence of a tree-like approach of some chapters of the $\mathbf{T}_{logy}$, like for vessels or nerves. It is necessary to define a specialized branch_of link equivalent to the part_of link.

The second reason is due to the existence of mixed sets in parallel to the single sets.

In the following descriptions of partonomic links, all links are considered as

part_of or an extension of part_of link. The part_of link is transitive. This means that if A part_of B and B part_of C then A part_of C.

13.6.1 SingleOfSingle (Part_of)

SingleOfSingle: SOS
`The SingleOfSingle link (definition) is a link between a child singular material entity and a parent singular material entity.`

Example: LA:*atrium dextrum* LA:*SingleOfSingle* LA:*cor*

This is the true part_of relation. At the instance level, it means that some quantity of matter of the child entity is also matter of the parent entity and that there is a complement matter such that the addition of the part and its complement is equal to the parent entity. The child can never be equal to the parent or equivalently said the complement is never an empty entity.

This relation can then be formally extended to the class level, which is the level of interest for the TAH. If for all a and b which are instances of the entities A and B at time t and if b part_of a at instance level, then B part_of A at class level at time t. The time dimension is necessary for this assertion to be true, but this fact will not be discussed here.

For example caput femoris SingleOfSingle os femoris. There is no doubt that the matter (the biological cells) of the head of femur belongs also to the whole femur and that some matter of the femur is disjoined from the head of femur.

Another example is pars cardiaca SingleOfSingle gaster. Here again the matter of the cardia is also a part of the matter of the stomach.

Distinction between regional part_of and constitutional part_of, as presented in the FMA, has, for the time now, not been entered in the TAH, but it could be achieved without disturbance to the present scheme. The same is true for other FMA distinctions like the shared attribute or the mandatory/optional flag.

13.6.2 SingleBrSingle (Branch_of)

Branch_of: SBS
`The SingleBrSingle link (definition) is a link between a child singular material entity and a parent singular material entity for tree-like structures.`

Example: LA:*arteria thoracoacromialis* LA:*SingleBrSingle* LA:*arteria axillaris*

This is an alternate link to the SingleOfSingle link above. An intuitive approach would be to say that the child is SingleBrSingle of the parent. If B is an artery which is a branch of another artery A, it is not directly a part of this artery because they are distinct entities; we cannot directly say that B SingleOfSingle A.

However, let us slightly change this link B SingleBrSingle A. We can consider A' as the tributary tree of which A is the trunk. It follows immediately that B SingleBrSingle A'. And we are back to the SingleOfSingle relation. In order to show this difference in interpreting A' as the tributary tree of A, we use SingleBrSingle in place of SingleOfSingle.

This relation is exclusively used for arteriae, venae, lymphatic vessels and nerves.

13.6.3 SingleOfSet

SingleOfSet: SOT
`The SingleOfSet link (definition) is a link between a child singular material entity and a parent composite material entity.`

Example: LA:*syndesmosis radioulnaris* LA:*SingleOfSet* LA:*juncturae membri superioris liberi*

It is basically the set membership relation, meaning that the child entity is one of the entities in the parent set entity. Due to the definition of anatomical sets (see above), the sum of all member_of children entities unequivocally defines the parent set.

13.6.4 SingleOfMixed

This link connects a single entity to its parent entity that is a mixed set. It is necessary in order to extract a single entity out of mixed set. It works in parallel to the link PairOfMixed for the extraction of a pair entity. These entities are necessary for mixed sets, because the usual SingleOfPair and SingleOfPset links are not allowed here.

SingleOfMixed: SOX
`The SingleOfMixed link (definition) is a link between a single material child and a mixed set.`

Example: LA:*os frontale* LA:*SingleOfMixed* LA:*ossa cranii*

13.6.5 SingleOfPair

SingleOfPair: SOU
`The SingleOfPair link (definition) is a link between a child unpaired member of a pair and the corresponding parent paired entity, valid for both material and immaterial entities.`

Example: LA:*ligamentum teres sinistrum uteri* LA:*SingleOfPair* LA:*ligamentum teres uteri*

This link connects a paired entity to any one of its lateral member. In addition to the constitutional and regional partitions, this link is known as a lateral partition. Such a partition is always a final explicit partition, without further descendants.

For example, if (1) humerus sinister SOU par humerorum, (2) par capitorum humeri UOU par humerorum and (3) caput humeri sinistri SOU par capitorum humeri, then (4) caput humeri sinistri SOS humerus sinister.

In other words, the rule is: SOU x UOU x _SOU) == SOS.

13.6.6 SetOfSingle

SetOfSingle: TOS
`The SetOfSingle link (definition) is a link between a child material set entity and a parent material entity.`

Example: LA:*vertebrae* LA:*SetOfSingle* LA:*columna vertebralis*
This link is particularly useful when entities with multiple occurrences are found as a part of a singular entity, more often in the lower part of the TAH hierarchy. This relation is not rare in the TAH where it is the expression of plural terms.

13.6.7 SetOfSet

SetOfSet: TOT
`The SetOfSet link (definition) is a link between a child material set and a parent material set.`

Example: LA:*musculi suprahyoides* LA:*SetOfSingle* LA:*musculi colli*
The SetOfSet relation is fundamentally subset relation, meaning that all the entities of the child are also entities of the parent. The child can never be equal to the parent.
This relation together with PsetOfPset, are the only relations connecting a set to another set.

13.6.8 SetOfMixed

SetOfMixed: TOX
`The SetOfMixed link (definition) is a link between a child material set and a parent mixed set.`

Example: LA:*cisternae basales rostrales* LA:*SetOfMixed* LA:*cisternae supratentoriae*

13.6.9 SetOfPset

SetOfPset: TOV
`The SetOfPset link (definition) is a link between a child member material set and a corresponding parent paired set.`

Example: LA:*columnae renales dextri* LA:*SetOfPset* LA:*columnae renales*

13.6.10 MixedOfSingle

MixedOfSingle: XOS
`The MixedOfSingle link (definition) is a link between a child mixed set and a parent single entity.`

This link allows to define a mixed set as part of a single material entity.

Example: LA:*ossa cranii* LA:*MixedOfSingle* LA:*systema skeletale axiale*
In this example, the set of cranial bones is made of 15 bones, of which 7 are single entities and 8 are pair entities.

13.6.11 MixedOfMixed

MixedOfMixed: XOX
`The MixedOfMixed link (definition) is a link between a child mixed set and a parent mixed set.`

It is possible for any mixed set to be the subset of another mixed set.

13.6.12 PairOfSingle

PairOfSingle: UOS
`The PairOfSingle link (definition) is a link between a child paired material entity and a parent unpaired material entity, with the parent entity being a midline entity.`

This link makes possible the creation of a first paired materialentity in the global partonomy based on the top entity corpus humanum. It can be demonstrated that only midline entities can be parent of paired entities. From this point in the hierarchy on, the descendants (except the lateral members) can only be paired entities.
Example: LA:*ala minor sphenoidalis* LA:*PairOfSingle* LA:*os spenoidale*
The sphenoid bone is indeed a midline entity.

13.6.13 PairBrSingle

PairBrSingle: UBS
`The PairBrSingle link (definition) is a link between a child paired material entity and a parent unpaired material entity, in the context of a dendronomy.`

Example: LA:*PairBrSingle*

13.6.14 PairOfMixed

PairOfMixed: UOX
`The PairOfMixed link (definition) is a link between a child material paired entity and a parent mixed set entity.`

Example: LA:*os parietale* LA:*PairOfMixed* LA:*ossa cranii*

13.6.15 PairOfPair

PairOfPair: UOU
`The PairOfPair link (definition) is a link between two material paired entities, which applies a part_of link to both of its members.`

This link is simply an extension of the part_of link to paired material entities.
Example: LA:*caput humeri* LA:*PairOfMixed* LA:*humerus*

13.6.16 PairBrPair

PairBrPair: UBU
`The PairBrPair link (definitionis a link between two material paired entities, which applies a SingleBrSingle link (SBS) to both of its members.`

Example: LA:*arteria cubitalis inferior* LA:*PairBrPair* LA:*arteria radialis*
This link is simply an extension of the branch_of link to paired material entities.

13.6.17 PairOfPset

PairOfPset: UOV
`The PairOfPset link (definition) is a link between a child paired entity and a parent paired set.`

This link allows to extract a pair from a pset or set of pairs.
Example: LA:*nervus trigeminalis* LA:*PairOfPset* LA:*nervus cranalis*

13.6.18 PairBrPset

PairBrPset: UBV
`The PairBrPset link (definition) is a link between a child paired entity and a parent paired set in a dendronomic context.`

13.6.19 PsetOfSingle

PsetOfSingle: VOS
`The PsetOfSingle link (definition) is a link between a child paired set material entity and a parent material unpaired entity out of which is extracted the pset.`

This link is the equivalent of the set_of link, necessary to create a set out of a singular entity, but adapted to the situation of pairs.
Example: LA:*dentes incisivi* LA:*PsetOfSingle* LA:*dentes permanentes*

13.6.20 PsetOfMixed

This link connects a pair set to its parent entity that is a mixed set. It is necessary in order to extract a pair set out of mixed set.

PsetOfMixed: VOX
`The PsetOfMixed link (definition) is a link between a material pair set and a mixed set.`

Example: LA: *cisternae laterales caudales* LA: *PsetOfSingle* LA: *cisternae infratentoriae*

13.6.21 PsetOfPair

PsetOfPair: VOU
`The PsetOfPair link (definition) is a link between a child paired set and a parent paired entity.`

13.6.22 PsetBrPair

PsetBrPair: VBU
`The PsetBrPair link (definition) is a link between a child paired set and a parent paired entity for tree-like structures.`

13.6.23 PsetOfPset

PsetOfPset: VOV
`The PsetOfPset link (definition) is a link between a child paired set entity and a father paired set entity.`

This link is the equivalent of the TOT link for unpaired entities.

13.6.24 PsetBrPset

PsetBrPset: VBV
`The PsetBrPset link (definition) is a link between a child paired set entity and a father paired set entity in a dendronomic context.`

13.7 Immaterial child from material father

13.7.1 VolExSingle

VolExSingle: MKS
`The VolExSingle link (definition) is a link between a child immaterial entity that is a volume and a parent material entity, defining a volume within the space occupied by the parent entity.`

This link concerns the situation of an immaterial cavity of three dimensions within a material entity.
Example: LA:*bulla ethmoidalis* LA:*VolExSingle* LA:*labyrinthus ethmoidalis*.

13.7.2 PsurExPair

PsurExPair: PKU
`The PsurExPair link (definition) is a link between a child paired immaterial entity that is a surface and a parent pair material entity.`

This link makes possible the creation of a first paired immaterial entity. It can be demonstrated that only immaterial mid-line entities can be parent of immaterial paired entities.

13.8 Immaterial child from immaterial father

13.8.1 SurInVol

SurInVol: M2IM3
`The SurInVol link (definition) is a link between a child immaterial entity that is a surface and a parent immaterial entity that is a volume, defining a surface related to a volume.`

This link concerns the situation of an immaterial cavity within an immaterial entity.
Example: LA:*vestibulum laryngis* LA:*SurInVol* LA:*cavitas laryngis*.

13.8.2 SingleInPair

SingleInPair: SIU
`The SingleInPair link (definition) is a link between a child paired immaterial entity and a parent unpaired immaterial entity, with the parent entity having the mid-line property set to true.`

This link makes possible the creation of a subcavity within a cavity.

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13.9 Log of updates

14 Feb 2024 Revision of all specializations of the part_of link.

30 Oct 2023 New section on fundation of partonomic lists, about generic lists.

09 May 2023 Extension of the chapter with a detailed introduction.

04 Apr 2022 Creation of the file.

13.10 Credentials

This document is part of the book "Universal Terminology" accompanying the website on Terminologia Anatomica. It expresses the vision of the authors of the $\mathbf{T}_{logy}$about the foundations of the science of ontology, supporting the here presented terminology. Despite it is as exact as possible, close to the reality of the database of the terminology and the surrounding software, approximations, errors and ambiguities are possible and should be considered as independent of their willingness and intents.

Identified comments about the content of the website and its presentation are welcome. An appropriate answer will be given when pertinent.

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