Universal Terminology

Chapter 13: Partonomy

The partonomy is the preferred hierarchy of the anatomists, because it is closed 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 th eye?
- 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.

Anyway, to do justice to the authors of the TA98 and in particular the chairman of its working committee Professor Ian Whitmore, 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. 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). These quasi simultaneous efforts was 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 exclusively with physical entity, either material or immaterial. Our working context is principally 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 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, as it was done in chapter 2.

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.

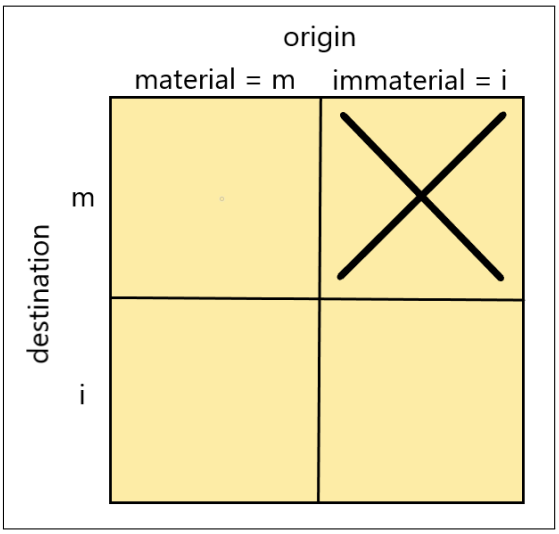

Figure 13.1: The allowed partonomic relations according to material and immaterial entities. The transition from a father immaterial entity to a child material entity does not exist in reality: a material entity cannot be a part of an immaterial entity! The total of allowed partonomic relations is by this evidence reduced to 3/4 of the whole.

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 13.1. 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.

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.

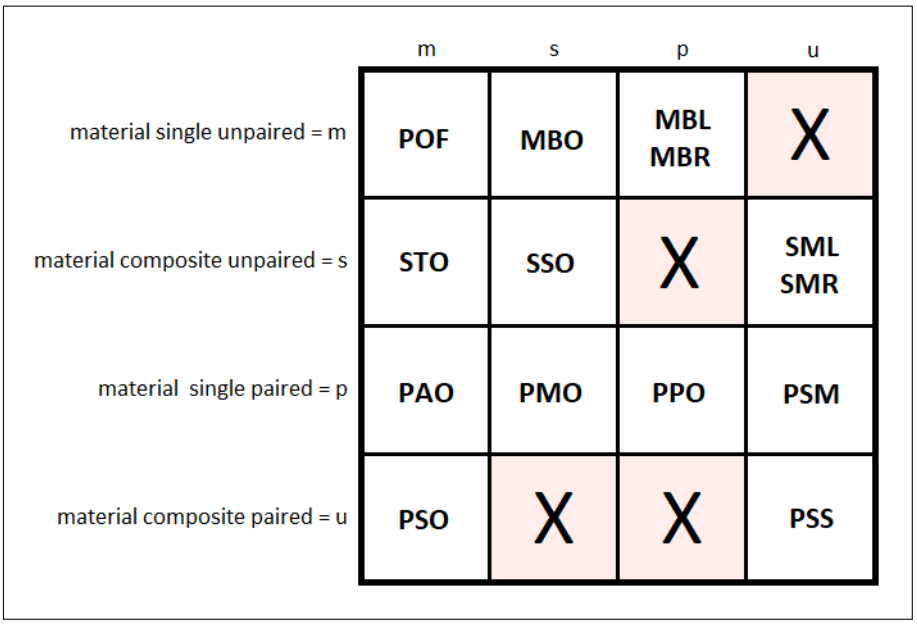

Figure 13.2: This figure presents all partonomic links from a father material entity to a child material entity. On a total of 16 possible links, 12 are instantiated in the $\mathbf{T}_{logy}$. They are represented by their acronym given with each definition. The double links occur with paired entities and stand for left and right members.

13.3 Material child from material father

This section enumerates the partonomic links occurring between a father material entity and a child material entity. In this condition, the number of links is limited to 4 x 4 = 16 possible origin/destination pairs.

All links are now explicitly detailed. See figure 13.2. 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.

13.3.1 Part_of

Part_of: POF
`The part_of link (definition) is a link between a child singular material entity and a parent singular material entity.`

Example: LA:*atrium dextrum* POF 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 part_of 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 part_of 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.

13.3.2 Branch_of

Branch_of: BOF
`The branch_of 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* BOF LA:*arteria axillaris*

This is an alternate link to the part_of link above. An intuitive approach would be to say that the child is branch_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 part_of A.

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

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

13.3.3 Member_of

Member_of: MBO
`The member_of link (definition) is a link between a child singular material entity and a parent composite material entity.`

Example: LA:*syndesmosis radioulnaris* MBO 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.

13.3.4 Left member_of

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

This link connects a paired entity to its left member, in parallel to the MBR link. 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 MBL par humerorum, (2) par capitorum humeri PPO par humerorum and (3) caput humeri sinistri MBL par capitorum humeri, then (4) caput humeri sinistri POF humerus sinister.

In other words, the rule is: MBL x PPO x inv(MBL) == POF.

13.3.5 Right member_of

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

This link connects a paired entity to its right member, in parallel to the MBL link. 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, though descendants may be inferred from the hierarchy of pairs.

13.3.6 Set_of

set_of: STO
`The set_of link (definition) is a link between a child material composite entity and a parent material entity.`

Example: LA:*vertebrae* MBO 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.

13.3.7 Subset_of

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

Example: LA:*musculi suprahyoides* MBO LA:*musculi colli*

It is fundamentally the subset_of 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 pairsubset_of, are the only relations connecting a set to another set.

13.3.8 Pair part_of

pair_of: PAO
`The pair_of 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 material entity 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.

For example, LA:*alae minores (par)* pair_of LA:*os spenoidale*. The sphenoid bone is indeed a midline entity.

13.3.9 Pair member_of

pairmember_of: PMO
`The pairmember_of link (definition) is a link between a child material paired entity and a parent material composite entity.`

This link is basically a subset_of link, because it extracts two members of the set. In addition these members form together a symmetrical pair.

For example, LA:*membra superiora (par)* pairmember_of LA:*partes principales corporis humani adulti*. The set of cardinal body parts is made of 7 members.

13.3.10 Pair part_of

pairpart_of: PPO
`The pairpart_of 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.
For example, LA:*caput humeri (par)* pairpart_of LA:*humerus (par)*.

13.3.11 Pair branch_of

pairbranch_of: PBO
`The pairbranch_of link (definitionis a link between two material paired entities, which applies a branch_of link (bof) to both of its members.`

This link is simply an extension of the branch_of link to paired material entities.

13.3.12 Pair Set Member_of

pairsetmember_of: PSM
`The pairsetmember_of link (definition)is a link between a child paired entity and a parent paired composite entity.`

This link allows to extract a pair from a pset or set of pairs.
For example la:*nervus trigeminalis (par)* pairsetmember_of la:*nervus cranalis (par)*.

13.3.13 PairSet_of

PairSet_of: PSO
`The pairset_of 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.
For example, la:*nervus cranialis (par)* pairset_of la:*pars peripherica systematis nervosi (par)*.

13.3.14 Pair Subset_of

pairsubset_of: PSS
`The pairsubset_of link (definition) is a link between a child paired composite entity and a father paired composite entity.`

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

13.4 Immaterial child from material father

13.4.1 Space_of

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

This link concerns the situation of an immaterial cavity of three dimensions within a material entity.

For example, la:*bulla ethmoidalis* space_of la:*labyrinthus ethmoidalis*.

13.4.2 Imm Pair_of

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

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.

13.5 Immaterial child from immaterial father

13.5.1 Space_in

space_in: SPI
`The space_in link (definition) is a link between a child immaterial entity and a parent immaterial entity of the same dimension, defining a space within a space.`

This link concerns the situation of an immaterial cavity within an immaterial entity.

For example: la:*vestibulum laryngis* space_in la:*cavitas laryngis*. In this situation, there are two 3 dimensional cavities, the child entity being included in the parent entity.

13.5.2 Imm Pair_in

immpair_in: IPI
`The immpair_in 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.

13.6 Log of updates

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

04 Apr 2022 Creation of the file.

13.7 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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