**RadLex 4.2**

**Total terms: 46,838**

**RadLex curation has been moved** from the desktop Protégé format **to webprotege**. For those who have access, it can be downloaded to desktop: click on the 3 bars at the right of the screen on the webprotege home page. Use the RDF/XML format.

Content changes:

--Terms added based on some **reporting templates and common data elements sets**: ‘CT Kidney and Abdominal Renal Mass’ and ‘US Chest COVID-19 Project’***.***

**--Terms updated for RADS terminologies** (BI-RADS, CAD-RADS [new to 4.2], LI-RADS, PI-RADS, TI-RADS)

**Known issue**: German translation terms and some synonyms marked as Latin language do not appear due to an incompatibility. We are working on this.

**Changes to the ontology to accommodate webProtégé:**

Because webprotege does not display annotations on annotations, 1 item has been restructured, and another does not display information included in these sub-annotations:

* Previously, information was recorded about changes made to an entity using the annotation “Radlex\_version\_of\_class\_change” The value for this was the RadLex version number (e.g “4.1”). There was then a sub-annotation called **“Changes\_made\_to\_class**” which identified the types of changes that were made for that version (e.g. “pref, loc” indicates that the preferred name and the hierarchical location of the class were changed). **This second annotation** **has been removed and the 2 types of information collocated in “Radlex\_version\_of\_class\_change”,** as e.g. “4.1 pref, loc”. Because the entries are all strings, they are still searchable, but in a more straightforward way. Values include
  + New: term was first published in the given version number
  + Obs: term was made obsolete
  + Pref: the value of the Preferred\_name was changed
  + Syn: a synonym was added, removed, or changed
  + Loc: the location of the term in the hierarchy was changed
* The other place where sub-annotations were used was in representing German synonyms of classes. When these were presented initially by the German Radiological Society (DRG), synonyms were categorized as preferred, clinical, anatomical, proper, or abbreviation. The preferred German terms were incorporated under the annotation “Preferred\_name\_German”. All others were added as “Synonym\_German” with a sub-annotation in “Term type” that identified one of those categories. With the second round of German translations, added to RadLex 4.1 and including terms that had been added since the initial translations, these categorizations were not included. DRG has since indicated that it is acceptable **to display the non-preferred German synonyms without the categorical information**, though that information is still encoded in RadLex.

Additionally, webprotege does not display Object Properties with a concatenated list of classes. This affected certain Properties associated with imaging signs: **Anatomical\_Site and May\_Be\_Caused\_By.** Because these are class properties that can vary based on individual instances, these were created with their values as “or” lists in a single entry of the property, rather than as multiple entries of the property, each containing one value, in order to more correctly represent logical inference (i.e. that no more than one value of these can apply to a given instance of the class). They were created as e.g. “May\_Be\_Caused\_By some ‘neoplasm’ or some ‘cyst’”. These properties failed to display at all in webprotege, so their **values were separated out into distinct property entries**: “May\_Be\_Caused\_By some ‘neoplasm’” and ““May\_Be\_Caused\_By some ‘cyst’”. We trust that any users who make use of these properties will understand the ‘or’ implications for use with instances of this class.

**RadLex 4.1, published November 2020**

**Total terms: 46,760 (includes non-RadLex terms from other ontologies)**

**RadLex terms: 45,850**

Added new terms requested for the **ACR TI-RADS** thyroid assessment system.

Added a set of terms related to **“3D printing process”.**

Updated the **LI-RADS 2020** Liver Imagingterms **(**<https://www.acr.org/-/media/ACR/Files/RADS/LI-RADS/Lexicon-Table-2020.pdf>) . These terms all currently have “LI-RADS 2020” in the Source property, and the terms are under “set of LI-RADS terms” with the Has\_Member property.

Added **German translations** for terms that were new to version 4.0.

Added a new top-level entity called “**Imaging specialty**”, which has as a child **a new entity called “imaging subspecialty”, for clinical imaging domain entities**, such as “abdominal imaging”. The existing class of “imaging modality” has also been placed under this new entity.

Issues with Bioportal display:

* The browser display may not show all children of a term, if there is a large set of them.
* Bioportal inserts its own property entitled “Synonyms”, which typically includes only one synonym, even where then are more for a given term. The RadLex property called “Synonym” will contain all of the synonyms for a term, except those designated as Acronym, which will be a separate property.

Issues noted with Bioportal files:

* The CSV file does not include annotation-on-annotation values. This includes term\_type (which identifies a category for German translations such as Clinical, anatomical, etc.), and Changes\_made\_to\_class (which identifies what kind of change was made for the version or date specified in Radlex\_version\_of\_class\_change).

**RadLex 4.0**

**Number of classes: 46636**

**With the release of RadLex 4.0, we move to a native OWL version of RadLex**. In previous releases, RadLex was maintained in a frames-based representation. A limited translation of that frames representation into OWL had been made available on BioPortal, although that translation lacked certain features of the full RadLex ontology. RadLex version 4.0 represents the comprehensive transformation of the base ontology into a native OWL representation. This enables the use of modern tools for ontology curation, improved interfaces for content browsing, and better interoperability with other biomedical ontologies.

**Other changes Implemented in RadLex 4.0**

**BIOPORTAL VS. RADLEX.ORG DIFFERENCES**

The RadLex hierarchy is available for viewing at both <http://bioportal.bioontology.org/ontologies> and <http://www.radlex.org/>. The display for [www.radlex.org](http://www.radlex.org) is derived from that on BioPortal, but there are some differences in interface.

**Search:** BioPortal only allows searching in the Preferred\_Name and Synonym properties. Radlex.org will search for the target string in any property.

**Top-level hierarchy**: BioPortal shows the entire existing hierarchy, including the top-level terms that may not be intuitive or useful for those not familiar with ontologies. Radlex.org shows only those terms that are under the “RadLex entity” term.

**Obsolete Terms:** Because the top-level hierarchy is not displayed in radlex.org, the Obsolete terms are not visible. Such terms may be found in the search process, but their RadLex entries will not display on the screen. To see those entries, please use BioPortal. [Note: the majority of obsolete terms are due to inadvertent duplications, mostly from automated imports. When a duplicate term is discovered, one such term is made obsolete, and the existing term will be found in the search process. Viewing the obsolete term will show a slot called “Replaced\_by” which will give the RID of the currently-valid RadLex term. For cases where a concept is no longer deemed relevant, and there is not an equivalent valid term in RadLex, the “Comment” slot will indicate why the concept is no longer active in RadLex.]

**File Downloads:** The file downloadable from Bioportal will include puns (essentially duplications that allow class-level terms to be reasoned over as individuals), whereas on radlex.org, both a puns and a non-puns version are available for download.

**KNOWN ISSUES:**

The “Part” relations (including Part\_of, Has\_Part, Constitional\_part\_of, Regional\_Part\_of, Has\_Constitional\_Part, and Has\_Regional\_Part) for anatomy terms may be incomplete or may have duplicate entries. RadLex anatomy was originally designed as a part-of hierarchy and then converted to an is-a hierarchy. Terms added after the initial composition may have incomplete part information. Some portions of the hierarchy were also initially developed with some inadvertent is-a categorizations, and these may not have been correctly converted. This can result in some terms representing generic part types where specific named parts should be used (e.g. some parts of “heart”).

Additionally, an automated import of terms from the Foundational Model of Anatomy may have duplicated some part-of information. (Duplication includes terms being listed twice in the “Part\_of” or Has\_Part” property and/or by being listed in both a Constitutional or Regional property and the generic Part property.)

**TRANSITION TO OWL**

**Protégé Usage Note:**

Because certain features are set at the program level in OWL, rather than the ontology-level as in Frames, certain features may need to be set each time RadLex is opened in Protégé, if another ontology with different feature values is opened in the interim.

The display property for ‘RadLex entity’ classes should be ‘Preferred\_name’. The display property for ‘Obsolete RadLex term’ should be ‘Preferred\_Name\_for\_Obsolete’. These can be set in the View tab by selecting “Custom rendering…”. Check the “Render by Annotation Property” box then click “Configure” and add those 2 annotations using the “Add annotation” symbol at the top left. Move ‘Preferred\_name’ to the top of the list and ‘Preferred\_Name\_for\_Obsolete’ second using the Move\_up button.

**Overview of the Transition from Frames to OWL**

In Frames, a class can have Slots, and the value of a slot can be specified as being another class, an instance, a number, a string, etc. In OWL, a class can have Properties and Annotations. Properties are considered to be meaningful to the specification of the class, and are usually filled with another class or an instance. Annotations, however, are generally metadata that are not relevant to the meaning of a class in the context of the ontology, but are information about that ontology entity that may be useful to a user, such as date the class was created, what the source was for the concept, etc. The rest of this document indicates how the various frames slots were converted for the OWL version. The starting point for the converter was a program that was developed to convert the Foundational Model of Anatomy (FMA) into OWL format. This was then customized to the particular slots in RadLex.

**Default Cls valued slot conversion**

The "default" conversion for Cls valued slots from Frames is to convert them to existential (some values from) restrictions on OWL object properties. So, if "heart" and "apex of heart" are classes in Frames, *has\_regional\_part* is a Frames slot, and we have the assertion

"heart" *has\_regional\_part* "apex of heart"

then we would generate the following in OWL (where we have created analogous classes "heart" and "apex of heart" as well as an object property *has\_regional\_part*):

"heart" *subClassOf* (*has\_regional\_part* some "apex of heart"), i.e. “heart” is a subclass of the set of things which have an “apex of heart” as a regional part.

The following RadLex slots were converted using this procedure:

*Anterior\_to*

*Attaches\_to*

*Blood\_Supply\_of*

*Bounded\_by*

*Bounds*

*Branch\_Of*

*Branch\_Part\_of*

*Constitutional\_Part\_Of*

*Contained\_In*

*Contains*

*Continuous\_With*

*Distal\_to*

*Drains\_Into*

*External\_to*

*Has\_Blood\_Supply*

*Has\_Branch*

*Has\_Branch\_Part*

*Has\_Constitutional\_Part*

*Has\_Entrapment\_Site*

*Has\_Innervation\_Source*

*Has\_insertion*

*Has\_Member*

*Has\_origin*

*Has\_Part*

*Has\_Regional\_Part*

*Inferior\_to*

*Innervates*

*Insertion\_of*

*Lymphatic\_Drainage*

*Lymphatic\_Drainage\_Of*

*Member\_Of*

*Origin\_of*

*Part\_Of*

*Posterior\_to*

*Projects\_From*

*Projects\_To*

*Proximal\_to*

*Receives\_attachment\_from*

*Receives\_Drainage\_From*

*Receives\_Input\_From*

*Receives\_Projection\_From*

*Regional\_Part\_Of*

*Related\_modality*

*Segment\_Of*

*Sends\_Output\_To*

*Superior\_to*

*Surrounded\_by*

*Surrounds*

*Tributary\_Of*

**Slots omitted from conversion**

Some slots were not converted from Frames into OWL. There are a number of reasons why this might be, but examples are:

* The slot was unused in Frames
* The slot was used in Frames but that use was deemed unneeded or incorrect
* A decision was made to change the way something was modelled, when migrating to OWL, which rendered a property superfluous.

The following slots were omitted:

*Left\_Lateral\_to*

*Right\_Lateral\_to*

*Neurolex\_ID*

*Neurolex\_Term*

*Branch\_Part\_of*

*Has\_Branch\_Part*

*ACR\_Term*

*ACR\_ID*

*Name*

*id*

*language*

*Has\_Subtype*

*Is\_A*

*Image\_URL*

*Term\_Status*

**Slots converted to simple annotation properties**

In Frames, there is no distinction between the OWL notions of datatype property and annotation property. Therefore, in the conversion, we must specify which slots will be converted to annotation properties, annotation properties being generally metadata. In the simplest case, we take a primitive valued slot from Frames (e.g. values are strings, integers, etc.) and convert it to a very similar representation in OWL. For example, if we have the following in Frames:

"heart" *UMLS\_ID* 'COOO18787'

we would generate the exact same expression in OWL, using an analogous class "heart" and annotation property *UMLS\_ID*.

RadLex slots using this conversion method are:

*Preferred\_Name\_for\_Obsolete*

*CMA\_Label*

*Comment*

*Definition*

*JHU\_DTI-81*

*JHU\_White-Matter\_Tractography\_Atlas*

*Source*

*FMAID*

**Terminology slots**

In RadLex Frames, terminology slots are reified, i.e. have more than one feature bundled together. Values for these slots have type "RadLex term". Each instance of RadLex term has slots *name*, *language*, and *term type* (this last one was added during the conversion project for use when incorporating a new, extensive, German term set).

One conversion strategy for converting reified slots in Frames is to use annotations on annotations. That is, we choose one of the slots within the reified instance to be the primary value and create a simple annotation based on that slot. The other slots and their values are used to annotate the primary annotation. For terms, the primary slot is "name". So, in Frames when we have entries like this:

"lung" *Synonym* "instance\_of\_RadLex\_term\_001".

"instance\_of\_RadLex\_term\_001" *name* "pulmo".

"instance\_of\_RadLex\_term\_001" *language* "Latin".

we create a simple annotation like this:

"lung" *Synonym* "pulmo".

We could further annotate the above statement with details regarding its language and term type. However, we actually do something a bit different with the feature ‘language’. OWL has a built-in way of tagging the language of strings used as property values. This takes the form of a language suffix. In this case of pulmo, it would look like this - "pulmo"@la (where "la" is the IETF language tag for Latin).

The RadLex slots converted using this strategy are all the ways to represent an alternative form of the entity name:

*Misspelling of term*

*Non-English\_name (converted to Synonym with language abbreviation of "la" if not specified)*

*Unsanctioned Term*

*Preferred\_name (with language abbreviation of "en" if not specified)*

*Synonym (with language abbreviation of "en" if not specified)*

*Acronym*

*Preferred\_name\_German*

*Synonym\_German*

For the German terms, we use the additional *term type* field. The allowed values for term type are: anatomical, clinical, proper, and abbreviation.

**External terminology slots**

Some slots are used to reference terms as used in other controlled vocabularies. In Frames these were reified (with instances of non-RadLex term having both id and name slots). In OWL we will again use an approach of choosing a primary slot (id) and creating simple annotation, and applying the other reified slots and values as annotation on the primary. For example:

"left amygdala" *AAL* '41'.

And then the entire statement above (call it S1, though it is not actually named) is further tagged with:

S1 *name* 'Amygdala\_LEFT'

RadLex slots converted using this approach are:

*AAL*

*Talairach*

*Freesurfer*

**External terminology slot combinations**

In RadLex Frames, some external term references were not represented as in the previous section (with reified values) but were instead represented using two different slots directly on the class. For example:

"apex of heart" *SNOMED\_ID* 'T-32004'.

"apex of heart" *SNOMED\_Term* 'apex of heart'.

The only way that the above SNOMED id and term are linked is by the fact that they are both applied to the same class. If there were more than one SNOMED term for a given RadLex class you would not be able to tell, using this representation, which ID went with which term. In the OWL conversion, we used the same OWL output pattern as we used in the previous section.

This approach was used for slots:

*SNOMED\_ID*

*SNOMED\_Term*

*UMLS\_ID*

*UMLS\_Term*

**Slots whose values should be interpreted as a union**

It is generally implicit that, when a Frames slot has multiple values, we mean all are true. So, for example, when we say:

"pancreas" *has\_constitutional\_part* "pancreatic duct tree".

"pancreas" *has\_constitutional\_part* "parenchyma of pancreas".

We mean that the pancreas has both the pancreatic duct tree AND the parenchyma of pancreas as parts. However, there are certain cases where this is not the intended interpretation. For example, if in Frames we saw:

"3 sign" *anatomical\_site* "anterior cerebral artery".

"3 sign" *anatomical\_site* "callosomarginal artery".

the above does not mean that an occurrence of 3 sign must be associated with both sites. This is an either-or (or both) scenario. In OWL we converted this to:

"3 sign" *subClassOf* (

*anatomical\_site* some ("anterior cerebral artery" OR "callosomarginal artery")

).

We used this approach to convert slots:

*Anatomical\_Site*

*May\_Be\_Caused\_By*

*May\_Cause*

**Slots whose value type was too general**

There were a couple of cases where string valued slots in Frames could be made more specific when transformed into OWL. Here are the affected slots:

*Created mm/dd/yyyy* (renamed to *Created* and given a Date type)

*Replaced\_by* (changed to *IRI data type*). This slot is used to indicate what term should currently be used in place of a term that has been designated as Obsolete.

**Metadata slots capturing the version when RadLex changes were introduced**

In RadLex Frames, there were two slots capturing major changes to a class and the version in which those changes were introduced. They were separate slots and, like UML and SNOMED terms above, they were problematic when multiple changes were included (e.g. there was no linking of which change goes with which version tag). These have been modified to use the annotations-on-annotations approach, with the version being the primary annotation.

The slots relevant to this approach are:

*RadLex version of class change*

*Changes made to class*