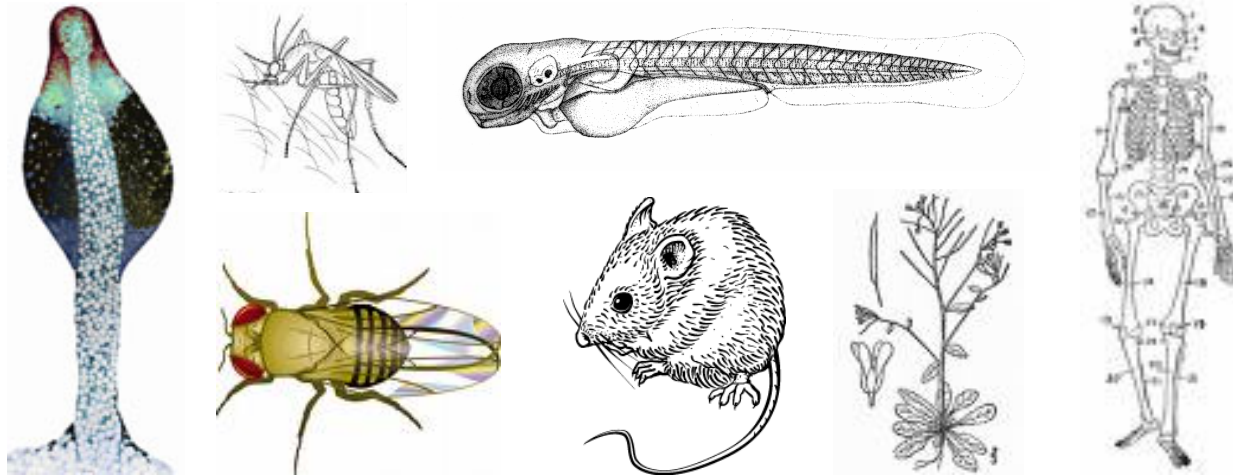


# The Common Anatomy Reference Ontology (CARO), the “über-ontology” (UBERON), and how they relate to *bones*



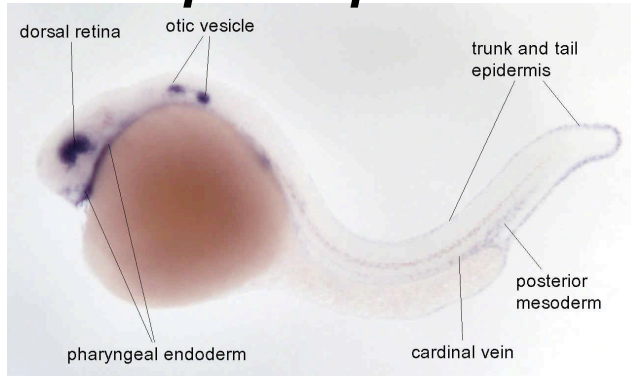
**Melissa Haendel**



# Why we build anatomy ontologies

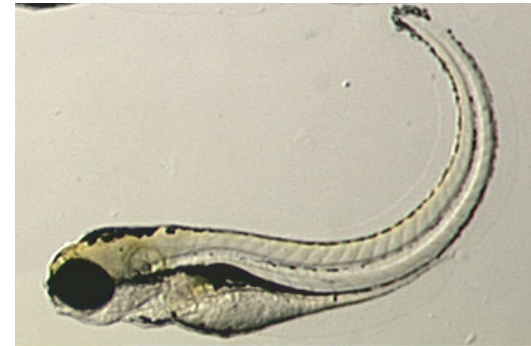
## Model organism databases (MODs): gene expression and phenotypes

### *bmp2b* expression



Entities: otic vesicle, cardinal vein, retina

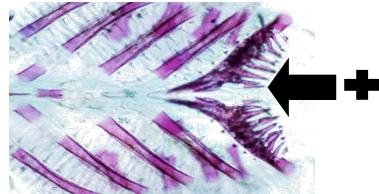
### *ctcf*<sup>-/-</sup> phenotype



Entity (AO): tail  
Quality (PATO): curved

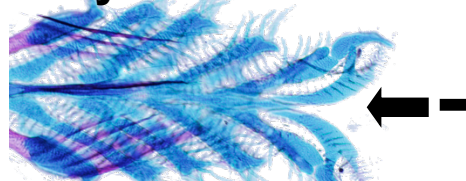
## Evolutionary biologists: recording character states

### Danio rerio



Entity (AO): ceratobranchial 5 tooth  
Quality (PATO): is\_present

### Gyrinocheilus

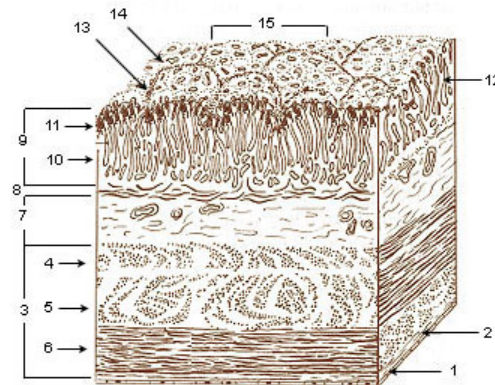
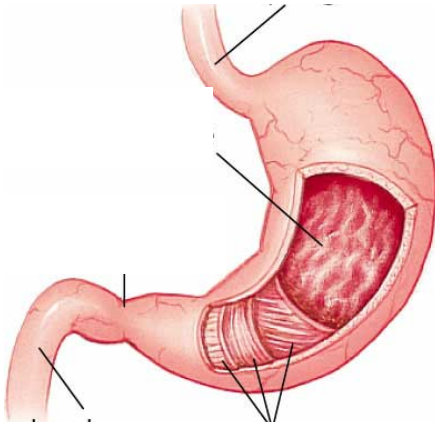


Entity (AO): ceratobranchial 5 tooth  
Quality (PATO): is\_absent

# Advantages of using anatomy ontologies for expression, phenotype and character recording

## Terms with written definitions:

More consistent annotation despite variable terminology



Stomach?

## Logically defined relations between types:

Allows annotations to be grouped



finger *part\_of* hand

# **CARO aims to standardize anatomy ontologies**

- **Provide a template containing standard types and relations**
- **Allow reasoning between different levels of anatomical granularity**
- **Support the alignment of data and development of common tools**
- **Allow reasoning across species**

# What is CARO?

**CARO is a single-inheritance structural classification  
based on granularity**

**From the bottom up:**

**Cell component**

**Cell**

**Portion of tissue**

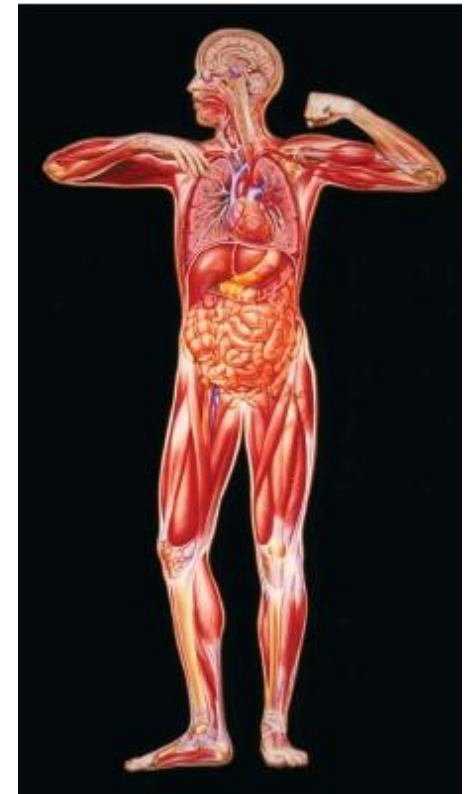
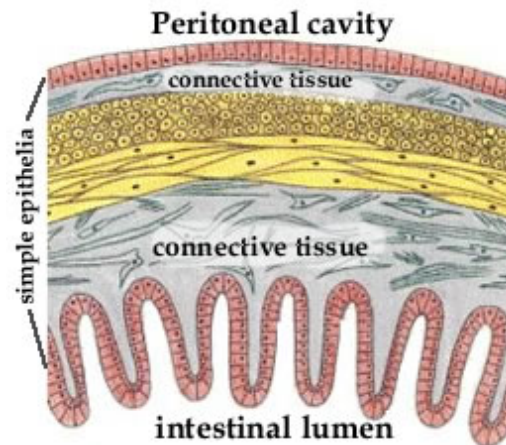
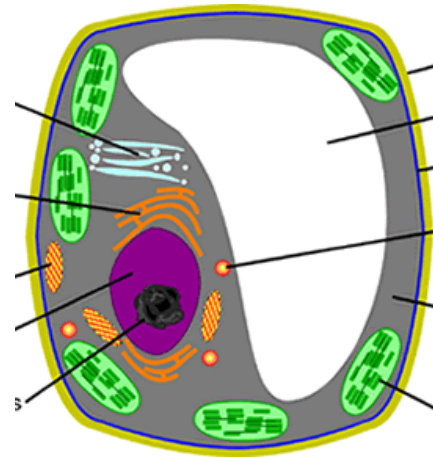
**Multi-tissue structure**

**From the top down:**

**Organism subdivision**

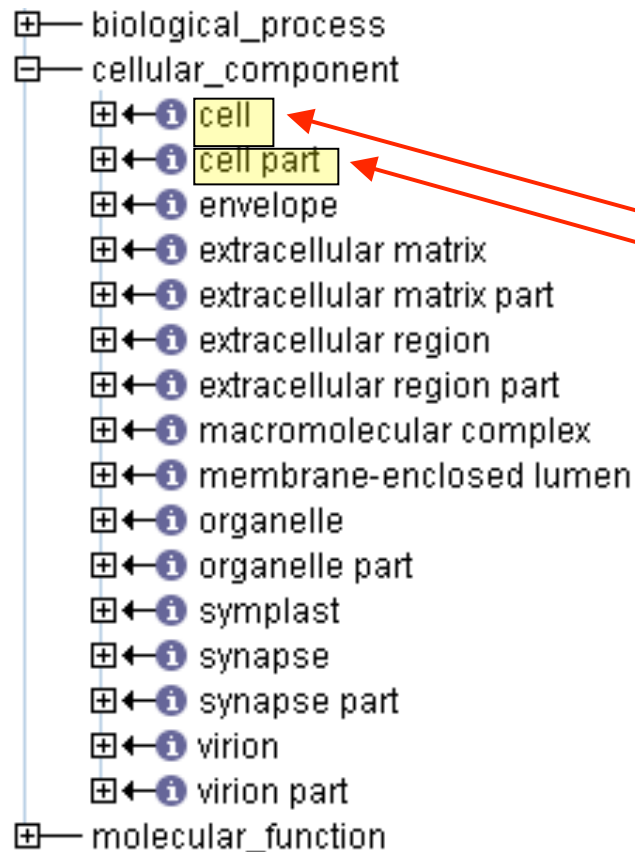
**Anatomical system**

**Acellular structures**

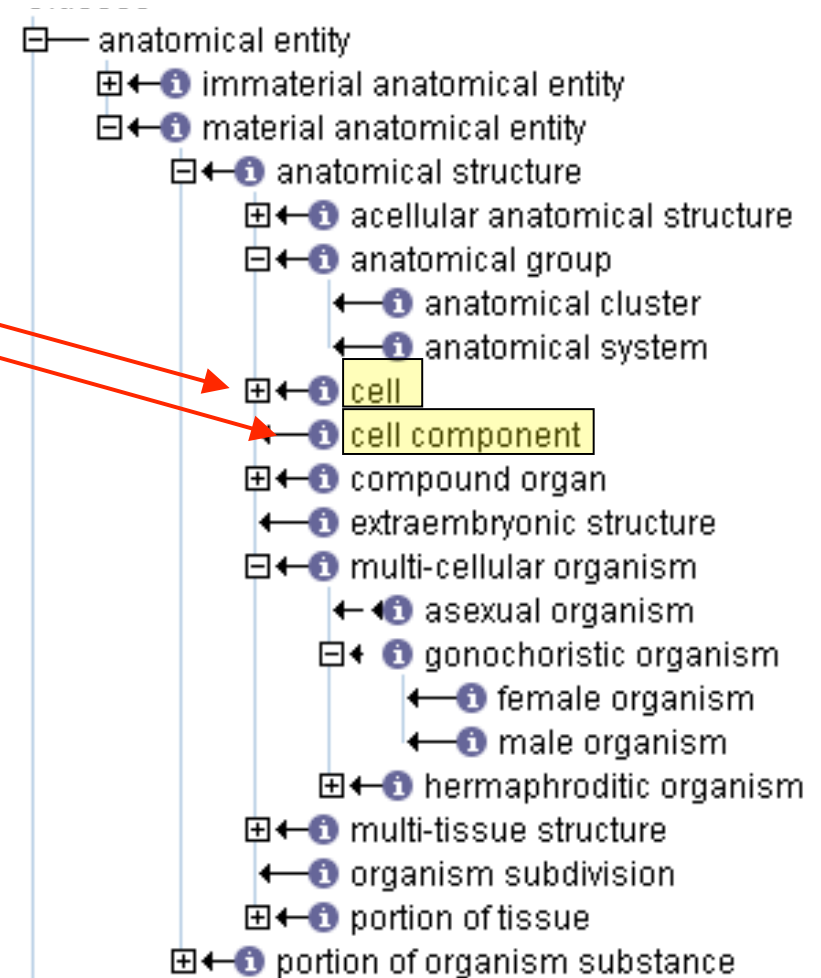


# CARO integration with other ontologies

## Gene Ontology



## CARO

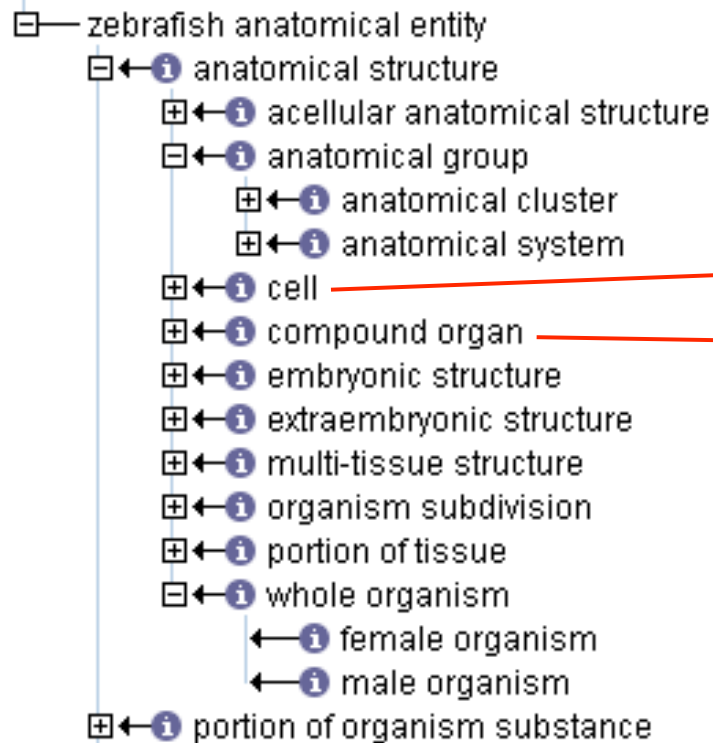


Xref

Cell and cell component are equivalent classes in CARO, GO and CL

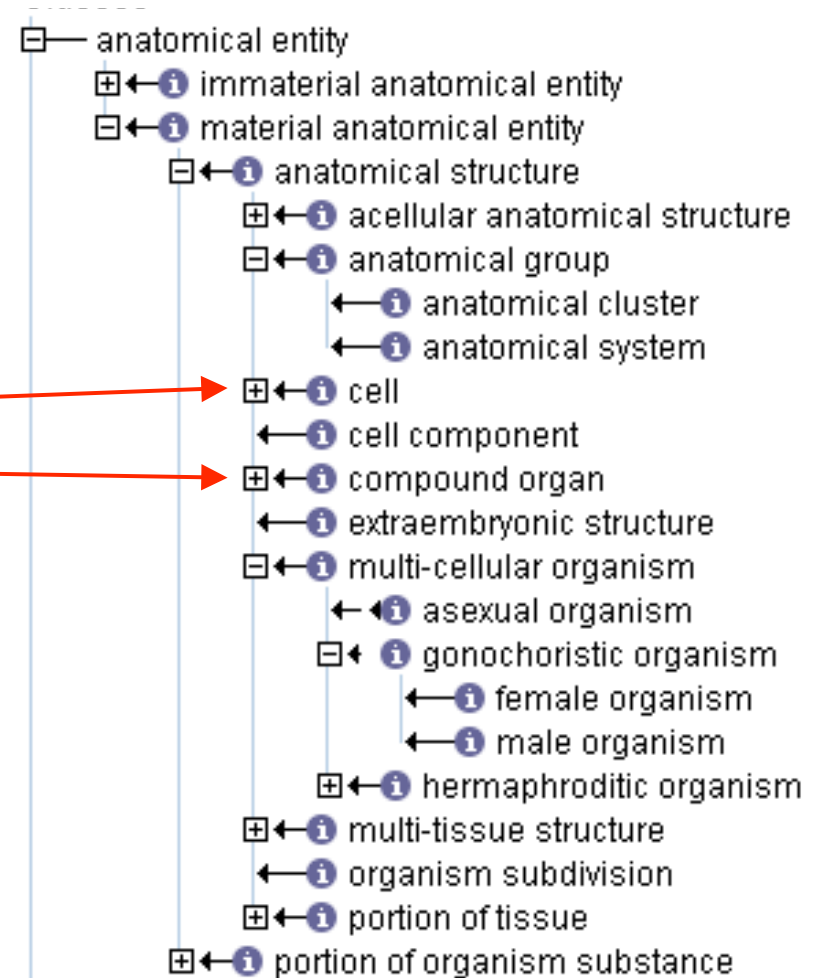
# Aligning a species-specific AO with CARO

## zebrafish AO



is\_a

## CARO



Species-specific subtypes of CARO types



# What CARO is not

CARO does not represent any of the following important differentia commonly used for anatomical structures:

*NO homology*

*NO function*

*NO qualities*

*NO participation in processes*

*NO development*

**These differentia can and should be made explicit using logical definitions (aka cross products or intersections)**



## How should 'bone' be classified structurally?

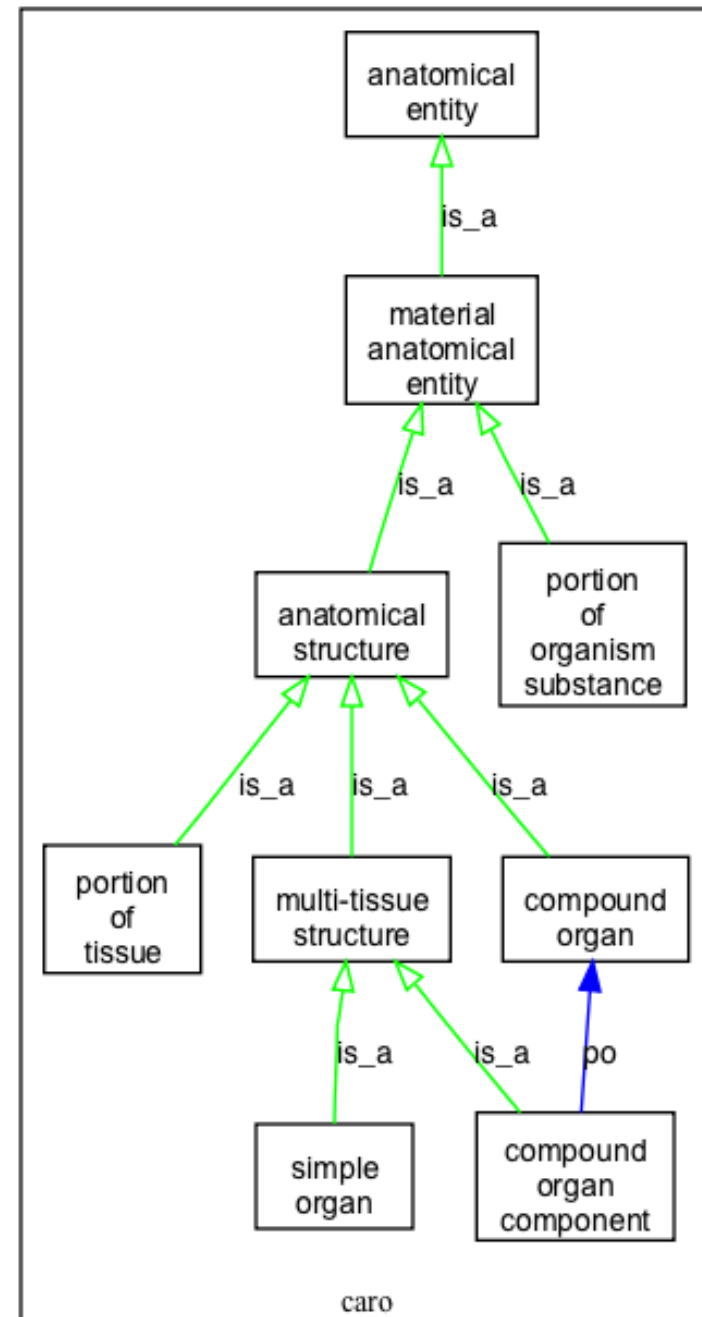
Should we have both “bone” the element and “bone” the tissue type?

What is bone the element?

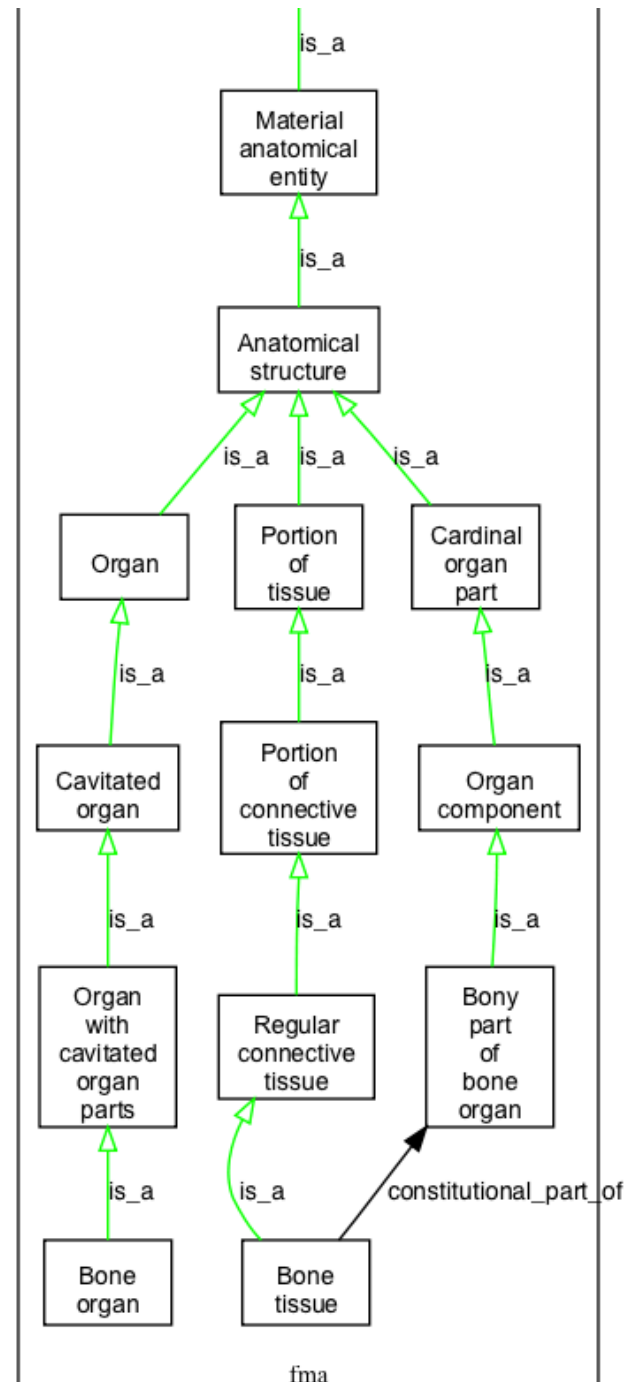
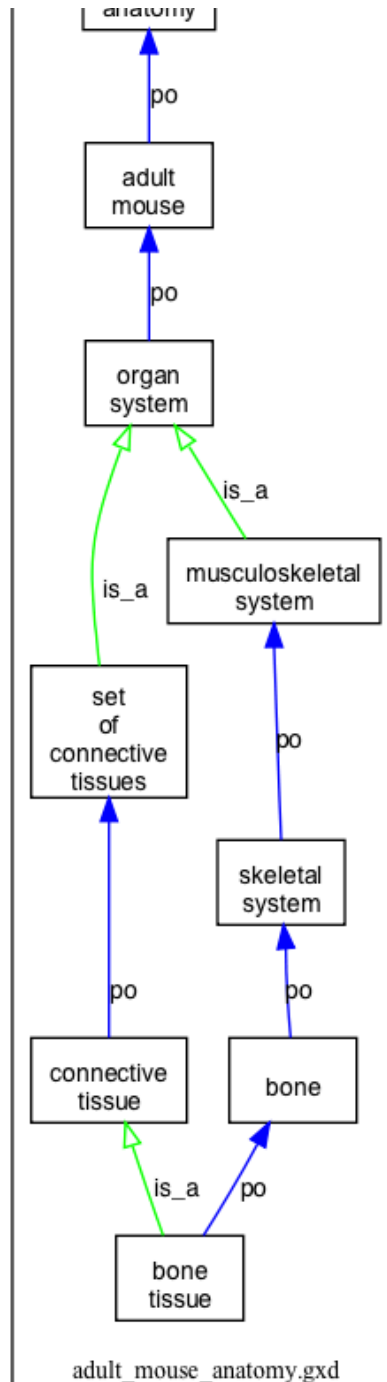
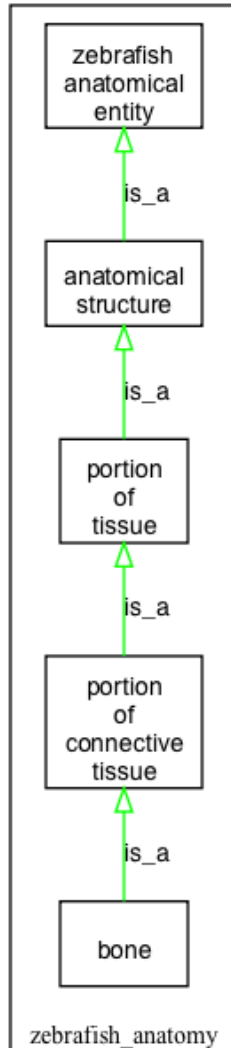
An organ? A multi-tissue structure?

***-lets not worry too much about this now***

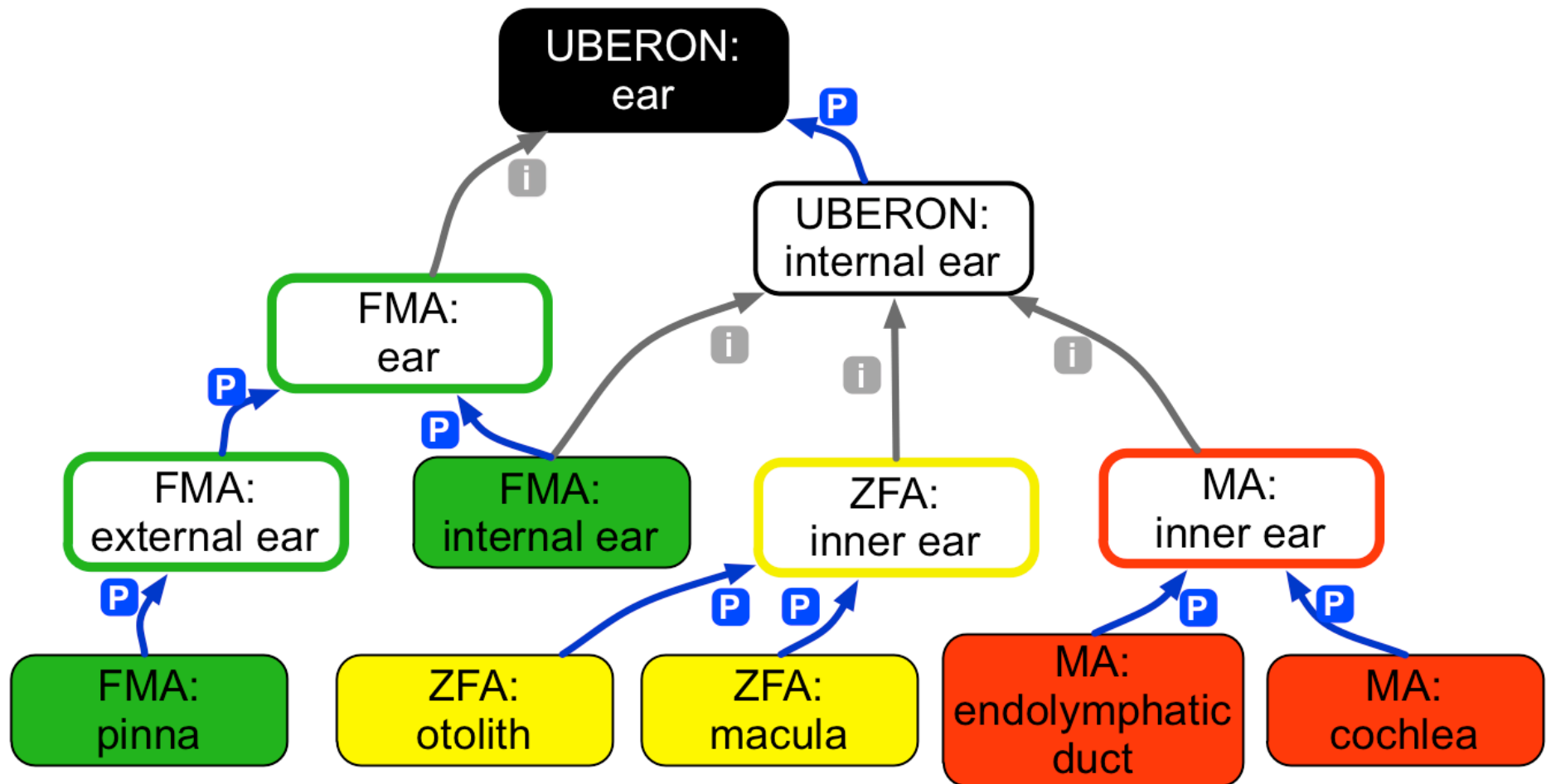
- Problems with the definition of “portion of tissue”
- Some bones may be comprised of more than one tissue type



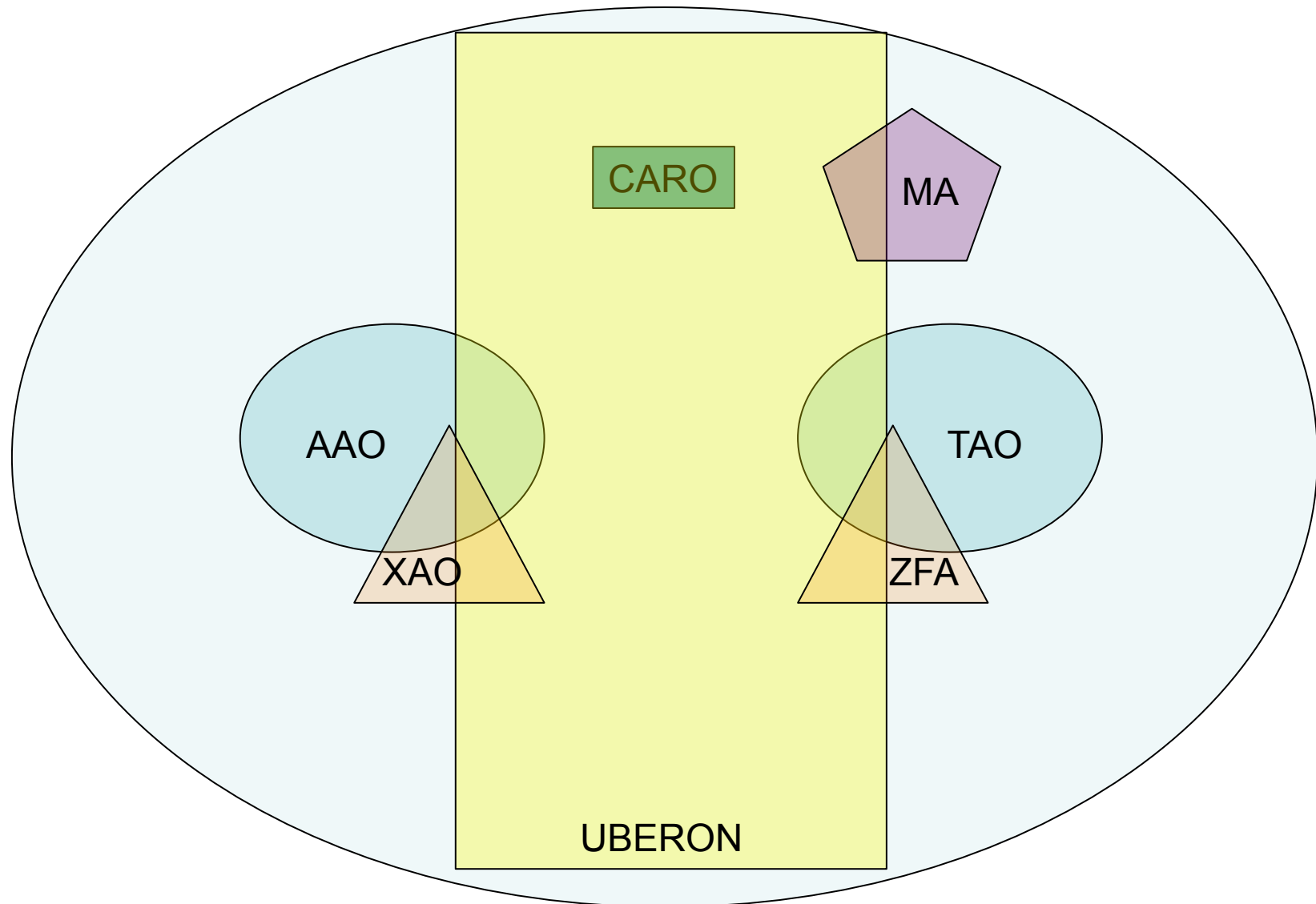
**Some AOs have both the tissue and the bone element, some only one entity to represent both**



**UBERON retains reverse is\_a links to the ssAO, and allows alignment across species**



# Ontology interoperability



# Aligning anatomy ontologies across species

