Given Constraint Reasons

1. Every artifact collected is a known species of animal (because “the official species name must be recorded”)
2. Staff ranks must be one of the items listed because those are the only ranks recognized by the institution (“rank is one of a technician, student, pre-tenure, or tenured”)
3. Because “COL, Genus, Species are derived from Catalogue of Life database,” and also because “each genus belongs to exactly one family,” (Genus is a subset of Family) every family has a unique genus. Therefore, you are subtracting the main set from the subset, resulting in an empty set.
4. Every genus must exist in the Genus relation, and since Species.genus is not unique (not a key), it must exist within the Genus relation. Thus, Species.genus is a subset of Genus.genus.
5. Since all collections are obtained on a “field trip,” and all collections contain at least one artifact (implied by this constraint), every CID in “Collection” must appear in “Collected” and vice-versa.
6. Every artifact must have its information recorded in “Artifact”, and all artifacts must belong to a collection (because “field trips” are the only way to acquire artifacts, and every field trip is a “collection,” there must be a one-to-one correspondence).
7. All collections are assembled by the staff of the institute i.e. only the institute’s own employees can go on“field trips” and collect artifacts. Also, Staff schema contains all the staff, but not all staff may go on an expedition, but only staff at the institute can go on a field trip. Therefore, staff on a field trip must be a staff at the institute.
8. Similar to 7, artifacts can only be maintained by the institute’s own employees.
9. The institute only recognizes the listed categories of artifacts (“type is one of tissue, image, model, or live”)
10. “Published” only contains artifacts collected by the institute (i.e. the institute is only concerned with mentions of its own artifacts, not publications of other institutes, etc.)

Queries

1

$$MAXSTAFF := \pi_{A.SID,date}(Staff) - \pi_{A.SID,date}(\rho_A(Staff) \bowtie_{A.date>B.date, A.SID \neq B.SID} \rho_B(Staff));$$

Holds the staff (one or more) who have held their current rank the longest

$$RELEVANTARTIFACTS := (MAXSTAFF \bowtie_{MAXSTAFF.SID=Collection.SID} (Collection \bowtie Collected \bowtie Artifact));$$

Holds the artifacts of these staff.

$$\pi_{Artifact.date}(RELEVANTARTIFACTS) - \pi_{A.date}(\rho_A(RELEVANTARTIFACTS) \bowtie_{A.Artifact.date<B.Artifact.date} \rho_B(RELEVANTARTIFACTS))$$

Holds the date of the most recent artifact(s) of these staff.

2

$$\text{ArtifactsMaintainedByStaff} := \text{Collected} \bowtie Artifact$$

Holds all artifacts together with who maintained them

$$\text{CollectionsMaintainedByDifferentStaff} := \rho_{(A)}ArtifactsMaintainedByStaff \bowtie_{A.sid \neq B.sid \cap A.cid=c2.cid} \rho_{(B)}ArtifactsMaintainedByStaff$$

Holds all artifacts that are in the same collection, but that two different staff maintain

$$\pi_{AllArtifactsMaintainedByStaff.sid} - \pi_{A.sid,A.cid}CollectionsMaintainedByDifferentStaff - \pi_{B.sid,B.cid}CollectionsMaintainedByDifferentStaff$$

Holds all staff members who maintain collections *not* in the previous relation (i.e. they are the only ones who maintains the artifact). Thus resulting in at least one collection maintained by only one staff member.

3.

$$\pi_{Collected.AN}((Collection \bowtie Collected) \bowtie_{Collected.AN=Artifact.AN \cap Collection.SID=Artifact.SID} Artifact)$$

Finds the tuples where the person who collected an artifact is the same person who maintains the artifact.

4.

$$ArtifactTraits := Artifact \bowtie Genus \bowtie Species$$

Obtains the type species, genus, and family of a given artifact

$$StaffAtLeast3SpeciesFromFamily := \pi_{sid,family,species} \sigma_{A.family=B.family=C.family \cap A.an \neq B.an \neq C.an \cap A.species \neq B.species \neq C.species \cap A.sid=B.sid=C.sid} (\rho_A(ArtifactTraits) \times \rho_B(ArtifactTraits) \times \rho_C(ArtifactTraits))$$

Obtains all staff that have at least 3 artifacts from species within a family

$$AllFamilyCombos := \pi_{Staff.sid,species,family}((Species \bowtie Genus) \times Staff)$$

This query gives all the possible combinations of staff and the artifact's catalog of life information

$$SpeciesInAFamilyNotFound := \pi_{sid,family}(AllFamilyCombos - StaffAtLeast3SpeciesFromFamily)$$

This results in all the possibilities where the species in a family were not discovered by the staff who have at least 3 species from the same family. This only selects the families that do not satisfy; all the families where all the species were not found by the staff who have at least 3 species from the family.

$$\pi_{sid}(\pi_{sid,family} StaffAtLeast3SpeciesFromFamily - SpeciesInAFamilyNotFound)$$

This subtracts all the families that do not satisfy the query (shown above) from all the staff who have had at least 3 from a species in a family, resulting in all the staff who have at least 3 artifacts from every species in some family.

5.

$$\text{PublishedArtifacts} := \text{Artifact} \bowtie Published;$$

Holds journals where our artifacts have been published

$$AtLeast2Published := \rho_A PublishedArtifacts \bowtie_{A.AN<B.AN \cap A.journal=B.journal} \rho_B PublishedArtifacts;$$

Holds journals where at least 2 of our artifacts appear

$$AtLeast3Published := \sigma_{C.AN<D.AN \cap D.AN<E.AN \cap C.journal<D.journal \cap D.journal=E.journal}(\rho_C PublishedArtifacts \times \rho_D(PublishedArtifacts) \times \rho_E(PublishedArtifacts));$$

Holds journals where at least 3 of our artifacts appear

$$\pi_{A.journal}(AtLeast2Published - AtLeast3Published)$$

Subtract the journals where an artifact appears 2 or more times with journals where artifacts appear 3 or more times, which then results in journals where exactly 2 artifacts appear

6

$$\text{ArtifactBioSpec} := \text{Artifact} \bowtie Species \bowtie Genus \bowtie COL;$$

Holds the full information of every artifact and its classifications

$$ArtifactFamLoc := \pi_{family,location}(ArtifactBioSpec);$$

Obtains the locations where any family was found

$$DidNotHappen = \pi_{location}(COL \times \pi_{location}(Artifact) - ArtifactFamLoc);$$

Gets all locations where an artifact from some family wasn't located by subtracting all the found locations from all possible locations.

$$\pi_{location}(Artifact) - DidNotHappen$$

Subtract all locations where some family was not found by all the locations that exist, resulting in all the locations that contain all families.

7

$$\text{EveryStaff} := \text{Collection} \bowtie Collected \bowtie_{Collected.AN=Artifact.AN} Artifact$$

Holds all artifacts, who collected them, and who maintains them

$$StaffWithTissues := \pi_{Collection.SID}(\sigma_{type='tissue'}(WholeCollection));$$

Holds all staff members who have collected a tissue sample

$$StaffWithNoTissues := \pi_{Collection.SID}(\sigma_{type\neq'tissue'}(WholeCollection)$$

Holds all staff members who have collected a non-tissue sample

$$StaffWithTissues - (StaffWithTissues \cap StaffWithNoTissues)$$

The intersection holds people who have collected both tissue/non-tissue samples. So this relation holds those who have tissue samples, but *not* non-tissue ones

8

$$\text{ArtifactsTotalCollection} := (\text{Collected} \bowtie Collection) \bowtie_{Collected.AN=Artifact.AN} Artifact$$

Has all the collections and its artifacts with the artifact's information

$$\text{AllPairs} := \pi_{Collected.cid,Collection.sid,Artifact.sid} \sigma_{Collection.sid \neq Artifacts.sid} ArtifactsTotalCollection$$

Gets all the possible pairs of staff who worked on the same collection together(ie maintainer and collector are different)

$$\text{ThirdPair} := \pi_{A.Collected.cid,A.Collection.sid,A.Artifact.sid} \rho_{(A)} AllPairs \bowtie_{(A.Collection.sid=B.Collection.sid \cap A.Collection.cid=B.Collection.cid \cap A.Collection.sid \neq B.Artifact.sid \cap A.Collection.sid \neq B.Artifact.sid \cap A.Artifact.sid \neq B.Artifact.sid)} \rho_{(B)} AllPairs$$

Gets all staff who have worked with one or more person outside of their first pair

$$UniquePairs := \pi_{AllPairs.Collection.sid,AllPairs.Artifact.sid}(AllPairs - ThirdPair)$$

Obtains all the unique pairs by subtracting all the staff who has worked with 2 or more people by the combination of all staff who have ever worked together, resulting in the staff who have only worked with each other

9

Cannot Be Expressed

Our constraints

1

$$\sigma_{Species.species=Genus.genus}(Species \times Genus) = \varnothing$$

The species being equivalent to the genus will never occur, thus an empty set

2

$$\rho_a(Genus) \bowtie_{a.family=b.family \cap a.genus>b.genus} \rho_b(Genus) = \varnothing$$

Shows schema of at least two genus in a single-family. This shows that a genus belongs to *only* 1 family is possible, as belonging to two or more is an empty set

3

$$(\text{Collection} \bowtie Collected) \bowtie_{Collected.AN \neq Published.AN \cap Collection.date>published.date} Published = \varnothing$$

The empty set should occur when each artifact's date is less than the published date since that means an artifact has not yet been collected

4

$$\text{Staff} \bowtie_{Staff.sid=Artifact.sid \cap Staff.rank='student' \cap Artifact.type='live'} Artifact = \varnothing$$

The empty set occurs when a student is maintaining an artifact that is live