SPECIMEN-BASED SCIENCE: AN INTRODUCTION TO DIGITIZED MUSEUM COLLECTIONS ON *Arctos*

OBJECTIVES

Completing this module will enable you to:

- Search museum specimen records on Arctos, by location and species
- Understand the wealth of information associated with an individual specimen
- Map all records from a single species
- Customize your specimen searches to answer research questions

INTRODUCTION

Natural history collections are archives of biological specimens, representing a record of past and present biodiversity. Scientists, naturalists, and explorers have been collecting and preserving specimens for hundreds of years. Because of careful preservation and curation, we can interact directly with these specimens today, often extracting new knowledge about biodiversity and how it is changing around us.

But do you have to visit museums in person to use specimens? Is it possible to study them from afar?

Substantial efforts have been made over the past two decades to **digitize collections**; that is, to make specimen information digital and accessible via the internet. This is opening up critical historic resources and allowing a global community of users to study biodiversity change through time. Now, a single **specimen occurrence** (the place and time of collection, a taxonomic identification) can be viewed by anyone in the world. A variety of other information about the organism and the collecting event is often available as well (*e.g.*, collector, habitat data, measurements taken on the specimen, or its associated species). This makes digitized natural history collections a treasure trove for new information on evolution, host-parasite dynamics, zoonotic disease transmission, toxicology, and other fields.

Arctos is one type of **collection management information system** that provides research-grade data on specimens to a community of curators, collection managers, researchers, and educators. Museums curate their specimen records on Arctos, and these records can then be accessed and downloaded publicly. Currently, 207 different collections contribute data to Arctos, so the platform is a major resource for biodiversity research. These records also are replicated on larger biodiversity data aggregators like GBIF.

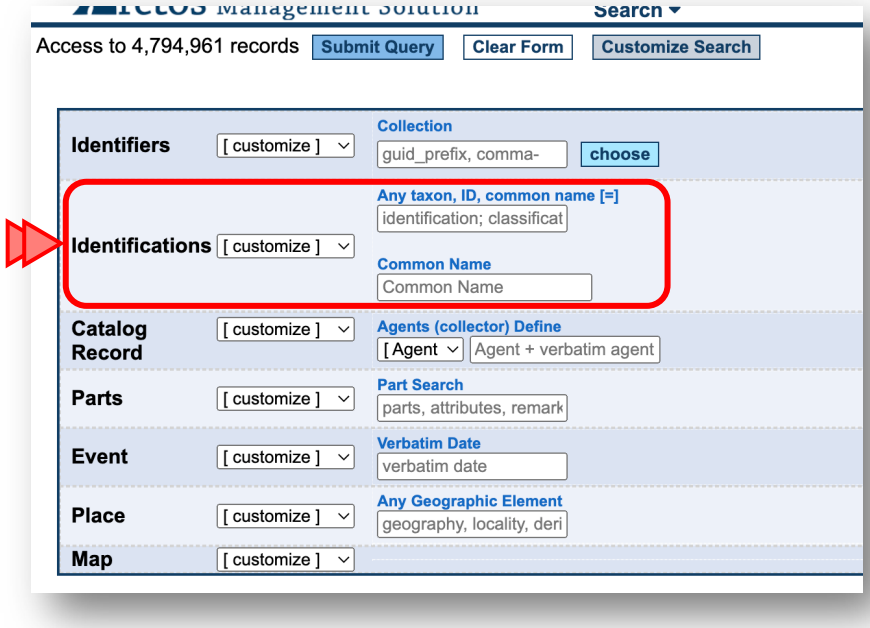
In this module, you will learn to **1)** explore specimen occurrences on Arctos and **2)** understand the types of data that anyone (including scientists) can find and utilize on this platform.

ACTIVITY 1: SEARCHING THE ARCTOS DATA PORTAL

We'll start this activity by navigating to Arctos and doing a targeted taxonomic search.

1. Go to the **Arctos search page**: https://arctos.database.museum/search.cfm.

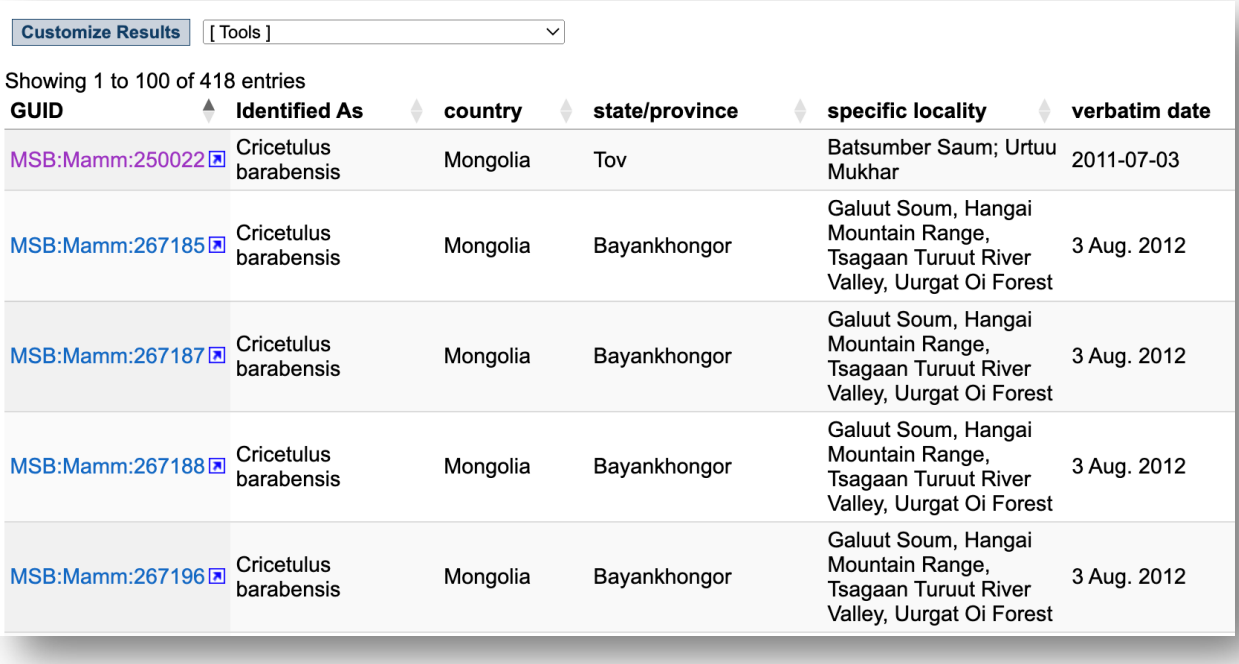
2. To begin your search, locate the **Identifications** tab of the search page. Note that you can also search on other fields such as specific museum collections or places.



3. We will conduct a search for the striped dwarf hamster, *Cricetulus barabensis*, which occurs throughout interior Asia.

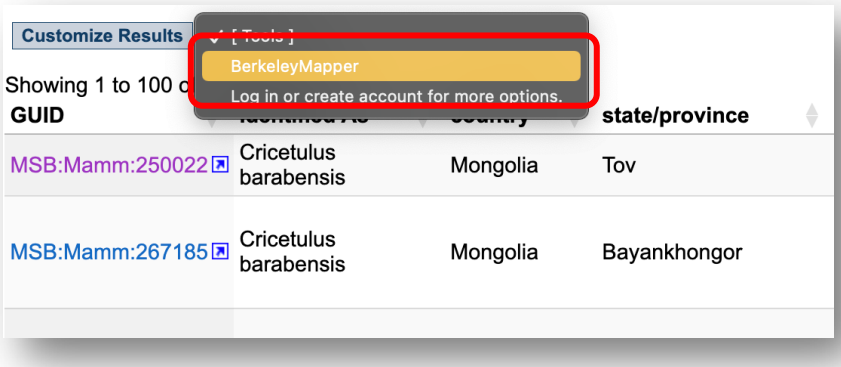
Figure 1. Image of a striped dwarf hamster from the ASM mammal image library.

4. Enter the species name above into the **Identifications** search box (Note it must be spelled correctly!).
    a. Click **Submit Query** at the bottom of the search form.
        i. How many specimen records did your search return?
        (To locate this number, make sure to find the total number of **entries** reported at the top of your search results).
        ii. What type of information about each **species occurrence** is shown by default on the search results form?



GUID	Identified As	country	state/province	specific locality	verbatim date
MSB:Mamm:250022	Cricetulus barabensis	Mongolia	Tov	Batsumber Saum; Urtuu Mukhar	2011-07-03
MSB:Mamm:267185	Cricetulus barabensis	Mongolia	Bayankhongor	Galuut Soum, Hangai Mountain Range, Tsagaan Turuut River Valley, Uurgat Oi Forest	3 Aug. 2012
MSB:Mamm:267187	Cricetulus barabensis	Mongolia	Bayankhongor	Galuut Soum, Hangai Mountain Range, Tsagaan Turuut River Valley, Uurgat Oi Forest	3 Aug. 2012
MSB:Mamm:267188	Cricetulus barabensis	Mongolia	Bayankhongor	Galuut Soum, Hangai Mountain Range, Tsagaan Turuut River Valley, Uurgat Oi Forest	3 Aug. 2012
MSB:Mamm:267196	Cricetulus barabensis	Mongolia	Bayankhongor	Galuut Soum, Hangai Mountain Range, Tsagaan Turuut River Valley, Uurgat Oi Forest	3 Aug. 2012

5. We're now going to map all specimen records that resulted from your search, so we can see where they were collected. In the **Tools** dropdown menu, select **BerkeleyMapper**. This should then generate a map showing where all specimens were collected. Once you've looked around, answer the following questions.



a. What do the **different colored clusters** mean?
b. In what country has the **majority of specimens** been collected?
c. Do you think this map represents the entire distribution of *Cricetulus barabensis*? **Why or why not**?

ACTIVITY 2: INFORMATION FOR INDIVIDUAL SPECIMEN RECORDS

Within an individual specimen record, there is potentially a *huge* amount of associated data. Things like the size, age, and reproductive condition of the organism are often recorded, as well as what type of materials were also collected from it (*e.g.*, parasites, tissue samples, fecal pellets). You can also find detail about where the individual was collected from, and if it is associated with a specific expedition, beyond just the date and general place.

Now, we will take some time to examine a specific record in detail and extract some information.

1. Select any individual specimen that appeared in your search by clicking on its **GUID**. This stands for **G**lobally **U**nique **Id**entifier, and it is the unique digitized record of that single individual.

2. Take a minute to look around and see what types of information are included in this record. Locate the **Record Attributes** section, part of the way down the page. Look through the types of information in this section and answer the following questions.

    a. Was the individual hamster that you selected a **male or female**?
    b. What was the animal's **weight**, in grams?
    c. What was the **tail length** of this hamster?
    (Note that some records may be missing these data. If so, go back and select a different GUID)

Figure 2. Examples of some specimen attributes for mammals in Arctos.

Record Attributes

Attribute	Value
age class	adult
ear from notch	17 mm
ectoparasite examination	yes
ectoparasites detected	yes
endoparasite examination	yes
endoparasites detected	yes
hind foot with claw	18 mm
reproductive data	CEL,PLSC=4R:5L
sex	female
tail length	27 mm
total length	130 mm
weight	26 g

3. Now, examine the **Locality**/**Place and Time** section, further down the page, which indicates where and when the animal was observed. Look around this section and then answer the questions below**.**

    a. What **country** was this animal collected from?
    b. At what **elevation** was this animal collected?
    c. In what **year and month** was this animal collected?

4. Finally, the **Parts** section at the bottom of the page shows what type of materials exist from the animal. This can include the skeleton, different tissue types, parasites, fecal samples, and others. Locate the **Parts** section of your record and answer the following questions**.**

    a. Were there any **organs** collected? If so, **how are they preserved**?
    b. Did this animal have any **ecto- or endoparasites**? If so, what type(s) were they?

TAKE A BREAK: LINKING OUT TO OTHER DATA PLATFORMS

Let's take a break. You should now have a general idea of how to search specimen records on Arctos, and about the rich data potentially associated with single specimens. Remember from the **GBIF module** that museum specimens exist alongside other types of biodiversity observations in larger **aggregators** (*e.g.*, GBIF or iDigBio). Aggregators may thus include local biodiversity censuses or citizen science observations. A useful function in Arctos is the ability to link from individual specimens to these aggregators.

Navigate to the **Links** tab at the bottom of the same specimen page in Arctos. If you don't see this tab, go back and select a different specimen record until you find a section with links. Click each possible link to view the specimen record in other data portals.

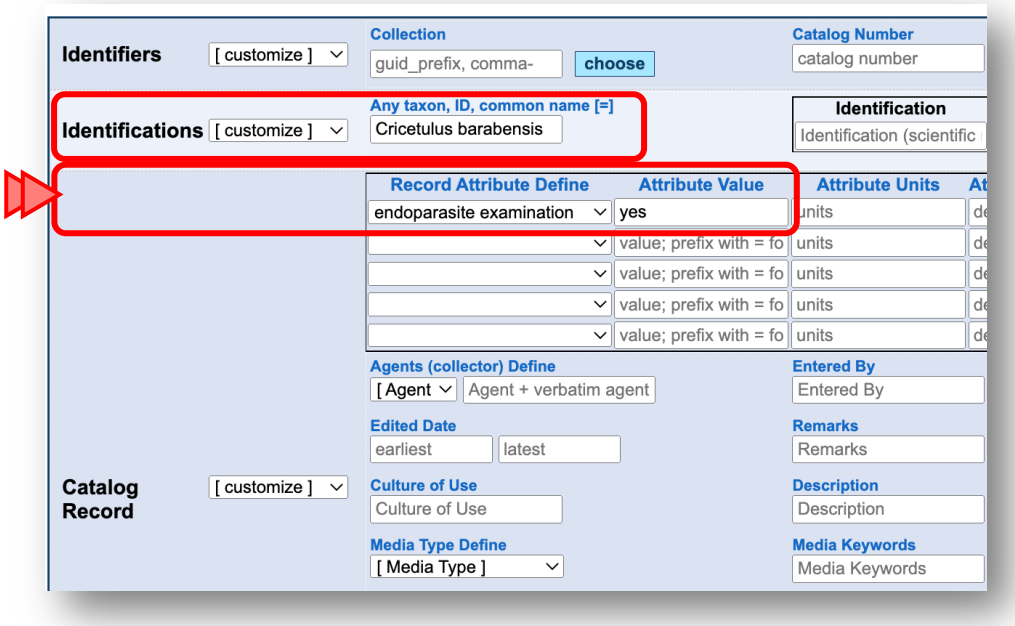
1. Take some time to compare the information available in Arctos, versus other data aggregators. (We will come back to this in the questions at the end)

    a. Which data interface is most **intuitive and approachable** to you (Arctos, GBIF, iDigBio)? (There is no WRONG answer!!)
    b. Are there types of information **lost** or **gained** when you move to aggregator (*i.e.*, those in GBIF or iDigBio)? **What types of information change between Arctos and these other databases**?

ACTIVITY 3: NARROWING YOUR ARCTOS SEARCH TO FIND SPECIFIC INFORMATION

Given the complexity of the Arctos landing page, it should be obvious that you can execute more detailed searches of specimen records on the platform. We will now conduct a tailored search for specimens of this same species (striped dwarf hamster) that have attributes we are interested in exploring, specifically, **whether they were infested with ectoparasites**.

1. Navigate back to the Arctos homepage and start with a clean search form. In the **Identifications** tab, enter the species name as we've previously done (*Cricetulus barabensis*). In the **Catalog Record** tab, go to the **Record Attribute** and in the pull-down menu select "**ectoparasite examination". Then** go to the **Attribute Value** field and enter **yes**. This will return all hamster records that were systematically examined for ectoparasites. Your form should look like this:

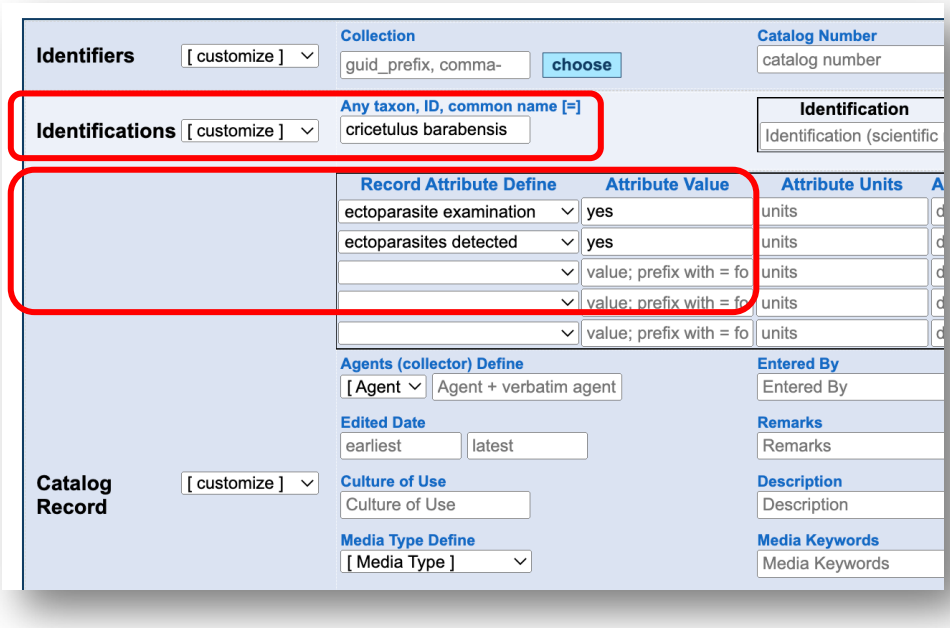


2. Once you've done this, click **Submit Query**.

    a. How many **specimen records** are there now?
    b. What **percent** of all *Cricetulus barabensis* on Arctos have been examined for ectoparasites?
    (Note: if you don't remember how many total records of *Cricetulus barabensis* there were, go back to **Activity 1** and perform that search again to calculate a percentage.)

3. You can now customize other aspects of your search. The final thing we would like to know is: ***what percentage of hamsters examined for ectoparasites are infested? i.e., what is the infection or infestation rate??***

4. To answer this, **conduct one more search**: one that includes two attributes for *Cricetulus barabensis* specimens. First, add one **Record Attribute** for "**examined for ectoparasites**" (value of **yes**) and one **Record Attribute** for "**ectoparasites detected**" (also set to **yes**). Your search form should look like this:



5. Once you've done this, click **Submit Query**.

    a. How many **specimen records** are there now?
    b. What **percent** of all *Cricetulus barabensis* on Arctos *that were actually examined for ectoparasites* were also found to be infested?
    (Note: go back to your number of search records from Question 2, and divide the new number by this previous one to get the infestation rate.)

Great work! You've learned how to explore museum specimens and their data on Arctos! Future modules will introduce us to additional types of biodiversity data, and the ways in which they differ from digitized museum records.

POST-ACTIVITY QUESTIONS

Section 1: Multiple Choice **(select only one answer!)**

1. Where can you obtain information about natural history specimens?
    a. Contact a museum curator
    b. Visit a museum collection in person
    c. Search an online museum database
    d. All of the above

2. Where do records on Arctos come from?
    a. Citizen scientists
    b. Museum collections
    c. Birders
    d. All of the above

3. Which types of organisms have records on Arctos?
    a. Fish
    b. Mammals
    c. Only vertebrate animals
    d. All plants and animals

4. Users can filter a search on Arctos in each of the following ways, ***except which one***?
    a. By taxonomy (species identity)
    b. By place and time
    c. By the citizen scientist who uploaded them
    d. By parasite presence

5. What is a **GUID**?
    a. General Underlying Identity
    b. Globally Unique Identifier
    c. Global Umpire Interpreter
    d. Gosh I Don't Know

Section 2: Short Answer **(answer in complete sentences!!)**

1. Name 5 ways that specimen records in Arctos differ from the same record in GBIF. (Note: you may need to go back to an individual record and compare them side-by-side).

2. Think of and write out a research question that you could answer using Arctos data. Describe in two to three sentences how you would answer the question using Arctos.