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| **Nature’s Flying Machines:**  **The Evolutionary Relationship of Avian Form & Function** |  |

*The original version of this laboratory module was developed by Blake Cahill as part of the BIO 620: Curriculum Design for the 21st Century Biology Classroom and the Biodiversity Literacy in Undergraduate Education: BLUE Network (National Science Foundation DBI 1730526). References and websites used in part or whole for the laboratory development are cited within the module.*

## Comparative Anatomy: The Evolutionary Relationship of form and function

Movement is a key function required for the survival and reproduction of organisms. Microorganisms, such as bacteria and unicellular protists, achieve movement via cellular structures such as cilia and flagellae. Plants and fungi are incapable of individual locomotion but can disperse their offspring via seeds and spores and can grow towards or away from environmental stimuli. Animals have evolved a multitude of methods for movement in terrestrial, aquatic, and aerial environments. One of the most successful types of animal locomotion is **flight**. Flight has evolved at least four separate times, in the insects, pterosaurs, birds, and bats.

In the field of comparative vertebrate anatomy, scientists study the evolutionary history of vertebrate morphology. The examination of the similarities and differences of vertebrate classes of the past with those living today provides a basis for identifying adaptations that arose through evolutionary processes. Comparative anatomy can also be used to identify the similarities and differences between species in order to identify how the form (body structure) of an organism correlates with function.

In this activity, birds will be used as the model organism. Birds belong to the taxonomical class Aves, which is where the word avian is derived from (Figure 1). The avian class is divided into approximately 23 orders (groups, i.e. hummingbirds) of birds which are organized into families containing over 9000 bird species worldwide.

We will examine the connection between body form and function over time by investigating the relationship between avian form and function. We will specifically be (beak and wing morphology) and function (food type; flight and migration). As you may have guessed, the ability to fly does not rely solely on the presence of wings. Species that fly have other anatomical and physiological adaptations that allow for flight. These adaptations will also be explored in order to understand how birds fly and the relationship between flight and migration patterns.

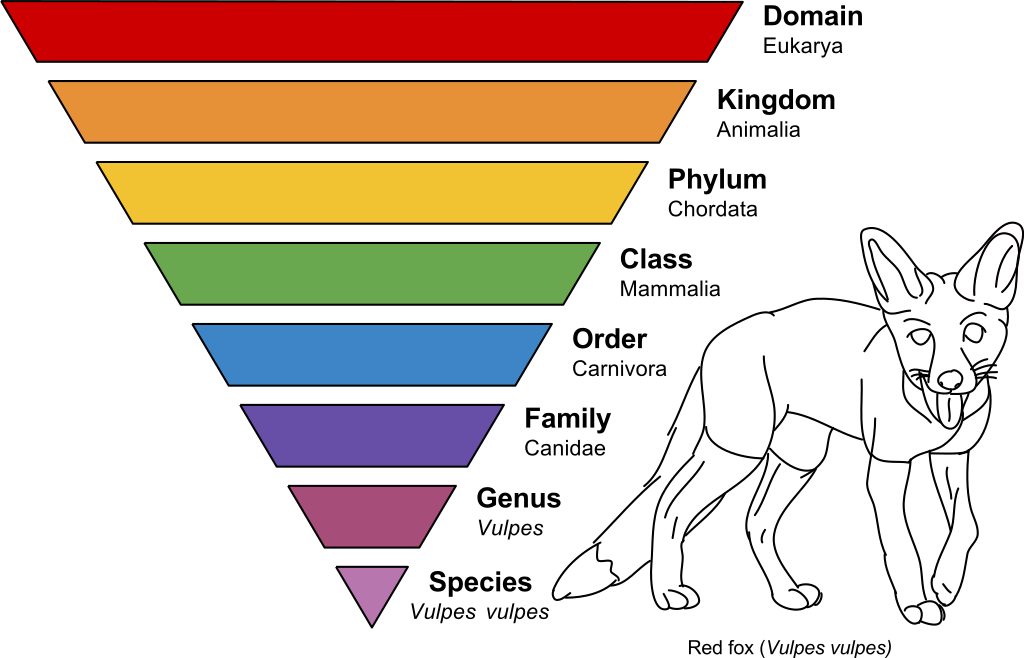


Figure 1. Taxonomic hierarchy. By Annina Breen - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=40559754

## Objectives for Identifying the relationship between form and function

1. Identify & compare beak types between various bird species from a digitized natural history collection.
2. Identify function and related food source for each beak type.
3. Identify flight patterns for various bird species.
4. Identify and compare the relationship between food sources (beak form and function) and migratory patterns (wing form & function).
5. Identify the relationship between food sources and reproductive strategies in migratory bird species.
6. Practice accessing digitized natural history data from an international biodiversity data base.
7. Participate in a collaborative team project.
8. Create a life history for a Michigan bird species in the form of a poster.

**This module consists of 3 preparatory activities and ends with a culminating poster project.**

**Activity 1: Introduction to Bird Anatomy**

Before we compare beak and wing types, we need to learn basic bird anatomy.

For this activity, students will be divided into teams of 2-3. Each team will be assigned a body system to research which will culminate in a data table that will be distributed to your classmates in order to create our own Bird Anatomy Digital Textbook. You will use the compiled textbook to take an online review quiz over bird anatomy before moving to Activity 2.

**Directions:** Go to the Cornell “All About Bird Anatomy” interactive website: (<https://academy.allaboutbirds.org/features/birdanatomy/>) to complete the task below for your team’s assigned body region. Once you have completed your team’s task, you will submit the final document to share with the class via a google folder. Each team will have their own folder to submit their data table. Your team is responsible for obtaining and reviewing the data tables of the other teams that will be used to take an online review quiz over bird anatomy and as part of future assignments in this module.

1. **Team Feathers:**
2. Create a table of each feather type listed, its location, and its function.
3. Provide a copy of the table to your assigned google folder.
4. Write & submit 2 multiple choice questions based on your data table.
5. **Team Skin:**
6. Create a table of each skin region listed, its location, and its function.
7. Provide a copy of the table to your assigned google folder.
8. Write & submit 2 multiple choice questions based on your data table.
9. **Team Musculatory:**
10. Create a table of each muscle type listed, its location, and its function.
11. Provide a copy of the table to your assigned google folder.
12. Write & submit 2 multiple choice questions based on your data table.
13. **Team Skeletal:**
14. Create a table of each bone type listed, its location, and its function.
15. Provide a copy of the table to your assigned google folder.
16. Write & submit 2 multiple choice questions based on your data table.
17. **Team Respiratory System:**
18. Create a table of each respiratory system structures listed, its location, and its function.
19. Provide a copy of the table to your assigned google folder.
20. Write & submit 2 multiple choice questions based on your data table.
21. **Team Digestive System:**
22. Create a table of each digestive system structures listed, its location, and its function.
23. Provide a copy of the table to your assigned google folder.
24. Write & submit 2 multiple choice questions based on your data table.
25. **Team Circulatory System:**
26. Create a table of each circulatory system structures listed, its location, and its function.
27. Provide a copy of the table to your assigned google folder.
28. Write & submit 2 multiple choice questions based on your data table.
29. **Team Female & Male Urogenital Systems:**
30. Create a table of each female and male urogenital structures listed, its location, and its function.
31. Provide a copy of the table to your assigned google folder.
32. Write & submit 2 multiple choice questions based on your data table.
33. **Team Nervous System:**
34. Create a table of each nervous system structures listed, its location, and its function.
35. Provide a copy of the table to your assigned google folder.
36. Write & submit 2 multiple choice questions based on your data table.
37. **Team Endocrine System:**
38. Create a table of each endocrine structures listed, its location, and its function.
39. Provide a copy of the table to your assigned google folder.
40. Write & submit 2 multiple choice questions based on your data table.

**Activity 2: The Relationship Between Beak Anatomy and Food Sources**

For this activity, we will examine the evolutionary relationship between form and function by examining beak anatomy. Each beak type has a specific function, in other words, it is useful for eating specific types of foods. Birds exploit a wide variety of foods including: seeds, fruit, nectar, insects, worms, fish, amphibians, reptiles, other birds, mammals, carrion, eggs, or a combination of these. Your team will be assigned to a specific food resource bird group for which you will do the following:

1. Your group will be assigned one of the following beak types:
2. Seed-eating birds.
3. Fruit-eating birds.
4. Nectar-eating birds.
5. Insect-eating birds.
6. Worm-eating birds.
7. Fish-eating birds.
8. Amphibian-eating birds.
9. Reptile-eating birds.
10. Bird-eating birds.
11. Mammal-eating birds.
12. Carrion-eating birds.
13. Egg-eating birds.
14. Identify the types of food this group exploits. Provide examples.
15. Describe the beak shape for your group and how it is ideal for this food source.
16. Provide 3 examples of Michigan bird species (be sure to include both the common and scientific name) that exploit this food type. Please provide pictures of each of the bird species and the specific type of food they rely upon. How do you know if it’s a Michigan species? Go to Cornell University’s “All About Birds” website: <https://www.allaboutbirds.org/news/>. Type in the name of your bird in the search box. Once you reach the page for your bird species, scroll down to the range map. You will want to select birds that either spend their breeding season in Michigan or live in Michigan year-round.
17. Create a 1-page handout to upload to the community google folder.
18. Be sure to include references for all of the resources you use including images.

To find your food group, go to: the Virtual Resources for Ornithology (VIREO) page supported by Drexel University: <http://vireo.ansp.org/bird_academy/bird_diets.html> . Scroll until you find your assigned food group, then click on the highlighted text linking to more information. This link will take you to a page where you will find more species in your food resource group.

**Activity 3: Using an Open Access Biodiversity Data**

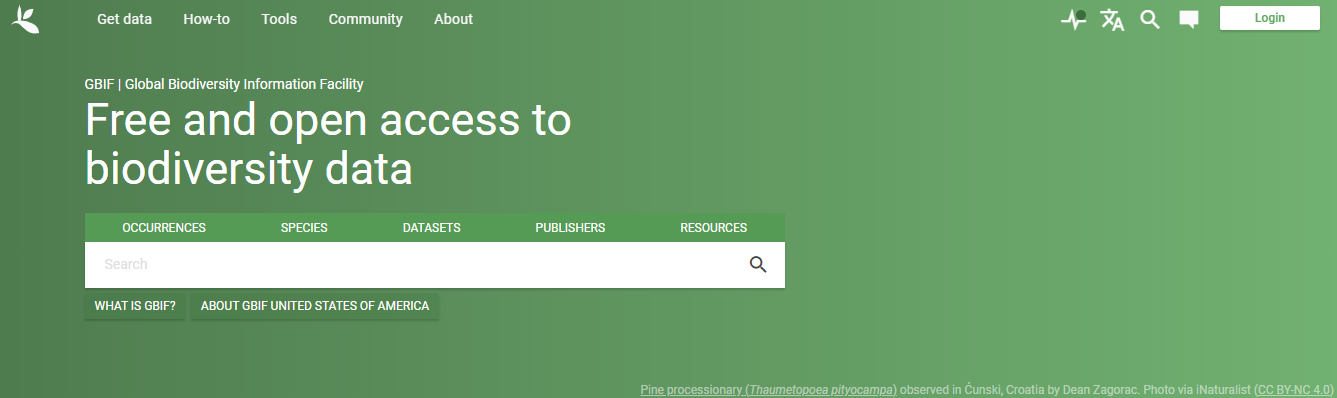
Online open access data sets and natural history inventories are becoming increasingly popular in the scientific world. They provide a wealth of information that can be used to conduct research. For this portion of the module, you will be learning how to use the open access biodiversity data site Global Biodiversity Information Facility (GBIF). Before beginning the activity, watch this video, which introduces GBIF and explains how to maneuver the site. The introductory video can be found here: <https://www.youtube.com/watch?v=2h9LNS8C764&t=1s>.

You will use information from the video to answer the following questions:

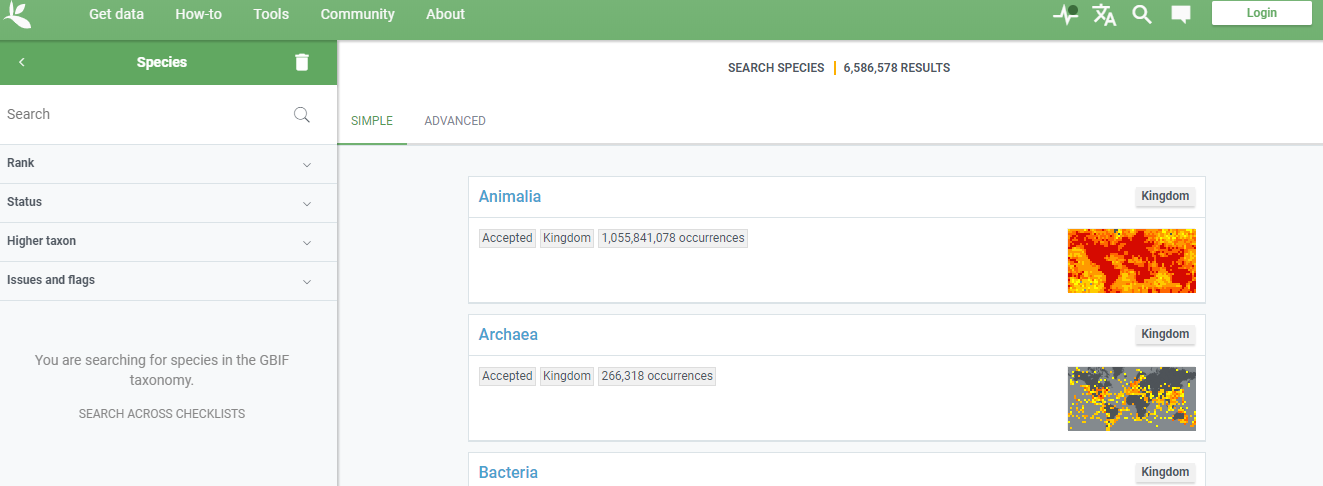
1. What is GBIF and what is its purpose?
2. How many centuries worth of data can be found on GBIF?
3. GBIF contains data from how many different species?
4. What is the benefit of having institutional information as a search option?
5. How is database search useful? What types of information can you find?
6. What is usefulness of the species search?

Once you have completed reviewing the video and have a basic understanding of how to use GBIF data, you will conduct a practice search for a species of your choice. For this practice run, we are going to focus on bird species. You can use the bird species that you plan to research for your culminating project (see separate information sheet), or another bird species if you choose.

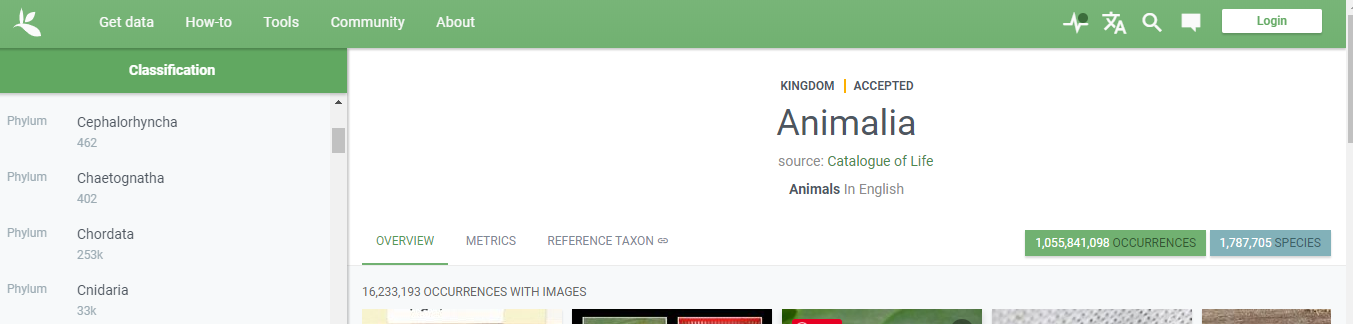
**Go to** [**https://www.gbif.org/**](https://www.gbif.org/)**. Click on the species option:**



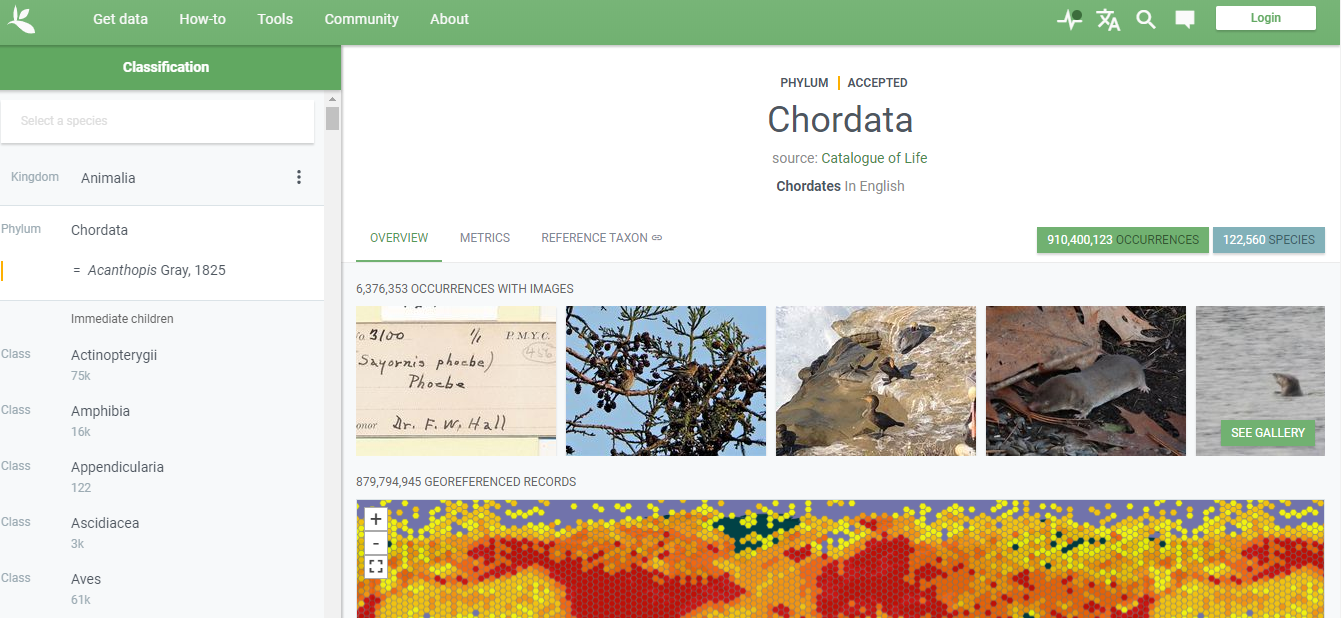
**From there, you will click on “Animalia.” Be sure that you are in the Simple Search Option.**



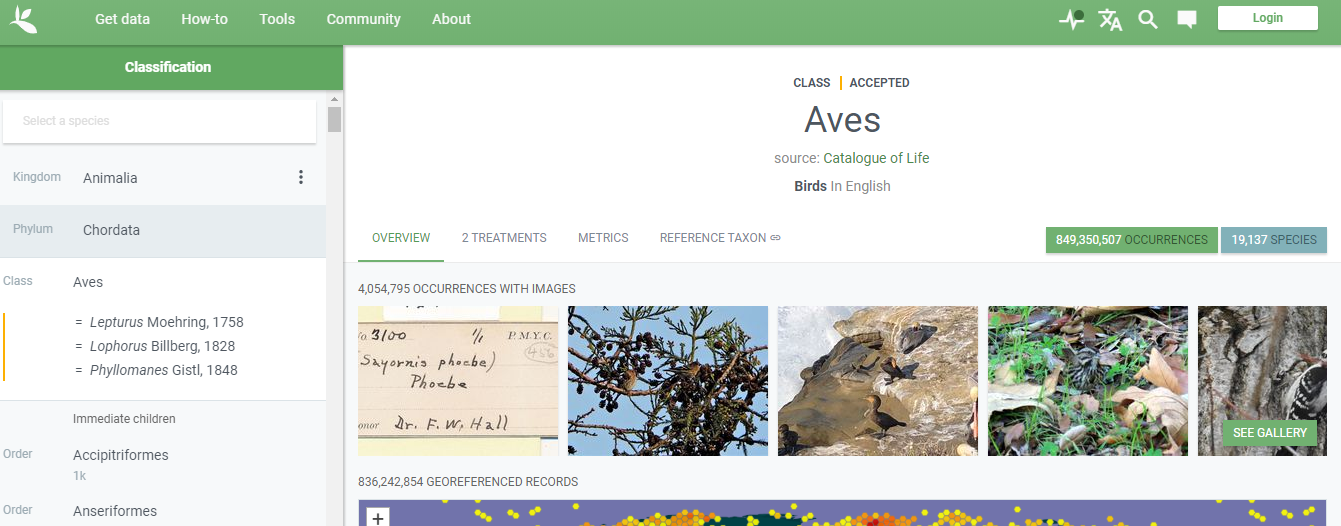
**Next, under Classification, scroll down until you reach Chordata (remember, birds have backbones). Click on Chordata.**



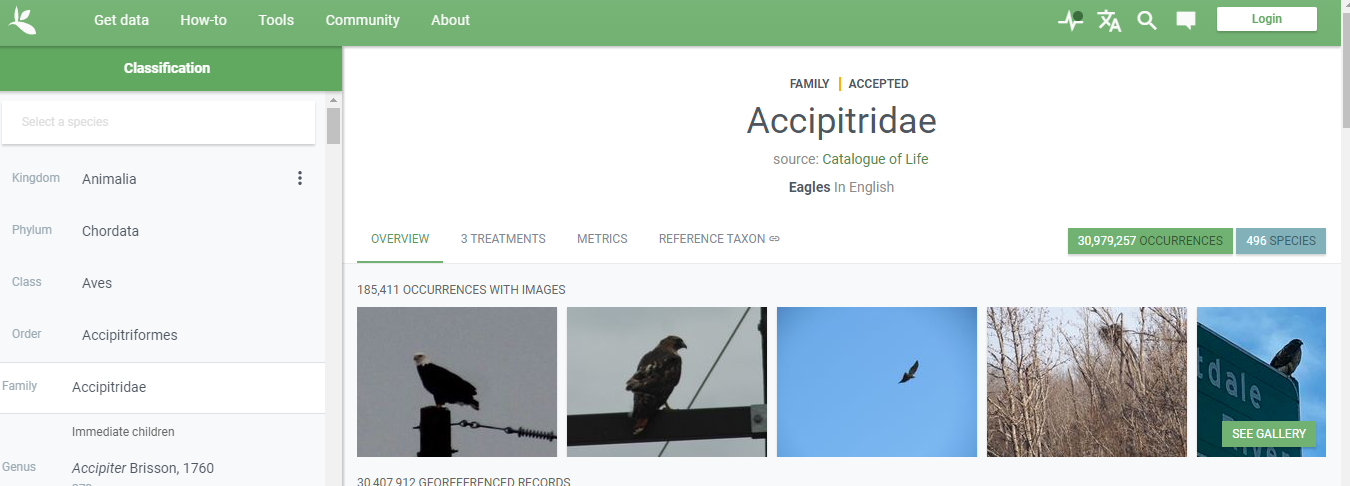
**Once you have clicked on Chordata, you will need to find the Class “Aves” for birds, by scrolling through the classification list.**



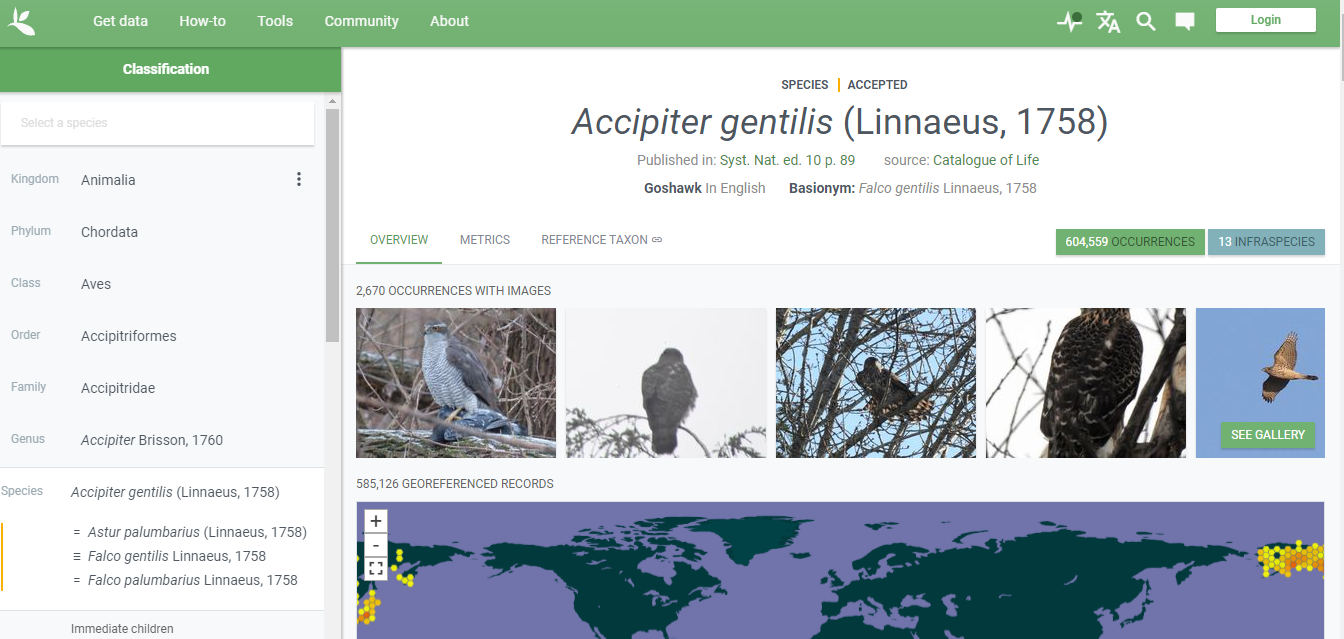
**For the next section, you will need to know the specific order of your species. For this practice run, we will use the Accipitriformes order (Birds of Prey).**



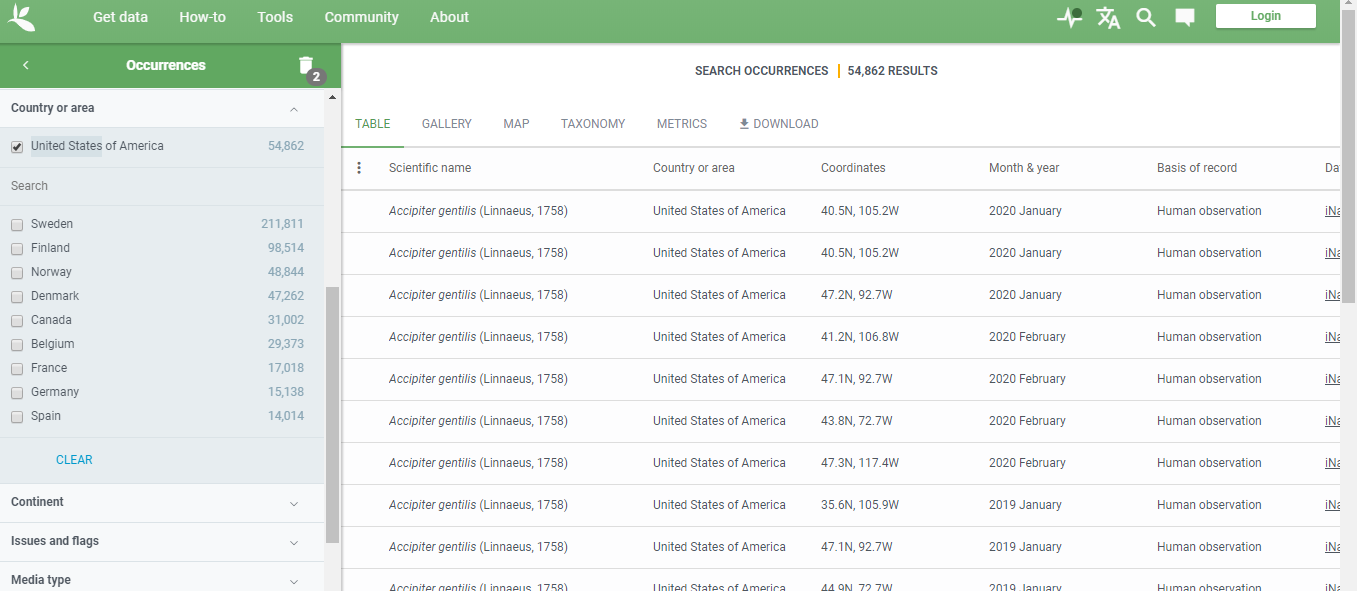
**After selecting the order, you will need to the family of your species. For practice, choose Accipitridae (blue arrow). From here, you can type in the name of your species in the search box (red arrow).**



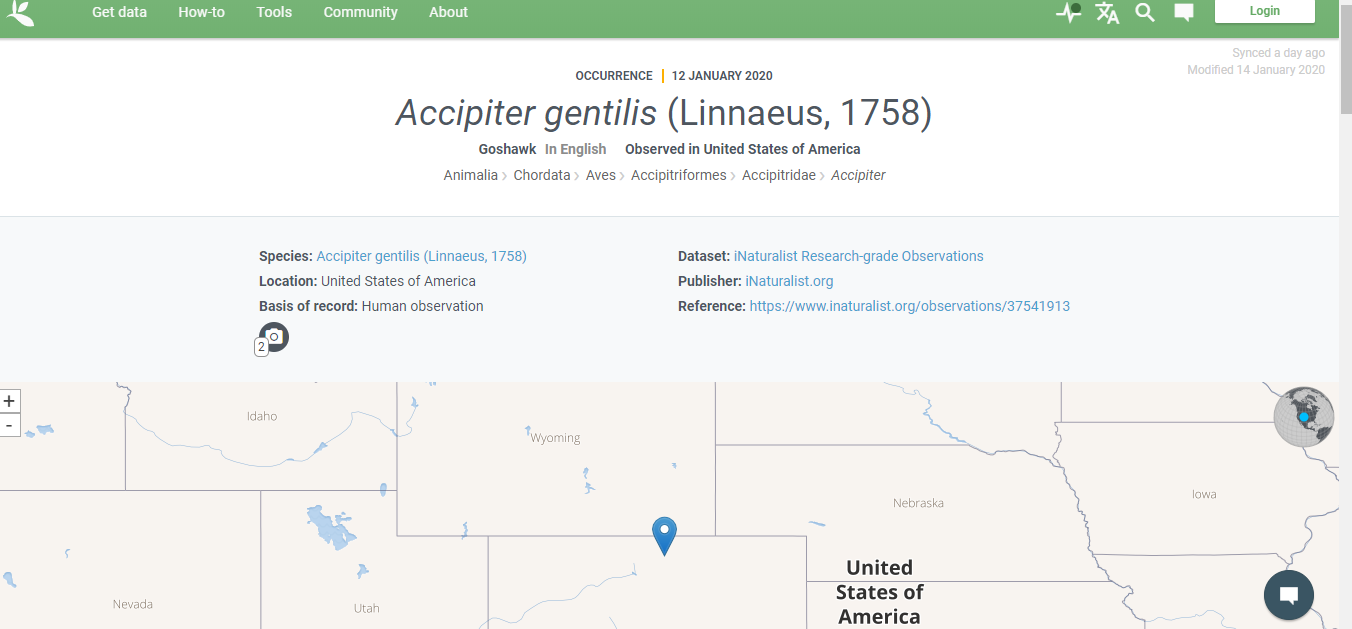
**Now you have options to collect data for your species. For this demo, the Northern Goshawk (Accipiter gentilis) will be used. From here, you can collect data on your species. You can see that there are many occurrences for this species. If you click on Occurrences (blue arrow), you will get a list of countries where this species has been identified.**



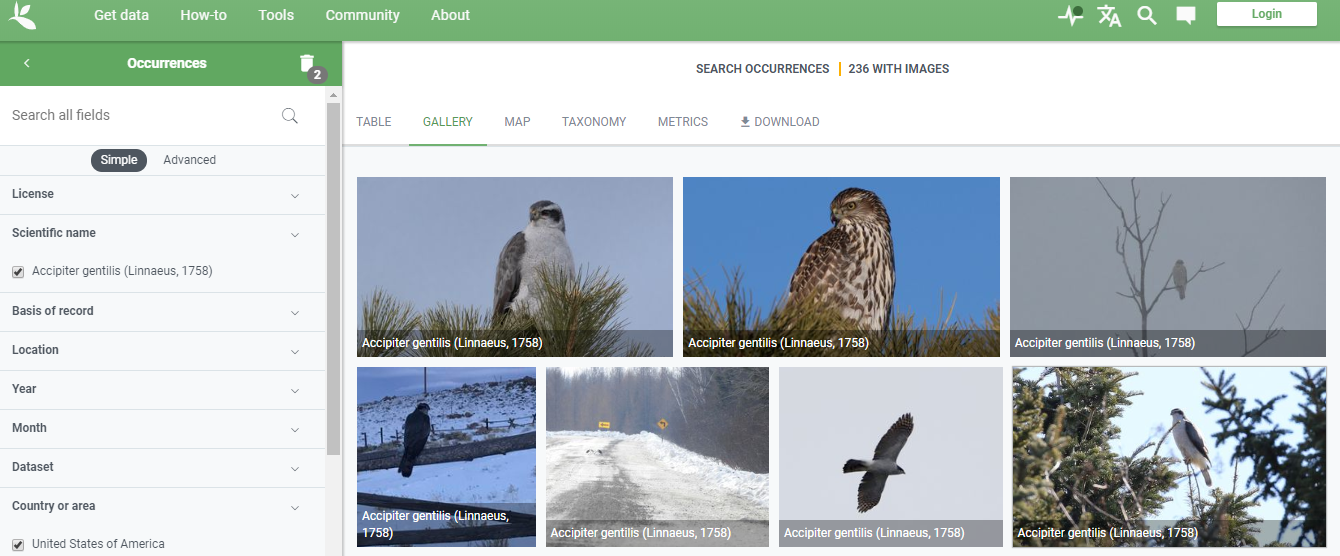
**Since this project emphasizes, birds of Michigan you will only use data from the United States. You can narrow this list down, by selecting the country you wish to search.**



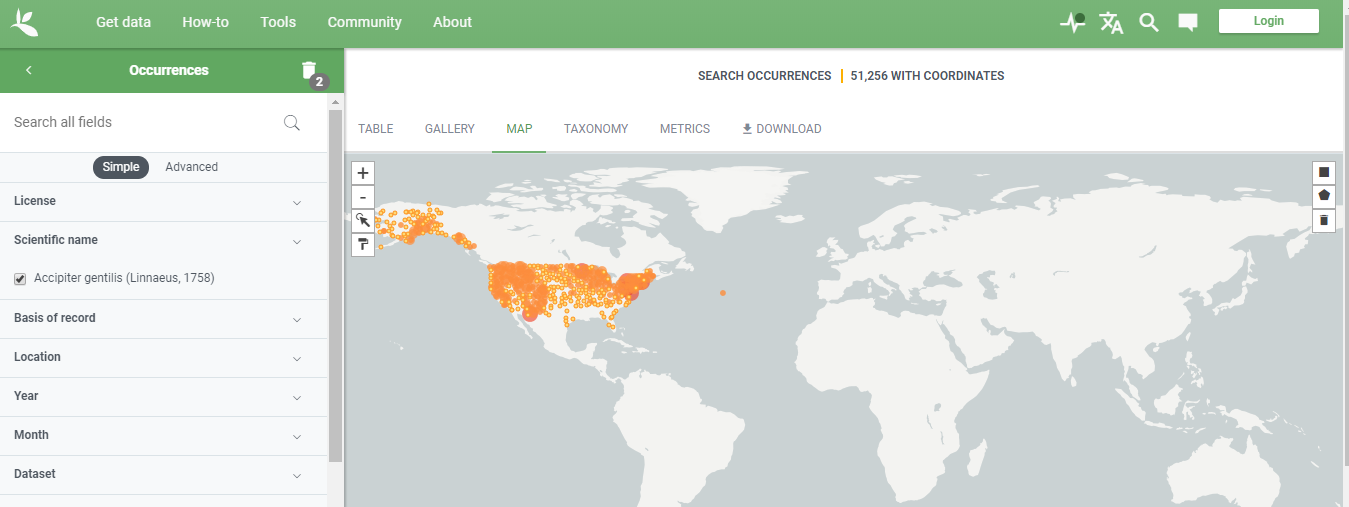
**Now you can click on the specimens identified in North America. Let’s look at one. Examine this data? What was the location where this bird was seen? Who was the publisher? Was this a scientist or a citizen scientist? What is a citizen scientist?**



**Go back (use your browser back button) to the initial search for the Northern Goshawk. Notice at that you can view the gallery of photographs of both living and non-living specimens by clicking on the gallery option. These snapshots could be used in your culminating presentation.**



**Next, click on the map. This shows you all of the geographic locations where coordinates were used to pinpoint the sighting of the species in the United States.**



**Next click on the Taxonomy option. This is provides a summary of the taxonomical information.**

**Culminating Project: Life History & Migration Patterns of a Michigan Bird Species**

1. Choose one of the bird species identified in Activity 2 (beak & food). Each student will be researching a different bird species. Pleas verify your species choice with your instructor to ensure that it was not already chosen by one of your classmates. Also, be sure your species is a Michigan year-round resident or migrates to Michigan for the breeding season. You can verify this for your chosen species the Cornell Website identified in #2 below. Click on the range map for your species.
2. **Use the information gathered in Activities 1-3, this website:** Cornell University’s “All About Birds” website: <https://www.allaboutbirds.org/news/>, GBIF (<https://www.gbif.org/>), and one other reputable resource of your choice.
3. **Create a scientific poster with the following sections:**
4. **Physical characteristics** – Hint: the beak resources would be helpful for this section, as well as the wing shape (think about the wing shape in relation to the distance of their migration and their migratory path). Also include a basic description of the bird (size, weight, and other identifying characteristics of this species).
5. **Taxonomy –** include class, order, family, genus and species.
6. **Life History Overview (minimum effort would include the following):**

* At what age do they start breeding?
* How many clutches do they produce in 1 year?
* What is average clutch size?
* How long does it take to raise a clutch & when do they fledge?
* Average lifespan?

1. **Habitat –** Hint: beak anatomy resources would be helpful for this section to determine the type of habitat your species exploits. Also, review the specific habitat in the natural communities database at the Michigan Natural Features Inventory website: <https://mnfi.anr.msu.edu/publications/abstracts>. Click on “Natural Communities” and scroll until you find the habitat for your species.
2. **Behaviors:** Food resources used, nesting behavior, and courting behavior at a minimum.
3. **Range –** including breeding season, non-breeding season, and year-round.
4. **Conservation Status –** is this species endangered or of special concern? What about the habitat or food sources it requires to survive?
5. Be sure to include figures, diagrams, or other graphics to help summarize your data.

**Why are we making a scientific poster?**

This project is being used to help you practice creating a scientific poster. However, instead of presenting experimental research results, you will be presenting the data you have collected throughout our BLUE Activities 1-3.