# **Connecting Students to Citizen Science and Curated Collections**

**Students Contributing to Our Understanding of Global Biodiversity**

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| **What?**  Learn about plant systematics and collecting in the context of our information-rich digital age. Connect physical plant specimens to citizen science observations and online herbarium databases. Explore how making these connections helps contribute to our understanding of global biodiversity. | **Why?**  This project will help prepare you to be an information- literate scientist, with an understanding of what biological collections data represent, where they come from, and how they can be used. | **How?**  You will complete this project through a combination of traditional plant taxonomy instruction, participation in citizen science, and exposure to online databases. |
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#### **I. ASSIGNMENT INTRODUCTION**

This semester you will undertake a project that integrates traditional taxonomic practices, ongoing citizen science initiatives, and digital-age herbarium curatorial skills. Your final project will be to produce archival-quality, research-ready plant collections that will become part of our national biodiversity archive. Biodiversity archives impact many areas of science and education as evidenced by a vast body of scientific literature reflecting the importance of well-curated, digitized herbarium collections. For hundreds of years, scientists studying plant diversity have documented and vouchered specimens from all over the world. These data, while always available at physical herbarium locations, can now be accessed virtually at the click of the mouse. This has led to an explosion of scientific and research innovation in the biodiversity community as specimens are being used in novel ways to address emerging environmental issues of global concern. Information from publicly available specimens is being used to understand how changing climates affect plant phenology ([Primack *et al.*, 2004; Miller-Rushing *et al.*, 2006; Willis *et al.* 2008](#ed2o2rkniidx)) and to track the spread of invasive species over time ([Novak and Mack, 2001](#ed2o2rkniidx)), not to mention that DNA can be successfully extracted from specimens for many different applications ([Lees *et al.*, 2011; de Vere *et al.*, 2012; Delye *et al.*, 2013](#ed2o2rkniidx)). Due to the importance of collections both in hand and online, the project you undertake in this course will emphasize the skills and best practices required to facilitate downstream applications of your collection and documentation of plant biodiversity. Herbarium specimens are not musty, dead plants hidden away in a cabinet; they are keys to the future of many biological disciplines.

The assignment is to archive plant specimens collected in the field. Students will 1) keep detailed field notes, 2) collect and document plant specimens for archival purposes, and 3) use traditional and emerging tools to reliably identify multiple plant species. As part of this exercise, students will interact with [iNaturalist](http://inaturalist.org)[[1]](#footnote-0), an observation-based online tool to bring together professional and citizen scientists documenting biodiversity. There may also be an opportunity to work with the virtual herbarium community and incorporate student collections into the [Symbiota](http://symbiota.org)[[2]](#footnote-1) digitization platform. Specific instructions will be given for each leg of the assignment, but students are encouraged to explore the potential of emerging technology and curatorial tools to learn about the value and utility of specimens and their virtual aggregation.

Items Due\*:

1. Herbarium-ready specimens
2. Specimen data recorded in iNaturalist
3. Detailed notes on plant identifications

*\*Details on specific requirements for number and diversity of specimens, due dates, and percentage points can be found in your instructor's class syllabus.*

See Appendix A—Checklist for course collection assignment.

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#### **II. LEARNING OBJECTIVES**

Students completing this assignment will be able to:

1. Maintain professional-quality specimen collection notes.
2. Collect plant specimens from the field using proper techniques and including adequate material for identification.
3. Identify unknown plant specimens using multiple forms of reliable evidence.
4. Prepare and deposit research-quality herbarium specimens.
5. Deposit species and occurrence data into national/international databases.
6. Explain the importance of herbaria in plant biology research.
7. Discuss the value of large data sets for investigating large spatial- or temporal-scale phenomena.
8. Evaluate the importance of citizen scientists to large data sets.

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#### **III. SUPPLIES**

The supplies you will need to complete this assignment are listed below. Please remember that your instructor may provide different supplies than those noted here; print out the unmarked supply list at the bottom of the page and bring it to class to determine exactly what you will need to gather for your class.

* Plant press
* Blotter paper
* Cardboard
* Newspaper
* Plastic bags to store collections temporarily
* Clippers for collection of woody specimens
* Trowel or other tool for digging up small herbs
* Field notebook (permanently bound)
* Mechanical pencils
* Digital camera (can be on a smartphone or tablet)
* GPS unit or access to mapping application, e.g. Google Earth or a smartphone
* Field lens/loupe
* Ruler
* Field identification manuals and appropriate keys

See Appendix B—Plant Collecting Supplies.

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#### **IV. SPECIMEN FIELD NOTEBOOK**

Lab notebooks and specimen collection are a fundamental part of any plant identification work. Anyone who works in field identification should have a collection notebook with detailed descriptions of the plant localities and habitats where plants are observed so that the sampled plant can be relocated using your specimen as a reference. Every field-collected specimen in the collection is accompanied by a collector’s name and a collection number. If you are just starting your field collection notebook, and you are the collector, then the first collection will be labeled “1”. These numbers will increase the more you collect throughout your lifetime. Once determined, the correct name, authority, and family of the specimen should be written into your field notebook. It is also helpful to include information on how the plant was identified (e.g., the key, monograph or flora used, field guide, internet image search and whether the plant was verified by an authority).

While you will not be graded on your field notebook in this course, maintaining one is necessary to help you accurately remember the information you need to upload to iNaturalist and to write your detailed plant identifications. Here is the information you should include in each field notebook entry, along with general format guidelines:

* **Collection Date**: Format should be DD-MMM-YYYY; e.g. "05 Oct 2014."
* **Collector Name**: Format should be first name, middle initial, last name; e.g. "Jonah J. Johnson."
* **Collector Number**: Please do not use Roman numerals or prefixes. Begin your field notebook with the number 1.
* **Country**, **State**, and **County** of collection
* **Municipality**: This is the town or region where you collected, e.g. "Minneapolis."
* **Locality Description**: These need to be detailed enough that someone else could find your collecting location. These are not “Driving Directions” but rather a written description of where you would go to find the locations. Feel free to use man-made (e.g. roads, street addresses) and geographical (e.g. rivers, mountains, drainages) landmarks.
* **Lat/Lon Coordinates**: If you have a GPS unit, smartphone, or GPS-enabled camera you can record this information in the field. Otherwise, please use Google Maps or another mapping application to add this information later.
* **Elevation:** In meters or feet, but note the units.
* **Description**: Record features that may not be preserved in the pressed specimen, such as color, odor, sap or latex, height, diameter, etc. Particular attention should be paid to phenology– Is tree in fruit or flower? If so, what color are flowers? You can also describe the plant’s habit–is the plant a tree, shrub, or vine? If you have reason to believe a specimen is cultivated or offspring of a cultivated specimen that has “escaped,” that information should be recorded as such. Please note, these need to be your description of the specimen you noted in the field. This should not be copied from a species description or a secondary source.
* **Habitat**: Record anything you know or can determine about soil type (sand, clay, loam), topography, slope, exposure, amount of sun, proximity to water sources such as streams or lakes, etc. Describe the site to the best of your ability. You can also include information about the level of disturbance of the habitat, e.g. does the area appear to be naturally forested? In agricultural use?
* **Associated Species**: If you know the identification (even to genus or family) of any other plants growing in the immediate surroundings of your collection, record them here. This information can help researchers assess what type of habitat is present at this location.
* **Identification Notes**: Record all methods used for identification. Key characters used in your identification should be listed for family, genus and species. Any close relatives which could be part of a misidentification should be discussed along with distinguishing characteristics.
* **Family Name**: Of the plant collected. Be sure to use the most current taxonomy.
* **Scientific Name**: This includes genus, species, and subspecies or variation if necessary. You may need to take the specimen back to identify in the lab; if so, you will add this information later. Italicize or underline the scientific name.
* **Authority**: The name of the botanist who first described this plant. You will find this following the scientific name in any taxonomic identification resource.
* **Common Name/s**: There may be more than one.

The categories above are included in the blank data entry sheet (Appendix C—Field Notebook Template), if you would like to download it as a template. Again, your field notebook data will be the basis of your iNaturalist observations, which will become your specimen labels. Therefore, it is essential to record careful and thorough data for every specimen you collect. Check out the record here for an example:

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#### **V. IDENTIFYING SPECIMENS**

While in the field, the collector should spend time identifying the plant. This is important. Often key characters for identification are observable on the plant in the field and can be lost or change once the plant is collected. Good field notes and well-kept field notebooks help circumvent this challenge. If you are a new collector, it is good to spend field time identifying. It will help you learn about key features and identifying characteristics as you work through the taxonomic keys.

Once you return to the lab you can work with the specimen for a few hours before it starts to dry. You can still identify your collections once the specimens are dried, but many beginning students find it much easier to identify fresh plant specimens. Good collections are properly identified to species (and subspecies or variety if applicable). Specimens without correct identification are of limited use. **Reminder!!!!** The correct name, authority and family should be written into the field notebook once they are determined. It is also helpful to include information on how the plant was identified (e.g., the key, monograph or flora used, field guide, internet image search, and whether the plant was verified by an authority).

**Specimen identification is the most challenging part of this assignment**. It seems daunting at first. How exactly do systematists identify an organism – either to find out its true scientific name and classification or to determine if it is a newly discovered plant/animal/bacteria/fungus altogether? Scientists use many techniques, including the following outlined by Simpson in *Plant Systematics* (2011):

1. [Taxonomic keys](#sg9ou8ovjhed), both dichotomous and polyclave.
2. [Written descriptions](#82193ly6458d) of organisms done by professionals and published in peer reviewed journals, monographs, floras, or field guides.
3. [Specimen comparison](#bagnrf6p8iin) of dried preserved specimens in natural history collections with unidentified specimens.
4. [Image comparison](#845xhq3teea2) using books, photographs, and even the internet.
5. [Expert determination](#mdsdzzjw9m6e) with the help of someone who knows a lot about your type of organism.

Remember that you will need to turn in written documentation of how you identified your specimens (see example below), so read these identification sections carefully.

See Appendix D—Example of identification notes.

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#### **A. Taxonomic Keys**

#### A taxonomic key is a simple tool used to identify a specific object. A taxonomic key is one of the most useful tools available to scientists trying to identify an unknown organism. Systematists rely on keys to help identify known organisms and determine whether they have discovered a new organism entirely. Taxonomic keys are useful tools guiding researchers towards the known name of an organism. However, all taxonomic keys are not created equally. They are often created on a regional level or for a particular group of organisms (i.e., Plants of the Great Lakes Region, Argentinean Monocots etc.). So it is important to pick a key that represents the diversity of the region or group of organisms you are interested in examining.

**Dichotomous keys** allow the user to determine the identity of items using a sequence of alternative choices. Dichotomous comes from the Greek root *dich*-, meaning "two" and *temnein*, meaning "to cut." Dichotomous keys always give two, mutually exclusive choices in parallel statements. The pair of statements is referred to as a **couplet** and each 1/2 of a couplet is a **lead**. At each couplet of a dichotomous key the user is presented with two choices about a specific **character** present in the group of organisms, a specific **character state** is described for each lead. Sometimes the characters are **quantitative** (i.e., measurements) and sometimes the characters are **qualitative** (e.g., texture). As the user makes a choice about a particular characteristic of an organism s/he is led to a new branch or couplet of the key. Each couplet provides characteristics that become progressively more specific until the final step is reached and identification is made. Followed correctly, keys will lead you to the correct name of an unknown organism or object. Dichotomous keys can be developed to identify anything in any sort of classification.

Example dichotomous keys:

* University of Michigan Herbarium's [General Keys to Families and Special Groups](http://michiganflora.net/family-key.aspx#key-a)[[3]](#footnote-2)
* Jepson eFlora's [Key to California Plant Families](http://ucjeps.berkeley.edu/IJM_fam_key.html)[[4]](#footnote-3)

**Polyclave keys** are tools used to help identify unknown objects or species. The keys are generated using interactive computer programs. Polyclave keys use a **process of elimination**. The user is presented with a series of choices that describe features of the species they wish to identify. The user then checks off a list of character states present in the organism they wish to study. The program looks to match those character states with all the species they can possibly match. If a species does not have that character state it is eliminated from the list. The more character states listed the more species that are eliminated. This allows the rapid elimination of large numbers of species that the specimen cannot be. The process continues until only one species (or a short list of species) remains. This allows the user to eliminate lots of potential species and identify the species or at least a short list of possible species. This continues until only one species is left. If all went well, *and the key fits your group of organisms*, that is the name of the species you have located! Even the best keys have their limitations, so make sure you verify your identification using multiple tools (image verification, herbarium specimens, expert identification, etc.).

Example polyclave keys:

* Symbiota's [dynamic species list and key generator](http://nansh.org/portal/checklists/dynamicmap.php?interface=key)[[5]](#footnote-4)
* Sagehen Creek Field Station's [Wildflower Guide on iNaturalist](http://www.inaturalist.org/guides/1104)[[6]](#footnote-5)

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#### **B. Written Descriptions**

When trying to determine the identity of an unknown plant one method of identification involves reading written descriptions of a group of possible plants. This first requires that the plant of interest can be narrowed down to a few species. An informal way of doing this is to examine descriptions in **floras** or **field manuals** (published descriptions of the plants of a particular region, geological period, or environment); formal **monographs** (publications on specific groups of related plants) can also help narrow your search. Otherwise, the identifier would have to read every possible description of plants in the world!

Written descriptions can be long comprehensive descriptions detailing all the characteristics of a plant species and can include value ranges for several characters. These types of descriptions are required when new species are described. This can help the description user to examine the plant carefully and fully determine if all the characteristics match the detailed description. One of the drawbacks to these long written descriptions is they do not really tell you the key diagnostic characteristics of your specimen. Sometimes there is just too much information to be helpful.

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#### **C. Specimen Comparison**

Specimen comparison is the process of taking a field-collected plant and comparing it to known, identified, and verified plants. Where do you find a collection of these type of plants? These collections of plants are found in natural history collections called **herbaria**. An herbarium is a massive warehouse of plant biodiversity. In large herbaria such as the U.S. National Herbarium at the Smithsonian, you will find examples of plants from all over the world. Small regional herbaria will house local plants from a specific region and plants from the taxonomic groups studied by researchers working in that collection. These plants can be used to help study plant variation, diversity, and evolution. Plants from herbaria have been integral parts of research on cancer drugs, virus transmission, invasive species, and climate change.

Plant specimens found in an herbarium have been meticulously collected, pressed to show key diagnostic morphological features, and mounted specially on archival quality paper. Properly cared for herbarium specimens last for hundreds of years. To provide some context, herbarium plant specimens are preserved from the Lewis and Clark expedition! Each herbarium plant specimen is accompanied by a descriptive label that includes information on the plant name (both Latin and common), the family the plant belongs to, the name of the person who first described the plant (authority), the location and date the specimen was collected, some information about the habitat where the plant was found, and the person who collected the plant. Often the specimen will also have **annotation labels**. Annotation labels are labels applied to the specimen after it has been included in the collection. These labels indicate another researcher has examined the specimen and verified or questioned the identity. You can image how a well-preserved herbarium specimen with lots of annotation labels is a very good resource on a plant’s identity!

Since literally millions of plant specimens can be housed in an herbarium, you cannot just start randomly searching through the specimens hoping to find your specific plant. First you have to narrow your search to family and genus. Sometimes you can narrow your search to a couple of species. Once you do this, you pull the specimens from where they have been carefully filled and examine them relative to the specimen you bring from the field. Careful examination, combined with taxonomic keys, written descriptions, and image comparison are critical in plant identification.

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#### **D. Image Comparison**

Image comparisons can be one of the quick and dirty ways to determine a plant identification. Images published in floras, monographs, and scientific journals have varying degrees of use. A good picture, taken in the field and properly identified cannot be underestimated in its utility. Often these images at least help you get to family or genus. The idea of, “it looks a lot like this,” can actually help significantly narrow the list of possibilities. Let’s be honest, even established experts in plant identification have been known to flip through a book and see if the images help. The problem exists in the details. Often species are differentiated based on cryptic characters that cannot be verified in an image. This can mislead the identifier into thinking “Eureka, I’ve found it!” when in fact you have missed out on some key defining characters. This has somewhat been alleviated by high resolution imaging of verified herbarium specimens, however, resolution is still limiting, and the inability to dissect an image can be a problem.

Images can come in many forms: pictures in a field guide, scientific drawings of precise scale and detail, and online images – both professional and unverified. Images of herbarium specimens are even available now! While online images are becoming widely available and field guides can be locality specific and very helpful – the user is still limited by the sampling and can often only find images for a subset of possibilities. In addition, images may lack the detail to differentiate close **congeners** (members of the same genus). Also, online resources are not always verified, and web pages are not static, making them potentially unreliable sources.

Any match using an image should be verified with technical description, herbarium specimens, digital keys, and/or expert determination.

#### **E. Expert Determination**

Ah! This is the best mode of identification. Find the expert in your plant of interest and just ask him/her. Wow, this is a lot easier than figuring it out yourself and surely the “expert” has the answer. However, this resource is not always so easy to locate and “experts” can be busy people too.

An expert can be useful in lots of ways. Often “experts” are people knowledgeable of a particular flora (plants of Michigan, wetland plants) or group of plants (sedges, orchids). There are experts in really large groups (all grasses) or very specific groups (*Cantua*, a small genus of ten species in Central and South America). Plant identification experts can be ecologists, taxonomists, avid natural history buffs, agricultural extension officers, and more.

So how do you find an expert? Experts are often found at universities and colleges, many times associated with herbaria. They can also be found at state and federal agencies associated with conservation and natural resources. You can also learn a lot from plant enthusiasts associated with your state or regional botanical clubs. Citizen scientists and well-informed amateur botanists are great resources!

What is the criterion for determining an expert? Does an expert have to have a Ph.D.? Not necessarily. Experts come in all shapes, sizes and degrees and…self-professed experts are not always right! So even though an “expert” can be really helpful, you are the one who has to be sure the identification is correct. So always verify an identification using the methods previously described: taxonomic keys, written descriptions, image comparison, and specimen comparison.

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#### **VI. COLLECTING SPECIMENS**

Plants need to be collected in a way that allows proper identification of the specimen. This means if possible, collect root, shoot, and leaf material along with flowers and fruit. For woody specimens, you need a representative stem cutting with leaves and flowers or fruit.

Some tips for collecting plants:

* Before you collect your specimen, photograph the plant *in situ*. Systematists use images to capture visual information that will be lost in a pressed specimens, such as color. For you, images are especially important because you must have them to upload your observation to iNaturalist. Make sure to **take multiple photographs to capture the identifying features of the plant**, e.g. leaves, flowers, roots, close-up, from a distance, etc. You will get better at this as you gain more experience collecting.
* You must collect all of your own samples. You cannot use samples collected by friends, family, or classmates.
* **Permits are required for collecting in city, county, state, and national parks and forests.** Permission is required for collecting on private land. Do not collect plants for this project from these areas unless you have the appropriate permissions and associated paperwork.
* **Do not collect from a plant that is obviously unhealthy**. Nor should you collect a branch that will have a negative impact on the plant or the immediate environment. If collecting along a trail, or otherwise highly traveled area, collect on the side of the plant away from the trail to limit aesthetic impacts. **DO NOT collect specimens from very small populations** (1 to only a few individual plants). A good general rule is to never collect more than either 5% of a population of annual plants or 5% of reproductive structures on any single shrub or tree, and do not collect at all unless you see at least 20 plants.
* For **woody specimens**, always use pruning shears or a sharp knife to cut your samples. This will limit damage to the plant’s branches and improve the quality of your specimen.
* Remember that **sun vs. shade leaves** may exhibit different morphological characteristics, so be sure that your specimen reflects variation exhibited in your plant.
* Collected **specimens can be kept temporarily in a plastic bag**. Keep the bag closed and specimens moist and out of the sun to avoid premature wilting. Specimens will remain fresh in a closed bag for several hours. Refrigerated bags of specimens may keep for 1-2 days before pressing.
* If **collecting at multiple localities during one collecting trip**, 1) place each group of specimens (that correspond to one locality) in separate plastic bags, 2) label each bag with a brief locality description to help you match each bag to your notebook entry when you go to press your specimens, and 3) make separate notebook entries for each collection location in your field notebook.
* If **more than one specimen is collected at a single locality on the same date**, the data for geographic locality, date of collection, and habitat/ecological conditions for these specimens can be recorded once in your field notebook, since these data are the same for each specimen. The collector numbers and descriptions of each individual specimen should immediately follow the collecting event information in your notebook.

#### **VII. PRESSING SPECIMENS**

When the plant is pressed for preservation, it needs to be laid out to dry in a way that fits an herbarium sheet and allows full examination of reproductive and vegetative characteristics.

Some tips for pressing and drying your plants:

* Specimens should be pressed and dried **within 24-48 hours of collection** to prevent both wilting and mold. Ideally, press specimens as soon as possible after collecting.
* Press specimens in the **plant press you check out in lab**, which is composed of 2 external wooden frames, corrugated cardboard stiffeners, blotter sheets (to absorb moisture), newspaper (to hold specimens), and straps to hold the press together tightly.
* Each specimen should be **pressed in a sheet of newspaper that is labeled** with the collector’s name and collector number assigned to the specimen in your field notebook. Write this information on the outside of the newspaper so that it can be read without disturbing the specimen! Newspaper may need to be trimmed to the appropriate size before using.
* Each specimen should be **arranged as naturally as possible** in the press. Strive to clearly illustrate the diagnostic features of the specimen. Avoid excessive overlapping of plant parts. This may require selective trimming of your specimen, such as trimming leaves or splitting stems. If you must trim leaves to increase visibility of other parts of the plant, leave the petiole so that an observer will know that a leaf was once there.
* **Large specimens that do not fit** in the press need to be folded so that all parts of the plant fit in the press. Do this by slightly breaking the stem and arranging the plant in a “V”, “N”, or “W” shape depending on the length of the specimen. Any parts of a specimen that protrude from the press will not be adequately preserved. Remember, once dry these will be glued to archival paper, the specimen needs to fit the paper and still leave room for the label, accessions number, herbarium stamp, etc.
* Try to **arrange leaves so that both surfaces are visible**. Large leaves can be folded to show both sides. Inflorescences and flowers often need to be spread out to reveal important parts. Consider pressing **some flowers open, some closed, and some split** to show internal structures.
* **Bulky parts**, such as roots or bulbs, can be split longitudinally in order to fit in the press.
* **Nothing (plant material or newspaper) should be sticking out past the edges of the wooden frame of the plant press.**
* Once placed in a press, specimens should be placed on edge in the **plant-drying oven**. Press straps may need to be tightened as the specimens shrink from evaporation. Plants typically dry in 1-4 days depending on the type of plant.

**VIII. MAKING OBSERVATIONS ON INATURALIST**

You will be digitally recording your collecting information on [iNaturalist](http://inaturalist.org/), an online social network of biodiversity enthusiasts sharing observations of and learning about nature. iNaturalist also functions as a crowdsourced species identification system, and an organism occurrence recording tool. **You will enter the data from each of your plant collections as an iNaturalist observation, along with photographs of the plant that you take prior to collecting it**. You and your classmates will contribute these observations to a course-specific project of themed iNaturalist observations, but they will also be publicly available for anyone to see. In addition, high-quality iNaturalist observations are published automatically to the [Global Biodiversity Information Facility](http://gbif.org/) (GBIF)[[7]](#footnote-6), which distributes your data to scientists, policymakers, land managers, and any other people who might be interested.

Entering your collection data on iNaturalist not only ensures that your occurrence data are contributed to an international biodiversity data hub, but also provides you with the opportunity to get plant identification opinions and confirmations from a wide network of other iNaturalist users. Many iNaturalist users are avid **citizen scientists** (people with an interest in science but no formal training or professional position), and more and more experts are also engaging in the iNaturalist community. Posting your collection data as an iNaturalist observation can help connect you to experts for help with determination, as mentioned above in [Specimen Identification: Expert Determination](#mdsdzzjw9m6e). Likewise, though you may not be an expert yet, you may find that you recognize and can help identify certain species for other iNaturalist users. You will practice doing this for your classmates as part of the assignment.

Please see the Student’s Guide to Using iNaturalist (Appendix E) for detailed instructions on using this tool. As you begin your collections, keep in mind that for **each specimen** you will do the following in iNaturalist:

* Photograph the plant *in situ* before collecting it. Make sure to **take multiple photographs to capture the identifying features of the plant**, e.g. leaves, flowers, roots, close-up, from a distance, etc. You will get better at this as you gain more experience collecting.
* Create an iNaturalist observation for your specimen as soon as you have **identified it to species**. Upload your photos and record your collection information as described in the Student’s Guide and Field Notebook to iNaturalist Guide (see below).
* Make sure that your observations are confirmed by at least one other iNaturalist user so that they can become “research grade” and published to GBIF.

See Appendix E—Student's Guide to Using iNaturalist.

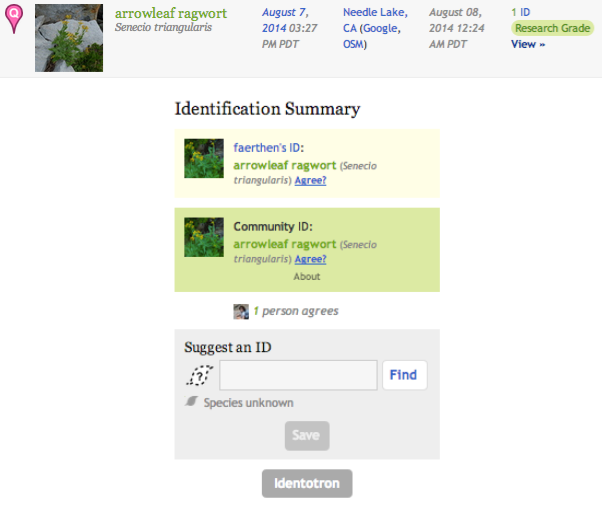
See Appendix F—Field Notebook to iNaturalist Guide.

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#### **IX. COMMENTING ON INATURALIST**

Commenting and adding identifications to your classmates’ observations is an important aspect of this class. Add an identification either to confirm your classmate’s identification, or to suggest a different one. Add a comment if you have questions about the identification or observation, or to share helpful identifying features, e.g. “I believe this is XYZ species because the leaves are tomentose, versus ABC species, which has glabrous leaves.”

1. To add an identification, first find one of your classmate’s observations that you are interested in. You can find a list of observations below the map on the project homepage. In the image here, notice that this observation of *Senecio triangularis* has been marked as “Research Grade” (two or more identical IDs); try to add identifications to observations that have not yet become research grade.
2. Click on the observation you want to ID, and you will see a box called “Identification Summary” on the right side of the observation page. This is also shown in the image below. You have two options: either “Agree” with someone else’s ID, or “Suggest an ID” below if you believe the plant has been misidentified.
3. You can add a comment at the bottom of the observation page.

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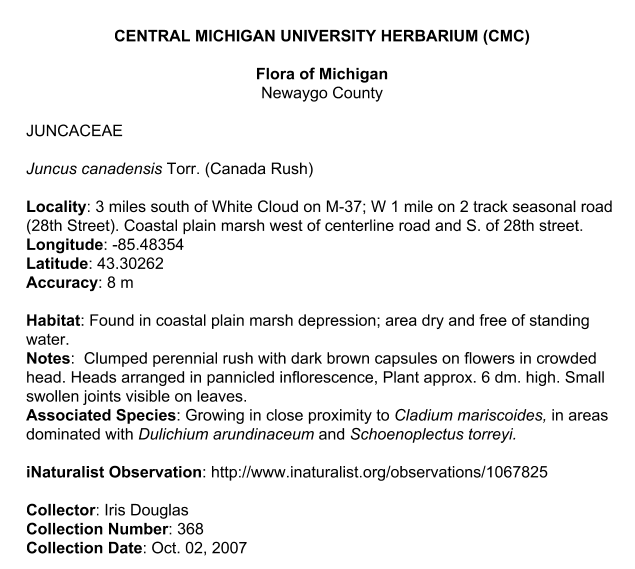
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#### **X. GENERATING SPECIMEN LABELS**

After a plant is recorded on iNaturalist, given a collection number, pressed and preserved, and properly identified, a specimen label needs to be created. Your instructor will be using the observation data you enter into the class iNaturalist project to create specimen labels, either via mail merge or through [Symbiota](http://symbiota.org/). Symbiota is a collection of web-based tools that facilitate the use of biological collections data. For herbaria, Symbiota offers a collections database application that is tied both to a taxonomic database (meaning name changes can be automatically updated), and to other herbaria databases through themed portals, such as the [North American Network of Small Herbaria](http://nansh.org)[[8]](#footnote-7). Just like iNaturalist observation data are published to GBIF so that researchers have one entry point to access multitudes of data, Symbiota aggregates collections-based data for similarly convenient access. In addition, Symbiota provides tools for herbaria to easily create vouchered flora checklists, print specimen labels, digitally annotate specimens, and generate custom polyclave keys.

Regardless of how specimen labels are generated, they should always be printed on archival paper and include everything you recorded in your collection notes that can help inform about the plant. This includes all information recorded in your iNaturalist observation, i.e plant identification, family, date, collector and collection number, exact coordinates of collected plant, plant locality, habitat, and distinguishing plant characteristics. Once printed, these labels need to be reconciled with the collected plant specimens. Never rely on your field notebook or iNaturalist entries staying connected to your specimens!

Your instructor will print labels (like the example below) for you once you provide the necessary specimen data in iNaturalist; you must include a label with each of your dried specimens.



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#### **XI. REFERENCE THIS PROJECT ON YOUR RESUME**

As an undergraduate, your coursework is a valuable measure for future employers. Citing this project on your resume allows prospective jobs to see specific skills and knowledge you possess. To cite this project (or any other academic coursework), you should include the name of the course, the title of the project, and a succinct list of skills or knowledge gained from this project. Make sure to include this information in a section of your resume clearly marked as "education" or "academic experience," so that you do not mislead employers into thinking you performed these duties on the job. For the list of skills and knowledge, feel free to get ideas from the project’s [Learning Objectives](#shhd8ucjazf4). We also recommend tailoring the skills and knowledge you include based on the job you are applying for. For example, a student applying for a botany field technician position may create a resume including the following:

***ACADEMIC EXPERIENCE***

***Systematic Botany (BIO 211)****: Connecting Students to Citizen Science and Curated Collections (collectionseducation.org)*

* *Collected and preserved plant specimens from ten families found in central Michigan wetlands.*
* *Identified specimens using multiple methods of reliable evidence, including traditional tools such as keys and specimen comparison, as well as digital age citizen science tools.*
* *Discussed the importance of large datasets, such as those generated from herbaria and citizen science, to science.*

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#### **XII. SUPPLEMENTARY MATERIALS**

Your instructor may direct you to resources available on this page for supplementary lessons to this *Connecting Students to Citizen Science and Curated Collections* project.

AIM-UP Module: [Plant Range and Distribution in Alaska](http://www.aim-up.org/educational-modules/plant-range-and-distribution-in-alaska)[[9]](#footnote-8)

AIM-UP Module: [Stomatal Density and Climate Change](http://www.aim-up.org/educational-modules/stomatal-density-climate-change)[[10]](#footnote-9)

BLUE Module: [The Evolution (and Coevolution) of Flowering Plants](https://qubeshub.org/qubesresources/publications/277/1)[[11]](#footnote-10)

BLUE Module: [The Effect of Climate Change on Butterfly Phenology](https://qubeshub.org/qubesresources/publications/469/1)[[12]](#footnote-11)

[Exploring Data with BISON](https://qubeshub.org/qubesresources/publications/1102/1)[[13]](#footnote-12)

Dickinson *et al.* [article](http://onlinelibrary.wiley.com/doi/10.1890/110236/full) (2012) on the current state of citizen science[[14]](#footnote-13)

Ferro & Flick [article](http://www.bioone.org/doi/abs/10.1649/0010-065X-69.3.415) (2015) on collection bias[[15]](#footnote-14)

**XIII. LITERATURE CITED**

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1. http://inaturalist.org [↑](#footnote-ref-0)
2. http://symbiota.org [↑](#footnote-ref-1)
3. http://michiganflora.net/family-key.aspx#key-a [↑](#footnote-ref-2)
4. http://ucjeps.berkeley.edu/IJM\_fam\_key.html [↑](#footnote-ref-3)
5. http://nansh.org/portal/checklists/dynamicmap.php?interface=key [↑](#footnote-ref-4)
6. http://www.inaturalist.org/guides/1104 [↑](#footnote-ref-5)
7. http://gbif.org/ [↑](#footnote-ref-6)
8. http://nansh.org [↑](#footnote-ref-7)
9. http://www.aim-up.org/educational-modules/plant-range-and-distribution-in-alaska [↑](#footnote-ref-8)
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15. http://www.bioone.org/doi/abs/10.1649/0010-065X-69.3.415 [↑](#footnote-ref-14)