User Guide - Overview

MORPHOBANK

HOMOLOGY OF PHENOTYPES OVER THE WEB &

A database of peer-reviewed morphological matrices

- 1. What is MorphoBank?
  - 1.1. Advantages of MorphoBank over desktop phylogenetics software
  - 1.2. Why use MorphoBank?
  - 1.3. Peer-review Policy
- 2. Common Types of Projects
  - 2.1. Phylogenetic Projects with Matrices
  - 2.2. Image-only Projects
  - 2.3. Collaborations Fusing Large Lists of Characters and Taxa from Many Matrices
- 3. Basic Concepts
  - 3.1. The "Project" Workspace
    - 3.1.1. Creating a project
    - 3.1.2. Project summary information
  - 3.2. Types of Data You Can Deposit
    - 3.2.1. Taxonomic names
    - 3.2.2. Specimens
    - 3.2.3. Media
    - 3.2.4. Matrices
    - 3.2.5. Characters
    - 3.2.6. Other data
  - 3.3. Folios
  - 3.4. Tools for Collaboration
    - 3.4.1. Membership
    - 3.4.2. Reviewer Access
    - 3.4.3. Managing access to data
    - 3.4.4. Tracking changes to your data
  - 3.5. Publishing
    - 3.5.1. Copyright considerations
    - 3.5.2. Selectively publishing project content
    - 3.5.3. Citing and Accessing your MorphoBank-hosted Project and Data
      - 3.5.3.1. Linking to a published project using permalinks
      - 3.5.3.2. Linking to a published project using a DOI
      - 3.5.3.3. Other ways to access published data
    - 3.5.4. Deleting a Project
- 4. Navigation
- 5. How to Get Access
  - 5.1. Resetting the Password for an Existing Account
  - 5.2. Duration of login
- 6. Funding for MorphoBank
- 7. Citing MorphoBank in your publications
- 8. MorphoBank API
- 9. References

1. What is MorphoBank?

MorphoBank is a web application with tools and archives for evolutionary research in phylogenetics, specifically systematics and cladistics (the science of determining the evolutionary relationships among species). Study of phenotypes, which is often visually-based, is central to contemporary systematics and taxonomic research. MorphoBank was developed specifically to provide much needed tools for the expansion and modernization of phylogenetic work on phenotypes for scientists who are collecting phenotypic (often called "morphological") data to build phylogenetic trees. MorphoBank provides four interrelated toolsets for researchers who are archiving their data associated with peer-reviewed publications:

- **a tool for management of uploaded 2D and 3D images** and the affiliation of data with those images (anatomical labels, species names, etc.)
- **an online matrix tool for editing and viewing**. This tool allows researchers to develop (or simply deposit) a morphological matrix in an online database such that they can collaborate with others on this matrix with other in real time (much like the way they would use Google Docs for manuscripts), they can affiliate images and notes with the cells in this matrix to document their homology statements, and they can share this matrix as a public archive of their work after publication.
- **tools for managing the taxonomic names, characters and states, specimens and views** used to classify images and populate phylogenetic matrices.
- **administrative tools** for managing access, publishing and backing up your data.

MorphoBank is project-centered, meaning teams of researchers create their own project-specific workspaces and share images and other data with each other during the research phase of their work. They do this in a password-protected environment. Because MorphoBank is web-based, team members can easily and efficiently work together no matter where they are located, as long as they can access the World Wide Web. Furthermore, MorphoBank's Web-centric foundations make it a natural tool for online publishing of project data once a paper associated with the project goes to press in a peer-reviewed scientific journal. In other words, scientists are archiving their data while they do their work, which is considered a scientific best practice.

The phylogenetic matrix capabilities of MorphoBank are designed to aid systematists working alone or in teams to build large phylogenetic trees using morphology (anatomy, histology, neurology, or any aspect of the phenotype). In contemporary systematic methods in which morphology is used to build trees of species (or higher taxa), one starts by constructing a matrix made of characters and taxa (which looks like a spreadsheet). Characters are features of an organism that appear in different forms (you can learn more here). For example, the character "eye color" might have the character states "blue," "green" or "brown" and the character "wings," might have the states "present" or "absent". To convert these biological observations to a form that fits in a matrix, one might translate these as "eyes: state 0 (blue), state 1 (green), state 2 (brown)." Traditionally this has been done with desktop programs such as MacCladee[1] or Mesquite[2], which encode this information in files adhering to a standard format such as TNT or NEXUS formats and run in desktop programs.

Desktop software cannot accommodate images associated with character states or matrix cells in a robust fashion, something that is becoming essential for researchers actively studying the phenotype and for later researchers trying to understand the anatomical basis of some comparisons that might have been made decades ago. Desktop programs also do not permit collaboration on a single matrix in real time. MorphoBank allows researchers to upload and download their NEXUS or TNT files, and to edit them collaboratively in the MorphoBank online workspace. MorphoBank also allows researchers to upload high-quality images affiliated with each cell in a matrix, to zoom in on these images for details, to collaboratively label the images and to affiliate various kinds of metadata with an image (e.g., species, specimen number, notes, etc.).

Data in MorphoBank have been deposited by professional scientists and the students supervised in their laboratories. Once a MorphoBank project is published on-line these data are freely accessible to the public.

1.1. Advantages of MorphoBank over desktop phylogenetics software

Previous generations of desktop systematics software - MacClade[1] in the 1990's and Mesquite[2], NEXUS Data Editor[3], etc. in this decade - were a boon to the community, greatly enhancing researcher productivity. However, subsequent to the development of these programs, with the explosive growth of the World Wide Web and the increasing sophistication of web browser software, a new category of software has emerged, the web application. Web applications leverage existing web-based data services (mapping, taxonomic lookups, and access to specimen and bibliographic databases, for example) and enhanced user interface techniques to produce software that combines many of the best features of desktop software with the ever increasing capabilities of the Internet.

MorphoBank was designed to address shortcomings in existing desktop systematics software using modern web-application techniques. Areas of enhancement included:

1. Seeing the images that document the basis for a character state is enormously helpful to researchers both during and after the research process. This is particularly important if a phylogenetic matrix is large, with hundreds of taxa and thousands of characters. Before MorphoBank there was little support for inclusion of imagery in phylogenetics software. A researcher would have had to trust their memory as they made comparisons among hundreds or thousands of species. It is much more effective to store an image of a character with labels to refer to repeatedly while adding new data.
2. A large quantity of documentary information - and the majority of visual documentation - was being lost when morphologists published phylogenetic trees. No archive existed for morphologists to store matrices and the images that backed up their character designations. This was wasteful and incurred a lot of repeated work due to lost information. Moreover, it is now a scientific best practice, and an expectation of many funding agencies, that researchers store digitally all of the data associated with peer-reviewed research so that all results may be verified.
3. Single-user file-based systems (i.e., the old fashioned files use on desktop programs) are wholly unsuitable for collaborative work, whether team members are dispersed across the hall or across the globe. For all but the smallest and most disciplined of teams, problems of file version control and conflicts quickly become untenable as copies of files proliferate with no one certain as to what the "real" dataset is. MorphoBank provides a central database for project data, ensuring that all team members are using the same dataset at all times. Changes made by one member are instantly visible to the rest of the team. Furthermore, all changes are logged making it possible to determine how any element of a project's dataset arrived in its current state.
4. Many valuable phylogenetic datasets are available on the Internet only in truncated form (typically lacking characters and states associated with numerical scores, and very often lacking images supporting homology) or not at all, in part because before MorphoBank there had been no simple mechanism with which to publish data to the Web from most desktop applications. TreeBASE has been a useful site for archiving matrices but is not a tool-based application for collaborating on and viewing phylogenetic matrices and does not store images. MorphoBank is inherently web-based, and publishing of project data is a matter of pushing a button.

1.2. Why use MorphoBank?

Here is a hypothetical case: you are working on a morphological phylogenetic matrix with a team of investigators. Because MorphoBank is a web application, your team can work on exactly the same data *at the same time*. All collaborators can see contributions from members of the team, including images associated with homology statements, as soon as they are made. Since everyone is always using the most up-to-date data, e-mailing of files and reconciliation of file versions is completely unnecessary.

All project information is kept private to the team, protected by password, until the team chooses to make it public. Moreover, in conjunction with a peer-reviewed scientific paper, an editor may ask you to allow reviewers to access your data. MorphoBank provides the ability to allow anonymous, password protected, reviewer access to your data.

When a paper is in press in a journal, that's often the time an investigator wishes realizes that data need to be archived and MorphoBank welcomes data at that late time in the research process. However, if the data have been archived during research process and the researcher has placed their morphological matrix (including any labeled images of your homology statements), additional images, lists of specimens and taxa, etc. in MorphoBank already, it is simply a question of pushing a button to release that information to the public. Additionally, journals cannot always publish all the digital images that support the research in a publication. MorphoBank can house many hundreds or thousands of images and serve them such that they are easy to view. Highlights include:

- Publishing of project data via a simple online form
- Ability to hold back publication of project data on a per-item basis
- Automatic conversion of images to web-viewable formats
- Pan and zoom feature for viewing and annotation of high-resolution imagery
- Online viewing of matrix data using a full-featured web-matrix software interface
- Virtually unlimited number of images and matrices
- Support for persistent URLs for MorphoBank-hosted data resources

Note that you do not need to be working with a matrix to be a content builder at MorphoBank. Many investigators have other scientific reasons to store media (with repository and specimen number) online as part of an upcoming publication. MorphoBank welcomes these contributions.

1.3. Peer-review Policy

MorphoBank permits the posting of peer-reviewed scientific research. Exceptions may be made (generally labeled "MorphoBank Exclusives") at the discretion of the Executive Committee. These studies have typically been conducted by students under the supervision of research scientists supported by federal funding for science. Pilot programs also exist for the use of MorphoBank for educational and popular initiatives. Those interested should contact Morphobank administrators.

2. Common Types of Projects

MorphoBank provides a generally useful set of tools to assist you with your research. While no particular workflow is mandated, many MorphoBank projects tend to fall into one of the three categories, described in the following sections. Your work need not conform to these examples, but they should give you an idea of the types of project for which MorphoBank can be useful.

2.1. Phylogenetic Projects with Matrices

MorphoBank's most important innovation is the support of collaborative editing of phylogenetic matrices and associated data (taxa, characters and states, cells with or without images, bibliographic citations), thus it includes a full-featured browser-based matrix viewing and editing application. This, combined with its ability to integrate annotated media with matrix cells, characters and character states make MorphoBank a natural fit for projects developing matrices.

MorphoBank is able to import and consolidate existing matrices contained in NEXUS files. This means you can take existing datasets created in MacClade, Mesquite, NEXUS Data Editor, or any other NEXUS-capable application and bring them into MorphoBank for collaborative editing, addition of media and, ultimately, online publishing.

MorphoBank can also output matrices in NEXUS, allowing MorphoBank to be integrated into an analytical workflow that includes NEXUS consuming programs such as PAUP.

2.2. Image-only Projects

While its matrix tools are a major asset, you don't need to be developing matrices to use MorphoBank. MorphoBank also provides a robust set of tools to view, annotate and classify (taxonomically and otherwise) large sets of images.

A `Batch Media Upload` tool allows you to upload large numbers of images for streamlined tagging with metadata. Many file formats are supported, including most popular image and video formats, and all files are automatically converted into web-viewable formats and sized appropriately. A media browser allows you to filter by taxonomic name and/or view, or to search for specific items. And MorphoBank's built-in pan-and-zoom viewer allows users to view high-resolution images online efficiently by preserving the full resolution of the uploaded file and only downloading the portions of an image that are actually visible on screen.

Its media handling features, its support for collaborative workgroups and web-based nature make MorphoBank an ideal platform for:

- sharing images with your colleagues in a password-protected environment
- developing an image-based dataset with colleagues
- publishing media online in support of a manuscript

2.3. Collaborations Fusing Large Lists of Characters and Taxa from Many Matrices

For projects merging many source matrices into one large matrix where there may be a subsequent need to evaluate, merge or edit extensive lists of characters and taxa by consensus, MorphoBank's taxonomic and character directories can provide useful services.

In a typical super-matrix project, a group of experts convene to survey existing literature for characters and, perhaps, taxa to be included in a single "super-matrix" covering all significant aspects of area of taxonomy. MorphoBank's central character list provides a tool for managing large lists of characters, annotating them with notes, reordering them as necessary, and attaching exemplar images to characters and specific character states.

It is particularly critical in projects of this type that all participants have access to the most up to date data at all times. MorphoBank's centralized database and web-based access ensures that this is always the case.

3. Basic Concepts

This section covers the **basics** of working in MorphoBank. For more details of all the functionalities, please refer to our User Guide - Project Creation and Management.

3.1. The "Project" Workspace

Workspaces on MorphoBank exist as separate "projects," completely independent from all projects and accessible only to the creator of the workspace and those to whom the creator has explicitly granted access. As we shall see, a workspace contains all of your project data - taxa, characters and states, specimens, bibliographic references, media (typically images, but also video and sounds), folios, documents and matrices. These data are completely private to the workspace and cannot be modified or, prior to publication, accessed by those outside of the project.

You are free to develop your dataset in any way you choose. While use of character ontologies, taxonomic authorities and specimen databases is in general good practice and highly encouraged, MorphoBank does not mandate their use. How you conduct your research in your workspace is entirely up to you. You can see published projects on our Browse Projects page.

3.1.1. Creating a project

You can create as many projects as you need; in general you should create a project for each discrete research problem or paper you are working on. Remember that workspaces are completely independent from one another and do not interact in any way. There is no sharing of data between project workspaces, and each workspace is only accessible to those to whom you explicitly grant access. If you have multiple workspaces with identical member lists and/or need of shared data, then you should consider consolidating them into a single project workspace.

We all stand on the shoulders of giants, and reuse of published data on MorphoBank is an important part of how science advances. To this end MorphoBank encourages investigators to download and reuse/modify/expand or duplicate and reuse/modify/expand the results of prior investigators (which, of course, should be cited as is standard scientific practice).

If you find that you need to create many small matrices that could be considered subsets of a large matrix, we recommend that you create a single large matrix and use the partition feature to create subsets of characters or taxa from that matrix.

To create a new project, login to MorphoBank and navigate to the My Projects section. You will see an orange "Create New Project" button at the top of the page.



Figure 3.1. Selecting the new project option.

This will display a `Project Info` form, which includes fields for project title and abstract, publication information and settings for allowing anonymous reviewer access to your data. To start you need only to specify a title, you can fill in other details such as the journal name and the paper's abstract as your work advances towards publication. You may edit this information at any time, many users provide provisional information at the start. For publications with an active DOI, you can enter the DOI into the Article DOI box and click on Retrieve and all bibliographic information except for the Abstract will be automatically populated.

3.1.2. Project summary information

It is important that as much of the information below as possible about a project be provided *before* the project is published. Note that Publication differs from project creation. When creating a MorphoBank project, the information below may not be known but it should be added by the time the project is published. The `project information` form contains fields for the following information that is used to display a summary of your project in the `Browse Projects` section of the site and on the `Project Overview` page:

- *Title*. The title of your project, not necessarily the same as your article's title but it can be.
- *Abstract*. The abstract for your project from your peer-reviewed publication.
- *Exemplar Media*. The media file you would like to feature in your project summary (MorphoBank will choose one by default if one is not selected).
- *Journal title*. Title of the peer-reviewed publication supported by the data package you are publishing on MorphoBank.
- *Journal url*. Address of your published article online.
- *Journal volume*. The journal volume in which your article appears.
- *Journal number*. The journal number in which your article appears.
- *Journal year*. The year of the journal in which your article appears.
- *Journal logo image*. For journals already appearing in MorphoBank, a journal logo will automatically appear when the journal title is selected. If you are entering a new journal in MorphoBank, curators will add a journal logo at the time of project publication. Feel free to contact support to ask for the journal logo to be added to MorphoBank.
- *Article authors.* The list of article authors.
- *Article title*. The article title as it appears in the citation.
- *Article pagination*. The article pagination as it appears in the citation.

Many of these fields are used on the project summary page when the project is published. MorphoBank understands that articles, and their associated MorphoBank data packages, are sometimes released early and information such as page numbers may not yet be known. Such projects can be published, please notify us via the "Ask Us" link on the home page and our curators will update your citation.

3.2. Types of Data You Can Deposit

Once your project workspace is established you and your collaborators can deposit various types of data to share amongst project members, edit collaboratively, or use in phylogenetic matrices. MorphoBank can accept the following kinds of data:

3.2.1. Taxonomic names

Your project workspace has a single list ("directory" in computer lingo) of taxonomic names. These names can be species or different taxonomic ranks (or unranked) - that is up to you and your research vision. These names become available to add as the terminal taxa (or rows) in your matrix. You may load your taxa by hand, one at a time, using the taxon entry forms or in a batch process using our interface or a tab-delimited file from Microsoft Excel or a similar application. Learn more about Managing Taxonomy.



Figure 3.2. Ways to add taxa in MorphoBank.

Once loaded you can validate the taxonomy against the Paleobiology Database. MorphoBank will use APIs to search the Paleobiology Database for higher ranks associated with your taxon and can import those ranks to your project. It will allow MorphoBank and PBDB to cross-link from one resource to the other.

Taxon names are also automatically checked against the NCBI Taxon hierarchy so that one can browse MorphoBank by taxonomy. The taxonomic hierarchy is generated by matching Taxa in MorphoBank to the NCBI taxonomic database through the Global Names Architecture, which collects names of living and extinct species. The Taxonomy Browser is updated nightly to reflect new data in MorphoBank and updates to taxonomic authorities. We understand that no taxonomic authority is perfect and that taxonomy is always being revised - this browser is simply a tool to facilitate data access within MorphoBank.

Each distinct taxon is represented once, and only once, in your taxonomic directory. When you use a taxon to identify specimens and in matrices, you are doing more than just tagging those items with a taxonomic name. You are actually linking your specimens and matrices to a taxonomic *concept*. If you subsequently change the taxon, your changes will automatically propagate to all of the specimens and matrices that reference the taxon.

3.2.2. Specimens

As with taxa, your workspace has a directory of specimens that are referenced in your project. Specimens can (and should) be associated with a taxonomic identification. They may also be depicted using uploaded media.

There are two types of specimens: vouchered and unvouchered.

Vouchered specimens are specimens that are numbered and catalogued, and that are typically part of a formal collection in an institution (i.e., a museum, a university). For vouchered specimens you must at a minimum provide an institution code and catalog number for each specimen. Both of these values should conform to the standards of the institution from which the specimen originates. If you are not sure of the formats for these values, contact the institution's collections manager. Typically, the institution code will be a 2-4 letter abbreviation of the institutional name (e.g., AMNH = American Museum of Natural History, YPM = Yale Peabody Museum). Whenever possible a collection code should be provided. As with the institutional code and catalog number, this should conform to institutional standards. Many, but not all, institutions use collection codes.

Unvouchered specimens are those obtained from sources other than formal collections, including literature and the Internet. You are encouraged to provide detailed notes about the origins of the specimen in the "notes" field. You can also attach a formal bibliographic citation to a specimen.

A taxonomic identification of the specimen should be provided for all specimens. The identification is used by MorphoBank's matrix editor to retrieve relevant media, and by the search/filtering system to organize your media. Unidentified specimens will be much less useful than identified ones.

Morphobank media number
M129092

Taxonomic name
Rattus norvegicus

Specimen
Rattus norvegicus (AMNH/Mammalogy:70290)

View
skull dorsal

Media loaded by
Marcelo Weksler

Copyright holder
AToL mammal morphology

Copyright information
Person loading media owns copyright and grants permission for use of media on MorphoBank

Media loaded on
July 10 2008 at 17:26:55

This media record has been viewed 13 times



» Zoom » Download

Figure 3.3. A vouchered specimen

Morphobank media number
M140524

Taxonomic name
Homo sapiens

Specimen
Homo sapiens (unvouchered)

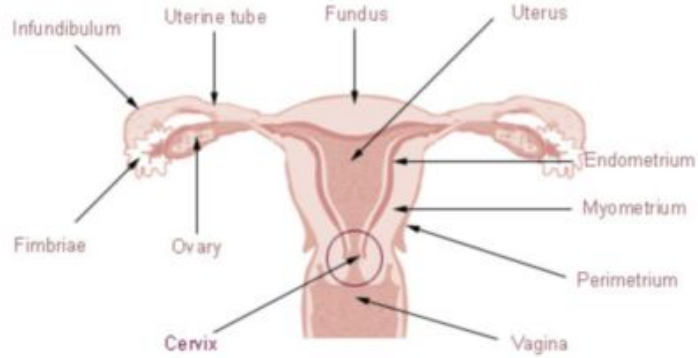
Media loaded by
Jonathan Bloch

Copyright information
Copyright expired or work otherwise in public domain

Web source of media
View media online »

Media loaded on
December 1 2008 at 15:13:34

This media record has been viewed 2 times



» Zoom » Download

Figure 3.4. An unvouchered specimen

3.2.3. Media

You can upload any number of media documenting specimens to MorphoBank. Most uploaded media are 2D or 3D images, although video formats are also supported. (Thus our use of the more neutral "media" terminology).

You will typically upload an image and tag it with a specimen identification, any pertinent copyright information and a view description (e.g., "skull, dorsal", "leaf, external", "cell wall").

Image Files: MorphoBank accepts a variety of image formats including JPEG, GIF, PNG, PLY, STL, ZIP, TIFF, DCM, and Photoshop. Note that Photoshop files that use layer effects may not render properly on MorphoBank. For consistent results we recommend converting these files to TIFF format before uploading. All image files should be in RGB mode. Files in CMYK mode and color manipulations may not render properly.

You should upload image files at the highest resolution that makes sense for your project. MorphoBank will automatically create sized versions for use on the site as well as a full-resolution version optimized for online viewing. The original uploaded file will be retained and can be made available for download.

Videos: MorphoBank also accepts the following video file formats: MPEG-4, QuickTime and WindowsMedia. The preferred video file format for upload to MorphoBank is MPEG-4. Files in QuickTime and WindowsMedia format will usually work so long as the compression method used is supported by MorphoBank's video processor. In general, videos compressed with WindowsMedia will work, as will most QuickTime compression methods (some very old and rarely used methods like GIF compression are the notable exceptions). AVI files usually will not work and should be converted to MPEG-4 prior to upload. In general if your uploaded file is being rejected by MorphoBank it is recommended that you try re-encoding the file in MPEG-4 format using one of the many video conversion tools available for Mac OS X, Windows and Linux.

PowerPoint: MorphoBank does not support the PowerPoint file format. If you need to upload images from a PowerPoint presentation, you should export them from PowerPoint in a supported format such as JPEG and then upload those files.

Media may be uploaded one file at a time using the "Add new media file" button. For large numbers of files, the `Batch Media Upload tool` may be more efficient. It is accessed with the "Add media batch" button and allows you to enter all the information on the standard media form for a group of media files that are uploaded as an archive in either Zip or Tar format. Learn more about the Batch Media Upload Tool.

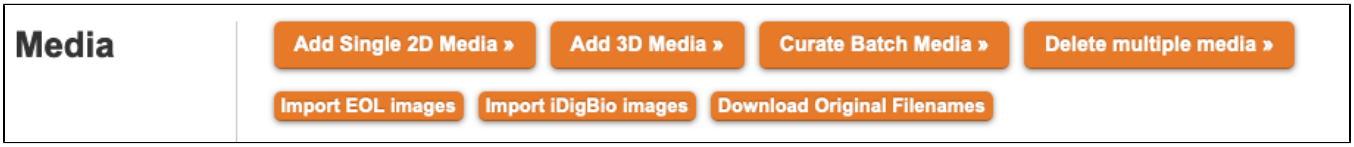


Figure 3.5. Add Media Buttons

> Audio files may be uploaded to MorphoBank in MP3, AAC, AIFF or WAV format in the Documents section. They are not supported as uploads to the Media section.

Morphobank also allows users to directly reference the Encyclopedia of Life (EOL.org) and Integrated Digitized Biocollections (iDigBio.org), to find and upload media for projects. Simply click the button that says: "Import EOL.org Media" or "Import iDigBio.org Media" from within the Media editor (or, alternatively, the Taxonomy editor), and select the Taxa for which you wish to search. A more complete description of this tool can be found here.

3.2.4. Matrices

Project members may create, edit and publish phylogenetic matrices using MorphoBank's matrix viewer/editor application. A matrix looks like a spreadsheet: its columns are composed of characters (see the section called “Characters”) and its rows are taxa (see the section called “Taxonomic names”). A "cell" is the box that represents the intersection of a row and a column. The cells of a matrix contain character states and, optionally, media (see the section called “Media”) with (also optionally) labels. Labels applied in a matrix cell are specific to that cell and automatically include text describing the cell's character state and taxon. Cells may also have attached bibliographic references, member comments and research notes.

You can start a matrix from scratch and populate it solely using the MorphoBank matrix editor, you can load an existing NEXUS or TNT format file as a starting point (including those downloaded from MorphoBank). Such files must include full character state labels or the import process will prompt review and editing of missing labels. Alternatively, you can duplicate an existing project matrix on MorphoBank and turn it into a new project. Regardless of how you begin, you can import the contents of additional NEXUS or TNT format matrix files (produced by desktop applications like MacClade or Mesquite) into your MorphoBank matrix at any time before project publication. All taxa and characters that do not already exist in your project will be automatically created when the file is imported. Importantly, note that states for existing taxa/character pairs that duplicate information already in your matrix will be merged with the existing data. It is important to look over your matrix carefully following the data import to be sure your intentions have been carried out.

In projects with multiple matrices, taxa, characters and media are shared across all matrices in your project. A change made to a taxon, character or media item in one matrix, or in the item-specific editing screens, will instantly be reflected in all matrices where the item is used. We strongly recommend a workflow that involves the creation of a single large matrix (sometimes called a supermatrix) from which you can designate any number of partitions or smaller matrices at any time to test parts of your dataset. This workflow tends to be less error-prone.

It is possible to download your matrix from MorphoBank as a NEXUS or TNT file at any time. The file will include all characters, taxa, cells and notes, but not images since they are not formally supported in the NEXUS or TNT format. Images can, however, be downloaded as a zipped folder to the desktop by clicking on the "Download Project" link on the `Project Overview` page. The archive will contain SDD XML format data files with associated matrix, character, taxon and specimen data. Note, however, that these images will not be viewable associated with cells in desktop programs reading the NEXUS or TNT file.

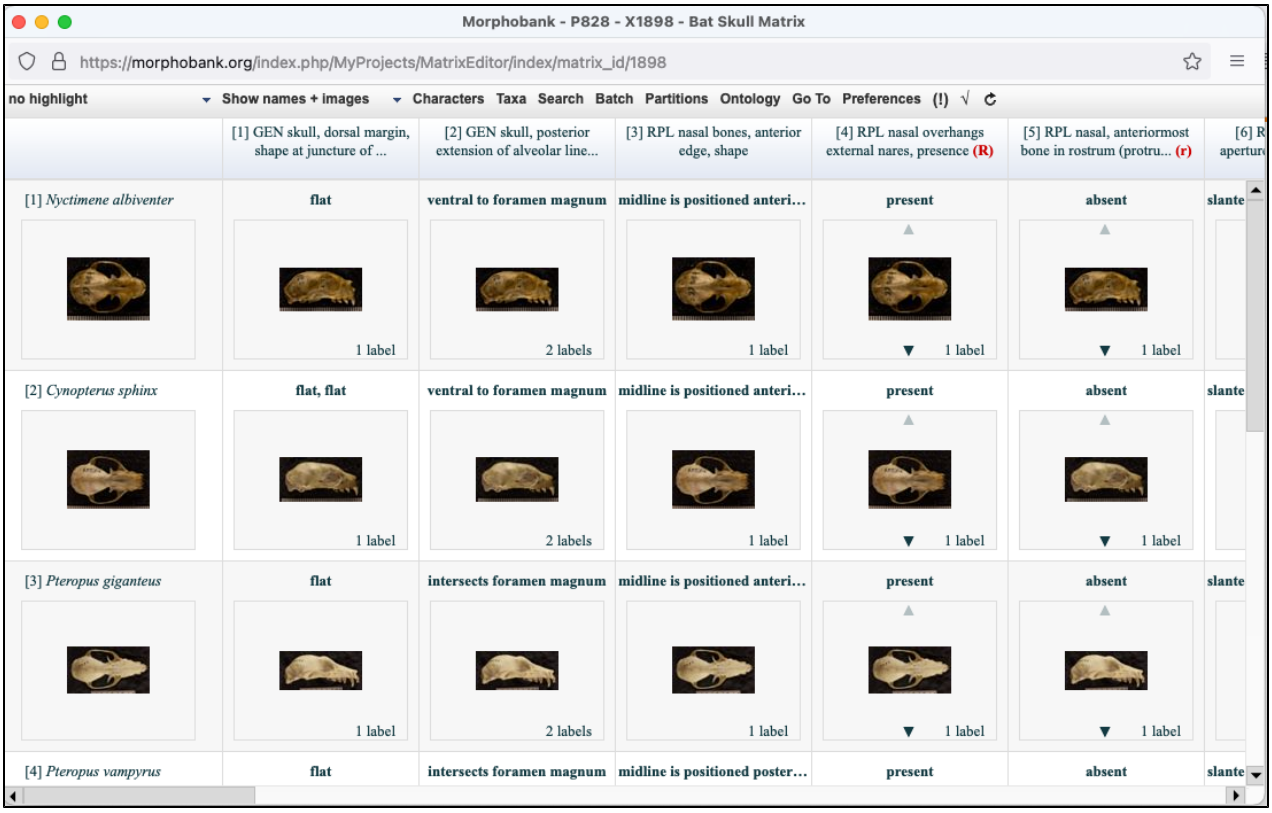


Figure 3.6. Matrix editor, which looks very similar to the matrix viewer.

3.2.5. Characters

As with taxa, your MorphoBank project has a single directory of characters and their associated states. Each distinct character is represented once, and only once, in your project's character list. When you use a character in a matrix, you are doing more than just bringing in the character's name. Rather, you are actually linking a characteristic *concept* to your matrix. Consequently, if the character is changed in one place, the change will propagate to all other places where the character is used. This way of working differs from working in desktop software.

Unlike taxa and other deposited data, characters cannot exist independently of matrices. That is, to exist in your project at least one matrix must reference the character. Put another way, if you delete a matrix all characters referenced only by that matrix will be removed as well.

Both discrete and continuous characters are supported in MorphoBank. **Discrete characters** describe a feature as a finite number of analytical *states*. Examples include "eyes: blue, green or brown" (a 3 state character) or "wings: present or absent" (a two state character). **Continuous characters** describe a feature or trait using a decimal quantity or pair of quantities defining a range. Because these quantities are decimals, they can represent any real value and are thus mathematically continuous. (Well, not quite: MorphoBank limits precision to 10 significant digits, but this should be more than enough for most analyses). Examples of continuous character values include "pH: 6.7" or "temperature range: 40.54C - 42.85C".

For discrete characters each state is assigned a name as well as a number, as well as any number of exemplar images. For example one might implement our previous example as "eyes: state 0 (blue), state 1 (green), state 2 (brown)." These numbers are used when scoring. For continuous characters a single specific quantity or a pair of quantities defining a range must be specified. The units for the quantity are specified in the character description. Each score is simply a decimal value, or pair of values defining the minimum and maximum of a range.

Characters may also have bibliographic citations and member comments attached. Images may also be associated with the character independent of a specific state.

3.2.6. Other data

Any number of documents can be added to a project. Documents may be in any format, and can document aspects of the project or provide data in formats that are not directly supported by MorphoBank (e.g., molecular datasets, morphometric datasets). Each document may include an optional title and description, and may be published along with other data (media, matrices, etc.) or kept private to the project.

When a project is published, all documents with a "publish when project is published" status will be listed and made available for download on the project's MorphoBank project page, accessible from the project browser and through the site `search`.

3.3. Folios

`Folios` are a useful mechanism for publishing annotated groupings of selected project media. Using the folios tab, you can create as many named folios as needed. You can then select specific media to add to your folios by clicking the "Edit folio media" link in your list of folios or by using the "Folio options" tool on the Media page. This tool allows you to add multiple media to a folio directly from media search results. Once you have added items to your folio you can return to the folios tab to change the order of the media and preview the resulting folio. Folios are published when the project is published, unless you set your folio's access drop-down to "never publish to project" and may be linked to using a `permalink` URL in the format: `https://morphobank.org/permalink/?F00` where 'F00' is your folio identifier. Folio identifiers always begin with the letter 'F' and appear next to the folio name in the project folios tab. Your project must be published for folios to be accessible to the public.

An example of a folio in use: you want to reference a sequence of images in a paper but there is not enough space, so you opt to publish the images online and print the URL in the paper. If those images are in your published MorphoBank project you can create a new folio (complete with title and introductory text), add the relevant images and place them in the proper order. When readers go to the URL printed in the paper they will see your introductory text and be able to click through to each image in the proper order.

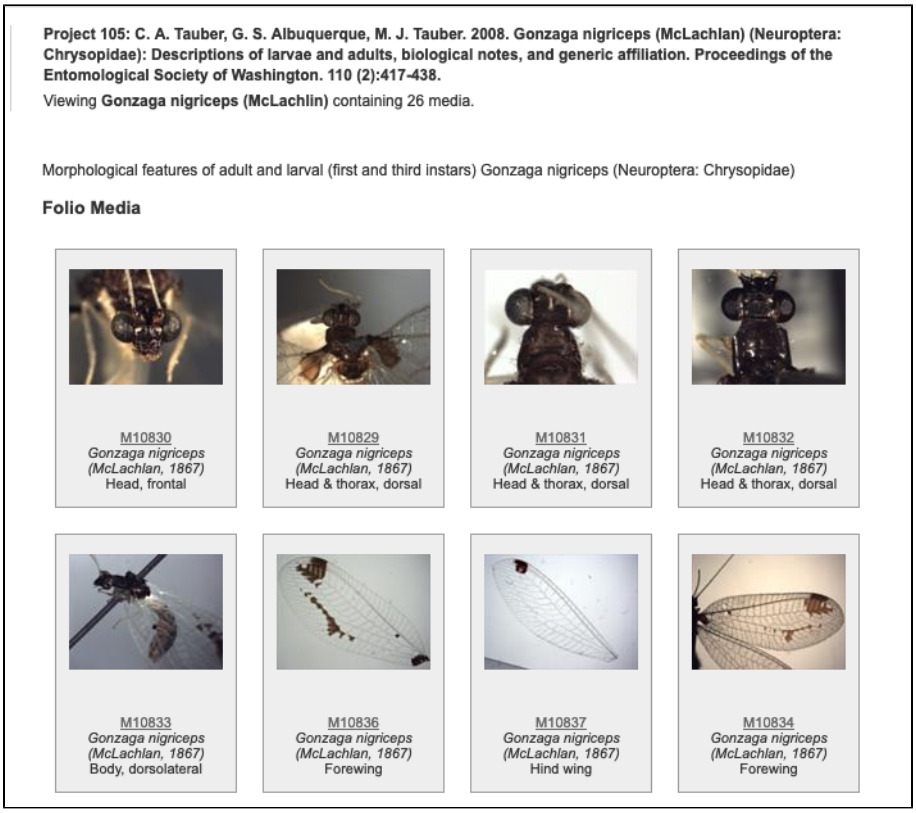


Figure 3.7 A sample folio, which can be viewed on MorphoBank as part of Project P105.

3.4. Tools for Collaboration

MorphoBank provides many advantages over traditional desktop software for collaborative workgroups. As a web-based system, it is available to anyone with internet access and reasonably modern web browser software. There is no need for specialized software and no software needs to be downloaded to the desktop. Virtually every modern operating system is supported (e.g., Windows, Mac OS X and Linux/Unix). Upgrades and bug-fixes to the MorphoBank software are done on a central server ensuring that all users are always benefiting from the most up-to-date version of the MorphoBank software. Furthermore, because all project data are centrally stored in the MorphoBank database, collaborators are always using the most up-to-date data. This working environment is in marked contrast to collaborative projects that use traditional desktop software where versioning issues often quickly become frustrating and time-consuming.

3.4.1. Membership

Until a project is published, a project's creator (who is also known as the "project administrator") may grant collaborators access. Any number of collaborators can be invited and they need not already be registered MorphoBank members to receive an invitation; they can register upon receiving an invitation.

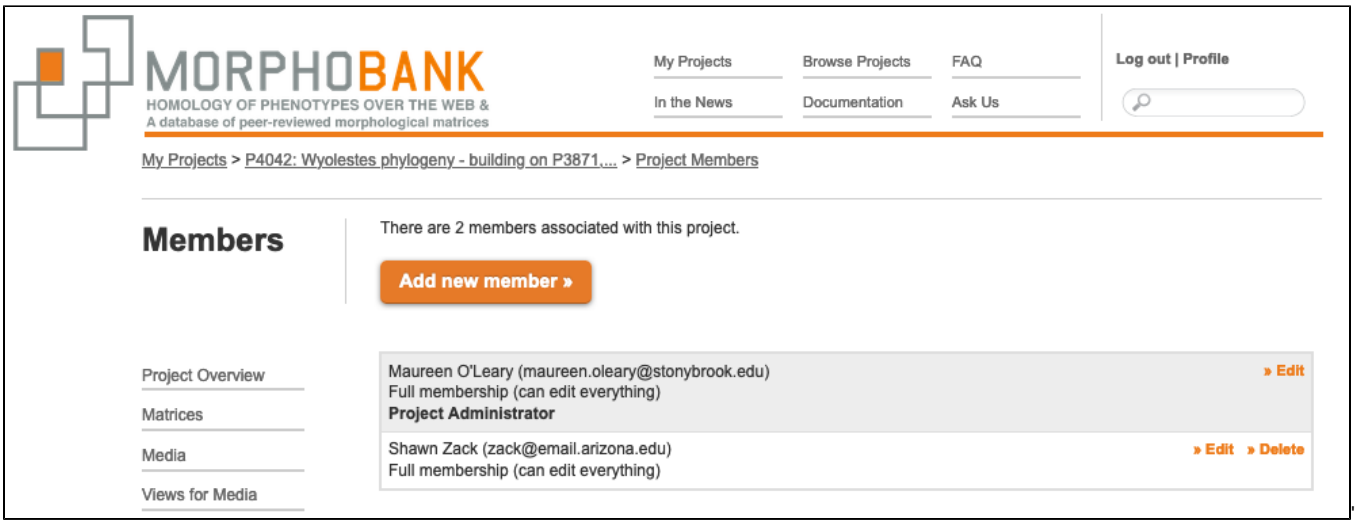


Figure 3.8. Membership type menu

There are four types of project membership:

- *Full members* may add, edit and delete project data, subject to access restrictions on individual data items discussed below.
- *Observers* may view all project data but are not allowed to add or change data in any way.
- *Character annotators* may add, edit and delete all project data except characters and character states, subject to access restrictions discussed below.
- *Bibliography maintainers* may only edit bibliographic entries. They can also view project data.

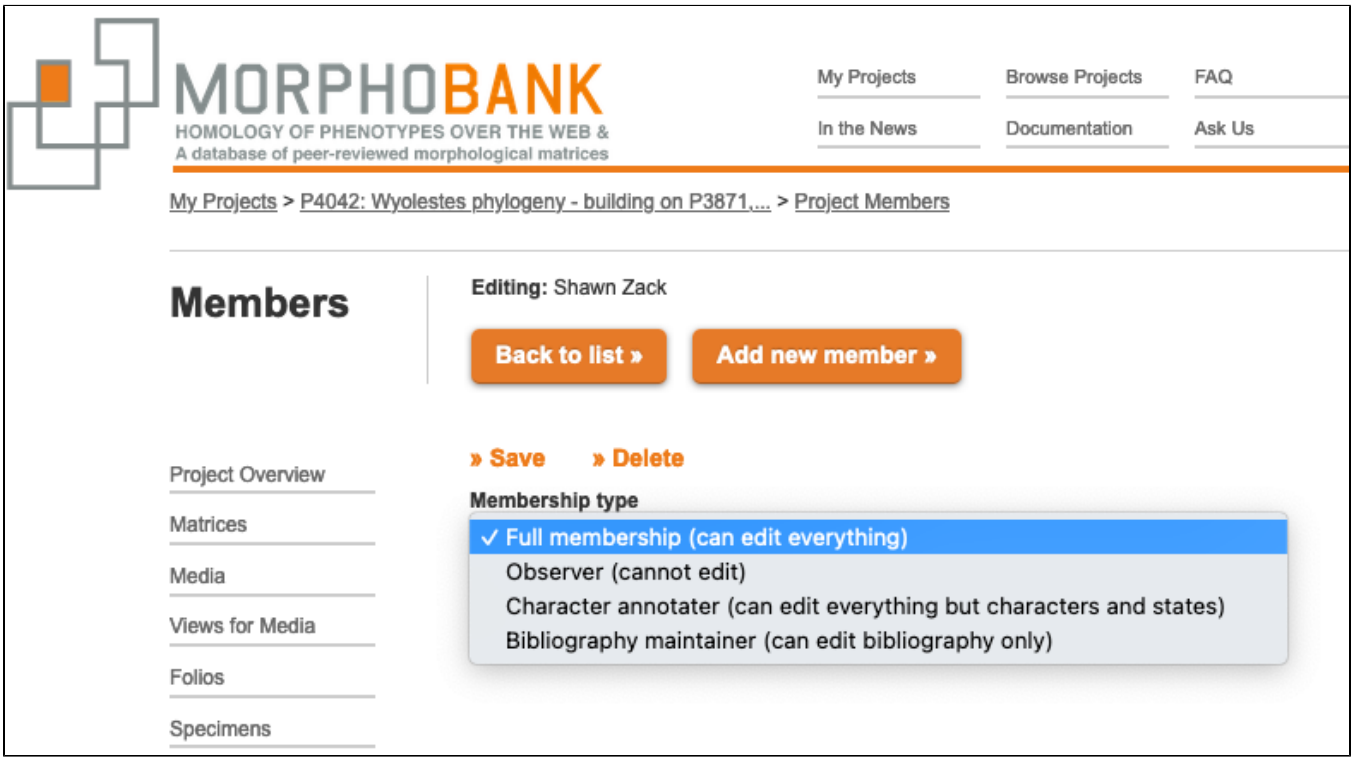


Figure 3.9. Membership type menu accessible to Project Administrator

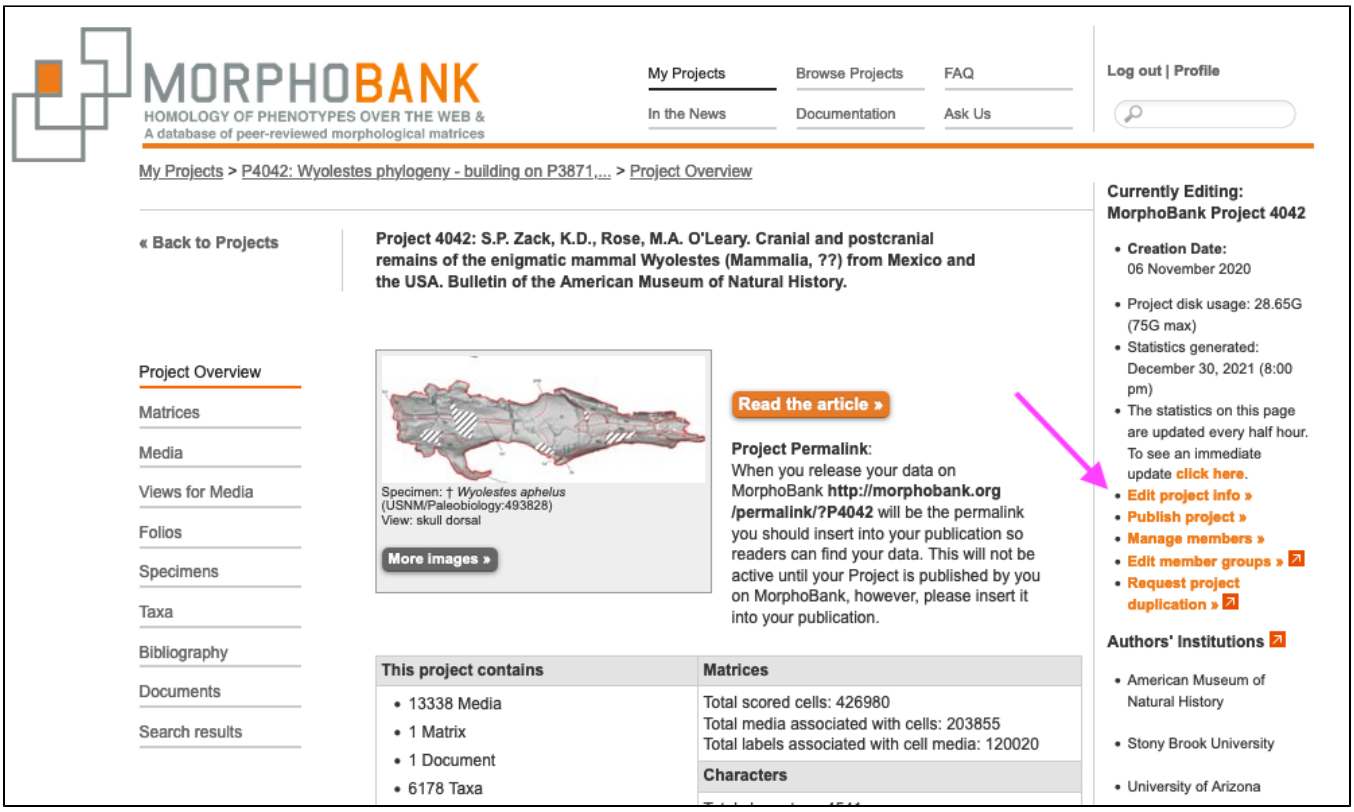


Figure 3.10. The Edit Project Info button accessible to Project Administrators only.

3.4.2. Reviewer Access

Project Administrators can enable an anonymous reviewer login for their project in the Project Info form accessed through the "Edit project info" link on the Project Overview page. **Once enabled, reviewers can login by (1) entering the project number in the email address field and (2) the reviewer login password entered by the Project Administrator in the Project Info form as the password.** Don't forget – you have to tell editors and reviewers your project number and reviewer password when you invite them to review your project.

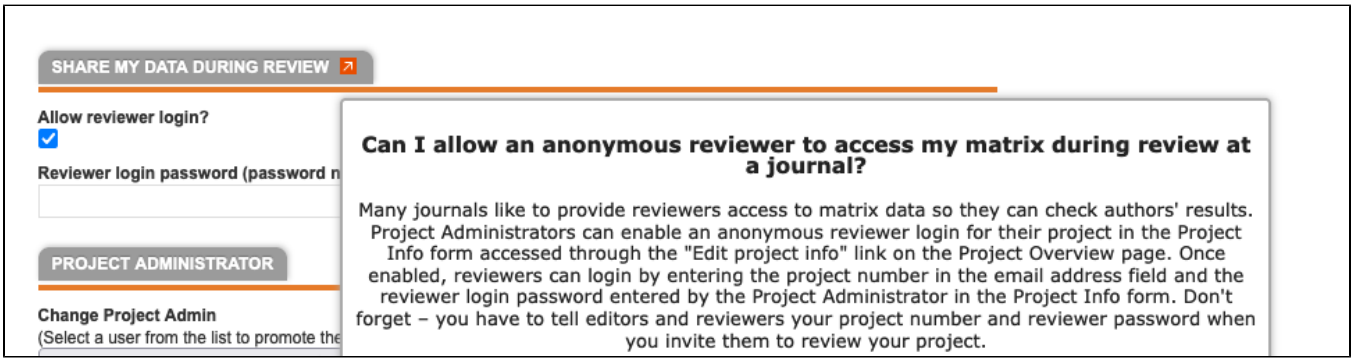


Figure 3.11. The form fields to allow anonymous access to your data by a reviewer or editor for use when a project is in peer review.

Scroll to the SHARE MY DATA DURING REVIEW section and set your login password. This access remains private to you and anyone with whom you share the password. You can change or revoke it at any time.

3.4.3. Managing access to data

MorphoBank adopts a streamlined approach to data access within a project. All primary data items (taxa, characters, specimens, media and matrices) are "owned" by the member who created them. The owner has the option of reserving editing access for themselves or allowing all full project members to edit. (Editing access includes the ability to delete an item.) By default all newly created items are editable by all; restricted access must be explicitly set by the creator.

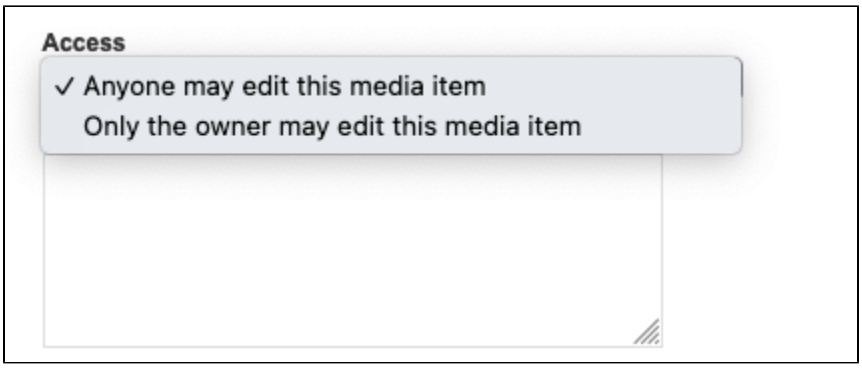


Figure 3.12. Access control menu visible to any Project member.

3.4.4. Tracking changes to your data

Changes to all data items and their constituents (taxa, characters and states, specimens, media and matrices including cells, taxa and characters and states) are logged by MorphoBank. Detailed change histories for any item, including the nature of the change, the time and date and who executed the change, may be accessed by project members.

3.5. Publishing

Newly created project workspaces are `unpublished`. Their contents are available only to members of the project, and to anonymous reviewers if anonymous reviewer access is enabled. When your research is completed and poised to be released in a peer-reviewed publication, you can `publish` your project, which will have the following effects:

1. Data will be publicly accessible via the MorphoBank search and project browser.
2. Data will be accessible using MorphoBank `PermaLinks` (see the section called “ Linking to a published project using `permalinks` ”). Permalinks are unchanging, easy-to-cite URLs that will always lead to your project data. They are a convenient way to cite data hosted on MorphoBank in a published paper.
3. Your project is **effectively frozen**, just as with a traditionally published scientific paper. The MorphoBank data packet is intended to be a snapshot in time of the information supporting a peer-reviewed paper. Data - in that Project - can no longer be modified and members no longer added. However, uou and other researchers can, and are encouraged to build on your data by creating a new project from it and going to work on a new paper for peer-review. This action simply requires the creation of a new project either by downloading and uploading a matrix from MorphoBank, or by duplicating a project, if there are important images to replicate.

The last item is particularly important. As with a paper or book, a project shouldn't be published until you are sure all elements are as you and your collaborators wish them to be.

3.5.1. Copyright considerations

MorphoBank does not own or assert any copyright on project data. Once a project is published, it becomes publicly accessible and the copyright status of the constituent data becomes a concern. In general, before uploading an image (or other data) to your project, make sure that one of the following applies:

1. You own the rights to the image (usually meaning that you created the image yourself).
2. You can prove that the copyright holder has licensed the image under a free license.
3. You can prove that the image is in the public domain.
4. You believe, and state, a fair use rationale for the specific use of the image that you intend.
5. You have obtained the required clearances from the copyright holder that specifically allow you to use the image on MorphoBank.

When cataloging media you will have the opportunity enter information about the copyright status of the media file you are uploading using various Creative Commons (CC) licenses. You will first be asked to indicate if the media is under copyright by checking the "Is under copyright?" checkbox. Leave this box blank if the owner of the media you are loading wants to release those media to the public domain (a CC0 designation). Checking the checkbox will add additional elements to the form to allow you to apply a different copyright license, indicate who the copyright owner is and that they have granted you permission to use the media in MorphoBank.

3.5.2. Selectively publishing project content

By default, when a project is published all data in it are made publicly accessible. It is possible, however, to keep specific media, matrices, folios and documents in a published project un-published. To hold back an item you must change the item's status from `publish when project is published` to `never publish to project` *prior to publishing the project*. The item status drop down, shown below is present in the primary editing forms for media, matrices, folios and documents.

> **Warning**
>
> Once a project is published you cannot change the status of any items in that project.



Figure 3.13. Item-level publishing status menu on the Media page.

3.5.3. Citing and Accessing your MorphoBank-hosted Project and Data

3.5.3.1. Linking to a published project using `permalinks`

Each MorphoBank project is issued a unique identifier beginning with the letter 'P' for project. This identifier is displayed in many places throughout the site, for example it is next to your project title in the `My Projects` list.

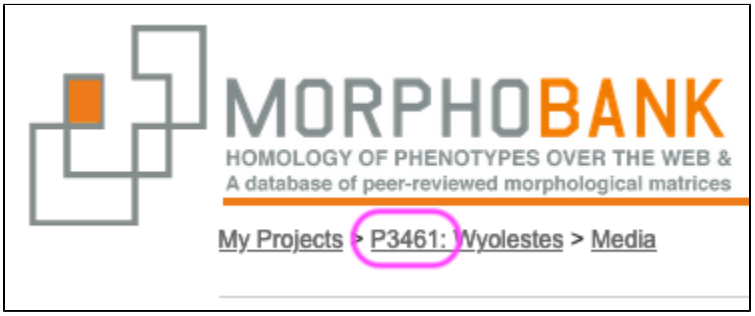


Figure 3.14. The MorphoBank project number.

Once your project is published you may link to your project with a URL in the format `https://morphobank.org/permalink/?P00` where 'P00' is replaced with your project identifier. This URL will always lead to your data and is a reliable way to cite MorphoBank-hosted datasets in published papers.

> **Warning**
>
> For unpublished projects, the only way to access data is by logging into MorphoBank.

3.5.3.2. Linking to a published project using a DOI

Since Spring 2014, MorphoBank has issued DOIs (Digital Object Identifiers) for each project and for each individual matrix within a project at the time of publication. DOIs are generated within a half hour of the project being made public. The DOI for the project as a whole will displayed below the abstract on the Project Overview page:

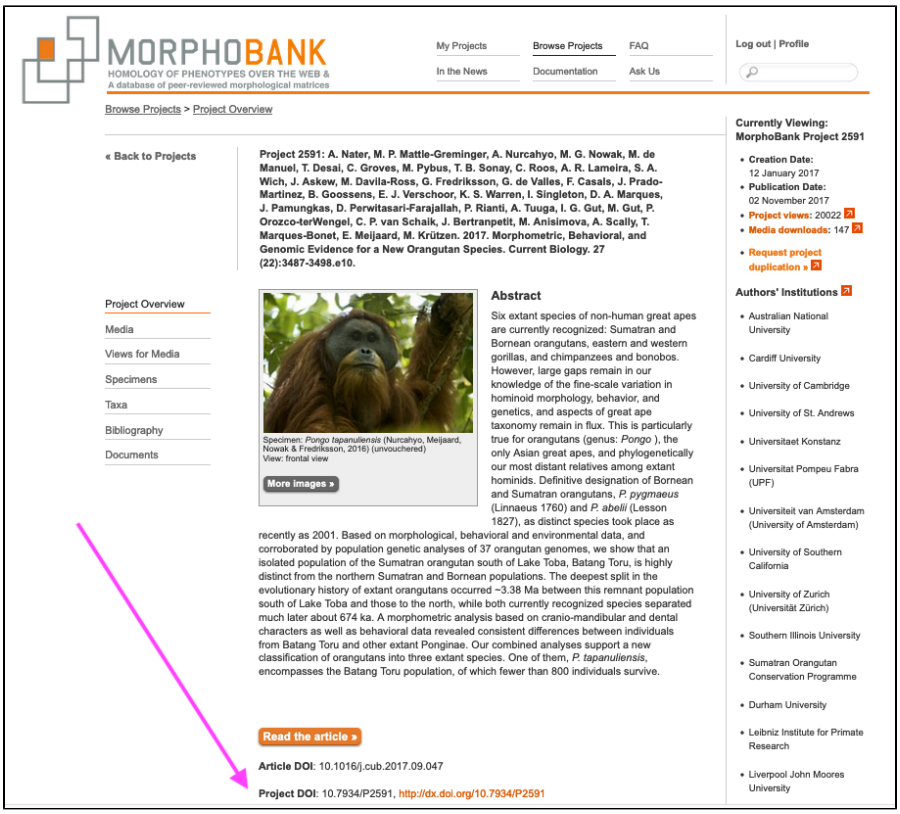


Figure 3.15. Project DOI

and the matrix DOIs will appear on the Matrices detail page:

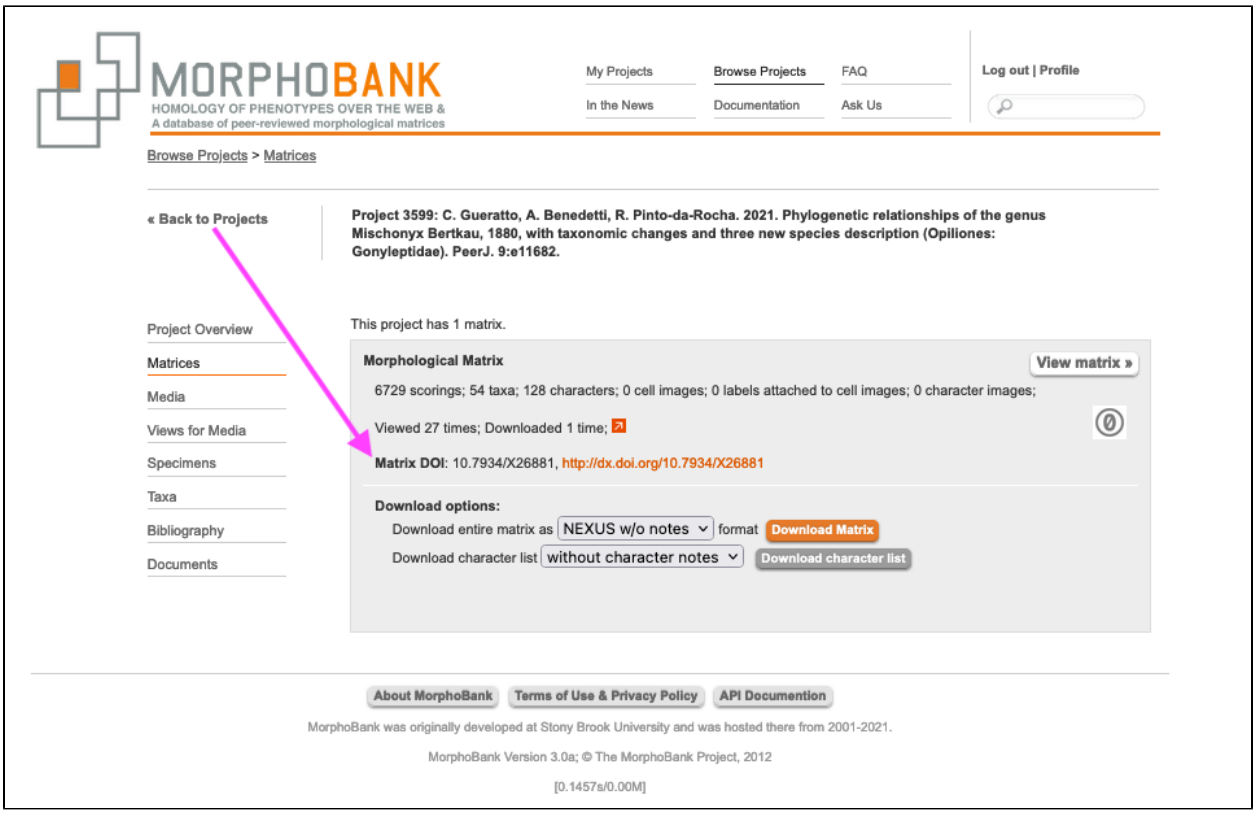


Figure 3.16. Matrix DOI

This feature is not retroactive and only applies to projects published after April 2014.

3.5.3.3. Other ways to access published data

Projects are also accessible:

- From MorphoBank's Browse Project page. You do not need to be logged in to view and use data.

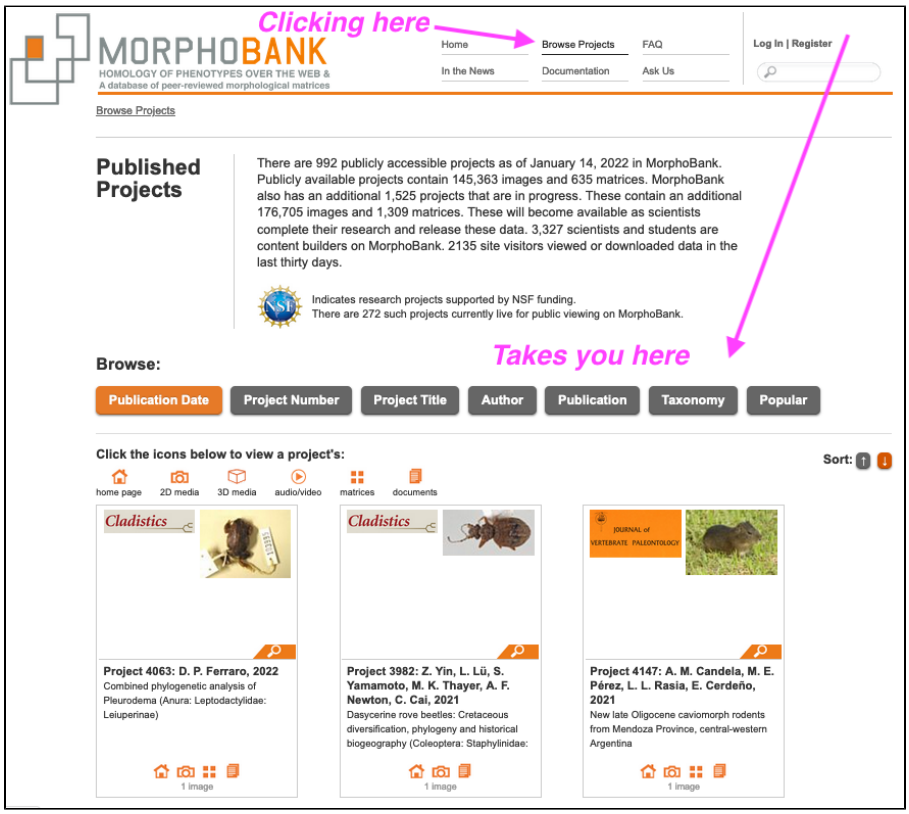


Figure 3.17. MorphoBank's Browse Project page, note the tools to filter data by criteria like title and author.

- From MorphoBank's home page as *lists of published matrices, media, views for media, folios, specimens, taxa, bibliographic citations and documents linked to from a project summary displayed in the Browse Projects section of MorphoBank.* All published projects on MorphoBank are displayed in the Browse Projects section. You can browse projects by Publication Date, Project Number, Project Title, Author, Publication and Taxonomy. When browsing by Publication date, icons are displayed to provide direct access to project home page, 2D/3D/audio/video media, matrices and documents. The lists of project data are similar to those found in the MorphoBank editing interface, but without editing capabilities.

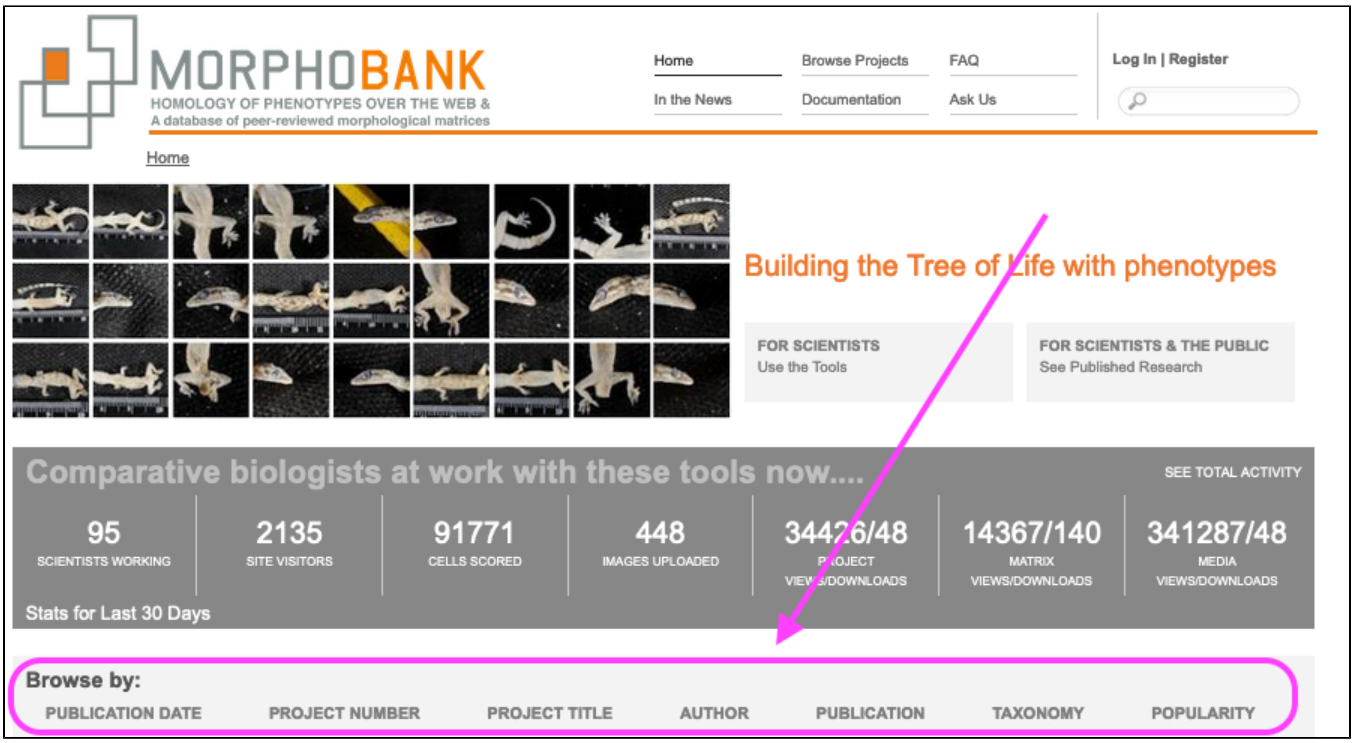


Figure 3.18. MorphoBank's home page showing options to filter and find published data.

- *in the MorphoBank search engine*. Your media and matrices will be included in the results of searches on the MorphoBank.org site.

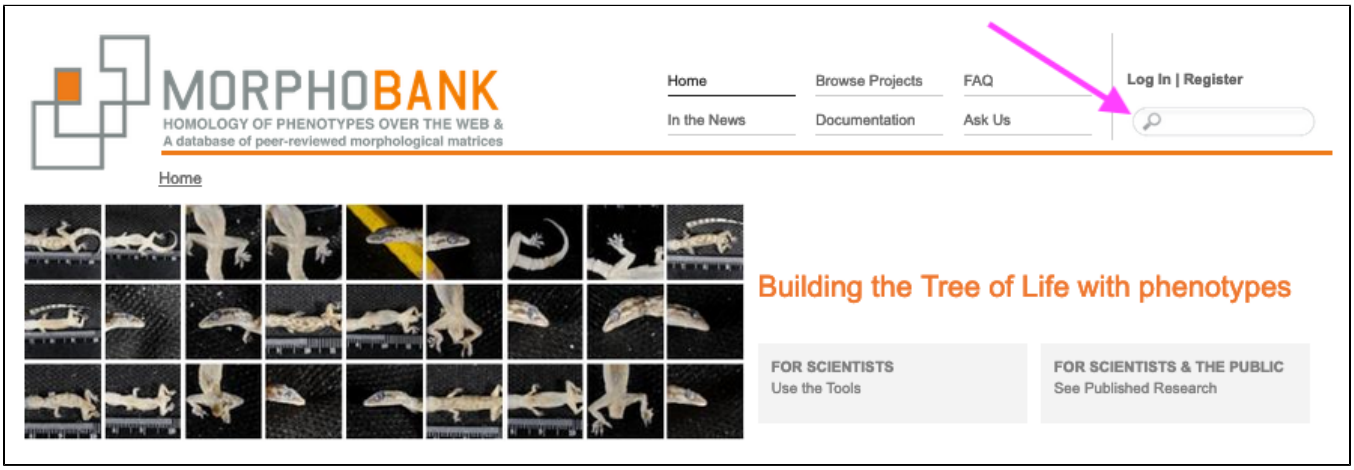


Figure 3.19. Search box on MorphoBank's home page where one can search such tags as anatomy, taxonomic names, author names, and project numbers.

3.5.4. Deleting a Project

Project administrators can delete entire projects if they are no longer useful and will not be published. Simply navigate to "Edit Project Info" on the right-hand side of the Project Overview screen, and then scroll to the bottom of the page where the options "Save," "Cancel" and "Delete" appear. "Delete" will only be visible to Project Administrators.

4. Navigation

One navigates among the various tools and options in MorphoBank using the main navigation bar at the top of the screen and the left, sub-navigation menu available on some site sections. The main navigation bar is composed of links which lead to a specific section of the site or tool.

The top-level set of links, as shown in the figures below, is the most general and provides access to the following features:

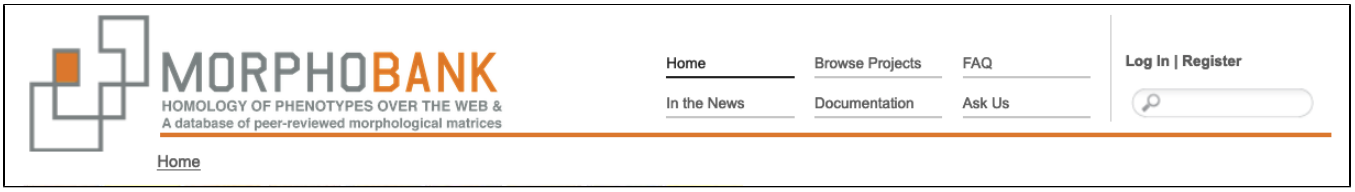


Figure 4.1. MorphoBank main navigation bar when not logged in.

- Home: a link to the home page of MorphoBank.org. This link is only available when you are *not* logged in to MorphoBank.
- Browse Projects: a list of project summaries for all published MorphoBank projects.
- FAQ: A list of frequently asked questions and answers.
- Documentation: contains tutorials and guides, including this document.
- Ask Us: contains a form for contacting MorphoBank system administrators. You can use this form to submit questions, bug reports and requests for new features.
- Search Box: a search form you can use to search published projects, and when logged in, data in projects for which you are a member, no matter their status.
- Log In: a form allowing existing members to log in to their account. This link is only available when you are *not* logged in to MorphoBank.
- Register: a form allowing new members to register for access to MorphoBank. This link is only available when you are *not* logged in to MorphoBank.



Figure 4.2. MorphoBank main navigation bar when logged in.

- My Projects: once you have logged in to MorphoBank, the Home link is replaced with the My Projects link. The My Projects section of the site is where you will find a list of your current projects, have the ability to make new projects and get access to all project-specific setup and editing tools. This is where you will spend most of your time when using MorphoBank. This link is only available when you *are* logged in to MorphoBank.
- Browse Projects: a list of project summaries for all published MorphoBank projects.
- FAQ: A list of frequently asked questions and answers.
- Documentation: contains tutorials and guides, including this document.
- Ask Us: contains a form for contacting MorphoBank system administrators. You can use this form to submit questions, bug reports and requests for new features.
- Search Box: a search form you can use to search published projects, and when logged in, data in projects for which you are a member, no matter their status.
- Logout: a link to logout of MorphoBank. This link is only available when you *are* logged in to MorphoBank. It is displayed in place of the Log In link.
- Profile: a form allowing members to update the information they provided during the registration process and change their account password or email address. This link is only available when you *are* logged in to MorphoBank. It is displayed in place of the Register link.

When editing a project in the My Projects section of the site or exploring a published project in the Browse Projects section, there will be additional sub-navigation options on the left-hand side of the screen resembling the menu shown in the figure below:

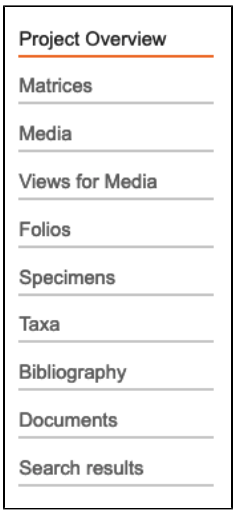


Figure 4.3. Typical side navigation bar.

5. How to Get Access

There are two ways to join Morphobank: through invitation or registration. To register fill out the registration form. Registrations are immediately activated. Invitations to join MorphoBank can also be given out by current members who are the project administrators of particular projects and who wish to invite collaborators. To add a member to your project, click the Manage Members link at the right side of the Project Overview page. You will then see an Add New Member button that allows you to link existing MorphoBank users to your project or invite new member to join your project on MorphoBank. Once a new person has joined by either means, they are free to create their own new, separate projects.

We welcome and encourage students to join and use MorphoBank in their studies. It is the policy of MorphoBank, however, to request that the student's advisor be made a member of any student project.

5.1. Resetting the Password for an Existing Account

If you already have an account but have forgotten your password, click on the "Forgot your Password?" link on the login page. You will be presented with a page explaining how to reset your password. Simply enter your e-mail address on that page, click the "go" button and a message will be sent with a link to another page where you may enter a new password for your account.

If you are still having trouble after resetting your password, or you fail to receive the reset password e-mail, contact us via the Ask Us form linked to in the main navigation.

Note that once logged in you will remain logged in for up to 72 hours, unless you explicitly log out.

5.2. Duration of login

Note that once logged in you will remain logged in - even if you close or quit your browser - for up to 72 hours, unless you explicitly log out.

6. Funding for MorphoBank

MorphoBank is currently funded by a Sustained Availability of Biological Infrastructure Award (DBI-2049965) from the National Science Foundation to MorphoBank Director Tanya Berardini at Phoenix Bioinformatics and by membership fees from academic institutions and museums around the world. Prior to this recent award, MorphoBank was funded by a number of federal awards to Maureen O'Leary at Stony Brook University as follows. MorphoBank version 1 was funded by the National Science Foundation grant DEB-9903964, with additional financial assistance from the American Museum of Natural History. MorphoBank version 2 was funded by NOAA (NA04OAR4700191). MorphoBank 2.5 and later versions developed between 2008-2021 were funded by an award from the National Science Foundation Division of Earth Sciences (EAR-0622359) and a Sustaining Award (DBI-1457925) from the Advances in Biological Informatics program of NSF's Division of Biological Infrastrucuture.

7. Citing MorphoBank in your publications

When you use MorphoBank please cite the software:

> *O'Leary, M. A., and S. G. Kaufman. 2012. MorphoBank 3.0: Web application for morphological phylogenetics and taxonomy. https://www.morphobank.org.*

You may also be interested in citing the conceptual paper describing the the database and tool:

> *O'Leary, M. A., and S. Kaufman. 2011. MorphoBank: phylophenomics in the 'cloud'. Cladistics. 27:1-9.*

8. MorphoBank API

The MorphoBank public API supports HTTP GET requests for published resources. API documentation is available here.

9. References

1. MacClade, http://www.macclade.org/macclade.html
2. Mesquite, https://www.mesquiteproject.org/
3. NEXUS Data Editor, https://www.softpedia.com/get/Science-CAD/NEXUS-Data-Editor.shtml