Osteoware Software Manual
Volume I

Developed by the Repatriation Osteology Lab, Smithsonian Institution

Grant Support:
National Center for Preservation Technology and Training (NCPTT) and the Smithsonian Web 2.0 Fund
Table of Contents

Preface.................................................................................................................................1

Chapter 1: Introduction to the Osteoware Program...............................................................2
by J. Christopher Dudar, Stephan D. Ousley, and Cynthia A. Wilczak

Chapter 2: Inventories, Adding Individuals, and Tracking Skeletal Elements .................10
by J. Christopher Dudar

Chapter 3: Age and Sex......................................................................................................19
by Gwyn Madden

Chapter 4: Taphonomy .......................................................................................................45
by Claire O’Brien

Chapter 5: Postcranial Metrics ..........................................................................................46
by Dawn Mulhern

Chapter 6: Cranial Non-metrics ..........................................................................................63
by

Chapter 7: Dental Inventory/Development/Pathology ......................................................64
by Erica B. Jones and J. Christopher Dudar

Chapter 8: Dental Morphology ..........................................................................................65
by Erica B. Jones and J. Christopher Dudar

Chapter 9: Macromorphoscopics ......................................................................................66
by Joseph T. Hefner

Chapter 10: Cranial Deformation ......................................................................................79
by Cynthia A. Wilczak

Chapter 11: Craniometrics .................................................................................................79
by Stephen D. Ousley

Chapter 12: Summary Paragraphs ....................................................................................80
by J. Christopher Dudar

Chapter 13: Extracting Data from the Database ................................................................84
by J. Christopher Dudar

Literature Cited ...................................................................................................................89
Preface

Osteoware is a relational database software program for documenting human skeletal remains. The protocols are based on Buikstra and Ubelaker’s 1994 Standards for Data Collection from Human Skeletal Remains, hereafter referred to as the Standards. Dr. Stephen Ousley developed and wrote the Osteoware program with the input of osteologists working in the Repatriation Osteology Lab (ROL) of the National Museum of Natural History, Smithsonian Institution. While researchers may have specialized variables determined by their research focus or follow other published guidelines for recording osteological data, the core observations established by the Standards are widely used within the field and provide baseline measures for comparing skeletal populations. The Osteoware software, website, and user manuals are works in progress with new modules and features in development, and user feedback will help determine the refinements and additions to future versions.

The user manuals are divided into two volumes. The first volume covers all aspects of data entry except for pathological conditions. The second volume is devoted to the Pathology Module because of the large number and complexity of the data entry screens and to accommodate more photographic examples. A separate installation guide for the software is available on the website. The manuals focus on relevant problems of data entry for users of Osteoware and are not intended to be a complete protocol reference for collecting osteological data. Readers should consult one of the many available reference works when more details are needed, e.g., Mays, 2010; Roberts, 2009; White and Folkens, 2005; Reichs, 1998; Bass, 1995; Ubelaker, 1989; Krogman and Iscan, 1986; Acsádi and Nemeskéri, 1970.

The authors of the manual chapters are all current or former contractors and employees of the ROL. However, many other members of the lab have contributed to refinements and testing of the various iterations of the program over the years; we would like to thank all of them for their contributions with special thanks to Jane Beck, Sarah Pelot, and Janine Hinton. We are especially indebted to Dr. Jane Buikstra, Arizona State University, for her support and encouragement during the development of the publicly available version of Osteoware. We also received advice and assistance from various staff members in the Anthropology Department, Smithsonian Institution; the curators, Drs. Don Ortner, Doug Ubelaker and Doug Owsley; collection manager, Dr. David Hunt; and the Program Manager of the Repatriation Office, Dr. William Billeck. In the past year, Dr. J. Christopher Dudar also recruited some of his colleagues and their students from various institutions to serve as beta testers for the software and their help is greatly appreciated.

We are pleased to be able to offer Osteoware at no cost to researchers. Financial support for web distribution of the Osteoware software and the manuals was provided for by grants (PI, Dr. J. Christopher Dudar) from the National Center for Preservation Technology and Training (No. MT-2210-10-NC-02), National Park Service, U.S. Department of the Interior and The Smithsonian Institution Web 2.0 Fund, Washington D.C.
Chapter 1: Introduction to the Osteoware Program
by J. Christopher Dudar, Stephan D. Ousley, and Cynthia A. Wilczak

The Osteoware software program provides a user-friendly way to enter qualitative and quantitative observations on human remains into a Structured Query Language (SQL) database. A separate database manager, currently the Advantage Data Architect™ version 9.1 by Sybase® Inc., can then be used to locate and extract specific data from the database. For more information on hardware requirements, installation, and the database manager, see the separate Installation Guide and Chapter 13 of this manual. The rest of the chapters, including this introduction, focus on data entry using the Osteoware program.

A Brief History of Osteoware
The need for a computerized database to store and manage data collected from human skeletal remains became critical at the National Museum of Natural History, Smithsonian Institution with the passage by Congress of the National Museum of the American Indian Act in 1989. Like the Native American Graves and Repatriation Act (NAGPRA), from which the Smithsonian is specifically exempted, the NMAI Act mandates the repatriation of skeletal remains and specific objects to culturally affiliated Native American groups. At the Smithsonian, this meant over 19,000 catalogue numbers for human remains needed to be inventoried and documented. Efforts to create a database to manage the massive amounts of data being generated by the documentation process were begun shortly after the Repatriation Osteology Lab (ROL) was established in 1991.

Figure 1.1 Old storage units (a) at the Museum of Natural History, Smithsonian Institution and new storage units (b) at the Museum Support Center.
The first ROL osteological data entry program was a DOS-based Paradox system with text screens and a flat file, non-relational database. It incorporated the “Chicago Recommendations”, which were a culmination and refinement of standardization efforts begun by the Paleopathology Association Skeletal Database Committee in 1988 and continued in a 1991 workshop funded by the National Science Foundation at the Field Museum of Natural History in Chicago (Verano et al., 1994). A Physical Anthropology Laboratory Data Manual, compiled and edited by former ROL lab director John Verano with Javier Urcid, was published by the Repatriation Office as a technical report and predated the publication of the Buikstra and Ubelaker (1994) Standards for Data Collection from Human Skeletal Remains by a few months (Figure 1.2). The Standards was also based on the Chicago Recommendations and was widely adopted and referenced by osteologists, particularly in the United States (over 1,200 citations in Google Scholar, July 2011). In 1992, Jerry Rose and the University of Arkansas’ Center for Advanced Spatial Technologies obtained funding from the National Science Foundation to develop a new computerized data system for skeletal data collection (Rose et al., 1996). The resulting DOS-based program, the Standardized Osteological Database (SOD), utilized the coding and structure of the ROL Paradox program, but it was a relational database, which enabled the linking of data across multiple tables.

In 1998, Stephen D. Ousley became director of the ROL and programmed the first Windows-based data entry program for the lab. In addition to moving from the now obsolete DOS-based system, like SOD, it utilized a relational database management system (RDMS). In an RDMS, the links across data tables are established by a unique identifier or Primary Key (the Catkey in Osteoware), allowing the extraction of data based on complex criteria. The recommendations of the Standards and the earlier Paradox program were used in the development of the data entry coding. The original Windows program has been revised over the years by Ousley, with input from osteologists working in the lab, into the current Osteoware program. Osteoware has proven stability in its 10+ years of use by the ROL, where over 141,000 data records have been entered across the eleven modules. Users of the Standards will be familiar with most of the data entry protocols although some modifications have been made over the years. Any changes are clearly explained in the appropriate sections of the user manuals.
The Osteoware Home Screen

The program and an installation guide are available for download on the Osteoware website. After installing the program, clicking the program icon (skull and crossbones, ProtMenu.exe) on your hard drive or desktop opens the Osteoware Home Screen (Figure 1.3). The Home Screen contains buttons for the various data entry Modules, special function buttons, and a Catkey window. You can test the functions and practice data entry in Osteoware using the test data subsets provided in the downloaded program. To enter your own catalogue numbers and data subsets (such as archaeological sites), you must first install the Advantage Data Architect and follow the steps in the installation guide. Setting up the database with site data and catkeys is an advanced function best left to the database manager, but a more user-friendly system for future versions of Osteoware is in development.

Data Subsets

In the top left corner of the Home Screen, the Data Subset window shows the organization of your database by site names, states, provinces, or any other division specified by the database manager (Figure 1.3). Click on the arrow to the right of the window to scroll through the list of available subsets. The example in Figure 1.4 shows two subsets, PPA Workshop and Test 1. Selecting one of the data subsets will open a list of all the Catkey numbers for that subset in the Catkey window.

Catkey Window

Catkey is the term used at the Smithsonian for the catalogue number, but it can be used for any label that is appropriate to your situation, such as a field number, as long as it is a unique identifier in the database. The Catkey window is arranged in a table with the following columns from left to right: a black triangle indicating the currently selected catalog number; the Catkey list of all catalog numbers in a data subset; a letter for distinct individuals (INDIV) associated with a Catkey; and the location (LOC) of the remains (Figure 1.5). Although
empty in the figure, the ROL uses the LOC column for temporary locations, e.g., the shelf number in the lab, or RET for remains returned to storage. The Trk column displays the total number of tracking numbers assigned to commingled elements for a catalog number. Adding Individuals and Tracking Numbers are explained in Chapter 2.

You can scroll through the list to locate a specific Catkey in the currently selected data subset. To quickly navigate to a Catkey, pressing the Control and the F key simultaneously (Ctrl + F) will open a pop-up search window (Figure 1.6). Input the Catkey and then press Enter to go to that record. This shortcut offers the quickest way to navigate to a specific catalog number because it will search the entire database and not just the active data subset.

**Home Screen Buttons**

The Osteoware Home Screen has 12 large buttons representing the main data entry modules. Each module corresponds to a table(s) in the database containing a specific type of skeletal data such as Postcranial Metrics or Taphonomy. The module buttons are color-coded to indicate the status of documentation (Figure 1.7):

- **Yellow** = documentation required
- **Purple** = documentation is complete
- **Orange** = not applicable/indeterminant
- **White** = no deformation (applies to the cranial deformation button only).

Figure 1.6 Press to Ctrl + F to navigate to a catkey.

Figure 1.7 The Osteoware Home Screen showing the color-coded module buttons: documentation required (yellow), complete (purple), not applicable (orange) and no cranial deformation (white).
Module button colors change automatically from yellow (not complete) to purple (complete) when a data record is saved, but the color-codes can also be changed by right-clicking a module button. A pop-up documentation status menu will appear with several status change selections (Figure 1.8).

There are some safeguards in place for the change in documentation status function. For example, if you right-click to change the status of the Inventory Module, the pop-up window shown in Figure 1.9 will appear to remind you that all Inventories must have at least a comment entered even when skeletal remains are no longer associated with that Catkey. Click okay to clear the window and then open the Inventory Module to enter appropriate data. If it is a reassociation, the note should identify the catkeys involved; the exact bones reassociated; and the reason(s) for the association to ensure that complete and accurate collections records are maintained. After entering a comment or data, the Inventory Module button will change to purple (complete).

A pop-up window also appears when you right-click the Age and Sex or Taphonomy Module buttons, but in this case, it is only a reminder, and you are not required to enter data into the module (Figure 1.10). Simply click the “Yes” button, and you will then be able to change the module documentation status from the Home Screen. Note for both of these modules, data should be entered for all remains even if they are very incomplete and fragmentary. The Age and Sex module has choices for Unknown or Indeterminate in these cases (Chapter 3).

In addition to the Main Module buttons, several special functions can be accessed from the Osteoware Home Screen, including Photo and X-ray requests (Figure 1.7).

**Photo Requests**

Photographs of the cranium and mandible from the standard aspects and the occlusal aspect are routinely taken in the ROL on all remains. All other photographs are “special requests” and they are taken for many pathological conditions, any unusual taphonomy, or other features of interest on the remains. Procedures will vary from lab to lab, but even if the same person who is entering data
will also be taking the photographs, entering special requests during the documentation process helps ensure that an important shot is not forgotten.

Clicking on the *Photo Request* button on the Osteoware Home Screen opens the window shown in Figure 1.11. The three data entry fields are: Bone, View; Pathology/Notes; and Special Instructions. In this case, mineral deposits that were causing pitting of the cortex were being documented as an example of a potential pseudopathology (Figure 1.12).

**BONE / VIEW:** A basic entry format that can be modified as needed is: Bone Side_ Bone Name, View. The bone name should be as specific as possible (T4 or C1-C7 rather than vertebrae) to ensure the correct photo is taken and the bones are properly identified. For View, terms such as superiolateral (oblique) can be used in addition to the standard aspects (e.g., lateral, posterior).

**PATHOLOGY / NOTES:** Including an adequate description of the condition to be photographed will help identify the image and facilitate searches and queries of the database. Description of pathologies can be copied and pasted into this field from the text comments of the Pathology Module. When typing pathologies or taphonomic descriptions directly into this section, be sure to include relevant key word. In the Figure 1.11 example, “Taphonomy” and “soil minerals” are key words that might be searched. Other examples of statements with key search terms are, “green staining, likely due to *in situ* contact with copper” or “adherent white substance, possibly adipocere”.

**SPECIAL INSTRUCTIONS:** Special instructions are comments to clarify the shot to the photographer. You might specify lighting conditions to enhance bone texture, ask to have bones articulated in the same image, or request that bones from another individual be included in the shot for comparison. Note that a single entry represents one photograph, so multiple shots of the same
bone are each entered as a separate Photo Request. Conversely, if more than one bone is desired in a single shot, they are entered as a single request and the Bone/View statement is modified accordingly. For example, R Femur, R Innominate, Anterior-Superior. You can then specify in the Special Instructions that you want a photo of the hip joint in articulation.

**X-Ray Requests**

Standard sets of x-rays are taken in the ROL on all remains and include the major planes of the cranium, dental x-rays (Figure 1.13), and the left femur, humerus, and tibia. The standard x-rays are normally taken before documentation so they can be reviewed by the osteologist as part of their analysis. Radiographs are necessary for complete dental documentation, and other standard x-rays have been crucial in identifying certain conditions such as diffuse bone loss (osteopenia) and lytic lesions that are not externally visible.

Ideally, all bone would be radiographed for complete documentation, but it is seldom possible with time and budget constraints. Instead, the X-ray Request button can be used when an x-ray is most appropriate. Pathological lesions are by far the most common X-ray Request in the ROL, but there have been occasional requests for x-rays of taphonomic alterations. The four fields for an x-ray request entry are Bone, View, Pathology/Notes, and Special Instructions (Figure 1.14).

**BONE:** The side (R, L, M) and specific bone name are entered into the Bone window. In Figure 1.14, the right parietal was entered.

**VIEW:** Unlike photo requests, multiple aspects can be requested at one time for x-rays by using the selections in the drop-down menu (Figure 1.14). Multiple views are often necessary for adequate visualization. For example, diaphyseal fractures may require x-rays from at least two orthogonal planes, e.g., AP and ML, to completely follow the...
path of the fracture line. For the best focus, remember to choose the direction opposite the aspect of the lesion or structure in order to place it closest to the x-ray film/digital pickup. For example, if a lesion is on the anterior aspect of a bone, choose the postero-anterior (PA) direction.

Even if standard x-rays in several directions are taken of the cranium, special requests may still be needed to adequately capture a lesion or anomaly. Figures 1.15 and 1.16 illustrate a special request for an oblique shot of lesions on the right parietal that were obscured by the complex midline and basilar structures of the cranium in x-rays taken from the standard directions.

PATHOLOGY / NOTES: A full description of the condition to be x-rayed will aid in identifying the image and facilitate searches and queries of the database. If it is a pathological lesion, you can copy and paste the description from the comments field in the Pathology Module. If the description of a lesion or taphonomic characteristic is being directly entered into the Pathology / Notes section, be sure to add notes that include key search terms such as, “possible projectile entry wound from gunshot trauma, x-ray for bullet wipe or splatter”.

SPECIAL INSTRUCTIONS: Special instructions are comments that clarify the request to the x-ray technician. They can be used to include right and left bones in the same x-ray exposure to detect asymmetric disuse atrophy or if you want the bones of a joint in the same exposure to compare degrees of subchondral sclerosis.

This introduction to Osteoware should have prepared you for entering data. Instructions for each module represented by the buttons on the Home Screen are given in Chapters 2 to 12, except for the Pathology Module, which is covered in Vol II. The special functions buttons that were not covered in Chapter 1, Add Individuals and Tracking, are included with the Inventory Module in Chapter 2. The last chapter introduces the use of queries to extract data from the database.
Chapter 2: Inventories, Adding Individuals, and Tracking Skeletal Elements
by J. Christopher Dudar

The inventory module and several accessory functions are designed to organize data records for single individuals and commingled remains, including bone lots identified under one catalogue number. The difficulties in organizing data for commingled remains is not explicitly dealt with in the *Standards*. In Osteoware, the key features for managing these data records are:

- Each identifying number, called the Catkey, is linked to a separate Inventory data record.
- Multiple individuals can be documented under the same Catkey by using the *Add Individuals* button.
- Commingled inventory data entry pages can be accessed from within the Inventory Module.
- Data can be collected for the individual skeletal elements in a commingled inventory by using the *Tracking* function.

**Inventories for a Single Individual**

The Inventory Module is opened by double clicking the Inventory button on the Osteoware Home Screen. The module has four data entry screens under the tabs labeled: *Cranium, Axial Skeleton, Appendicular Skeleton, and Hands and Feet* (Figure 2.1). Bones, sections of bones, or groups of bones are listed, and each has an associated box for entering inventory codes. The coding boxes are blank when a record is opened for the first time, and they are left blank when a bone is missing/absent. If the bone is present, the degree of preservation is entered on a scale of 1 to 3, following the *Standards* inventory protocol. The preservation codes are summarized in the lower right corner of the Cranium data entry screen (Figure 2.1).

Elements whose coding differs from the general degree of preservation scale are indicated in turquoise as seen for the “Teeth required” box on the bottom left of the Cranium data entry screen.

*Figure 2.1 Cranium data entry screen of the Inventory Module.*
INVENTORY FOR TEETH: If a value is not entered in the box, you will be prompted to enter a code when you try to save or exit the data record. This is the only inventory box that cannot be left blank. The values entered from 0 to 3 represent:

0 = No teeth present (postmortem loss).
1 = Complete (all teeth present postmortem that were likely present antemortem)
2 = Nearly Complete dentition (some teeth lost postmortem, but > 50% present from the determined antemortem dentition)
3 = Partial Dentition (< 50% of the antemortem dentition is present)

The Inventory Module only provides a general code for teeth to assist in locating Catkeys requiring further dental documentation. Full dental inventories with scoring for antemortem and postmortem loss by individual tooth are entered in the Dental Inv/Dev/Path module.

AXIAL SKELETON: The Axial Skeleton data entry screen is similar to the cranium screen with white boxes for entering the preservation scores for different skeletal elements (Figure 2.2). The turquoise boxes are counts of each element rather than preservation scores. In the final two columns of turquoise boxes, only complete or nearly complete elements (greater than 75% present) are included in the counts.

Figure 2.2 Axial Skeleton data entry screen of the Inventory Module.
APPENDICULAR SKELETON: Data entry for the Appendicular Skeleton is completed is similar to first two screens, but each long bone is divided into sections following the Standards protocols (Figure 2.3).

The box is a shortcut for data entry. Clicking a button will auto-fill the boxes for all sections of an element with the preservation code entered for the fill-in value.

HANDS AND FEET: Data entry for the Hands and Feet is similar to the other screens with preservation scores entered into the white boxes and counts entered into the turquoise boxes for unidentified (Unid.) bones and all phalanges (Figure 2.4). In the final two columns of turquoise boxes, only complete or nearly complete elements (greater than 75% present) are included in the counts.

INVENTORY COMMENTS: The comments box for the Inventory Module is located on the Appendicular Skeleton data entry screen (Figure 2.4). Inventory comments can be directly transferred into the Summary Paragraph Module, and it is standard protocol in the ROL to give a complete written description of the inventory that can be used later for various reports.

An example inventory summary is given below:

The postcranium, partial mandible, and a left maxilla are present. Elements that are nearly complete include the thoracic, lumbar and sacral vertebrae, innominates, femora, left patellae, left tibia, right fibula, bones of the pectoral girdle, the sternum, and many of the hand and foot bones. The right tibia and left fibula are partially complete. The ribs are fragmented but fairly well represented. Two cervical vertebrae are also present.

Reassociation notes should be included in the Inventory Comments and copied into both the donor and recipient catkeys. Give details about the bones reassociated, their original catalogue numbers,
and a justification for the reassociation such as consistent taphonomy, sex, age and morphology. An example reassociation note is given below:

**Reassociation Note:** Several elements of the individual under the catalog number 227211 were reassociated from other catalogue numbers in accession number 42109. The left femur, two cervical vertebrae, and the L5 vertebra were reassociated from catalog number 227003 based on compatible articular surfaces, consistent age indicators, and similarities in size and morphology. The left clavicle was reassociated from catalog number 227001 based on similarities in size and morphology to the right clavicle of the 227211 individual.

**Adding Individuals**

Individuals are added when skeletal elements that clearly represent multiple individual have the same catalogue number, i.e., commingled. The “Add Individual” button on the Osteoware Home Screen creates a unique record by appending a letter to the original CatKey (Figure 2.5). All modules, including inventories, are generated for the new catalogue number and the data is separately documented and stored. Commingled elements can also be documented by entering them under a commingled inventory and then tracking elements that require further documentation (discussed below). The decision on how to enter commingled elements should take into account the archaeological context, the elements represented, and their completeness. At a minimum, one should be reasonably certain that the commingled elements do not belong to another individual from the site before they are added as a separate individual (Figures 2.6). If documentation of the entire site is not complete, commingled elements can be tracked and added later as an individual if they cannot be reassociated. Bone lots, particularly when they are large and curated by element, are complex and how they are entered will depend on the specific circumstances.
Commingled Inventories

Commingled inventories are used when elements are present that do not belong to the main individual of a catalogue number, but they may belong to another individual from the site even though there is not enough evidence for reassociation (Figure 2.7). For bone lots, all elements can be entered into the commingled inventory and the main individual data entry screens can be left blank.

Figure 2.7 Cranial fragments from a multiple burial were commingled because the unfused basilar suture and thickness of the vault were consistent with the remains of two different adolescents from the burial (photo by C. Wilczak).

The Commingled Inventory data entry screens are opened by checking the box on the first screen (Cranium) of the Inventory Module (Figure 2.8). The code box in the lower right corner turns turquoise to indicate you have exited the main Inventory Module and are now in Commingled Inventories. There are four tabs for data entry arranged in the same layout as the inventory screens for the main individual. Note, however, that the numbers entered into the white boxes represent the minimum number of individuals (MNI) and not degree of preservation. For example, if there are six adult clavicles, then a six is entered in the box regardless of whether they are complete or not.

The new data entry screen also has a purple box in the center which is used to access commingled inventory data entry screens for Infant, Subadult, and Adult remains by clicking on the relevant radio button. Data for all three age groups can be entered in succession for a single catalogue number. The red box on the right side of the screen is a reminder of the age group for which you are currently entering data.

Figure 2.8 Commingled data entry screen for Infant remains. Clicking the radio buttons in the purple box gives access to screens for Subadult and Adult remains.
Tracking Commingled Bones

The Tracking function is used for detailed documentation of specific commingled elements. A tracking number is only assigned to a bone when informative data can be collected such as measurements, estimates of age or sex, evidence of pathological conditions, or descriptions of unusual taphonomy (Figure 2.9). To begin tracking, return to the Osteoware Home Screen and click the button in the upper right corner (Figure 2.5). A new screen will open and the first element entered will be assigned the tracking number “1”, which is displayed in the white box at the top right of the tracking screen (Figure 2.10).

TRacked EElEmEnts Data Entry

Tracking screens are contextually driven so the data entry boxes displayed will depend on both the bone and age group selected. Use the arrow to the right of the Bone window at the top left of the Tracking screen to access the bone drop-down menu (Figure 2.10). Scroll through the list until you find the correct bone, then highlight and press Enter to select it. Alternatively, you can type the first letter of the bone name in the window and the list will automatically jump to bones that begin with that letter, e.g., press ‘f’ and the list jumps to Femur. Once the bone name has been correctly entered, fill in the Side (R = right, L = left, M = midline, U = unknown), and Completeness (1, 2, 3 as coded for single individual inventories) fields to the right of the Bone window. The first screen will also display the epiphyses and metrics for the element. Fill in the scores for epiphyseal fusion (see Chapter 3 Age and Sex), or press the button to autofill the epiphysis fields with 2’s. The default for the age group

Figure 2.9 Fragmentary elements from a single catalogue number were entered as commingled. The mandibular molar crown was tracked because dental development and could be documented (photo by C. Wilczak).

Figure 2.10 An empty data entry screen for tracking number 1 (red circle). Adult is selected for the age group using the radio button at the bottom of the screen (yellow) and the bone is selected from the drop-down menu.
radio buttons in the yellow box at the bottom of the screen is Adult, but the relevant measurements for bones with unfused epiphyses will be listed if subadult is selected (Figure 2.11).

In the upper right corner of each of the three tracking data entry pages are buttons for X-ray requests (Xray Req) and Photo requests (Photo Req), as well as Taphonomy and Pathology data entry modules (Figure 2.10). Data entry for tracked elements in these modules follows the same protocol as data entry for the main individual, and detailed instructions for each module can be found in the relevant chapters of this manual.

Like the available Bone Metrics, access to different modules and data tabs are contextual. For example, dental data entry buttons (Dent Morph and Dent Inv) only appear in the upper right hand corner when dentition, mandible, or maxilla is selected from the bone drop-down menu (Figure 2.12). Similarly, if innominate was selected, a data screen tab for entering pelvic morphology would become accessible.

Figure 2.11 The Epiphysis/Metrics of the tracking data entry screen for a subadult femur (yellow box). Compare the subadult Bone Metrics menu to the adult metrics in Figure 2.10.

Figure 2.12 The Epiphysis/Metrics of the tracking data entry screen for a mandible showing Dental Morphology and Inventory buttons are now available.
Summaries Screen

The Summaries screen of the Tracking System is accessed by clicking on the second tab of the Tracking data entry screen (Figure 2.13). Summary Age, Summary Sex, Minimum Age (Min Age), and the Age Unit must be filled in before you can save or exit a data record (see Chapter 3 Age and Sex for complete data entry instructions).

Fields for recording Antimere and Articulating element tracking numbers (Artic. Track Nos) are located in the bottom left corner of the Summaries screen. The example in Figure 2.13 and 2.14 shows a case where the commingled left femur was entered as tracking number 8 and the antimeric right femur was entered as tracking number 7. Note that an ‘8’ would also be entered into the antimere box on the Summary screen for the right femur of tracking number 7. Physically labeling elements with their tracking numbers (Figure 2.14) will enable later association of the bone with its record in the database. Tracking numbers for all articulating elements can be entered into the Artic. Track Nos. box. In Figure 2.13, the articulating elements were tracking numbers 5 (innominate) and 6 (tibia).

There is also a Notes text field for entering comments about the bone documented under the tracking number. Entering complete written summaries in the Notes for each tracked element is useful for identifying potential reassociations or as summaries for site reports.

Figure 2.14 The right and left femurs were tracked as antimeres (see Figure 2.14, photo by C. Wilczak).
Entries Screen
The Entries screen of the Tracking System is accessed by clicking on the third tab of the Tracking data entry screen. Entries will display a table with all the tracking numbers for a given CATKEY in rows and the codes entered for each data field listed in the columns (Figure 2.15). The Notes/Comments for the highlighted record will be shown at the bottom of the screen. Once data for a Tracking number is saved, the button must be clicked to make changes to the record, including modifying the comments or adding an antimere tracking number. If additional elements need to be tracked, click the button and a blank record will open in the Tracking System. The data for each tracking number was saved when you completed the individual tracking records so you may simply close the window from the entries screen to return to the Osteoware Home Screen and access other modules.

Figure 2.15 The Entries data screen with the list of the tracking numbers entered under the Z33344 catkey.
Chapter 3: Age and Sex

by Gwyn Madden

Osteoware provides data entry coding for well-established methods of aging and sexing in an easy-to-use format. The methods employed are briefly discussed in this chapter, but for more information the reader is referred to the many excellent references related to age and sex estimation in the skeleton, e.g., Acsádi and Nemeskéri (1970); Krogman and İşcan (1986); Ubelaker (1989); Bass (1995); Latham and Finnegan (2010).

Several changes have been made to the Standards protocols for documenting age and sex:

- Documentation screens for subadults and adults are merged to ensure complete data collection for each individual.
- For bilateral elements, the greatest degree of epiphyseal fusion is recorded.
- Suture closure scoring is slightly revised for clarity; both sides are scored for bilateral sutures, and fusion of the mental symphysis and metopic suture closure are added.
- The complete six-stage pubic symphysis scoring for the Suchey-Brooks system is used instead of an abbreviated five-stage version (Brooks and Suchey, 1990).
- Several observations for age and sex determination have been added.

Note that age-related changes in the dentition are recorded in the Dental Inventory/Development/Pathology Module and age-related degenerative changes (e.g., arthritis, bone loss) are recorded in the Pathology Module. Measurements used in metric estimates of age or sex are entered in the Craniometrics and Postcranial Metrics modules. All other indicators are documented in the Age and Sex module on four data entry screens: Postcranial Epiphyses, Cranial Sutures, Morphology, and Summary.

**Postcranial Epiphyses**

For each bone on the Postcranial Epiphyses data entry screen, secondary centers of ossification are listed (Figure 3.1). Leave the data box empty if a bone is absent or the epiphysis is not scorable. The code for stage of fusion is entered into the corresponding box: 0 (open), 1 (partial fusion), or 2 (complete fusion). An open epiphysis has total separation of the primary bone and the epiphysis (secondary center of ossification); partial fusion includes any

---

1 All photographs by the author unless otherwise indicated.
bony connection of the epiphysis; and in complete fusion the epiphyseal line is obliterated (Figure 3.2). The side with the highest degree of fusion is scored for paired bones. If the degree of fusion is significantly different between bilateral elements, it can be noted in the Comments field of the Summary screen.

The guidelines that follow for age estimates based on development and fusion of the secondary centers of ossification (epiphyses) are compiled from Scheuer and Black (2004) and Baker et al. (2005) unless otherwise indicated. These works can be consulted for more details along with Fazekas and Kósa (1978) and Scheuer and Black (2000).

**SCAPULA**

Fusion of five secondary ossification centers are scored for the scapula.

**Coracoid:** The coracoid process usually begins ossification during the first year of life (Figure 3.3). It fuses with the subcoracoid epiphysis, which forms the superior portion of the glenoid fossa, around 14–15 years of age. Complete fusion of the coracoid/subcoracoid epiphysis with the scapula is complete by 16–17 years.

**Glenoid (Lateral):** The epiphysis for the lateral glenoid cavity begins to develop between 14–15 years of age, and fusion is complete between 17 and 18 years (Figure 3.4).

**Acromion:** Between 14–16 years of age, the epiphyses begin to develop for the acromion process, with complete fusion occurring between 16 and 25 years (Mann and Hunt, 2005; Figure 3.4). Occasionally, the lateral tip remains unfused throughout life, a non-metric trait known as os acromiale (Mann and Hunt, 2005). The presence of os acromiale should be discussed in the Comments field of the Summary screen.
**Inferior Angle and Medial Border:** Epiphyses for the inferior angle and medial border of the scapula appear between 15 and 17 years of age and complete fusion between 19 and 23 years of age.

**CLAVICLE**

The only independently distinguishable epiphysis of the clavicle is on the medial end and it is scored for degree of fusion (Figure 3.6).

**Medial:** The sternal epiphysis of the clavicle begins to develop as early as 12 years of age or as late as 21 years of age in some individuals (Bass, 1995). Complete fusion is common by 25 years of age (Baker et al., 2005; Bass, 1995) although it may fuse as late as 30 years of age (Buikstra and Ubelaker, 1994).
HUMERUS
At least six secondary centers of ossification are present in the humerus; two are proximal and four are distal. Prior to fusion with the diaphysis, these separate elements fuse together at each location. Thus the epiphyses for the head and greater tubercle are scored as one unit for the proximal humerus, and the capitulum, trochlea, and lateral epicondyle are scored as one unit for the distal humerus. The medial epicondyle of the distal humerus is scored separately from the other distal ossification centers (Figure 3.9).

Proximal Humerus: Ossification of the humeral head usually begins between birth and six months of age (Figure 3.7). By 5–7 years the humeral head will be completely fused to the greater tubercle to form the proximal epiphysis, but fusion has been reported in individuals younger than 3 years of age. Age of complete fusion of the proximal humerus to the diaphysis is normally between 13 and 20 years. Bass (1995) reports late fusion up to 24 yrs. Fusion is earlier for females (13-17) than for males (16-20).

Distal Humerus: By 10–14 years of age, the three distal epiphyses (capitulum, trochlea, and lateral epicondyle) are present and fused to each other. The distal epiphysis is completely fused to the metaphysis between 11 and 17 years of age (Figure 3.8). McKern and Stewart (1957: 44) suggest that complete fusion of the distal humerus can occur as late as 18 years of age. Females typically fuse at earlier ages (11-15) and males at later ages (12-17).

Epicondyle (Medial) Humerus: Appearance of the epiphysis for the medial epicondyle of the humerus does not occur until adolescence. Fusion of this epiphysis occurs earlier in females (13-15) and later in males (14-16). According to McKern and Stewart (1957: 44), complete fusion may not be present until 19 years of age.
RADIUS and ULNA
The radius and ulna have two secondary centers of ossification, proximal and distal, and both are scored (Figure 3.12).

Radius The distal epiphysis of the radius begins ossification around 1–3 years of age, while the proximal epiphysis does not ossify until 5–6 years of age (Figure 3.10). Although ossification begins first distally, fusion begins first at the proximal end of the radius at 11–15 years of age in females and 14–17 years of age in males. The distal end of the radius fuses at 14–17 years of age in females and 16–20 years of age in males.

Ulna: The distal epiphyses appear between five and seven years of age, while the proximal epiphyses appear around eight years of age in females and ten years of age in males (Figure 3.11). Again, as seen in the radius, the proximal epiphysis of the ulna fuses first. Fusion occurs at 12–15 years of age in females and 13–17 years of age in males. The distal epiphyses fuse at 15–17 years of age in females and 17–20 years of age in males.
PELVIS
The three primary centers of ossification for the innominate fuse together at the acetabulum during adolescence and each pair is scored: ilium-pubis, ischium-pubis, and ischium-ilium (Figure 3.13 and 3.15). Epiphyses of the ischial tuberosity and iliac crest are also scored.

**Ischium-Pubis:** The first bones of the ox coxae to fuse are the ischium and pubis between four and eight years of age.

**Ilium-Pubis and Ischium-Ilium:** The fused ischium/pubis fuses to the ilium at 11–15 years of age in females, and 14–17 years of age in males.

**Ischial Tuberosity:** This secondary center of ossification for the ischial tuberosity begins to develop around 13–16 years of age and is fully fused by 20–23 years of age.

**Iliac Crest:** The iliac crest is a long thin epiphysis that has two centers of ossification, one anterior and one posterior, that grow together centrally into a single unit along the superior margin of the ilium (Figure 3.14). Ossification begins between the ages of 12 and 15 years, and fusion is complete by 23 years of age.
SACRUM

Fusion of the sacrum is complex with three to five primary ossification centers per segment and numerous epiphyses (Figure 3.16). Between the ages of two and five years, the separate elements (centrum, neural arches, ala) of S1-S3 begin to fuse, while S4-S5 fuse slightly later at 2–6 years of age. Sacral lamina do not fuse together posteriorly until 7-15 years. Only fusion of the sacral vertebrae to one another are scored in the data entry boxes in Osteoware, but notes on epiphyseal fusions can be added to the Comments field on the Summary screen.

S1 to S5 Fusions: Fusion of the individual sacral vertebrae to one another begins at 12 years of age on the lateral aspect of the inferior elements and moves superiorly. By 20 years of age, the lateral aspects are fused, but complete fusion between the centra does not occur until the mid to late 20’s. Data entry boxes on the Epiphysis data entry screen score each fusion for S1–S2, S2–S3, S3–S4 and S4–S5. When fusion is asymmetric, enter the higher score (Figure 3.18).

Figure 3.16 Composite of S1 elements. Centrum (center); neural arch (left) and ala (right).

Figure 3.17 First sacral vertebrae with complete fusion of the ala (left, score = 2) and incomplete fusion (right, score = 1).

Figure 3.18 Partial fusion (score = 1) of S2 to S5. S1-S2 is open (score = 0) but glued into place. (photo by C. Wilczak)

Figure 3.19 Sacrum with age of fusion between the sacral segments.
FEMUR
Four secondary ossification centers are scored for the femur: proximal femur, greater trochanter, lesser trochanter, and distal femur (Figures 3.20 and 3.21).

Proximal Femur/Head: Ossification begins within the first year of life for the femoral head although it does not reach its characteristic shape until 10–12 years of age. Fusion of the femoral head occurs by 12–16 years of age in females and 14–19 years of age in males.

Greater Trochanter: The greater trochanter appears between one and five years of age, fusion occurs at 14–16 years of age in females and 16–18 years of age in males.

Lesser Trochanter: Between 7 and 12 years of age the lesser trochanter appears, fusing between 16 and 17 years of age in both sexes.

Distal Femur: The distal femur begins to ossify before birth but does not reach its characteristic shape until 3–5 years of age. Fusion of the distal femur occurs at 14–18 years of age in females and 16–20 years of age in males.

Figure 3.20 Femoral shaft with unfused head and distal epiphyses.

Figure 3.21 Femur with age of epiphyseal fusions.
TIBIA and FIBULA

The tibia and fibula have two secondary centers of ossification, proximal and distal, and both are scored.

**Tibia:** The proximal epiphyses appear in utero, while the distal epiphyses ossify during the second year of life (Figure 3.22). Fusion occurs first for the proximal epiphyses of the tibia at 13–17 years of age in females and 15–19 years of age in males. The distal epiphyses fuse at 14–16 years of age in females and 15–18 years of age in males.

**Fibula:** The distal epiphyses appear between one and two years of age, while the proximal epiphyses appear around four years of age in females and five years of age in males (Figure 3.24). Fusion begins at the same age for the proximal and distal epiphyses of the fibula although the proximal end may persist unfused for a longer period. Proximal fusion occurs at 12–18 years of age in females and 15–20 years of age in males, with the distal epiphyses fusing at 12–16 years of age in females and 15–18 years of age in males.
VERTEBRAE

Four areas of fusion are scored for each vertebral region: arch to centrum, superior rim, halves of the arch (lamina), and inferior rim (Figure 3.25 and 3.26; Table 1). Note that fusion is only scored for the typical cervical vertebrae, C3-C7. When fusion is asymmetric, score the higher degree of fusion.

Ossification of the neural arches and centra begins between the second and third fetal month. Fusion commences between the neural arches at the spinous process, beginning in the thoracolumbar border region and moving superior and inferior. The neural arches of the thoracic vertebrae fuse toward the end of the first year of life and into the second, while the neural arches of the cervicals fuse in the second year and the lumbar fuses from the first year for L1 to the fifth year for L5. The next stage of fusion, neural arch to the centrum, begins first in the lumbar vertebrae at age two and in the cervical and thoracic vertebrae by three years of age. By five to six years of age, all vertebrae should display fusion of the neural arches to the centra. Figures 3.24 illustrates various stages of fusion. There are a number of secondary centers of ossification but only the superior and inferior epiphyseal rims are scored (Figure 3.27).
Although fusion varies regionally in the vertebral column, it may commence in the thoracic as early as 14 years in females with fusion complete in all vertebrae by 25–27 years (Albert and Maples, 1995; Scheuer and Black, 2005). If other secondary centers of ossification (e.g. tips of the spinous processes or transverse processes) are used in aging for the vertebrae, discuss the observations in the Comments field on the Summary screen.

### Cranial Sutures

The Cranial Sutures tab is located to the right of the Postcranial Epiphyses tab in the Age and Sex Module (Figure 3.28). Data entry boxes are grouped into sixteen locations for scoring ectocranial sutures, five for endocranial sutures, and eight for palatal sutures. Turquoise boxes for scoring fusion of five primary cranial ossification centers in juveniles are at the center of the screen.

![Figure 3.27 Stages of fusion for the superior epiphyseal ring (rim): unfused (bottom); partial fusion (middle); and full fusion (top).](image)

**Table 1.1 Age of fusion for Vertebrae in Years**

<table>
<thead>
<tr>
<th>Components</th>
<th>Cervical</th>
<th>Thoracic</th>
<th>Lumbar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural Arches</td>
<td>2</td>
<td>1–2</td>
<td>1–5</td>
</tr>
<tr>
<td>Arches to Centrum</td>
<td>3–4</td>
<td>3–6</td>
<td>2–4</td>
</tr>
<tr>
<td>Superior &amp; Inferior Rims</td>
<td></td>
<td></td>
<td>14–27</td>
</tr>
</tbody>
</table>

**Cranial Sutures**

Recording of cranial suture closure differs slightly from the Standards protocol by defining the lower and upper limit of Stage 2 as percent closure. The stages used in Osteoware are 0 = open, no closure; 1 = less than 50% closed; 2 = more than 50% but less than 95% closed; and 3 = completely fused, >95%. If a suture cannot be scored, the data entry box is left blank. The boxes for cranial suture closure in juveniles are turquoise to remind you that they are scored differently than the rest of the screen; they use the same 0 to 2 scale as the postcranial epiphyses.
CRANIAL SUTURE FUSION IN JUVENILES: Fusion of the right and left half of the mandible (mental symphysis) and frontal bone (metopic suture), lateral occipitals to the squama, lateral occipitals to the basi-occipital, and the occipital to the sphenoid (basilar suture) are scored (Figures 3.29 & 3.30). The codes for fusion are 0 = open, 1 = partial fusion, or 2 = complete fusion. For the lateral occipital, the side with the greatest degree of fusion is scored. If fusion is significantly different between the right and left side, it can be noted in the Comments field of the Summary screen. If fusion of a suture cannot be scored, the data entry box should be left blank.

The two halves of the mandible fuse at the symphysis during the first year of life (Baker et al., 2005). While the frontal fuses at the midline between 1 and 4 years in most individuals (Scheuer and Black, 2004), persistence of a metopic suture into adulthood can reach frequencies of greater than 10% in some populations (Mann and Hunt, 2001). The lateral occipitals generally fuse to the occipital squama by 4 years of age and to the basi-occipital by 7 years of age (Baker et al., 2005). Fusion of the basilar suture begins around puberty and completes closure by 16 years of age in most females and by 18 years in most males (Scheuer and Black, 2004).
ECTOCRANIAL SUTURE CLOSURE: Following the protocol of the Standards, ectocranial suture are scored over a 1 cm length surrounding each cranial landmark. There are four midline and six lateral landmark points scored; the latter are scored for both sides. Stages of fusion are illustrated in Figure 3.31 and the approximate locations of the ectocranial landmarks are shown in Figure 3.32. The Standards provides a detailed explanation of the Meindl and Lovejoy (1985) method for estimating age based on ectocranial suture closure, and Nawrocki (1998) has published regression equations that utilize ectocranial, endocranial, and palatal suture closure.

**Figure 3.31** The four stages of cranial suture closure illustrated at obelion.

- 0 = open
- 1 = <50% closure
- 2 = >50% but <95%
- 3 = complete closure

**Figure 3.32** Cranial landmarks for scoring ectocranial suture fusion. Numbers correspond to the following landmarks:

1) midlambdoid
2) lambda
3) obelion
4) anterior sagittal
5) bregma
6) midcoronal
7) pterion
8) sphenofrontal
9) inferior sphenotemporal (see Figure 3.28)
10) superior sphenotemporal
ENDOCRANIAL SUTURE CLOSURE:
One midline (sagittal) and two bilateral sutures (coronal and lambdoid) are scored endocranially. The sutures are scored across the segments recommended in the Standards. For the lambdoid and coronal sutures, the segment definitions follow Acsádi and Nemeskéri (1970) [Figure 3.33].

Sagittal: Full length of the suture.
Coronal: The suture is divided into three equal parts and closure is assessed across the two segments closest to the midline (pars bregmatica and pars complicata).
Lambdoid: The suture is divided into three equal parts and closure is assessed across the two segments closest to the midline (pars lambdica and pars intermedia).

Endocranial sutures can be difficult to see on intact crania, but many times they can be scored by inserting a flexible light through the foramen magnum. If the complete segment is not clearly visible, the data entry box should be left blank.

PALATAL SUTURES: The five sutures of the maxilla scored in Osteoware are the incisive, anterior median palatine, posterior median palatine, transverse palatine, and greater palatine foramen. Scoring is the same as cranial vault sutures: 0 = open, 1 = less than 50% closed, 2 = more than 50% closed but less than 95% closed, and 3 = completely fused, or should be left blank if the sutures can’t be scored. The entire length of each suture should be scored. Figures 3.34 and 3.35 shows suture location and examples of the different stages of fusion for the palate and Table 1.2 gives age range estimates.

Table 1.2 Age of fusion for the maxillary sutures*

<table>
<thead>
<tr>
<th>Suture</th>
<th>Age in yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisive</td>
<td>20-25</td>
</tr>
<tr>
<td>Anterior Median Palatine</td>
<td>50+</td>
</tr>
<tr>
<td>Posterior Median Palatine</td>
<td>25-35</td>
</tr>
<tr>
<td>Transverse Palatine</td>
<td>Lateral 35+/Medial 40+</td>
</tr>
</tbody>
</table>

*after Mann et al. (1991), “fusion” refers to any degree (Scores 1 to 3)
Morphology

Pelvic morphology, cranial morphology, and rib morphology are scored on the Morphology data entry screen of the Age and Sex Module (Figure 3.36). All the methods recommended by the Standards for age and sex estimation are included, but a few observations have been added.

PELVIC MORPHOLOGY: SEX

The observations of pelvic morphology that are related to sex estimation are in the top row of the data entry screen. The locations of the landmarks on the pelvis are illustrated in Figures 3.37. Five of the morphological traits are scored as male, female, or ambiguous (?). Scoring for the remaining two traits is explained in more detail below. Radio buttons allow selection of only one choice for each trait. If a trait is not observable, leave it blank. If you inadvertently select a choice that should be left blank, click on the box for that trait and then press escape (esc) on your keyboard to clear the entry. Side is
not differentiated in recording morphological variation in the pelvis relating to sex. Consider both sides in the evaluation of the trait; if one side is markedly different, make a note of it in the Comments box on the Summary screen.

**Ventral Arc:** On the ventral surface of the pubis, lateral to the pubic symphysis, is an “elevated ridge of bone” that when present indicates female sex (Buikstra and Ubelaker, 1994; Bass, 1995; Figure 3.38). In Osteoware, select the button for male if no arc is present, the button for female if an arc is present, or the “?” button for ambiguous.

**Subpubic Concavity:** The inferior border of the ischio-pubic ramus forms a relatively straight (or slightly convex) line from the pubic symphysis in males and a concave line in females (Buikstra and Ubelaker 1994; Bass 1995). This trait should be viewed from the dorsal aspect. In Osteoware, select the button for male if the border is straight or convex, the button for female if there is concavity, or the “?” button for ambiguous.

**Ischiopubic Ramus Ridge:** Inferior to the pubic symphysis, the ischiopubic ramus displays a broader and flatter medial surface in males and a narrow surface or ridge in females (Buikstra and Ubelaker 1994; Bass 1995). In Osteoware, select the button for male if the ramus is broad and flat, the button for female if it is narrow and ridged, or the “?” button for ambiguous.
Auricular Surface Elevation: Auricular surface elevation is an addition to the observations recommended by the Standards. According to Weaver (1980:192), an elevated surface is defined as “elevated from the ilium along its entire length and along both the anterior and posterior edges of the sacro-iliac surface.” An elevated auricular surface suggests female sex, while a flatter surface suggests male sex (Figure 3.39). In Osteoware, select the button for male if there is no elevation, the button for female if there is elevation present, or the “?” button for ambiguous.

Greater Sciatic Notch Width: Width of the greater sciatic notch corresponds with the greater width of the female pelvis and the narrower male pelvis. The five point scale in the Standards is represented by descriptive statements in Osteoware (Figure 3.40). If the greater sciatic notch is very wide (#1), select definite female, if however, the notch is moderately wide select probable female (#2). A very narrow notch is scored as definite male (#5), while a moderately narrow notch is scored as probable male (#4). If the notch is neither wide nor narrow (#3), select the “?” button for ambiguous.

Figure 3.39  Auricular surface elevation. a) flat surface typical of males; b) elevated surface typical of females (photos by T. Gore)

Figure 3.40  Sex Differences in the Greater Sciatic Notch. Drawing by P. Walker (from Buikstra and Ubelaker (1994) Figure 2, pp. 18, reproduced with permission from the Arkansas Archaeological Survey).
Preauricular Sulcus: According to Bass (1995:210), “The preauricular sulcus is a depression between the sciatic notch and the sacroiliac joint.” A preauricular sulcus is more common in the female pelvis. Following the Standards, the sulcus is scored as absent, wide and deep (more than 0.5 cm, lobular), wide and shallow, narrow and shallow (well defined), and narrow and smooth walled (posterior) [Figure 3.41]. Select the corresponding button for the individual under observation.

Sacral Curvature: Sacral curvature is an addition to the observations suggested in the Standards. View the sacrum with the auricular surface facing you (Figure 3.42). The sacrum is generally more curved in males and flatter in females (Bass 1995). Click on the male button for a curved sacrum and the female button for a flat sacrum. If the sacrum is neither curved nor flat, select the “?” button for ambiguous.

Figure 3.41 Scoring for the Preauricular Sulcus. Drawing by P. Walker (after Milner 1992). (1) over 0.5 cm wide and deep, (2) more than 0.5 cm and shallow, (3) well defined, narrow, and less than .05 cm deep, (4) narrow (less than 0.5 cm wide), shallow, and smooth walled (from Buikstra and Ubelaker (1994) Figure 3, pp. 19, reproduced with permission from the Arkansas Archaeological Survey.).

Figure 3.42. Comparison of sacral curvature. a) curved sacrum typical of males; b) flat sacrum typical of females.
CRANIAL MORPHOLOGY: SEX

The focus of this section is on the morphological features of the skull used in estimating sex. While measurements can be useful in determining sex, cranial measurements can be used for other analyses, so they are recorded in a separate Craniometrics Module.

The six data entry boxes in the middle of the Morphology data entry screen in the Age and Sex Module correspond to the cranial features recorded (Figure 3.43). They are the same features as recommended in the Standards protocol but glabella and the supraorbital ridge are scored separately. Enter a score into each box on a scale of 1 to 5, where 1 represents the most gracile (female) condition and 5 the most robust (male) condition. Clicking in a box will bring up the line drawings from the Standards for that feature (Buikstra and Ubelaker, 1994; Figure 4, pp. 20), which were based on the work of Acsádi and Nemeskéri (1970). Consider both sides in the evaluation of each feature; if one side is markedly different, make a note of it in the Comments field on the Summary screen. If a feature is unobservable, leave the corresponding box blank.

Unlike pelvic morphology, expression of sexual dimorphism in the skull varies markedly between populations (Buikstra and Ubelaker 1994), so the scores are not designated as male or female a priori. Familiarity with the morphological variation of the population under study is important if cranial features are used in the final sex estimation on the Summary screen.

Figure 3.43 a) male and b) female skull. The morphological features scored for sex estimation are labeled (photos by C. Wilczak).
PELVIC MORPHOLOGY: AGE
The pubic symphysis, auricular surface, and sternal rib ends are scored for use in age estimation.

*Pubic Symphysis:* Morphological observations are recorded for the left and right pubic symphyses based on the Todd (1920, 1921) and Suchey-Brooks (Brooks and Suchey, 1990) methods of age estimation. The two systems will not be discussed in detail, but in general a younger individual will display a system of hills and valleys (billows) on the pubic symphyses, as middle age approaches the symphyses begin to flatten and develop defined margins, and in older individuals the symphyses exhibit a breaking down of the definition of the margins and an increase in irregular ossification (Figure 3.44). For more details, the original publications should be consulted. Casts of each stage for both methods are available from France Casting (www.francecasts.com).

In Osteoware, enter the phase for both the left and right pubic symphysis in the data boxes under Pelvic Morphology, phases 1 to 6 for Suchey-Brooks and phases 1 to 10 for Todd. Leave the box blank if the symphysis is missing or not scorable.

*Auricular Surface:* Similar to the pubic symphyses, age-related morphological change has been documented for the auricular surface of the innominate. The features used in scoring are illustrated in Figure 3.45. A phase from 1 to 8 should be entered into the data entry box for both the right and left side following the methodology of Lovejoy et al. (1989). If an auricular surface is not observable, leave the data entry box blank. Lovejoy et al.’s (1989) summary description of “paramount” changes associated with each phase and examples of the auricular surfaces for known age individuals follows. However, to accurately assess the correct phase, the details of the methodology from the original publication should be consulted.
Young Adult
Phase 1: Billowing and very fine granularity (20–24 yrs).
Phase 2: Reduction of billowing, but retention of youthful appearance (25–29 yrs).

Young to Middle Adult
Phase 3: General loss of billowing, replacement by striae, and distinct coarsening of granularity (30–34 yrs)
Phase 4: Uniform coarse granularity (35–39 yrs)

Figure 3.46 Auricular surface of individual 18 years of age (photo by T. Gore).

Figure 3.47 Auricular surface of individual 31 years of age (Photo by T. Gore).
Middle Adult
Phase 5: Transition from coarse granularity to dense surface; this may take part over islands of the surface of one or both faces (40–44 yrs)

Phase 6: Completion of densification with complete loss of granularity. (44–49 yrs)

Older Adult
Phase 7: Dense irregular surface or rugged topography and moderate to marked activity in periauricular areas (50-59 yrs).

Phase 8: Breakdown with marginal lipping, macroporosity, increased irregularity, and marked activity in periauricular areas (60+).

Figure 3.48 Auricular surface of individual 41 years of age (photo by T. Gore).

Figure 3.49 Auricular surface of individual 54 years of age (photo by T. Gore).
RIB MORPHOLOGY: AGE

Sternal rib ends are not scored for age estimation in the Standards, but they were added to Osteoware as an additional aging technique. Phase assessment follows the methods of İşcan and colleagues (İşcan et al., 1984, 1985, 1987; İşcan, 1991). Although ribs are among the most fragile portions of the skeleton, there may be cases where other regions used for aging cannot be reliably scored, and increasing the number of aging techniques may improve skeletal age estimates in well-preserved remains. In Osteoware, the number of the rib observed is recorded in a data entry box and should be preferentially scored on the right side (Figure 3.34). While the methodology was developed using the right fourth rib, it may not be present or not identifiable in all cases. Research has shown phasing of ribs 3 through 9 does not differ significantly from rib 4 and can be used with caution (Dudar, 1993; Yoder et al., 2001). Yoder et al. suggest a composite phasing when rib 4 is not available. If the number of the rib cannot be determined, the data entry box can be left blank and the estimate of rib number, e.g., likely 4 to 6; right or left side; and use of a single rib versus a composite method for phase assessment can be entered into the Comments field on the Summary screen.

A brief overview of age associated changes in rib morphology is given below. For correct phase assessment, the original publications should be consulted for more details. Note that there are separate descriptions and age ranges for males and females as well as population-specific differences.

Juvenile to Late Teens
Phase 0, 1: The rim is smooth and rounded or slightly wavy. The surface is billowy or flat with a transition to initial pit formation (Figure 3.50).

Young Adult
Phase 2, 3, 4: Rim still smooth and rounded but transition from scalloping of edge through a loss of scalloping and beginning irregularity. The walls may show some thinning. A v-shaped pit forms on the surface, transitioning to a deeply flared V or narrow U-shape (Figure 3.51).
Middle Adult

Phase 5, 6: Sharper, irregular rim with no scallops and thinner walls, bony projections first appear. The floor of the pit begins to deteriorate with porosity and plaque-like deposits possible in females (Figure 3.52).

Older Adult

Phase 7, 8: Rim irregular with bony projections increasingly pronounced. In later stages “windows” may form in the walls. Pit deep, wide, and U-shaped but may become filled with bony projections. Bone quality markedly decreased (Figure 3.53).

Summary

The final tab on the Age and Sex data entry screen is the Summary screen (Figure 3.54). In the Summary Age box, there are a number of predetermined selections for age. After the first year, the age categories are in approximately five year intervals through the teens with 15 year intervals for young and middle adults. Individuals over 50 are grouped in a single category. In some cases, it is necessary to use the generic subadult, adult, or unknown designations when too little information is present on the skeleton to obtain a more specific age. A Summary Age must be selected or you will not be able to save the data.
The Minimum Age and Maximum Age data entry boxes allow for more specific ages or age ranges that overlap the predefined categories to be entered for the individual. The system will not allow you to save the information entered in the Age and Sex Module without entering a minimum age in the appropriate box. The exception is when Unknown age is selected; in this case, data can be saved without entering a minimum age. The Maximum Age data entry box may be left blank. For example, an individual that is estimated to be an adult with no definitive age range may have a minimum age entry of 20 years with no maximum age entry. Once the Minimum Age and Maximum Age data entry boxes have been completed, select one of the time/developmental indicators from the drop-down menu: years, months, intrauterine months, or intrauterine weeks.

The Summary Sex selections correspond to the overall sex assessment categories recommended by the Standards. It is suggested that definite male and definite female should only be selected when the pelvis is present because it has higher accuracy then the cranial indicators. Individuals with indicators for both male and female are classified as ambiguous. If there is too little information available for sex estimation, the indeterminate button should be selected. When assigning sex for a juvenile, select indeterminate when the morphology suggestive of sex has not yet developed.

Notes regarding the observations related to ages and sex estimation can be recorded in the searchable text of the Comments field. Added comments can be automatically copied into the Summary Paragraph (Chapter 12). Detailed comments should focus on the data observations from this module and any auxiliary information used in age or sex assessment that is not covered by the defined fields such as gonial eversion. Degenerative changes, dental development, and other methods used for determining age should be discussed in the summary sections for Pathology and Dental Inventory/Development/Pathology. However, information related to age and sex from all of the relevant data entry screens should be briefly summarized for a holistic age and sex estimate. If information is later collected in other modules that influences Summary Sex, Summary Age, or Minimum Age, it is recommended that you return to this module to revise your estimations. This insures that queries based on the Summary Age and Sex data fields will return the correct information.
Photographs of morphological indicators (pubic symphysis, auricular surface and sternal rib ends) used for age estimation are highly recommended. You can note presence or absence of photographs, type of media (e.g. digital), and storage location of photographs in the Comments box. In future versions of Osteoware, we hope to incorporate a method to directly link digital media to the relevant data records.

Remember, after you enter new information into the Age and Sex Module, you will need to click the [Save] button on the Summary tab. If you do enter data and forget to save before attempting to exit the module, a prompt will come up reminding you to save the data. Before you can save information and exit the Age and Sex Data Entry screen, you will also be prompted to add a Summary Age, Summary Sex, and Minimum Age if any of these has been left blank. If you do select the button or [Cancel] the close window [X] icon without saving, you will lose any new information that has been entered.
Chapter 4: Taphonomy
by Claire O’Brien
Chapter 5: Postcranial Metrics
by Dawn Mulhern

The Postcranial Metrics Module has data entry screens for skeletally immature and mature individuals. Changes from the Standards recommendations consist of additional adult measurements.

- For paired bones, measure right and left sides when possible.
- Addition of vertebral body measurements.
- Addition of metacarpal and metatarsal length measurements.
- Additional measurements for the scapula, humerus, radius, ulna, femur, and tibia.

With the added measurements, stature can be estimated using the Fully method when remains are complete or nearly complete (Fully, 1956; Raxter et al., 2006; Raxter et al., 2007; Auerbach 2011).

Opening the Module
Selecting the Postcranial Metrics Module button on the Osteoware Home Screen opens a pop-up window that prompts you to select data entry for either immature or adult remains (Figure 5.1). Choose a radio button and click “Go” to access the appropriate data entry screens. Although the adult choice indicates that all epiphyses should be united, you may choose to select adult when only a few epiphyses are unfused.

Measurements for a data record (catkey or individual) can only be entered as either immature or adult, not both. If you select the wrong skeletal maturity category, you must reset the module for that catkey by right clicking on the Postcranial Metrics button from the Home Screen. From the pop-up menu, select Clear for new data entry (Figure 5.2). Any data already entered into the module will be lost when this selection is made.

Data Entry: Adult
Adult measurements are distributed across three data entry screens, which are accessed by clicking on the tabs at the top of the page (Figure 5.3). Both left and right side bones should be measured when possible. The default for sided ele-
ments is “L” so all data entry rows will be set for the left side when the screens are first accessed. The button above the side field is used to switch to measurements for the antimer. Note that the side field turns turquoise when “R” is selected for data entry.

Measurements are recorded to the nearest millimeter. If a value is entered that is not within the typical range for that measurement, a pop-up window warning will prompt the user to check the entered value (Figure 5.4). Clicking on the “No” button returns the user to the data entry box to correct the error. Clicking on “Yes” will enter the value into the database. Bones affected by pathological changes or with minimal postmortem damage should be measured. These measurements can be entered into the main screen or the comments text box, but in both cases the conditions affecting the measurements should be clearly noted in the comment field. Include the keyword “estimate” in the comments so these measurements can be identified or filtered in a data query.

IMPORTANT: Once data entry for Postcranial Metrics is complete, you must click on the green Save button to exit the module (Figure 5.5). Clicking the cancel or exit window button will delete all entered data.

**Measurements: Adult**

The adult measurements defined below are from Zobeck (1983), Bass (1987), and the Standards (1994). The latter follow Moore-Jansen et al. (1994). Measurements for vertebral body heights and ankle height (Fully, 1956) as well as metacarpal and metatarsal lengths are also included. Corresponding measurement numbers from the Standards are identified when applicable.

---

Figure 5.3 First data entry screen; Clav, Scap, Hum, Rad.

Figure 5.4 Pop-up window warning for suspect measurements.

Figure 5.5 Third data entry screen; Tib, Fib, Calc. Click on the Save button before exiting (blue arrow). Clicking on the close window X or the Cancel button (red arrows) will erase all data for that record.
CLAVICLE

1. **Maximum Length**: (Osteometric board) Maximum distance between the lateral and medial extremities. Place the sternal end of the clavicle against the fixed end of the osteometric board and press the movable upright against the acromial end. Move the bone from side to side and up and down until the maximum length is obtained. *Standards Manual #35.*

2. **Anterior-posterior Diameter of the Midshaft**: (Sliding caliper) Determine the midpoint of the diaphysis on an osteometric board and mark it with a pencil. Measure the distance from the anterior to the posterior surface of the midshaft. *Standards Manual measurement #36.*

3. **Superior-inferior Diameter of Midshaft**: (Sliding caliper) The distance from the cranial to the caudal surface of the midshaft. *Standards Manual #37.*

SCAPULA

4. **Maximum Height**: (Sliding caliper) The maximum straight line distance from the superior to the inferior border. *Standards Manual #38.*

5. **Maximum Breadth**: (Sliding caliper) From the middle of the dorsal border of the glenoid fossa to the spinal axis on the vertebral border. This last landmark can be defined by marking a line on the triangle formed by the vertebral border and the two ridges of the spine at a point that divides it into two equal halves. *Standards Manual #39.*

6. **Spine length**: (Sliding caliper) From the end of the spinous axis on the vertebral border to the most lateral point of the acromion process.

7. **Supraspinous line length**: (Sliding caliper) From the end of the spinous axis on the vertebral border to the tip of the inferior angle.
8. *Infraspinous line length*: (Sliding caliper) From the end of the spinous axis on the vertebral border to the tip of the inferior angle.

9. *Glenoid cavity breadth*: (Sliding caliper) Taken at a point just below the constriction of the ventral border. Measured across the breadth of the glenoid cavity from the ventral to the dorsal margin.

10. *Glenoid cavity height*: (Sliding caliper) Taken from the superior to the inferior margin of the glenoid cavity, being sure that the measurement is taken perpendicular to the glenoid cavity breadth.

11. *Midglenoid to inferior angle length*: (Sliding caliper) Taken from the middle of the glenoid cavity to the inferior angle.

**HUMERUS**

12. *Maximum length*: (Osteometric board) Place the head against the fixed vertical end of the board and adjust the moveable upright to the distal end. Raise the bone slightly and move it up and down as well as from side to side until the maximum length is obtained. *Standards manual # 40.*

13. *Proximal epiphyseal breadth*: (Osteometric board) Widest distance across the upper epiphysis; include the greater tubercle.


16. *Maximum head diameter:* (Sliding caliper) Taken from a point on the edge of the articular surface of the bone to the opposite side. The bone is rotated until the maximum distance is obtained. *Standards Manual #42.*


18. *Minimum circumference:* (Metal tape) The minimum diameter is located approximately on the second third of the shaft, distal to the deltoid tuberosity.

**RADIUS**

19. *Maximum length:* (Osteometric board) Maximum length from the head to the tip of the styloid process. The head is placed against the fixed vertical end of the board and the movable upright is adjusted to the distal end. Bone is raised slightly and moved up and down and from side to side until the maximum length is obtained. *Standards Manual #45.*

20. *Maximum head diameter:* (Sliding caliper) Taken from a point on the edge of the articular surface of the bone to the opposite side. The bone is rotated until the maximum distance is obtained.


*Figure 5.11 Radius Measurements #19 to 22.*
ULNA


24. *Physiological length:* (Spreading caliper) The two measuring points are the deepest point in the longitudinal ridge running across the floor of the semilunar notch and the deepest point of the distal surface of the head, not including the groove between the head and the styloid process. *Standards manual # 51.*

![Figure 5.12 Ulna Measurements #24 to 30.](image)

25. *Maximum breadth of the trochlear articular surface:* (Sliding caliper) Measured from the medial and lateral margins of the trochlear articular surface at its greatest breadth.

26. *Minimum breadth of the trochlear articular surface:* (Sliding caliper) Measured from the medial and lateral margins of the articular surface of the olecranon process where the constriction on the medial margin becomes apparent.

27. *Olecranon process anterior-posterior length:* (Sliding caliper) Measured in an anteroposterior direction from the anterior most portion of the olecranon process to the posterior most portion.

28. *Anterior-posterior diameter of the shaft:* (Sliding caliper) The maximum diameter of the diaphysis where the crest exhibits the greatest development. *Standards Manual #49.*

29. *Medial-lateral diameter of the shaft:* (Sliding caliper) The diameter measured perpendicular to the anterior-posterior diameter at the level of greatest crest development. *Standards Manual #50.*


![Figure 5.13 Ulna Measurement #27.](image)
SACRUM

31. Anterior height: (Sliding caliper) The distance from a point on the promontory positioned in the midsagittal plane to a point on the anterior border of the tip of the sacrum measured in the midsagittal plane. Standards Manual #53.

32. Anterior-superior breadth: (Sliding caliper) The maximum transverse breadth of the sacrum at the level of the anterior projection of the auricular surfaces. Standards Manual #54.

33. Maximum breadth of S1: (Sliding caliper) The direct distance between the two most laterally projecting points on the sacral base measured perpendicular to the midsagittal plane. Standards Manual #55.

INNOMINATE

34. Innominate height: (Osteometric board) The distance from the most superior point on the iliac crest to the most inferior point on the ischial tuberosity. Place the ischium against the fixed vertical end and press the moveable upright against the iliac crest. Move the ilium sideways and up and down to obtain the maximum distance. Standards Manual #56.

35. Iliac breadth: (Spreading caliper) The distance from the anterior-superior iliac spine to the posterior-superior iliac spine. This measurement is not necessarily identical to the maximum breadth of the ilium as taken with an osteometric board. Standards Manual #57.
36. *Pubis length*: (Sliding caliper) The distance from the point in the acetabulum where the three elements of the innominate meet to the upper end of the pubic symphysis. The measuring point in the acetabulum can be identified by: 1) an irregularity in the acetabulum and inside the pelvis; 2) a change in thickness which may be seen by holding the bone up to a light; or 3) by the presence of a notch in the border of the articular surface in the acetabulum. In measuring the pubis, care should be taken to hold the caliper parallel to the long axis of the bone. *Standards Manual #58.*

37. *Ischium length*: (Sliding caliper) The distance from the point in the acetabulum where the three elements forming the innominate meet to the deepest point on the ischial tuberosity. Ischium length should be measured approximately perpendicular to the pubis length. *Standards Manual #59.*

**FEMUR**

38. *Maximum length*: (Osteometric board) Place the most inferior point of the medial condyle against the fixed vertical end of the board and slide the movable upright to the head. Raise the bone slightly and then move up and down and side to side until the maximum length is obtained. *Standards Manual #60.*

39. *Bicondylar (physiological) length*: (Osteometric board) Place both condyles in contact with the fixed vertical end of the board, adjust the movable end so it is parallel to the foot board and tangent to the head. *Standards Manual #61.*

40. *Trochanteric length*: (Osteometric board) The greatest distance between the top of the greater trochanter and the lateral condyle.
41. **Subtrochanteric anterior-posterior diameter:** (Sliding caliper) Taken on the shaft just below the lesser trochanter with the gluteal tuberosity avoided. *Standards manual #64.*

42. **Subtrochanteric medial-lateral diameter:** (Sliding caliper) Taken at the same level as the anterior-posterior diameter and perpendicular to it. *Standards Manual #65.*

43. **Midshaft anterior-posterior diameter:** (Sliding caliper) Locate the midshaft point on an osteometric bone and mark the bone with pencil. Measure the maximum anterior-posterior diameter. *Standards Manual #66.*

44. **Midshaft medial-lateral diameter:** (Sliding caliper) Taken at right angle to the anterior-posterior diameter. *Standards Manual #67.*

45. **Vertical head diameter:** (Sliding caliper) The greatest head diameter in the vertical plane passing through the axis of the neck.

46. **Horizontal head diameter:** (Sliding caliper) The maximum diameter at right angle to the vertical head diameter.

47. **Lateral condyle, anterior-posterior diameter:** (Sliding caliper) The projected distance between the most posterior point on the lateral condyle and the lip of the patellar surface taken perpendicular to the axis of the shaft.

48. **Medial condyle, anterior-posterior diameter:** (Sliding caliper) The projected distance between the most posterior point on the medial condyle and the lip of the patellar surface taken perpendicular to the axis of the shaft.

49. **Epicondylar breadth:** (Spreading caliper) Measured across the most outstanding points of the patellar surface taken perpendicular to the axis of the shaft. *Standards Manual # 62.*

50. **Neck minimum vertical diameter:** (Spreading caliper) The minimum vertical diameter of the neck.
51. Midshaft circumference: (Metal tape) The circumference measured at the midshaft at the same level as the anterio-posterior and medio-lateral diameters. If the linea aspera exhibits a strong projection that is not evenly expressed across a larger point of the diaphysis, then this measurement is recorded approximately 10 mm above the midshaft. *Standards Manual #68.*

TIBIA

52. Lateral condylo-malleolar length: (Osteometric board) Place the tip of the malleolus against fixed vertical wall of the osteometric board with the bone resting on its dorsal surface. The long axis should be as parallel as possible to the long axis of the board. Slide the movable upright to the most prominent part of the lateral half of the lateral condyle. *Standards manual #69.*


55. Anterior-posterior diameter at the nutrient foramen: (Sliding caliper) Maximum anterior-posterior diameter of the shaft at the nutrient foramen. *Standards Manual #72.*

56. Medial-lateral diameter at the nutrient foramen: (Sliding caliper) Maximum transverse diameter at a right angle to the anterior-posterior diameter. *Standards Manual #73.*

57. Position of the nutrient foramen: (Sliding caliper) Measured from the top of the lateral intercondylid eminence to the most distal point of the foramen.

58. Circumference of the nutrient foramen: (Metal tape) The circumference measured at the level of the nutrient foramen. *Standards Manual #74.*

![Figure 5.21 Tibia Measurements #52 to 58.](image-url)
FIBULA


60. Maximum diameter at midshaft: (Sliding caliper) The maximum diameter is most commonly located between the anterior and lateral crests. Find the midpoint on the osteometric board and mark with a pencil. Place the diaphysis of the bone between the two branches of the caliper while turning the bone to obtain the maximum diameter. Standards Manual #76.

CALCANEUS

61. Maximum length: (Sliding caliper) The distance between the most posteriorly projecting point on the tuberosity and the most anterior point on the superior margin of the articular facet for the cuboid. The measurement is taken in the sagittal plane and projected onto the underlying surface. Standards Manual # 77.

62. Middle breadth: (Sliding caliper) The distance between the most laterally projecting point on the dorsal articular facet and the most medial point on the sustentaculum tali. The two measuring points lie at neither the same height nor in a plane perpendicular to the sagittal plane. Accordingly, the measurement is projected in both dimensions. Span the calcaneus from behind with the square branches of the caliper so that the stem of the instrument is positioned in a flat and transverse plane across the bone. Standards Manual # 78.
VERTEBRAE

63. Anterior vertebral height, C2-L5, supernumerary, S1 (Sliding caliper): The maximum height of the anterior vertebral body. Note this is usually at the anterolateral corner and not on the midline. For C2, the measurement includes the dens.

ANKLE

64. Ankle height: (osteometric board): Height of the articulated talus and calcaneus. Raxter et al. (2006, pp. 382) describe the measurement as follows: “Place the trochlea against the stable end of the osteometric board, with both lateral and medial edges of the trochlea contacting the board. Position the trochlea of the talus so that the stable end of the board forms a tangent to the midpoint of the trochlear surface. Place the mobile end of the osteometric board against the most inferior point of the calcaneal tuber, parallel to the stable end.”

METACARPALS (1-5)

65. Metacarpal Maximum length (Sliding caliper): Maximum length of each metacarpal.

METATARSALS (1-5)

66. Metatarsals Maximum Length: (Sliding caliper) Maximum length of each metatarsal.
Data Entry: Subadult (Immature)
Subadult cranial and postcranial measurements are found on three data entry screens that are accessed by clicking on the tabs at the top of the page (Figures 5.28–5.30). Both left and right sides should be measured when possible, and measurements are recorded to the nearest tenth of a millimeter.

IMPORTANT: Once data entry is complete, you must click on the green Save button to exit the module. Clicking cancel or the exit button will delete all entered data.

Measurements: Subadult
The subadult cranial measurements should be used for fetal remains and infants under 1 year of age. These measurements are modified in the Standards from Fazekas and Kósa (1978). Postcranial measurements are intended for individuals younger than 18 years with unfused epiphyses. The only exceptions are width measurements for the ilium and ischium, which are only for individuals younger than 1 year of age. For long bones, if one epiphysis is united, the bone should be measured by approximating the end of the diaphysis on the fused end. In this case, indicate which epiphyses are fused in the comment field and include the keyword “estimate.” All subadult cranial and postcranial measurements are taken with a sliding caliper.
Cranial Measurements

SPHENOID

1. Lesser Wing of the Sphenoid
   a. **Length**: Distance from the lateral tip of the lesser wing to the midline of the synchondrosis intersphenoidialis. In very young fetuses, measure the distance between the tip and the medial end of the lesser wing. *Standards Manual #1a.*
   b. **Width**: Greatest width of the lesser wing measured across the optic canal. *Standards Manual #1b.*

2. Greater Wing of the Sphenoid
   a. **Length**: Greatest distance between the medial pterygoid plate and the lateral tip of the greater wing. *Standards Manual #2a.*
   b. **Width**: Greatest distance between the sphenoidal spine and the anterior end of the pterygoid plate. *Standards Manual #2b.*

3. Body of the Sphenoid
   a. **Length**: Distance measured in the midline between the synchondrosis intersphenoidalis (raised ridge) and synchondrosis spheno-occipitalis. *Standards Manual #3a.*
   b. **Width**: Greatest distance measured transversely in the plane of the middle part of the hypophyseal fossa. *Standards Manual #3b.*

TEMPORAL BONE

4. Petrous and Mastoid Portions of the Temporal Bone:
   a. **Length**: Greatest distance between the apex of the petrous part and the superior-posterior end of the mastoid part. *Standards Manual #4a.*
   b. **Width**: Greatest distance measured in the vertical plane on the posterior surface of the petrous bone across the arcuate eminence. *Standards Manual #4b.*

OCCIPITAL BONE

5. Basilar Part of the Occipital
   a. **Length**: Distance measured in the sagittal plane between the foramen magnum and synchondrosis spheno-occipitalis. *Standards Manual #5a.*
   b. **Width**: Greatest distance perpendicular to the length. *Standards Manual #5b.*
ZYGOMATIC BONE

6. Zygomatic Bone
   a. Length: Distance between the anterior end of the infraorbital margin (marginal process) and the posterior end of the temporal process. Standards Manual #6a.
   b. Width: Distance between the anterior end of the infraorbital margin (marginal process) and the frontosphenoidal process. Standards Manual #6b.

MAXILLA

7. Maxilla:
   a. Length: Distance between the anterior nasal process and posterior border of palatal process in the sagittal plane. Standards Manual #7a.
   b. Width: Distance measured between the posterior end of the palatal process (intermaxillary suture) and the end of the zygomatic process. Standards Manual #7b.
   c. Height: Distance between the anterior alveolar part and the frontal process measured in the vertical plane. Standards Manual #7c.

MANDIBLE

8. Mandible
   a. Length of Body: Distance from the tuberculum mentale to the ipsilateral angle. Standards Manual #8a.
   c. Full Length: Distance between the tuberculum mentale and the articular condyle. Standards Manual #8c.
Postcranial Measurements

SHOULDER GIRDLE

9. Clavicle

10. Scapula
    a. Length: Distance between the superior and inferior angles of the scapula. Standards Manual #10a.
    b. Width: Distance between the margin of the glenoid fossa and the medial end of the spine. Standards Manual #10b.
    c. Length of Spine: Distance between the medial end of the spine and the tip of the acromion. Standards Manual #10c.

ARM

11. Humerus

12. Radius

13. Ulna
**INNOMINATE**

14. *Ilium*
   b. *Width*: Distance between the middle part of the iliac crest and farthest point on acetabular extremity. This measurement is for infants < 1 year only. *Standards Manual #11b.*

15. *Ischium*
   b. *Width*: Greatest distance of the acetabular portion. This measurement is for infants < 1 year only. *Standards Manual #12b.*

16. *Pubis*

**LEG**

17. *Femur*

18. *Tibia*

19. *Fibula*
Chapter 6: Cranial Non-metrics

by

---

Volume I 63
Chapter 7: Dental Inventory/Development/Pathology
by Erica B. Jones and J. Christopher Dudar
Chapter 9: Macromorphoscopics
by Joseph T. Hefner

Establishing peer-perceived ancestry is one part of the biological profile constructed from human skeletal remains. Traditionally, this has been accomplished through the visual inspection of certain morphological, nonmetric variants of the skull, primarily from bony structures in the midfacial skeleton. Ousley and Hefner (2005) termed these traits ‘macromorphoscopic’. Macromorphoscopic traits are the cranial nonmetric traits used in forensic anthropological research and many of them can be considered quasi-continuous variables of the cranium reflected as soft-tissue differences in the living. In a sense, macromorphoscopic variables fall under Brues’ (1958) second class of traits, which “due to the contour of bone in areas where it closely follows the surface are apparent in both skeleton and living” (Brues 1958). These traits are subdivided into five classes: 1) assessing bone shape (e.g., nasal bone structure); 2) bony feature morphology (e.g., inferior nasal aperture morphology); 3) suture shape (e.g., zygomaticomaxillary suture); 4) presence/absence data (e.g., post-bregmatic depression); and, 5) feature prominence/protrusion (e.g., anterior nasal spine) (Hefner 2009).

When assessing ancestry from an unknown set of skeletal remains, rather than relying on typological trait lists that supposedly typify the skull of an individual derived from a specific ancestral group, *sensu* Rhine (1990), a better approach involves focusing on individual traits (characters) and the variable expression of those traits (character states) within a given population. The need to maintain a consistent scoring structure between observers, and thus reduce subjectivity, has lead Hefner (2009) to define and improve standards for many of these variants. The scoring system developed by Hefner (2007, 2009) has proven useful for assessing ancestry in forensic contexts.

---

*Figure 9.1 Macromorphoscopic traits of the cranium.*

---

1 All photographs by the author
The Osteoware Macromorphoscopics module is the latest module added to the program and the traits scored are not part of the Standards. Through detailed descriptions, and the presentation of multiple illustrations, the module provides invaluable assistance on scoring each of the 16 traits listed in Hefner (2009). Each trait definition is provided along with individual character states and line drawings. Collecting macromorphoscopic data in Osteoware is a menu-driven process designed to decrease observer error and idiosyncratic interpretation of trait states. The end user of Osteoware will find each of these features to be a convenient and practical method for collecting macromorphoscopic trait data.

**Data Entry**

For each cranium, up to 16 traits can be scored (Figure 2). A detailed definition for each trait is provided in the box located on the bottom, right side of the data entry screen. These definitions describe the trait and any special requirements or tools for assessing the individual character states. For example, when assessing the nasal bone contour (NBC), a contour gauge is used to reduce subjectivity, but the precise implementation of that tool is described in detail in the trait definition box. The individual character states are also defined in detail. These can be found beneath the line drawing box and trait name. For example, in Figure 2 an inferior nasal aperture score of ‘5’ is defined as “5 = A pronounced ridge (nasal sill) obstructing the nasal floor-to-maxilla transition.”

The appropriate character state is selected using either the computer mouse or the computer keyboard. In the data box, the user can scroll through the various character states of each trait using the left and right arrow keys. This is helpful for considering the full range of variability for each trait. Once the appropriate score is located, the user presses ENTER to record the trait and advance to the next screen. For unobservable traits (e.g., damaged, obliterated, pathological), the data box is left BLANK and a note can be added in the field.

If an incorrect value is collected—for instance when an unobservable trait is accidentally recorded—reselect the trait and press DELETE to make the score blank and advance to the next trait.

---

**Figure 9.2 The Inferior Nasal Aperture (INA) data entry screen.** Note that all trait descriptions, as well as oblique and cross-sectional illustrations, change to reflect the active score of the trait; in this example a score of 5 is selected.
Macromorphoscopic Traits

All 16 traits are outlined below. The trait and character state definitions are drawn directly from the Osteoware user interface; however, rather than repeating the line drawings presented in the program, illustrative photographs are provided. These photographs are not meant to replace the line drawings. Rather, they serve as examples of the wide range of variability in trait expression that has been observed. Scores are provided in the figure caption.

ANTERIOR NASAL SPINE (ANS), Figure 9.3: The anterior nasal spine is scored progressively as slight, intermediate, and marked. 1 = Slight - minimal-to-no projection of the anterior nasal spine beyond the inferior nasal aperture; 2 = Intermediate - a moderate projection of the anterior nasal spine beyond the inferior nasal aperture; 3 = Marked - a pronounced projection of the anterior nasal spine beyond the inferior nasal aperture.

INFERIOR NASAL APERTURE (INA), Figure 9.4: Inferior nasal aperture (INA) is an assessment of the shape of the inferior border of the nasal aperture just lateral to the anterior nasal spine, which defines the transition from nasal floor to the vertical portion of the maxillae. Bilateral asymmetry may occur. If so, the left side is used. The morphology of INA ranges from an inferior slope with no delineation of the inferior border (1) to a sharp, vertical ridge of bone, or nasal sill (5). 1 = An inferior sloping of the nasal floor which begins within the nasal cavity and terminates on the vertical surface of the maxilla, producing a smooth transition. The morphology is distinct from INA 2 regarding the more posterior origin and the greater slope of INA 1; 2 = Sloping of the nasal aperture beginning more anteriorly than in INA 1, and with more angulation at the exit of the nasal opening; 3 = The transition from nasal floor to the vertical maxilla is not sloping, nor is there an in-
tervening projection, or sill. Generally, this morphology is a right angle, although a more blunted form may be observed; 4 = Any superior incline of the anterior nasal floor, creating a weak (but present) vertical ridge of bone that traverses the inferior nasal border (partial nasal sill); 5 = A pronounced ridge (nasal sill) obstructing the nasal floor-to-maxilla transition.

**INTERORBITAL BREADTH (IOB), Figure 9.5:** Interorbital breadth (IOB) is assessed in the following nonmetric forms: narrow, intermediate, and broad. This assessment is made relative to the facial skeleton. 1 = A narrow IOB; 2 = A medium IOB; 3 = A broad IOB.

**MALAR TUBERCLE (MT), Figure 9.6:** The malar tubercle (MT) is a caudally protruding tubercle located on the inferior margin of the maxilla and zygomatic bone in the region of the zygomaticomaxillary suture. The presence of a malar tubercle is scored by placing a transparent ruler from the intersection of the zygomaticomaxillary suture and the inferior margin of the malar to the
deepest point on the curvature of the maxilla. An assessment is then made on the extent of protrusion beyond the ruler's edge. In instances where the suture is directly on the tubercle, the ruler is placed from the deepest curvature of the maxilla to the deepest anterior curvature on the zygomatic. Note: A malar tubercle may be present on the maxilla, the zygomatic, or along the zygomaticomaxillary suture. Observers should not consider the tubercles on the lateral zygomatic arch. A completely absent MT is rare. 0 = No projection of bone; 1 = A trace tubercle below the ruler's edge (about 2 mm or less); 2 = A medium protrusion below the ruler's edge (roughly 2 to 4 mm); 3 = A pronounced tubercle below the ruler's edge (roughly 4 mm or more).

Nasal Aperture Shape (NAS), Figure 9.7: The shape of the nasal aperture (NAS) is assessed by observing both the lateral contours of the nasal aperture and, directly related, the position of greatest lateral projection of the margin. 1) teardrop, with lateral projection intermediate to 2 and 3; 2) bell shape, with greatest lateral projection at the inferior margin; and, 3) Bowed, with greatest lateral projection at midline.
NAURAL APERTURE WIDTH (NAW), Figure 9.8: The width of the nasal aperture is assessed relative to the facial skeleton. It is scored as narrow, medium, or broad. 1 = A narrow NAW; 2 = A medium NAW; 3 = A broad NAW.

NASAL BONE CONTOUR (NBC), Figure 9.10: Nasal Bone Contour (NBC) is defined as the contour of the midfacial region (particularly the contour of the nasal bones and the frontal process of the maxilla) approximately 1 cm below nasion. Visual interpretation of nasal contour is not the most effective manner of analysis due to high inter- and intra-observer error. The use of a contour gauge permits more reliable and consistent assessment of nasal contour. To assess NBC, the cranium should be placed in a position that allows the observer to gently, but with consistent and balanced pressure, place the contour gauge directly on the nasal bones approximately 1 cm inferior to nasion, while maintaining the gauge roughly perpendicular to the palate and parallel to the orbits. Most observations require approximately 20 mm at the deepest point on the contour gauge for proper assessment although a lower or higher mid-face may require adjustments of this procedure. The contour gauge should be used multiple times to ensure correct assessment. Misalignment of needles may result in incorrect assessment; realign needles after taking each contour. 0 = Low and rounded nasal bone contour. NBC 1 presents a circular shape and lacks steep walls. Brues (1990) suggests the term Quonset-hut to describe this shape although the term is somewhat dated; 1 = An oval contour, with elongated, high, and rounded lateral walls; 2 = Steep lateral walls and a broad (roughly 7 mm or more), flat superior surface "plateau," noted on the contour gage as a flat cluster of needles in the midline; 3 = Steep-sided lateral walls and a narrow superior surface "plateau"; 4 = Triangular cross section, lacking a superior surface "plateau".

Figure 9.8 Example variation in NAW. Scores: a) 1 = narrow; b) 2 = medium; c) 3 = broad.

Figure 9.9 Example variation in NBC. Scores: a) 2 = broad plateau; b) 1 = high rounded, oval; c) 0 = low rounded, circular; d) 3 = narrow plateau
NASAL BONE SHAPE (NBS), Figure 9.10: Nasal bone shape (NBS) is assessed from the anterior view with the cranium positioned in approximate anatomical position. A determination is made regarding 1) the position of nasal pinch, if any, and 2) the amount of lateral bulging. While making the assessment, the observer should not consider the frontonasal suture, the nasal suture, or the symmetry of the nasal bones. Rather, an assessment is made of the lateral contours of the nasal bones. 1 = Nasal bones with no nasal pinch. The nasal bones may be wide or narrow; 2 = Nasal bones with a superior pinch and minimal lateral bulging (note: To differentiate a score of 2 and 3, the amount of lateral bulging in the inferior region should be assessed); 3 = Nasal bones with a superior pinch and pronounced lateral bulging of the inferior region (note: To differentiate between a score of 2 and 3, the amount of lateral bulging in the inferior region should be observed); 4 = Triangular-shaped nasal bones.

NASAL OVERGROWTH (NaOvg), Figure 9.11: Nasal overgrowth (NaOvg) is an inferior projection of the lateral border of the nasal bones beyond the maxillae at nasale inferius. Assessment of nasal overgrowth does not include anterior bulging of the nasal bones. Observations should be made of the left side if it is undamaged. If the left side is damaged, the right side may be substituted. If both nasal bones are missing or fractured (ante-, peri-, or postmortem), leave BLANK. It may be useful to run your finger along the borders of the maxilla and nasal bones near nasale inferius to determine whether a projection is present. 0 = No overgrowth; 1 = Any projection of the lateral border of the nasal bones (at nasale inferius) beyond the maxillary border.
Nasal overgrowth (NaOvg) is an inferior projection of the lateral border of the nasal bones beyond the maxillae at nasale inferious. Assessment of nasal overgrowth does not include anterior bulging of the nasal bones. Observations should be made of the left side if it is undamaged. If the left side is damaged, the right side may be substituted. If both nasal bones are missing or fractured (ante-, peri-, or postmortem), leave BLANK. It may be useful to run your finger along the borders of the maxilla and nasal bones near nasale inferious to determine whether a projection is present. 0 = No overgrowth; 1 = Any projection of the lateral border of the nasal bones (at nasale inferious) beyond the maxillary border.

Figure 9.11 Example variation in NO. Scores: a & b) 0 = no overgrowth; c - e) 1 = overgrowth.

NASOFRONTAL SUTURE (NS), Figure 9.12: The nasofrontal suture is the suture separating the nasal bones from the frontal bone. The shape of the suture is assessed. Nonmetric variants include: round, square, triangular, and irregular. Assessment is best made from the anterior view. The symmetry of the nasal bones should be ignored. If nasal bones evince extreme pinching of the superior border (as in NBS 4), observation should be left BLANK - unobservable. 1 - Nasofrontal suture is round and lacks angles; 2 - Nasofrontal suture appears square (approximate right angles at nasale superious); 3 - Nasofrontal suture appears triangular; 4 - Nasofrontal suture is irregular, lacking any definitive shape.

Figure 9.12 variation in NS. Scores: a & d) 2 = square; b & c) 4 = irregular; e) 1 = round.
**ORBITAL SHAPE (OBS), Figure 9.13:** Orbital shape includes the following nonmetric variants: Rectangular, Circular, and Rhombic. Observation is best from the anterior view. The shape of the orbit is defined by the orbital margin of the superior, lateral, and inferior borders. The medial border of the orbit is defined by the anterior lacrimal crest and the maxillary process of the frontal bone. Observers should assess whether the margins are angular (rectangle), curvilinear (circular), or irregular (rhombic). Bilateral asymmetry may occur. All observations should be made from the left orbit. 1 = Rectangular - Orbits with horizontal margins longer than the vertical margins, but otherwise parallel (i.e., rectangle); 2 = Circular - Orbital margin is approximately equidistant from center on all sides (i.e., circle); 3 = Rhombic - Medial border height is shorter than lateral border height (aviator sunglasses).

![Figure 9.13 Example variation in OBS. Scores: 1 = rectangular; 2 = circular; 3 = rhombic (aviator sunglasses).](image)

**POST-BREGMATIC DEPRESSION (PBD), Figure 9.14:** Post-bregmatic depression is a slight to broad depression along the sagittal suture, posterior to bregma, which is not the result of pathology. Observed in lateral profile, the trait is scored as either absent (no depression) or present. 0 = No depression present; 1 = A marked depressed area posterior to bregma along the mid-sagittal plane.

![Figure 9.14 Example variation in PBD. Scores: a) 0 = no depression; 1 = marked depression.](image)
POSTERIOR ZYGOMATIC TUBERCLE (PoZygT), Figure 9.15: The posterior zygomatic tubercle (PoZygT), or the marginal process, is a posterior projection of the zygomatic bone at approximately midorbit as viewed in lateral plane. To observe the various degrees of expression, a small, transparent ruler is placed on the frontal process of the zygomatic from the landmarks frontomalare posterale to jugale. The extent of bony protrusion beyond the ruler’s edge is then assessed. 0 = No projection of bone; 1 = A weak projection of bone (less than 4 mm); 2 = A moderate projection of bone (approximately 4 to 6 mm); 3 = A marked projection of bone (generally > 6 mm).

SUPRANASAL SUTURE (SPS), Figure 9.16: In adult crania, a secondary complex suture may persist, which is generally referred to as the supranasal suture, or sutura supranasalis. This suture does not represent the nasal portion of a persistent metopic suture, which is generally a single, non-oscillating line, but rather is the fusion of the nasal portion of a frontal suture. SPS appears as a complex of interlocking bony spicules at glabella. 0 = completely obliterated; 1 = Open (unfused); 2 = Closed, but visible.

ZYGOMATOCONASAL SUTURE (ZS), Figure 9.17: The zygomaticoconasal suture (ZS) is the suture between the maxilla and the zygomatic. The course of the suture is best observed in the anterior view. In instances of asymmetrical manifestations, the left side is preferred. The infraorbital suture should be ignored when making a determination. Assessment of ZS is based primarily on the approximate location of greatest lateral projection of the suture, and also on the number of major angles present. Sutures having greatest lateral projection at the inferior margin, but a slight angle near the midpoint of the suture should be scored as 0. 0 = A suture with no angles and greatest lateral projection at the inferior margin of the malar (note: Sutures having greatest lateral projection at the inferior margin, but a slight angle near the midpoint of the suture should be scored as 0); 1 = A suture with one angle and greatest lateral projection near the midline; 2 = A suture with two or more angles (presenting a jagged and/or S-shaped appearance) with variable greatest lateral projection.

TRANSVERSE PALATINE SUTURE (TPS), Figure 9.18: The course of the transverse palatine suture (TPS) is highly variable, although certain themes persist. TPS is not scored unilater-
ally although asymmetrical sutures are not uncommon. The entire suture is observed, but concentrate on the medial one-half in the region of the palatine suture. When an asymmetrical suture is present (the two branches of the suture do not come into contact at midline) the general theme is recorded (e.g., straight, jagged, etc.). Slight undulations of the suture should not be considered when making a determination. If the suture is obliterated, leave BLANK.

1 = The suture crosses the palate perpendicular to the median palatine suture, with no significant anterior or posterior deviations.

If the right and left halves of the suture do not contact each other at midline, but the suture is otherwise straight, score the suture 0; 2 = The suture crosses the palate perpendicular to the median palatine suture, but near this juncture a significant anterior deviation, or bulging, is present; 3 = The suture crosses the palate, but deviates anteriorly and posteriorly (e.g., M-shaped) in the region of the median palatine suture; 4 = The suture crosses the palate perpendicular to the median palatine suture, but near this juncture a posterior deviation, or bulging, is present.

---

**Figure 9.17** Example variation in ZS. Scores: a) 2 = jagged/s-shaped, b) 1 = one angle; c) 0 = no angles.

---

**Figure 9.18** Example variation in TPS. Scores: a & c) 2 = anterior bulge, b) 3 = M-shaped; d) 4 = posterior bulge.
Examples
The next two crania demonstrate how the various macromorphoscopic traits are scored using the Macromorphoscopic module. The following observations, although difficult to make from photographs, are meant to guide the user through some aspects of trait determination.

EXAMPLE CRANIUM 1 SCORES:

- Anterior Nasal Spine projects well beyond the vertical portion of the maxilla (ANS = 3).
- Although difficult to observe in the photograph, a thin ridge of bone is present along the inferior nasal aperture border (INA = 4).
- Relative to the face, the interorbital breadth is intermediate (IOB = 2).
- Malar tubercle is roughly 2 mm (MT = 2).
- Greatest lateral projection of the nasal aperture is intermediately position (NAS = 1)
- Width of the nasal aperture is intermediate (NAW = 2).
- Contour of the nasal bones is steep-sided with a broad surface plateau (NBC = 2).
- Shape of the nasal bones is most consistent with a superior pinch and pronounced lateral bulging (NBS = 3).
- Nasal bones project beyond the maxillae at nasale inferius (NO = 1).
- Nasofrontal suture is square (NS = 2).
- Orbits are roughly circular (OS = 2).
- A post-bregmatic depression is not present (PBD = 0).
- Posterior zygomatic tubercle is markedly projecting (PZT = 3).
- Supranasal suture is closed, but remains visible (SPS = 2).
- Zygomaticomaxillary suture has one angle near midline (ZS = 1).
- From the photograph, the transverse palatine suture is unobservable and therefore not scored (TPS = BLANK).

Figure 9.19 Example cranium 1 a) anterior; b) left lateral
The anterior and lateral views of the second cranium provide another series of traits. The following scores apply to Example Cranium Two.

**EXAMPLE CRANIUM 2 SCORES:**

- Anterior nasal spine is only minimally projecting (ANS = 1).
- Inferior nasal aperture is sloping, but is also slightly angulated at the transition to vertical maxilla (INA = 2).
- Interorbital breadth is wide relative to the facial skeleton (IOB = 3).
- Malar tubercle is a roughly 3 mm projection (MT = 2).
- Greatest lateral extent of the nasal aperture is near the midline (NAS = 3).
- Nasal aperture is wide relative to the midface (NAW = 3).
- Nasal bone contour is low and round (NBC = 0).
- Nasal bones show a superior pinch and minimal lateral bulging (NBS = 2).
- No nasal overgrowth is present (NO = 0).
- Nasofrontal suture is irregular (NS = 4).
- Orbits are rectangular (OS = 1).
- Post-bregmatic depression is present (PBD = 1).
- Posterior zygomatic tubercle is weak, but present (PZT = 1).
- Supranasal suture is closed, but visible (SPS = 2).
- Zygomaticomaxillary suture has two angles and is S-shaped (ZS = 2).
- From the photograph, the transverse palatine suture is unobservable and therefore not scored (TPS = BLANK).

*Figure 9.20 Example Cranium 2 a) anterior; b) left lateral.*
Chapter 12: Summary Paragraphs

The summary paragraph is a compilation of the observations for a catkey, and they should be composed after completing documentation in all applicable modules. The Summary Paragraph Module consists of a single screen with buttons on the right side that directly add the comments from other modules to the summary paragraph composition window (Figure 12.1). Clicking on the buttons copies the comments so they are also retained in the original module. Comments can be rearranged by copying and pasting (use control + C and control + V keystroke shortcuts) to suit your report style and requirements. When finished, press the green Save button and follow the Osteoware spellcheck prompts. Words can be added to your dictionary when appropriate.

Many of the comments will be more detailed than the final summary paragraph and skilled editing is needed to convey the key information documented for a catkey. Well-constructed summary paragraphs can be included in a report with minimal editing. When multiple researchers are writing summary paragraphs for a site, having clear guidelines in place will help ensure continuity in style and substance. The following descriptions reflect the standard style for summary paragraphs in the ROL, which you may need to modify to suit the particular needs of your lab and the intended purpose of the summaries.

**Age, Sex, and Inventory**
The first sentence should include whether the cranium, mandible, and postcranial skeleton is complete, nearly complete, partial, or fragmentary and the estimated age and sex of the individual. For example: “The remains identified with this catalogue number consist of the nearly complete cranium and partially complete postcranium of a female between 25 and 35 years of age.” Next is a complete list of the exact bones present or alternatively exactly what bones are absent, depending on the degree of completeness. Always state whether the cranium and mandible are present or absent to avoid confusion.
In the case of reassociations between catalog/catkey numbers: 1) identify the catkeys involved; 2) list the exact bones reassociated from each; and 3) give your reason(s) for the association such as consistent age and sex, taphonomy, morphology, etc. This information should appear in the summary paragraph and inventory comments section(s) of the recipient as well as the original/donor catkey number(s) where the bones were found in order to establish a trail to reconstruct the original context should it be required in the future. An example of a reassociation note is given in Chapter 2 and in an example summary paragraph at the end of this section.

For commingled remains, the summary paragraph should include an estimate of the Minimum Number of Individuals (MNI) present and the basis for the calculation, e.g., complete right femurs or proximal left tibiae. Whenever possible, you should attempt reassociations across catalogue numbers and antimere matching for tracked elements within a catalogue number. Inconsistent age, sex, size, and morphology can also be considered for the tracked elements when determining MNI. Taking these variables into account may suggest there are more individuals present than a simple count of the most frequent bone, and it is therefore very important to consider carefully and report all variables used in the MNI estimates of the summary paragraph.

**Taphonomy**
A well-constructed comments section for Taphonomy usually requires little editing. For the summary, the information on Taphonomy should include: 1) the color and general degree of preservation; 2) additional staining; 3) description of any adherent materials; 4) evidence of animal activity; 5) postmortem cultural modification such as cut marks or burning; 6) curation damage or modification; and 7) complete recording of anything written on the bones or notes found in association with the remains. As noted in Chapter 4, it is the convention of the ROL to place anything written on the bones or on notes found with the remains in quotation marks. Transcribe this information completely and accurately because it can be important for reconstructing the excavation or curation history of the remains.

**Cranial Deformation**
A summary statement of cultural cranial deformation should include a general description of the overall form and severity. When deformation is not mentioned in the summary paragraph, it is assumed to be absent.

**Dental**
The first part of the dental summary should include the number of teeth present and whether the absent teeth were lost antemortem or postmortem. The degree of occlusal wear and a summary of any dental pathologies should also be stated.

**Pathology**
All Pathology Module comments are added to the summary paragraph composition field by clicking on the add Pathologies button. You may organize Pathology comments by first summarizing...
any trauma, followed by infectious, metabolic and neoplastic diseases; congenital conditions and vertebral anomalies; arthritis and stress markers; and finally a simple list of anatomical variants such as a vastus notch. When pathologies are extensive, judicious editing may be necessary for a concise description that includes the most meaningful observations. When appropriate, a single condition affecting multiple bones can be easily condensed, for example, “Moderate to severe osteoarthritic changes are observed on all articular surfaces of the right shoulder and arm, and on both hip and knee joints.”

Example Summary Paragraphs

EXAMPLE 1, 380453
The remains identified with this catalog number consist of the cranium, mandible, and incomplete postcranial skeleton of a young adult male, aged 25 to 35 years old at death. The bones were reassociated by unknown personnel at an unknown date from catalog numbers 380453 (cranium), 380454 (mandible), 380456 (femora), 380457 (tibiae), 380459 (humeri), 380460 (ulnae), 380461 (radius), and 380463 (rib, sacrum, and innominates). They were likely reassocated based on a similar pathological condition affecting the elements. However, the left and right ulnae (labeled 380460) and a left radius (labeled 380461) may not belong to the primary individual as the proximal right ulna has extensive septic arthritis and the distal right humerus displays none. The right fibula labeled 380458 may not belong with this individual as it is longer and does not articulate correctly with the right tibia. The left and right scapulae (labeled 380462) and two left ribs (labeled 380463) probably belong to a larger individual, and are tracked separately.

The bone is soil-stained tan to medium brown in color with small amounts of soil and roots adhering in recessed surfaces. Many of the bones are at least partially sunbleached. Within the crest of the left innominate, there is a considerable amount of soil and a mud wall, suggesting insect nesting activity. There are several areas, especially on the innominates, where unknown animal activity has perforated the cortical bone. A clear preservative was applied to the teeth. A large circular bone sample (28 mm in diameter) was removed from the left parietal, exposing unstained bone. The bones come from several catalog numbers and are labeled “380453” (cranium), “380454” (mandible), “380456” (femora), “380457” (tibiae), “380459” (humeri), “380460” (ulnae), “380461” (radius), and “380463” (rib, sacrum, and innominates). All bones also have "Gallery Hill", "Gallary Hill", “G.H.” or "G. Hill" written on them in black ink or pencil. The distal left femur is labeled "36 [circled]" and the distal right femur is labeled "35 [circled]", both in pencil. A paper tag attached to the left femur is labeled “380456/09-404-06-08”.

Twenty-two teeth are present in their respective sockets, and the mandibular canines were lost postmortem. Occlusal wear is moderate and there are no carious lesions or apical abscesses. The alveolar bone is slightly porotic and the interproximal crests are moderately resorbed. Linear enamel defects are present on the maxillary canines. There is extensive evidence of a systemic disease in this individual. Multiple lesions, both lytic and proliferative, are suggestive of either yaws (a treponemal disease) or an unidentified osteomyelitis.
EXAMPLE 2, 380440
The remains identified with this catalog number consist of a postcranial bone lot containing five incomplete adults and two incomplete subadults. The bones present include the following: three left and four right tibia of which there are two antimere pairs (Catalog number 380440 Tracking numbers 2 and 3, and Tracking numbers 4 and 5) as well as one subadult left tibia 380440-1 and one subadult right tibia 380440-9 (not antimere pairs). There are therefore a minimum of seven individuals based on age, antimere pairs, and the most frequent element.

The bones display a range of taphonomic alterations, including varying expression of sunbleaching (Tracking numbers 2, 3, 4, 6, 9), green algae stains (tracking numbers 2, 3, 4) as well as soil staining, slight excavation damage to all articular surface margins, desiccated tissue on the distal articular surface of Tracking number 8, and adhering roots (Tracking numbers 4 and 5). Found with the bone lot is a calendar sheet with "380,440" written in pencil on the blank side and the machine printed date, "SATURDAY / FEB. 19 1949". All the bones have "380440 / Bartolombo Bay / Australia" written on them in black ink.

Pathological conditions include Osgoode-Schlatter disease (Ortner 2003:353) for Tracking numbers 380440-4, and 380440-5, fracture of the distal metaphysis on Tracking number 7, and squatting facets on Tracking numbers 2 and 3.

EXAMPLE 3, 380445
The remains identified with this catalog number consist of the incomplete postcranial skeleton of a 4.5 to 6 year old of indeterminate sex. The postcranial elements present are a partial right clavicle, both humeri, the right radius, possibly the 5th lumbar vertebra, right ilium, both femora, left tibia and fibula, right calcaneus, and some hand bones. The cranium and mandible are not present. Three unnumbered deciduous teeth originally stored with these remains were reassociated to catalog number 380444 and 380446 based on positive placement in matching tooth sockets.

The bones are soil stained a medium brown to light tan color and a sandy soil adheres in most recessed areas. Sun bleaching with periosteal cracking is present on the lateral side of the left humerus, the proximal femora, the left distal tibia and fibula, and the right calcaneus. There is a diffuse green stain, possibly algae, on the lateral aspect of the ilium. Some epiphyses are glued to their matching diaphyses. "380,445 / Bartolombo bay / Australia" is written in black ink on most bones, and coated in a clear preservative. Included with the remains is a piece of paper with, "#380445 / 09-404-06-09 / yaws" written in pencil.

The left tibial and fibular diaphyses display pseudobowing due to abnormal bone formation on the anterior aspect, consistent with sabre-shin that results from a chronic infectious disease such as yaws (Ortner 2003: 274-277). No dental remains are present.
Chapter 13: Extracting Data from the Database
by J. Christopher Dudar

The Osteoware graphic user interface, or GUI, is simply a ‘front end’ portal for users to enter data; it allows limited editorial access to a single data record at one time. However, all observations are stored in tables within a database structure ‘back end’ that is easily accessible through a Relational Database Management System (RDBMS). Relational database tables superficially resembles spreadsheets, but unlike spreadsheets, the tables can be managed and queried using the RDBMS and Structured Query Language (SQL). Thus meaningful data with complex relationships across tables can be systematically extracted for subsequent statistical analyses.

The RDBMS used in conjunction with Osteoware is the Sybase® Advantage Data Architect™, which offers useful features for managing, querying, and extracting data (Figure 13.1). Supported file formats for data export are html, .txt, .rtf, .csv, and .dif as well as Microsoft Word and Excel. You can download the Advantage Data Architect version 9.1 for free from the link provided on the Osteoware website Downloads page, and then you can install it following the instructions in the Osteoware Installation Guide. Because the Advantage DBMS is not required to enter data, you may not wish to install it on computers in a teaching laboratory or in other contexts where you want to restrict access to valuable aggregate data.

Structured Query Language (SQL) Basics
While graphic user interface tools are available that can write Structured Query Language (SQL) statements for you, they do not necessarily build good SQL and may not retrieve everything you desire from the database. Therefore, querying for optimal results requires some knowledge of SQL. It is beyond the scope of this user manual to provide a comprehensive SQL resource, but do not be intimidated, it is relatively easy to learn and is a powerful skill to have. If you are learning SQL, you should keep in mind that a poorly worded query may result in “no results” or a “false negative”; therefore, it is a good idea to begin with practice queries that you know will return results.

A relational database is composed of multiple tables that are organized by row and column with different types of data stored in each table. The Connection Repository on the left side of the Advantage Data Architect screen lists all of the Osteoware tables (Figure 13.1). The Tables are linked together (become relational) via a common column containing unique values that are shared across tables. This column/field is called a Primary Key or Unique Identifier. In Osteoware the Primary key is usually the Catkey; however, when commingled bones are documented within a catalog number then the Primary key will be composed of a combination of Catkey, Indiv (Individual A or B...), and sometimes the Trackno (Tracking Number), depending on the table. The Primary Key may be used to build relationships, or Joins, across tables using SQL and thus data can be simultaneously extracted from different tables, e.g., a query for males with fractures joins or links data stored in the Age and Sex table with data from the Trauma table.
The Basic SQL Query

A SQL query is composed of a Select, From, and Where statement as seen in the example in Figure 13.2. The Order By statement is optional and is not required for a query. With the database table of interest open, click on the SQL Utility button (identified by the red arrow in Figure 13.2) to open the SQL Utility window and then type in a new query statement or copy and paste a saved query.

```
SELECT column name1, ... , column nameX [or type * to select all columns]
FROM table name
WHERE filter condition [<, >, =, like, et cetera]
ORDER BY column name [ASC or DESC for ascending or descending, this is optional]
```
More Complex Queries: Table Join Statements

The potential of SQL becomes apparent when table join statements are executed. Tables are joined on the primary key in the query example below with the statement WHERE a.catkey = c.catkey (Figure 13.3). This is an old syntax standard for table join statements, but it is more intuitive for beginners. Also note that each letter is assigned to one table, so you use the same letter prefix for every column of data that is from the same table.

SELECT    a.column name1, a.column name2, ... c.column nameX (a. and c. are table name aliases established in the FROM statement below)
FROM      table name a, table name c
WHERE     a.primary key = c.primary key (the join condition)
AND       filter condition(s)

Null and Not Null

Note in the Figure 13.3 example that the last of the three filter conditions is entered as: and c.PORSTDeformed is not null. The not null condition will only retrieve data records that are not empty, or in other words, individuals with some degree of posterior cranial deformation. In contrast, a null record has no value entered, i.e., blank, but it is not the same as a record with a zero (0) entered; zero is not null.
Exporting Query Results

Exporting query results is very straightforward. Simply right click within the data results portion of the SQL Utility window and a supplementary menu appears (Figure 13.4). Choose ‘Export to HTML, Excel…’, and the ‘Export to’ window opens with various file format export options provided (Figure 13.5).

Example Query Statements

20. A query for “tuberculosis” in the pathology description field where % is a wildcard.

```
SELECT p.catkey, p.Indiv, p.trackno, p.description
FROM Pathology
WHERE "Description" like '%tuberculosis%' 
```

21. A query for ribs (Bonecode=370) with fractures (PathType=5) and pseudarthroses (OBS7=71). The letter prefixes and a join statement are not used because all the data are from the same table.

```
SELECT catkey, Indiv, Trackno, RECR, BONECODE, PathType, OBS7, description
FROM Pathology
WHERE Bonecode = 370
 AND PathType = 5
 AND OBS7 = '71'
```
3. A table join query to retrieve Craniometric and Age/sex data. The asterisk (*) selects all columns from the cranmetr table. The last AND statement limits data extraction to the listed catkeys.

```sql
SELECT a.catkey, a.sumarsex, a.minage, a.maxage, a.ageunit, c.*
FROM cranmetr c, AGESEX a
WHERE c.Catkey = a.Catkey
AND c.Indiv = a.Indiv
AND c.catkey in ('201288',..., '201299')
```

4. A table join query using American National Standards Institute, ANSI, standard syntax. This query will find all pathology fracture entries (regardless of commingled status) made by a certain recorder (Recr) that do not have an x-ray request. Note that ANSI is a newer syntax than the other examples and offers more advanced options, but it is also more difficult for a new SQL user to learn.

```sql
SELECT *
FROM Pathology as p
LEFT OUTER JOIN XRayRequests as x
ON p.catkey = x.catkey
AND p.Indiv = x.Indiv
AND p.TrackNo = x.Trackno
WHERE Recr like 'MCS'
AND Pathtype = 5
```

5. A query to determine if dental documentation was completed before the x-rays were taken.

```sql
SELECT d.catkey, d.indiv, d.trackno, d.recr, d.entrydate, x.entrydate
FROM dntindvw d, [x-ray] x
WHERE d.catkey=x.catkey
AND d.indiv=x.indiv
AND d.trackno=x.trackno
AND x.entrydate > d.entrydate
```

**Resources**

**SYBASE ADVANTAGE™ MANUAL:**


**ONLINE SQL RESOURCES:**

SQL web resources:  [http://www.sql.org/](http://www.sql.org/)
Additional SQL tutorials:  [http://www.sqlzoo.net/](http://www.sqlzoo.net/)


Grey (1918)


