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Version 1

# ArchaeoScale Protocol: Inserting digital scale bars into scientific images – Full step-by-step guideline for anthropological and archaeological specimen photography V.1



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None

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**We use this protocol and it's working**

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## Disclaimer

No real human remains were used for this protocol; instead, a detailed synthetic replica of a human crania was used.

Inspirations for this protocol come from personal experiences as well as observations and recommendations published in Jambor et al. 2021 and Ferrucci et al. 2016.

Please cite this protocol when using it. Note that scientific protocols published on Protocols.io are not peer-reviewed. No guarantee of its correctness or applicability can therefore be granted by the author. However, I assure you that this protocol was generated with the best intentions to improve scientific practices and to freely share open methods. Feel free to validate the use of this protocol and its provided materials. Any suggestions or criticism will be considered and incorporated into future versions of this protocol. Also note that I have published other kinds of scientific protocols on methods in virtual anthropology and archaeology that you might find interesting and useful for your work.

Supplementary Information including a demonstration on the effect on digital scale bar size based on the physical scale bar position are available on Zenodo.com (link: <https://zenodo.org/record/7495468>, DOI: 10.5281/zenodo.7495468).

## Abstract

Geometric scale bars, also known as photography scales or photomacrographic rulers, are small but important details used in digital photography that allow for a quick visual understanding of size dimensions in images and should therefore be included in all scientific photographs. Scale bars exist in different sizes, shapes, and types, but they all aim to help the audience make proper connections between the presented photograph and the real subject. Inserting scale bars into pictures thus reduces interpretation biases and improves scientific readability, transparency, and quality. It should not be taken for granted that dimensions can be correctly understood based on mere intuition. However, scale bars are still often missing from many archaeological and anthropological publications, or their position tends to be inadequate. This protocol aims to change this by presenting a fast, step-by-step guideline for how to create digital scale bars in every photograph using the free and open-source image processing software ImageJ® (Schneider et al. 2012). Additionally, this protocol presents helpful tips regarding the type, size, creation, placement, and location of digital scale bars. The suggested workflow can easily be implemented in any photographic workflow as it does not require sophisticated and expensive equipment. Researchers that already work with scale bars on a regular basis might also find interest in this protocol, as there are certain aspects to the choice, type, position, and location of scale bars that are often not considered and that can reduce their effectiveness and usefulness.

## Image Attribution

All images and illustrations were produced by the author. All image rights are reserved.

## Guidelines

Texts written in *italic* refer to software functions.

This protocol was created using Windows 10 (version 21H2). Used and reported commands such as keyboard shortcuts may be different depending on your operating system.

## Materials

DSLR camera and supplied equipment (batteries, charger, data storage medium like a SD card and external hard drives for backup copies; used camera: Nikon®: D5100 with the Nikon® DX AF-S Nikkor 15-55 mm camera lens (1:3.5-5.6 G))

General photography equipment (studio lights, tripod, remote camera control, background material, color calibration card, etc.)

Physical scale bar of appropriate length (preferentially with millimeter indication; used scale bar: 5 cm metal scale bar)

Computer or laptop (used: Bullman® V-class laptop, CPU: Intel® Core™ i7-7700HQ, 2.80 GHz; GPU: 1. Intel® HD Graphics 630, 350 MHz; 2. NVIDIA GeForce GTC 1060, 6 GB, 8 Gbps, 1708 MHz; RAM: 64,0 GB, OS: Windows 10 Pro (version 21H2), 64-bit)

ImageJ® (Schneider et al. 2012; free, open-source, download via <https://imagej.nih.gov/ij/download.html>; used version: 1.53k)

Illustration software such as GIMP® (free, download via <https://www.gimp.org/downloads/>) or Adobe® Photoshop® (used version: 13.0 20120315.r.428)

## Troubleshooting

## Safety warnings

- ⚠ Useful information on subject safety during photography of osteological subjects is summarized in the FOROST Skull Photography Protocol (Báez-Molgado et al. 2013). The provided protocol may not be used in medicolegal contexts where certified and officially approved scale bars such as the ABFO No. 2 are used (Hyzer and Krauss 1988).

For a general guideline on (small) object photography in archaeology, which can also be applied to human remains, see the SOAP protocol published by Cerasoni & Rodrigues (2022).

## Before start

General tips and useful recommendations:

- 1) Scale bars must be included in all scientific images.
- 2) Purchase scale bars with high accuracy, i.e.,  $\pm 0.1$  mm or higher, and a dull, resistant, non-reflective surface.
- 3) Other objects, such as coins or tools, should not be used as "scale bars." Always use metric scale bars.
- 4) Select a scale bar that fits the dimensions of the feature or subject it complements, i.e., scale bars should not be too small nor too large.
- 5) Scale bars must be readable, i.e., easily identifiable. Avoid thin, reflective, colored, and excessively small-scale bars. The scale bar should be fully visible in the image. Do not crop out parts of it.
- 6) With respect to color, scale bars with high contrast to the photographed subject are usually either white or black or a combination of both. If necessary, place the scale bar outside the image or within a box with a more distinct background color than the actual image color. Black and/or white scale bars will also ensure colorblind friendliness.
- 7) For reasons of consistency, add the scale bar in the lower right corner of the image, as this seems to be the preferred scale bar location among most publications.
- 8) When placing the physical scale bar next to the subject or feature of interest, ensure that it is aligned properly and parallel with the subject and photograph, i.e., the camera lens.
- 9) Annotate the metric dimensions of the scale bar on the image along with the bar. Do not just mention its length in the image legend or caption. Use simple length units such as 1 cm, 2 cm, 5 cm, or 10 cm.
- 10) Before final publication, carefully check the page and image proofs of the respective journal to see whether all scale bars are clearly visible.
- 11) When generating multiple photos in a row, make sure the scale bars are consistent with the same length and units to avoid confusion.
- 12) Keep scale bars in a protective cover when not in use to protect them from light and mechanical damage, such as surface scratches.
- 13) If made of plastic, their white color components can change and turn into a grayish-yellow hue. Changes in the dimension of the scale bar can also occur and, depending on the geometry and material properties of the scale bar, can be substantial after a few years (Ferrucci et al. 2016). Therefore, it should be considered to replace



used scale bars after a few years or earlier when they are used extensively on a regular basis. More information on this is provided at the end of this protocol.

14) Scale bars should not include more information than necessary. In most anthropological or archaeological research, scale bars serve no purpose other than to provide a quick indication of the size of an object or subject. As mentioned, and further discussed in the supplementary information (link: <https://zenodo.org/record/7495468>, DOI: 10.5281/zenodo.7495468), no measurements should be taken from images, even if there is a scale bar inserted, unless the image has been specially calibrated (not further elaborated on here). As a result, a simple line with a length indication, such as that provided by ImageJ© software, may be sufficient.

15) If more complex scale bars are required, other image processing software can be used in addition to the presented protocol, along with special templates or models for digital scale bars.

## Digital scale bar insertion using ImageJ

- 1 Take high-quality images according to your personal or project guidelines. For each session, take photos first with and then without the scale bar in the proper position and location. Make sure that you do not move the object before all the pictures have been taken.

Take images in RAW format and convert them afterward to high-quality JPEG or TIFF files using free and open-source software such as IrfanView® and its required plugins (available via <https://www.fosshub.com/IrfanView.html>). Always save the images at the highest possible quality. To save time, it is advised to take three photos per setting, whose quality can be checked during post-processing steps. Choose the visually best image.

- 2 Open the ImageJ® software (fig. 1).



**Fig. 1:** Opened ImageJ® software.

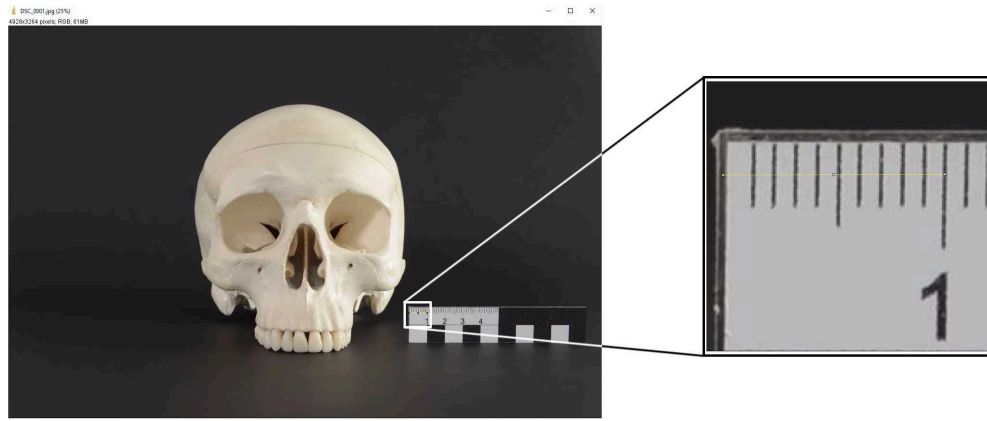
- 3 Load the image, including the physical scale bar, into ImageJ® (fig. 2). Either drag and drop the image from the folder into the ImageJ® toolbar (blank gray bar beneath the icons toolbar) or via *File|Open|navigate* to the target folder and select image *file|Open*. Note to always use a copy of the original file and never the original file itself as a backup.



**Fig. 2:** Photograph of a subject with a physical scale bar in proper alignment with the coronal frontal plane of the skull's face. All parts of the scale bar are present, and it is parallel to the image sensor.

- 4 Click on the *Linear Selection Tool* (also called the *Line ROI [region of interest]* or *Straight Line Tool*) from the icon toolbar (see the selected icon in fig. 1).
- 5 With the line tool selected, trace a distance from the physical scale bar in the image (fig. 3). Note that any distance shown on the scale bar can be used. For convenience and consistency, try to always use the same measurement (e.g., 1 cm), which will help you to avoid confusion and errors. For more precision, zoom into the image to increase the scale bar. Place the endpoint of the straight line directly in the middle of the scale bar and its metric unit markers.





**Fig. 3:** Indicated distance of 1 cm on the physical ruler (thin yellow line with markers at both ends and the center) using the linear selection tool. A close-up image for better visibility is shown on the right.

- 6 Click on *Analyze* in the top menu bar.
- 7 Within the *Analyze* menu, click on *Set Scale...*
- 8 A new window called *Set Scale* will appear, showing different parameters (fig. 4). The first parameter shows the measured *Distance in pixels* as measured by the linear selection from step 5. The second parameter indicates the *Known distance*, which represents the distance that is measured on the physical scale bar with the *Linear Selection Tool* (i.e., 1 cm in the current example). By default, this value is set to 0.00. The third parameter indicates the *Pixel aspect ratio*, which by default is set to 1.0. The next parameter shows the *Unit of length*. The default is set to "*pixel*". Change it to either centimeters ("cm") or millimeters ("mm"). Note that you should only use the metric system in scientific contexts. Enable the *Global* option. Doing so will apply all the just defined parameters to any subsequently opened image in the current ImageJ® session. All settings will be reset upon closing and reopening the program or if new parameters are defined in the *Set Scale...* menu. Note that the *Global* option is only valid for pictures where the position of the scale bar has not been changed; otherwise, the scale bar will be off and false. To avoid this, it is recommended not to apply the *Global* option to other images than the actual pair.
- 9 Click on *OK* to apply the parameters.



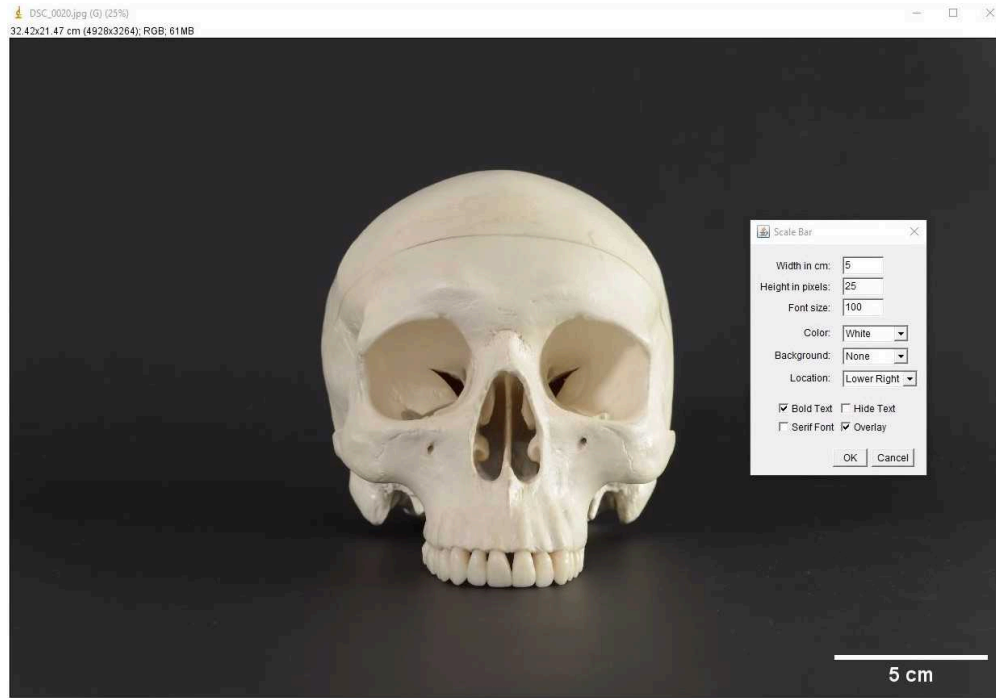
**Fig. 4:** Adjustment of the scale parameters.

- 10 Open the corresponding image without a physical scale bar into the current ImageJ® session (i.e., without closing the program) following the instructions for loading images into the software mentioned in step 3 (fig. 5).



**Fig. 5:** Skull image without physical scale opened in ImageJ®.

- 11 Click on the *Analyze* button in the top menu bar.
- 12 Within the *Analyze* menu, click on *Tools* and then on *Scale Bar....* A new window will open called *Scale Bar* where the digital scale bar can be specified (fig. 6). The first parameter indicates the width (i.e., length) of the bar in the previously defined unit (*Width in cm*). The scale bar width depends on the displayed feature. Here, a length of 5 cm was chosen. The second parameter defines the bar's *Height in pixels*. Good results with bar height can be achieved with a height of 25 pixels. In general, the bar should be neither too thick nor too thin. The third parameter will define the size of the text. A font size of 100 produces a label size that can be easily read. As *Color* choose either white or black depending on the background hue to achieve the greatest contrast. Leave *Background* on its default setting, i.e., *None*. For the *Location*, it is recommended to use the *Lower Right* corner. Beneath these parameters enable *Bold Text* and *Overly* to create an aesthetically pleasing result.



**Fig. 6:** Defining the digital scale in the scaleless image.

- 13 Click on *OK* to apply the parameters. This will create a permanent digital scale bar in the input image (fig. 7).



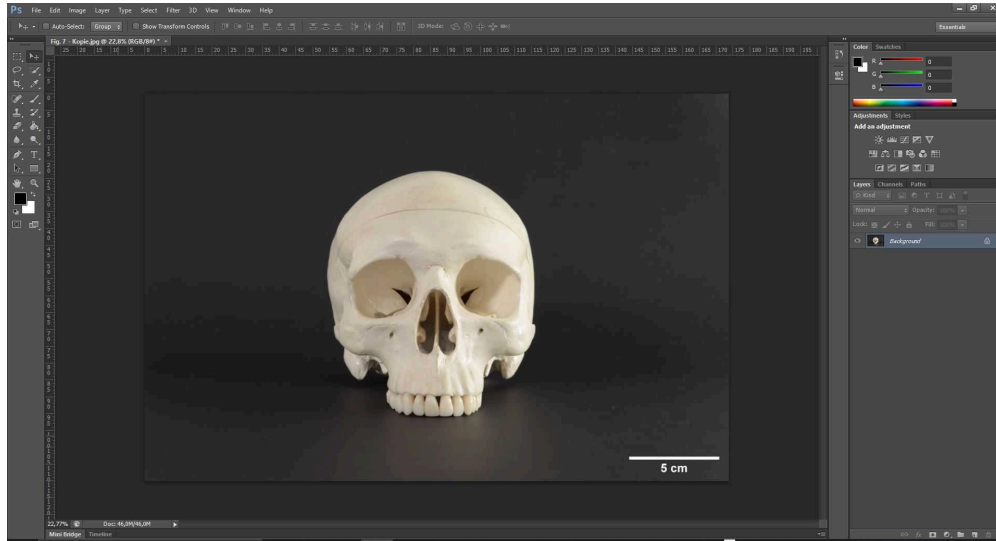
**Fig. 7:** Final image with an inserted digital scale.

- 14 To save the final image with a digital scale bar, press on *File* in the top menu bar and then on *Save As*.
- 15 Select your desired file format, e.g., *Jpeg...* and click on it.
- 16 Within the opened window, navigate to the target folder, name the file, and press the *Save* button.
- 17 At this point, your image is essentially done. Follow the next steps if you want to improve the image, e.g., to further adjust the position of the digital scale bar or replace the image background.

As you might have noticed, the scale bar of the current example is slightly off and somewhat far away from the actual subject. This can cause difficulties in comparing the scale bar with the subject and its size. Alternatively, it is also possible to customize the ImageJ® scale bar using the Line Selection Tool before step 11. Simply draw a horizontal line with the cursor after selecting this tool at the intended position with the approximate length of the final digital scale bar, and then follow the subsequent steps as described above (steps 11 through 16).

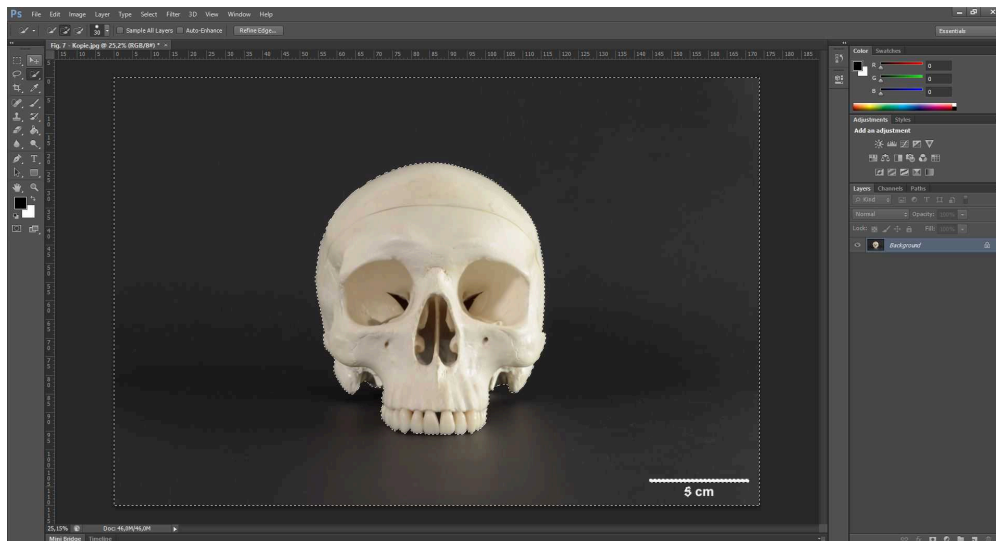
## Scale bar post-processing using Photoshop (or similar software)

- 18 Load the image with the digital scale bar into the illustration software of your choice, such as GIMP® or Adobe® Photoshop® (fig. 8). The latter software (Adobe® Photoshop® CS6 version 13.0 x64) installed on Windows 10 Pro was used in this protocol.



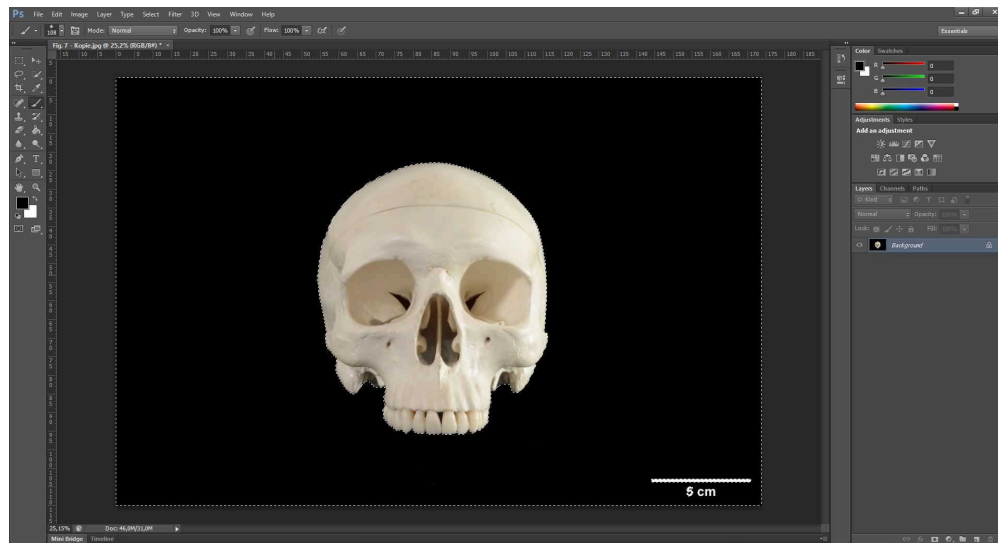
**Fig. 8:** Image with digital scale bar opened in Adobe® Photoshop®.

- 19 Use a selection tool such as the *Quick Selection Tool* to select the entire background (fig. 9).



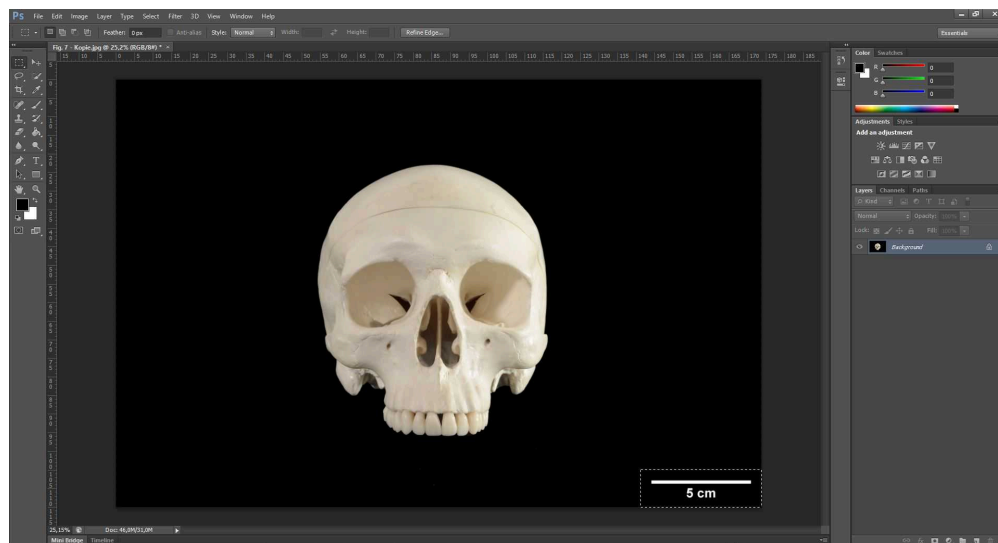
**Fig. 9:** Selected background.

- 20 Use the *Paint Bucket Tool* to fill out the selected background with black color (hex color code: #000000) (fig. 10).



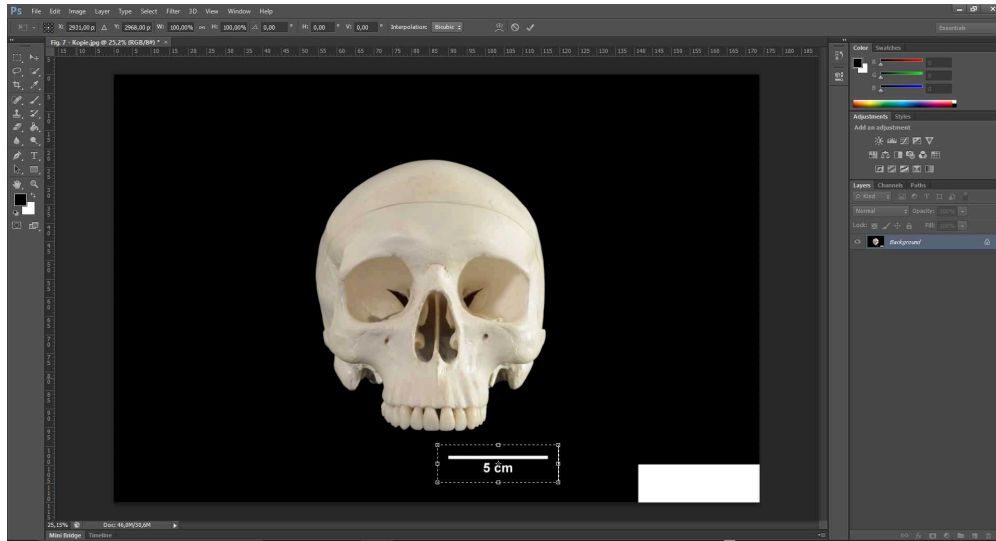
**Fig. 10:** Selected background changed to black.

- 21 To begin, deselect the previously selected background (i.e., by pressing **Ctrl + D** in Adobe® Photoshop®). Then choose the *Rectangular Selection Tool* and select the digital scale bar (fig. 11).



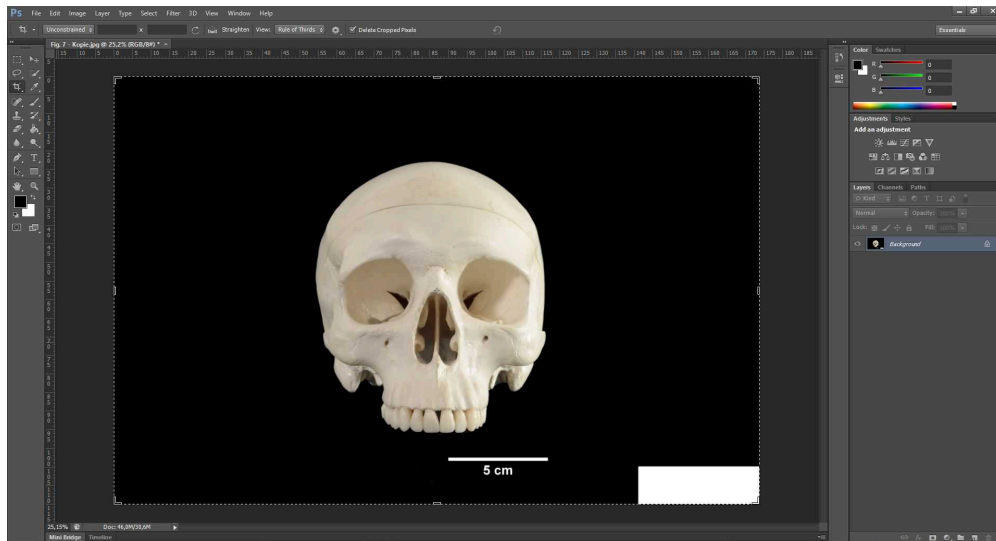
**Fig. 11:** Selected scale bar.

- 22 Press **Ctrl + T** to move the selected scale bar with the cursor to its final position (fig. 12).



**Fig. 12:** Moved scale bar.

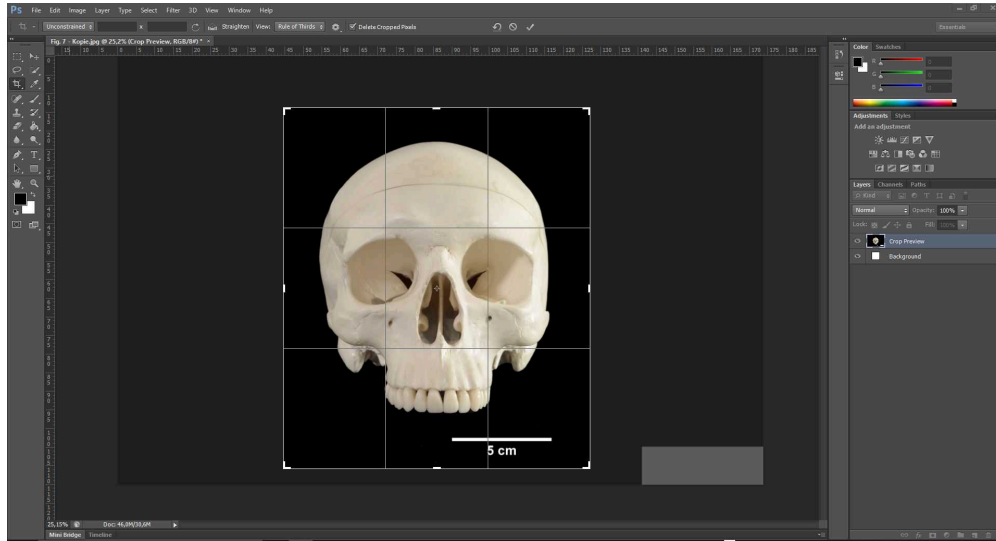
- 23 To confirm the placement, press *Enter* on the keyboard, followed by *Ctrl + D* to deselect the selection. Then select the *Crop Tool*(fig. 13).



**Fig. 13:** Image cropping mode activated.

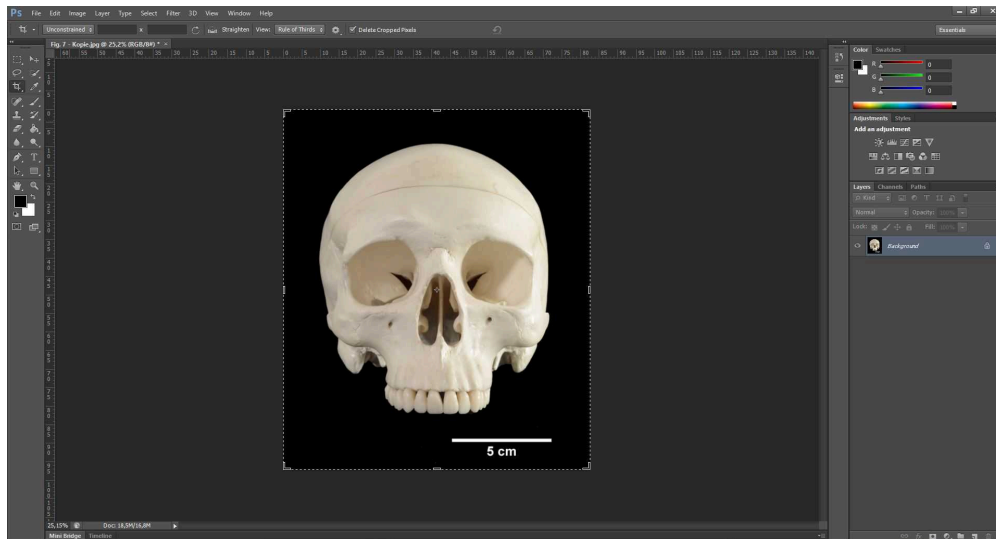
- 24 Crop the image to your desired dimensions (fig. 14).





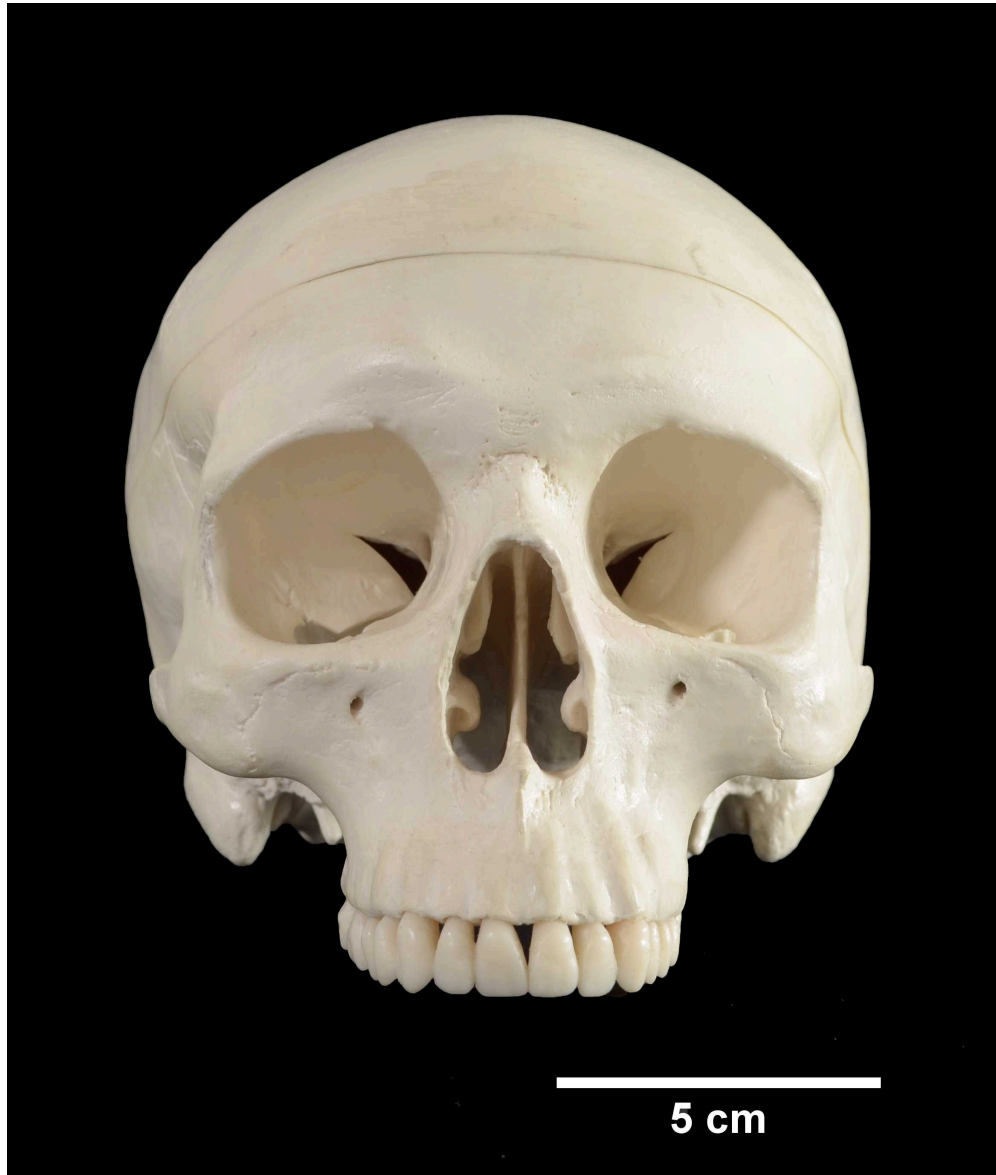
**Fig. 14:** Adjustment of image dimensions in the cropping mode.

25 Confirm your adjustment by pressing *Enter* on your keyboard (fig. 15).



**Fig. 15:** Cropped image.

26 Save the final image in your desired image file format, such as TIFF or JPEG. In Adobe® Photoshop® click on *File* in the top menu bar, and then on *Save as...* Navigate to the target folder, select the file format, and name the file. (fig. 16). Done.



**Fig. 16:** Final image.

### Additional information on scale bar position

27 At this point, your image with the digital scale bar is done.

As mentioned before, the right position of the scale bar is important. To demonstrate the effect of mismatching scale bar positions, I carried out a brief, non-peer reviewed experiment alongside this protocol. This experiment's related PDF can be found on Zenodo.com (DOI: 10.5281/zenodo.7495468, link: <https://zenodo.org/record/7495468>).

