

User guide for the Open Science Laboratory

Hominid Skull Evolution Activity

Welcome to the Hominid Skull Evolution Activity.

Once you have signed in to The Open Science Laboratory and selected the Activity from the list, your browser should look similar to the one below (Figure 1).

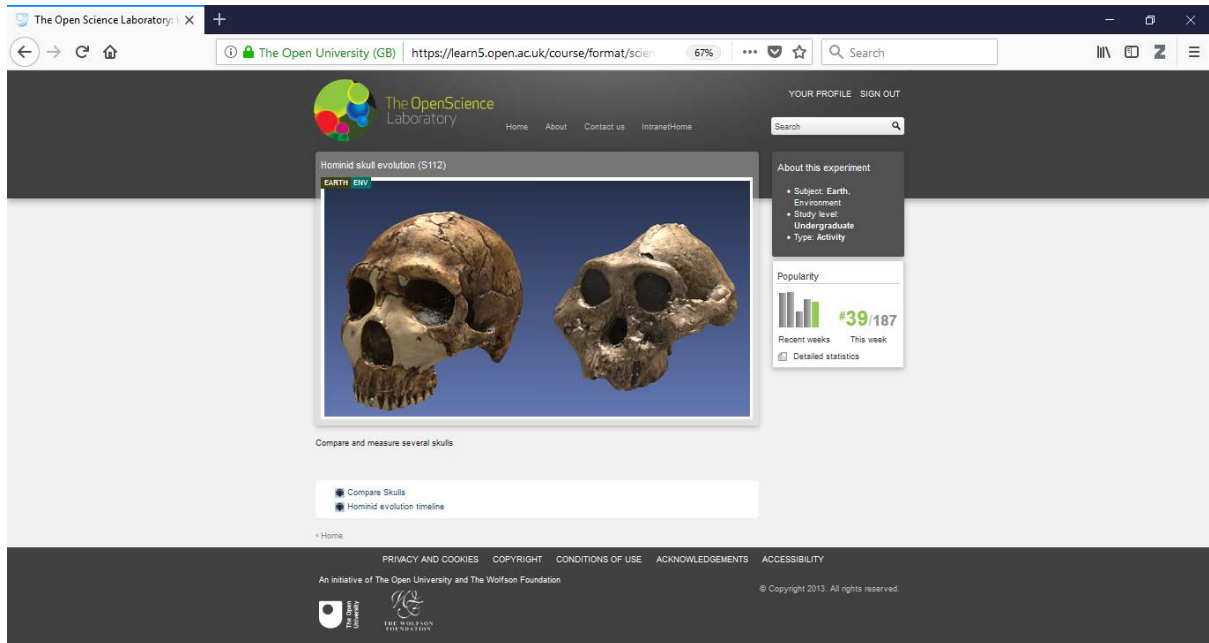


Figure 1: Opening screen for the Hominid Skull Evolution Activity

To access the skulls, scroll to the bottom of this screen and click the 'Compare Skulls' link. Your browser screen should then show the interface (Figure 2).

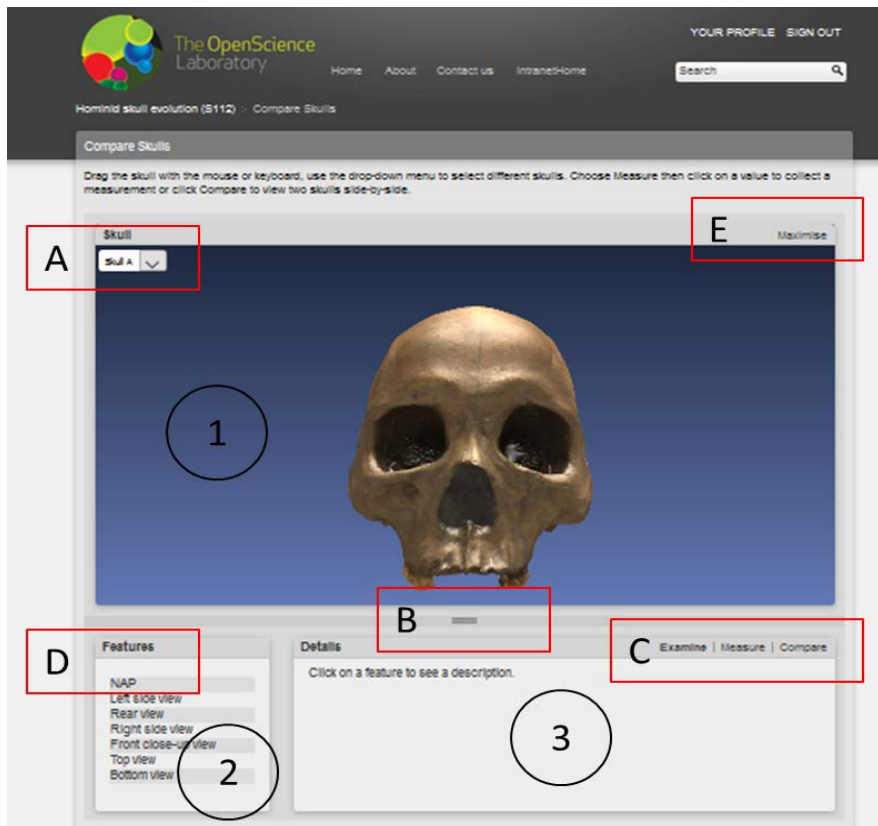


Figure 2: Interface opening screen with several key areas and tools highlighted.

1 = Skull visualisation area

2 = Feature quick link area

3 = Description / measurement recording area

A = Skull selector drop down menu

B = Skull visualisation area size controller (click, hold and drag up or down)

C = Mode selector (Examine → Measure → Compare)

D = Feature links

E = Screen maximise/minimise selector

If your browser screen does not show these features, troubleshoot by doing the following:

1. Change browser – the interface should function in most browsers but this may vary depending on the exact settings of your computer. Try starting the activity in Google Chrome, Mozilla Firefox or Microsoft Internet Explorer.
2. Check your screen zoom settings – you may not be able to view the whole interface on a single screen if your zoom level is set too high. You can also use the Screen maximise/minimise selector above the Skull Visualisation Area to remove the Open Science Laboratory frame from around the interface.

3. If these measures do not allow you to see the interface, please contact your Tutor who will let the Module Team know.
4. If the interface does not appear in the list displayed when you sign in to the Open Science Laboratory or when you perform a search for 'skulls' using the search box in the top right hand corner of the Open Science Laboratory Welcome screen, please contact your Tutor who will let the Module Team know.

Once the interface is running, it is time for you to start exploring! All of the 3D models in the Portal have been produced from specimens held by the Leverhulme Centre for Human Evolutionary Studies (LCHES) at the University of Cambridge that have been collected from all over the world over many years. These samples are so precious that they are rarely handled by anyone aside from a limited number of very experienced scientists so being able to view these models in the detail you can here is closer than most people are ever able to get!

Exercise 1:

Controlling the interface:

After opening the interface, it will be in 'Examine' mode and a very familiar skull should be displayed in the Skull Visualisation Area. This skull is listed as Skull A in the Skull Selection Drop Down Menu (Figure 3).

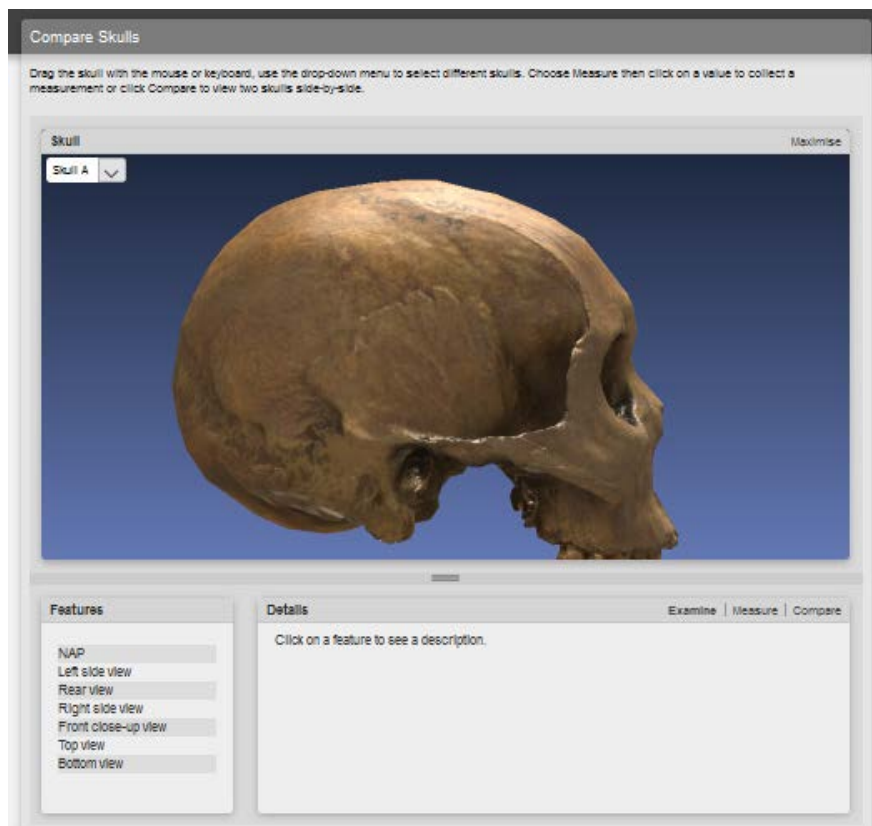


Figure 3: Interface showing Skull A in the Skull Visualisation Area.

This is the skull of a *Homo sapiens* and we are going to use it to demonstrate some of the key features of the interface.

First, look at the list of features in the Feature Quick Link Area. Find the NAP link – this stands for Normal Anatomical Position. Click the link and the skull should rotate so the face is displayed (Figure 4).

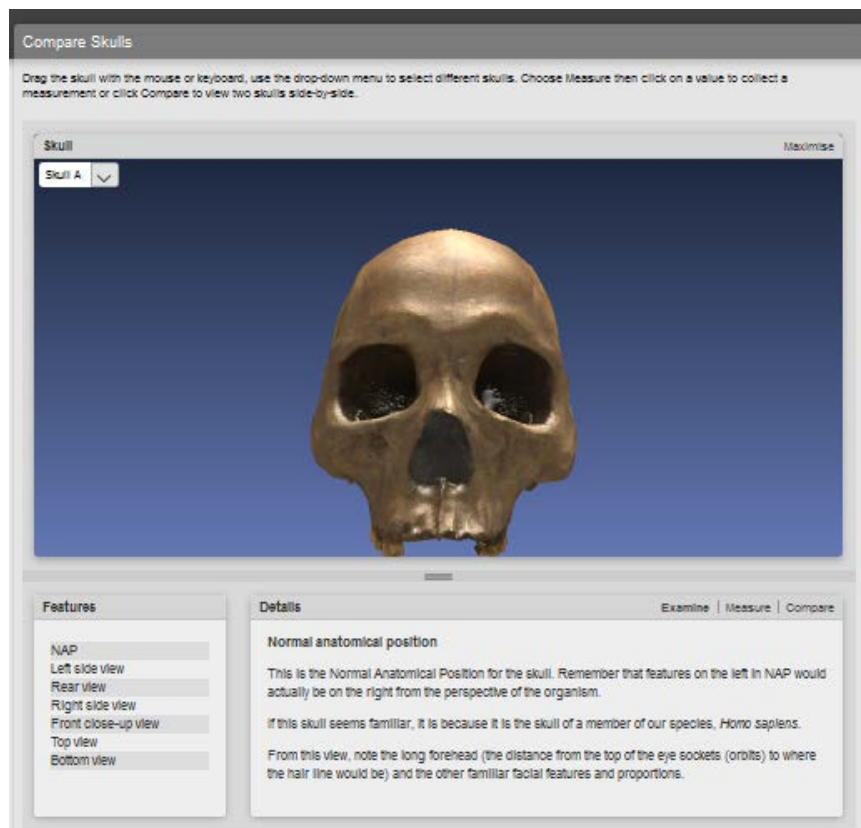


Figure 4: Interface showing Skull A oriented in NAP (Normal Anatomical Position)

Now try rotating the skull. You can do this by clicking your mouse in the Skull Visualisation Area, holding the mouse button down and then dragging the cursor in the direction you want or by using the arrow keys on your keyboard.

You can also zoom in on the skull by using the standard ‘pinch’ gesture if your computer has a track pad, the wheel if you are using a standard mouse or the page up and page down keys on your keyboard.

You can return the skull to NAP at any time by clicking the link in the Feature Quick Link Area.

By rotating and zooming in and out on the skull, try to find the markings placed on the skull by scientists. You should be able to find a label that has been attached to the skull and also some text that has been etched into the surface of the skull.

Make a note of what the label and the etched text say in a text document and save a copy on your computer.

(Hint: Take a close look at the top and bottom surfaces of the skull).

The Feature Quick Link Area contains a number of links in addition to NAP. Before moving on, try clicking on some of these. You will see that for each link some text appears in the Description / measurement recording area that highlights an important feature of the skull that corresponds to what is being displayed in the Skull Visualisation Area. These pieces of text can only be viewed when the interface is in 'Examine' mode and will be useful when you complete the hominid evolution activity later on.

Exercise 2:

Making measurements using the interface:

First make sure the skull is oriented in NAP (click the NAP link in the Feature Quick Link Area). Now switch the interface to 'Measurement' mode by clicking 'Measure' in the Mode Selector.

Switching to 'Measurement' mode should cause your screen display to change and look as shown in Figure 5. Importantly, a spreadsheet should appear in the Description / measurement recording area.

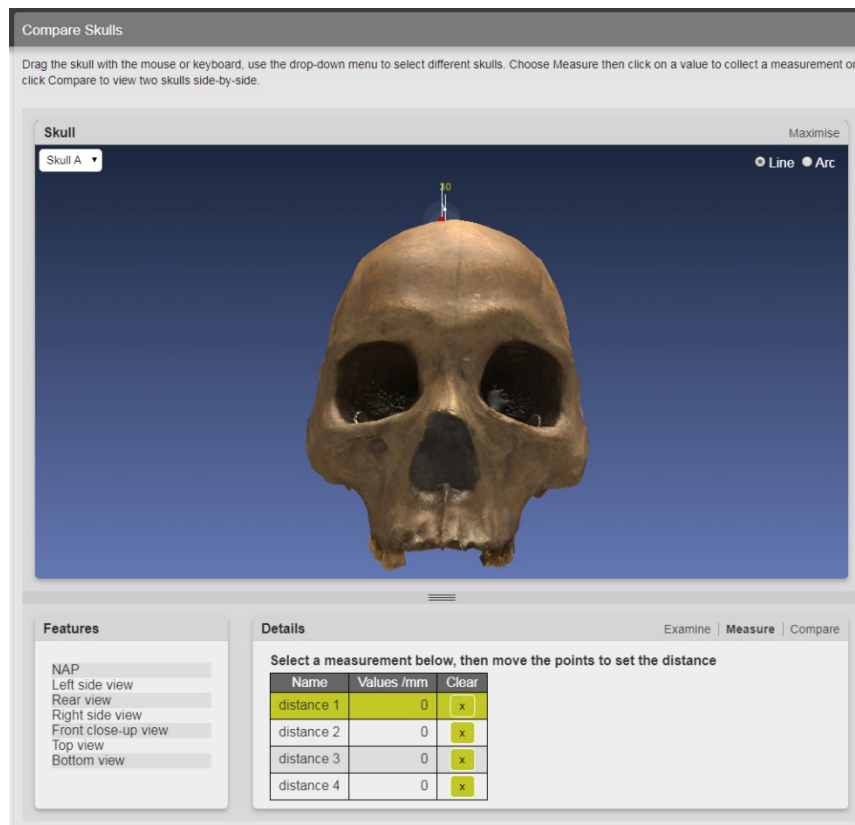


Figure 5: Interface in 'Measurement' mode showing the data recording spreadsheet in the Description / measurement recording area.

You should now use the measurement tool (which should be set to 'Line' mode by default but check the selector buttons in the top right hand corner of the Skull Visualisation Area to make sure) to determine the width of the right eye socket (also known as the orbit). As the skull is in normal

anatomical position and you are facing it, the right eye socket is actually the orbit on the left side of the skull.

First click in the cell in the Values / mm column in the same row as distance 1. This row should turn green. If you now rotate the skull so you are viewing the top, you should see two red circles with a line connecting them. This is the measurement tool.

By clicking the mouse over one of the red circles and holding it, you should be able to drag the first measuring point across the surface of the skull. As you do so you will notice that the line connecting the two circles gets longer. Position the first circle so it is above the right orbit. Now repeat the process with the other red circle (Figure 6).

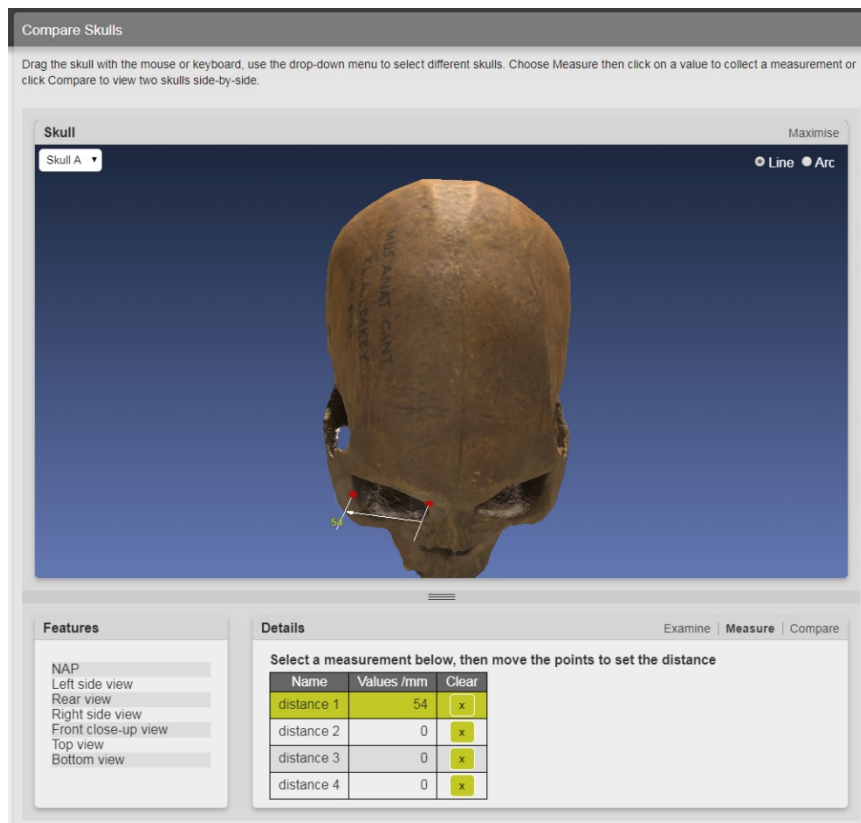


Figure 6: Interface showing approximate positioning of measurement tool around right orbit.

Now return the skull to NAP by clicking the appropriate link in the Feature Quick Link Area. Using the same click and hold approach to position the two measuring points, move one circle of the measuring tool to the 9 o'clock position on the right orbit and the other to the 3 o'clock position. The number that appears near the measuring tool represents the width of the orbit in millimetres (Figure 7).

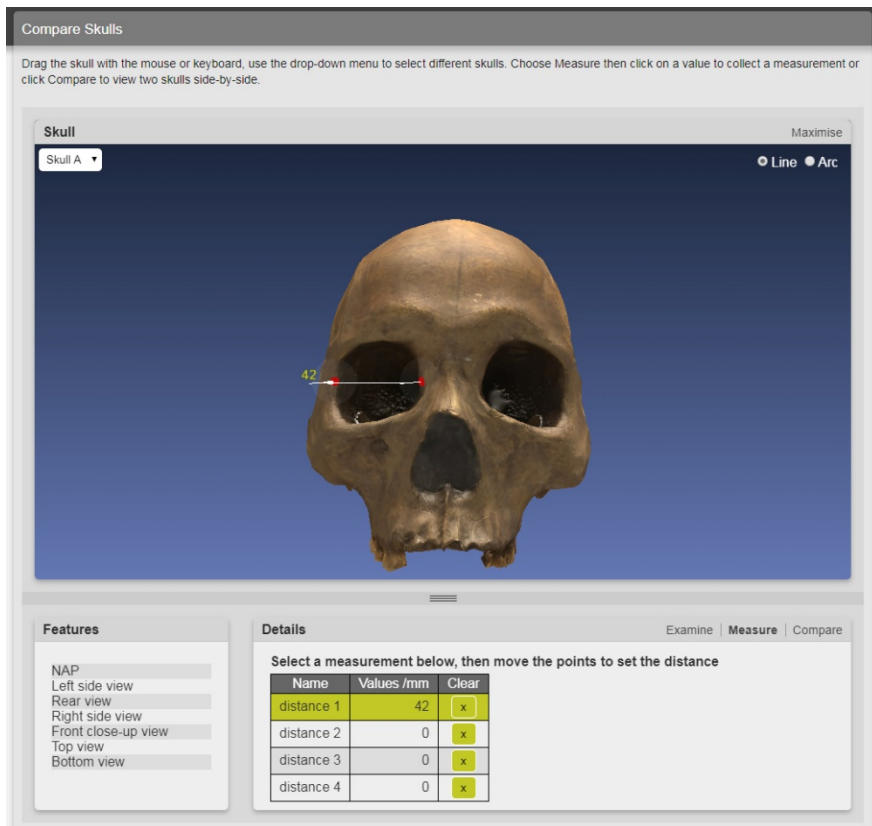


Figure 7: Interface showing right orbit width measurement. Please note that your measurement may be slightly different to that shown as the positioning of the two measurement points will likely differ between users.

If you now look at the spreadsheet in the Description /measurement recording area, you should see that it has automatically updated to show the measurement you have just made (Figure 8).

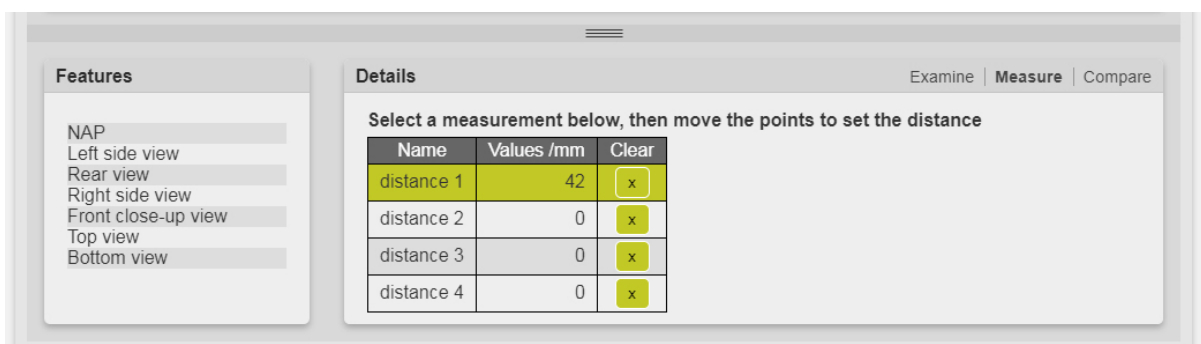


Figure 8: Close up of interface showing spreadsheet updated with right orbit width measurement. Please note that your measurement may be slightly different to that shown as the positioning of the two measurement points will likely differ between users.

If you want to change the position of the measuring tool and re-take the measurement of the orbit, you can do so by clicking the cross in the Clear column of the spreadsheet in the same row as

distance 1 (Figure 8). This will remove the entry from the spreadsheet. You can then reposition the measuring tool and the spreadsheet will update with the new measurement.

Now take a measurement of the width of the left orbit. To do this, first click in the spreadsheet cell in the Values / mm column next to distance 2. This row should now turn green. Then, using the same click and drag approach, move the two red circles of the measuring tool across the skull and position them at the 3 o'clock and 9 o'clock positions of the left orbit. Check that your spreadsheet has updated appropriately and note down the two measurements you have made, making sure to clearly identify which one is related to which orbit.

Exercise 3:

Making comparisons using the interface:

Once you have completed Exercise 2, return the skull to NAP by clicking the appropriate link in the Feature Quick Link Area.

You should now switch the interface to 'Comparison' mode by clicking 'Compare' in the Mode Selector. This will cause the display to change and look like Figure 9.

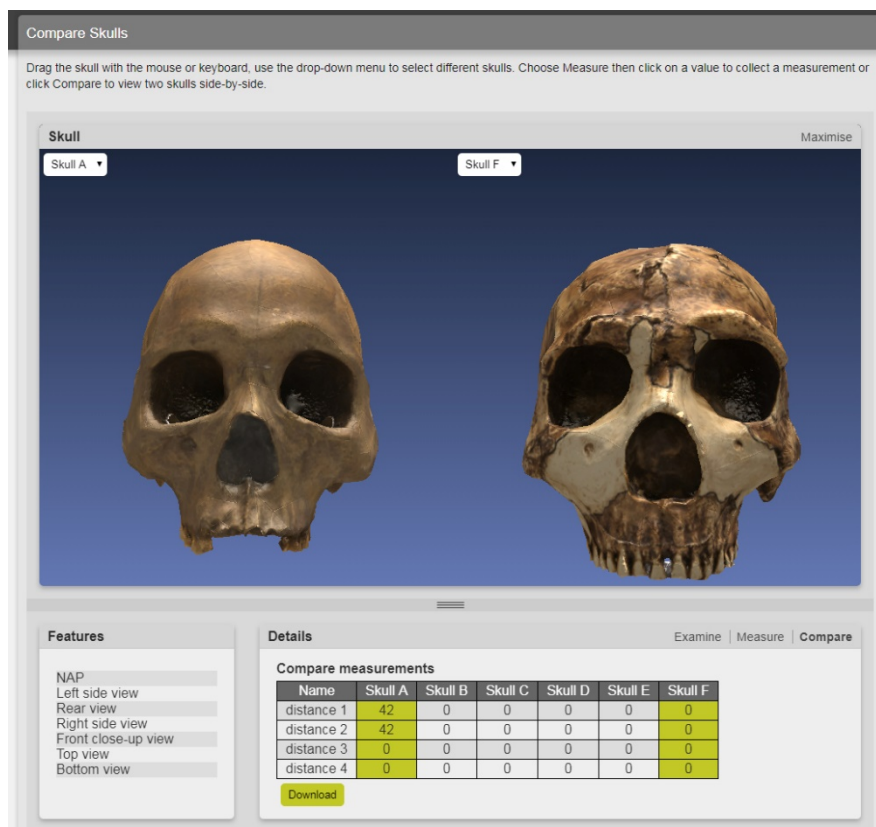


Figure 9: Display configuration when interface in 'Comparison' mode.

The most important change is the appearance of another skull on the right side of the Skull Visualisation Area. Using the same gestures you learned about in Exercise 1, you can rotate and zoom in or out on the two skulls simultaneously. You can also compare any two skulls in the model collection by changing the letters in the two Skull Selector Drop Down Menus. Clicking on features in the Feature Quick Link Area also causes the interface to automatically rotate both skulls to the same

position, allowing you to focus on comparing a particular feature if you wish to. Try this now by selecting 'Top View' from the Feature Quick Link Area. Once you have done this, return the skulls to NAP.

The Description / measurement recording area also now shows a larger spreadsheet in which any measurements you collected in 'Measurement' mode can be directly compared. The spreadsheet should currently contain the eye orbit width measurements you collected from Skull A (*Homo sapiens*) earlier.

Using what you learned in Exercise 2, return the interface to 'Measurement' mode and take a measurement of the width of the right orbit of Skull F. Make sure this value appears in the spreadsheet for Skull F as distance 1 (Figure 10).

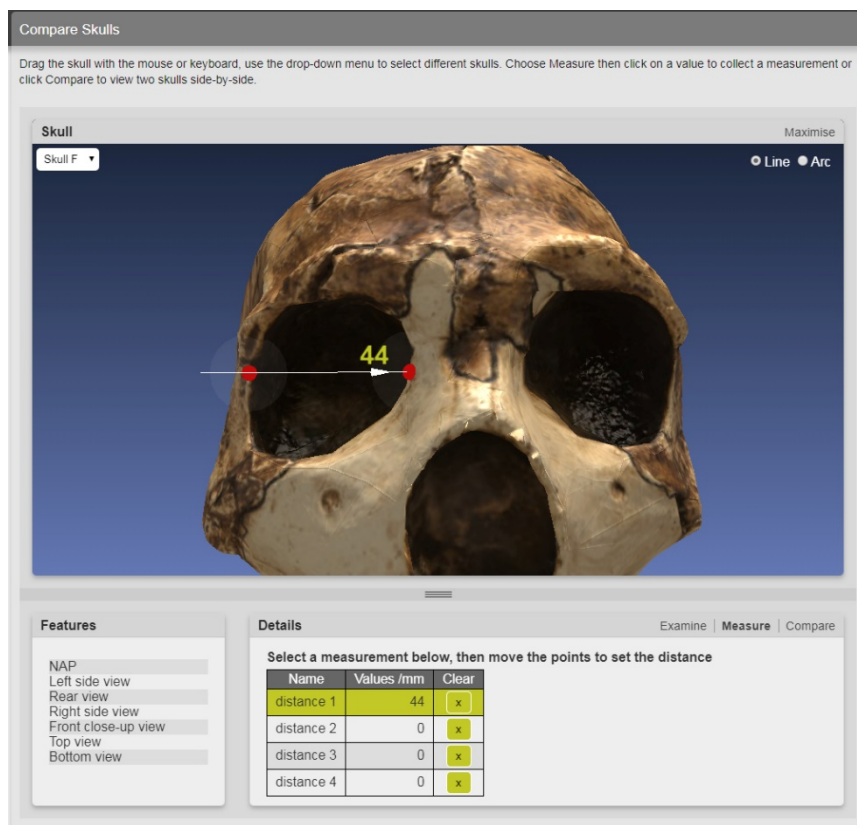


Figure 10: Showing interface in 'Measurement' mode indicating the right orbit width of Skull F with the measuring tool and with the spreadsheet. Please note that your measurement may be slightly different to that shown as the positioning of the two measurement points will likely differ between users.

Now return to 'Comparison' mode by clicking 'Compare' in the Mode Selector. The spreadsheet should now be updated with the right orbit width measurement collected from Skull F (Figure 11).

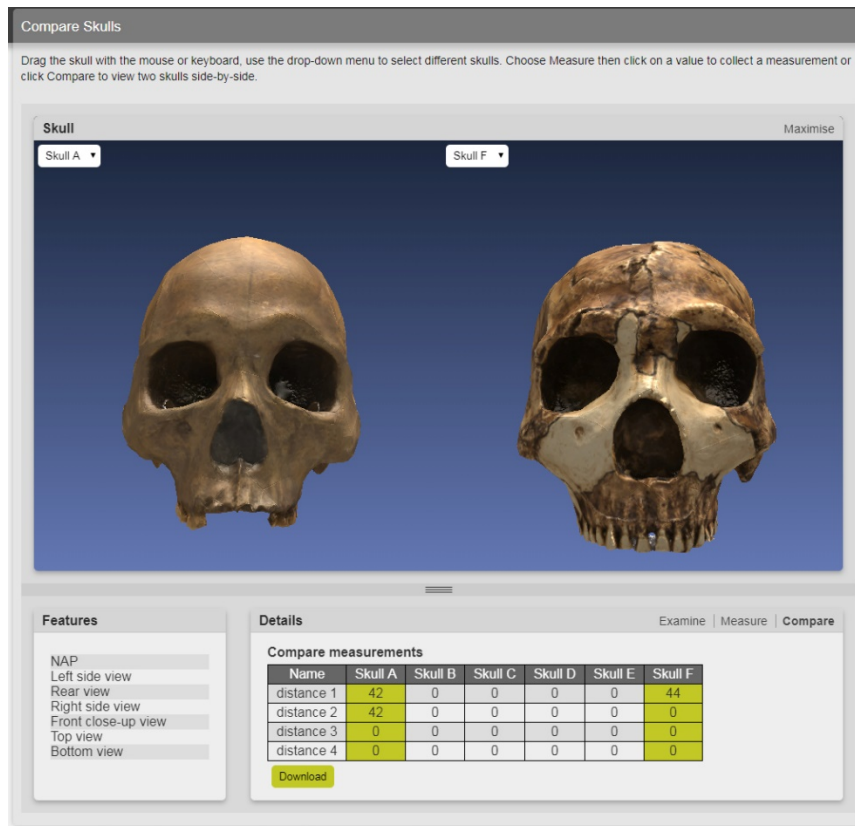


Figure 11: Interface in 'Comparison' mode showing the spreadsheet updated with the right orbit width measurement collected from Skull F. Please note that your measurements may be slightly different to those shown as the positioning of the two measurement points across the various widths recorded will likely differ between users.

Repeat this process to collect a measurement for the width of the left orbit of Skull F and add it to the comparison spreadsheet.

Once you have completed this, download a copy of the spreadsheet to your computer by clicking the green 'Download' button which appears underneath the comparison spreadsheet when the interface is in 'Comparison' mode (Figure 11).

You have now successfully completed the exercises required for you to use the interface in the activity.

Studying the march of bipedalism through the fossil record:

The development of bipedalism is considered to be a very critical event in the evolution of hominids. As you know from the module materials, evolution is a process of gradual change and so it was with the various adaptations of the skeleton required to support the transition to bipedal motion.

Among these adaptations was the gradual movement of the foramen magnum (the hole in the bottom of the skull through which the spinal cord and brain stem connect to each other). This occurred because for a bipedal organism to stand upright and have its eyes facing forwards (rather than upwards) there needs to be an approximate right angle between the spinal cord and the base

of the skull. Movement of the foramen magnum towards the centre of the skull enables this angle to be accommodated and provides the joint with sufficient strength and stability.

As a comparison consider a quadrupedal organism like a domestic cat. When the animal is moving on all fours, the eyes of the animal also face forwards (rather than upwards). In this case though, the base of the skull and the spinal cord are almost in line with each other. To accommodate this angle, the foramen magnum is positioned much closer to the back of the skull.

The position of the foramen magnum on the base of the skull and the development of the bipedal posture can therefore be used as way of determining the evolutionary relationships between the various ancestors of *Homo sapiens* with earlier (i.e. older) species having a foramen magnum closer to the back of the skull.

To determine the position of the foramen magnum, two measurements are required:

1. The distance between the back of the skull and the edge of the foramen magnum closest to the back of the skull (also known as the Foramen Magnum Distance to Back) (Figure 12).



Figure 12: Example of Foramen Magnum Distance to Back measurement

2. The total distance between the back of the skull and the front edge of the palate (roof of the mouth) (also known as the Skull Length) (Figure 13).



Figure 13: Example of Skull Length measurement

Dividing the value for Foramen Magnum Distance to Back by the value for Skull Length for a particular skull generates a value known as the Foramen Magnum Index for that skull:

$$\text{Foramen Magnum Index} = \frac{\text{Foramen Magnum Distance to Back (mm)}}{\text{Skull Length (mm)}}$$

An organism adapted for bipedal movement should have a Foramen Magnum Index of approximately 0.3. This value will be smaller in less well-adapted (and therefore less recently evolved) organisms, reflecting the change in foramen magnum position.

Activity

1. Using the measuring tool in the 'Measurement' mode of the interface, take measurements of the Foramen Magnum Distance to Back and Skull Length of each of the skulls.
2. Switch the interface to 'Comparison' mode and download a copy of the spreadsheet containing all of your measurements to your computer.
3. Add a column to your spreadsheet that calculates a Foramen Magnum Index for each skull and save a copy on your computer.
4. While important, the movement of the foramen magnum is not the only change in the hominid skull that occurred in the evolution of *Homo sapiens*. A number of other features also changed and several of these are highlighted in the text displayed in the Description / measurement recording area when the interface is in 'Examination' mode. For each skull, work through each of the links in the Feature Quick Link Area and read the text that appears in the Description / measurement recording area.
5. Based on what you have read about each skull and using your list of Foramen Magnum Index values, place each skull within the hominid evolution timeline which you can access from the opening page (Figure 1). When you have completed the timeline take a screenshot of it and save a copy of the image on your computer.

