

# 3D DIGITIZATION FOR FACILITATING RESEARCH IN PALEONTOLOGY

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A workflow from physical fossil to digital curation

Arianna Harrington, Patricia Holroyd, Doug Boyer

# Studying and comparing locality samples

## Features

- Large number of bones



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## Risks/Difficulties

- Unwieldy size of bones (big or small)



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- Unwieldy size of bones (big or small)
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- Loss of association between specimen and number
- Communicating observations to collaborators/community



# Studying and comparing locality samples

## Risks/Difficulties

- Unwieldy size of bones (big or small)
- Fragile (handling or caliper measures)
- Loss of association between specimen and number
- Communicating observations to collaborators/community
- Limited time for borrowing museum specimens



# Studying and comparing locality samples

## **Solution**

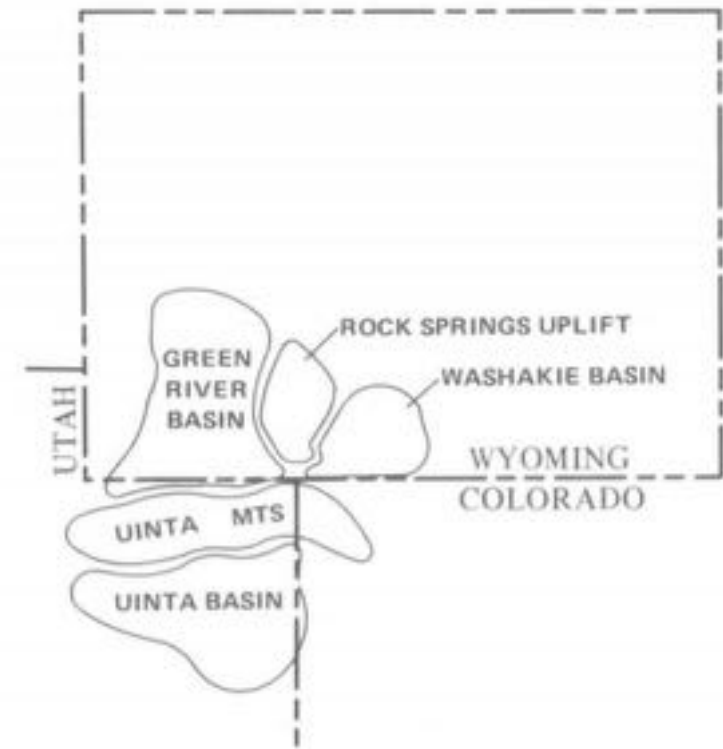
- 3D digitization and curation in 3D archive (MorphoSource)



# Studying and comparing locality samples

## Case study

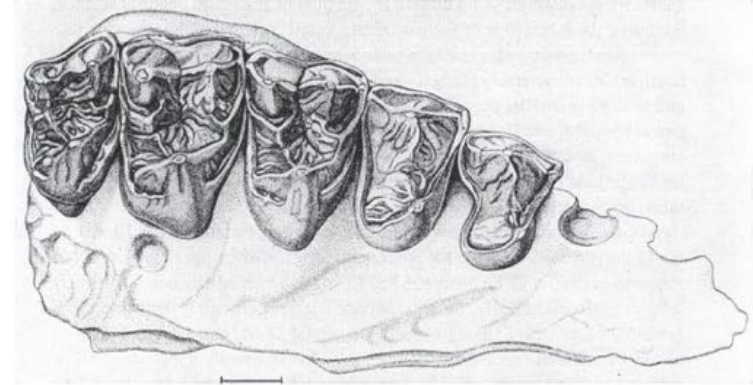
- Early Eocene Bittercreek Fauna (Savage and Waters, 1978) curated at the UCMP
- Thousands of bones from early Eocene sites in the Washakie Basin, Wyoming
- Collecting started by Don Savage in 1970's
- Continued by Berkeley Crews through 90's
- At least 450 primate bones borrowed by Duke University in 2012



# Eocene primates from the UCMP

## Importance

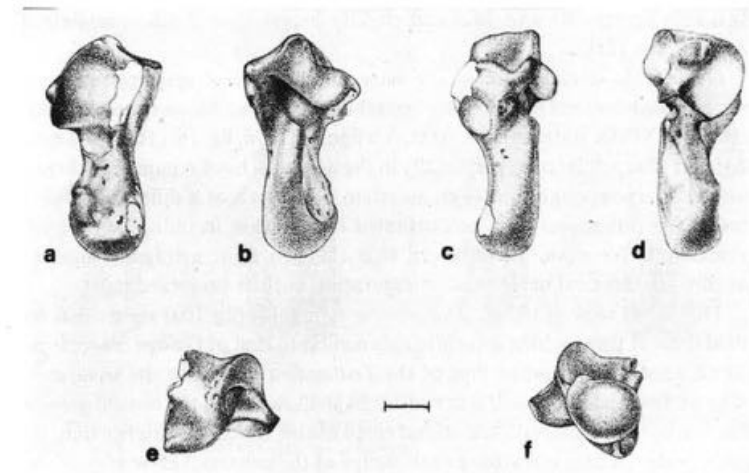
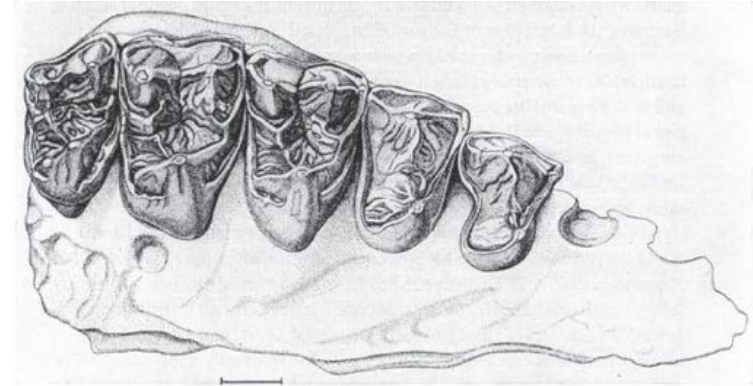
- Postcranial skeleton of early Eocene primates mostly unknown
- Many questions about primate origins remain
- Berkeley sample contains many bones of at least 5 species

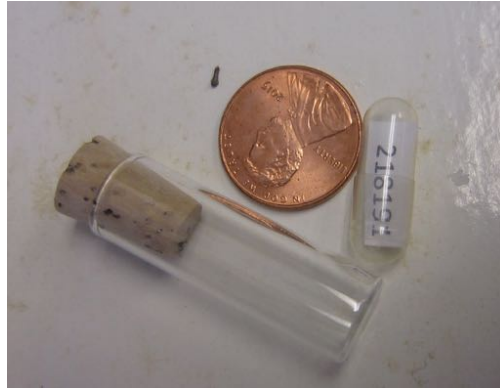


# Eocene primates from the UCMP

## Importance

- Meaningful study requires
  - many measurements and comparisons in order to....
    - sort bones into anatomical element categories, and morph classes
    - Figure out which morphs correspond to which dental classes
    - Assess overall morphological similarities and differences between taxa
- This process is very impractical with physical specimens

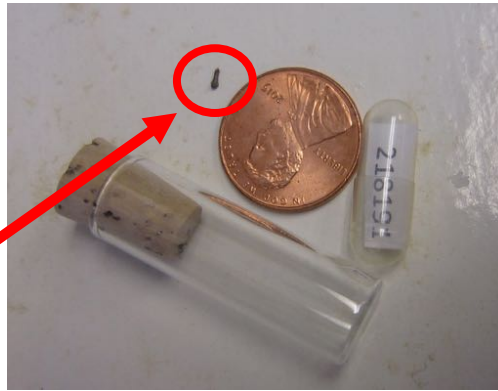




# Difficulties

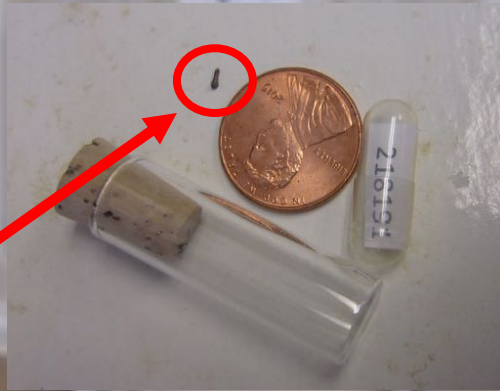


small



Difficulties





small

Difficulties

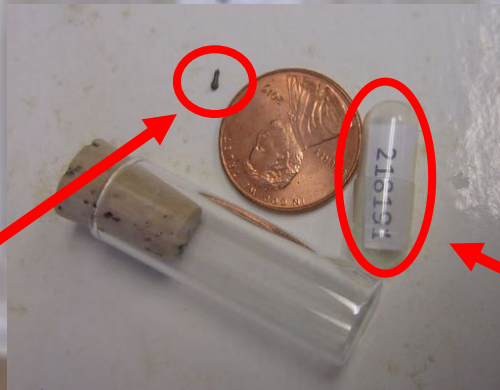
numerous

small

Difficulties

non-obvious  
ID

numerous



small



non-obvious  
ID

Difficulties

numerous

loss danger

# Goal

Physical fossil



Digital representation



Digital curation



# Planning the process



**MORPHO SOURCE**  
UNIVERSITY OF CALIFORNIA MUSEUM OF PALEONTOLOGY COLLECTIONS

ABOUT | HOW TO USE | CONTACT | SEARCH

UNIVERSITY OF CALIFORNIA | 1001 SHALICE DRIVE | BERKELEY, CA 94720-1334 | TEL: 415.495.7000

HOME | ABOUT | CONTACT | SEARCH | FILTERS

Project Name:

Number of Project Field Sites:

Number of Project Field Sites:

Project Name View:

Storage Level:

Number of Locations:

Number of Clusters:

Created On:

**355 Project Specimens**

Order By:

# Planning the process

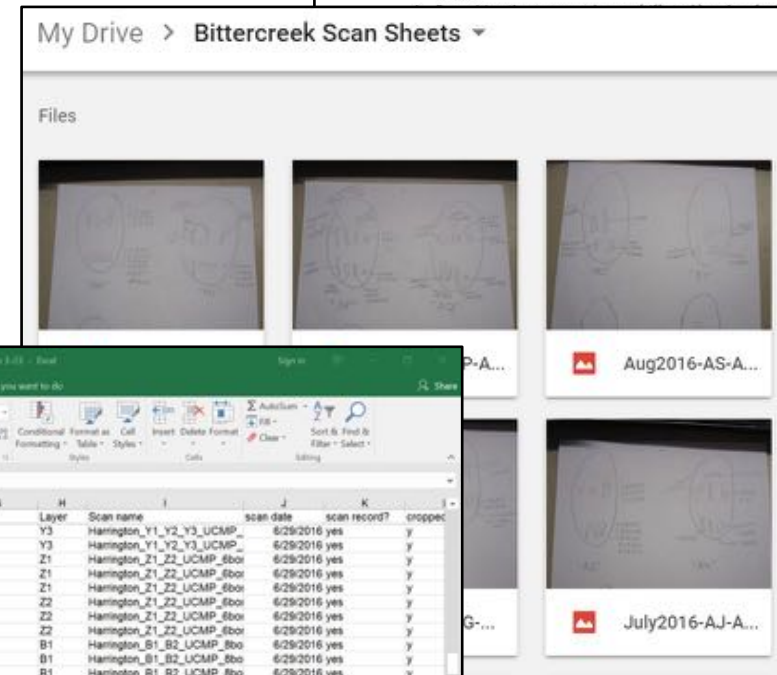
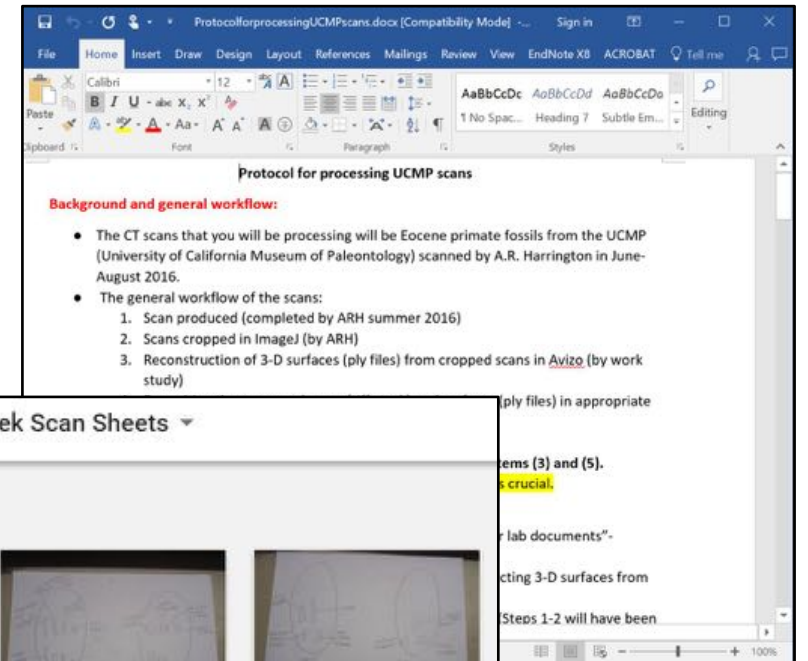
## The chosen workflow must be:

1. Efficient
  - Multiple specimens in one scanning event
2. Traceable
  - Must be able to keep track of what specimens are being scanned

# Planning the process

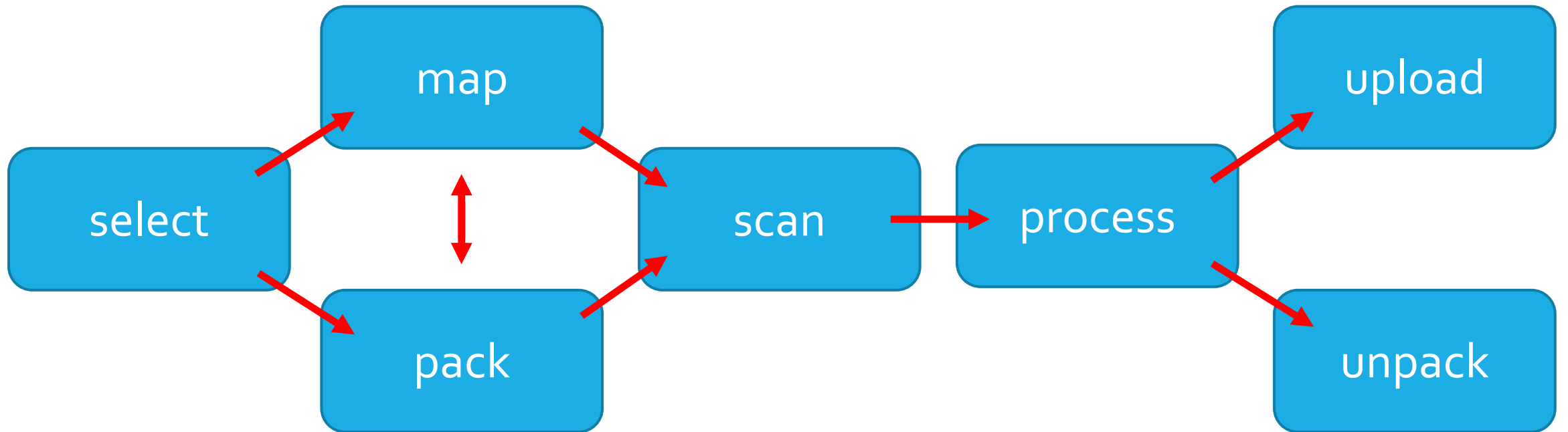
## Entails:

- Careful, detailed record-keeping
- Organized workflow with protocols outlined each step of the way



Inst/Don	Specimen	Unpacked Genus	Species	Element	Side	Layer	Scan name	scan date	scan record?	cropped
132	UCMP	218163	y			Y3	Harrington_Y1_Y2_Y3_UCMP_	6/29/2016	yes	y
133	UCMP	218164	y			Y3	Harrington_Y1_Y2_Y3_UCMP_	6/29/2016	yes	y
134	UCMP	218144	y			Z1	Harrington_Z1_Z2_UCMP_	6/29/2016	yes	y
135	UCMP	218149	y			Z1	Harrington_Z1_Z2_UCMP_	6/29/2016	yes	y
136	UCMP	218167	y			Z1	Harrington_Z1_Z2_UCMP_	6/29/2016	yes	y
137	UCMP	218179	y			Z2	Harrington_Z1_Z2_UCMP_	6/29/2016	yes	y
138	UCMP	218180	y			Z2	Harrington_Z1_Z2_UCMP_	6/29/2016	yes	y
139	UCMP	218285	y			Z2	Harrington_Z1_Z2_UCMP_	6/29/2016	yes	y
140	UCMP	218161	y			B1	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
141	UCMP	218206	y			B1	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
142	UCMP	218213	y			B1	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
143	UCMP	217997	y			B1	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
144	UCMP	218141	y			B2	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
145	UCMP	218140	y			B2	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
146	UCMP	218201	y			B2	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
147	UCMP	218203	y			B2	Harrington_B1_B2_UCMP_	6/29/2016	yes	y
148	UCMP	217976	y			E1	Harrington_E1_E2_UCMP_	6/29/2016	yes	y
149	UCMP	217981	y			E1	Harrington_E1_E2_UCMP_	6/29/2016	yes	y
150	UCMP	217980	y			E1	Harrington_E1_E2_UCMP_	6/29/2016	yes	y
151	UCMP	218123	y			E2	Harrington_E1_E2_UCMP_	6/29/2016	yes	y
152	UCMP	218124	y			E2	Harrington_E1_E2_UCMP_	6/29/2016	yes	y
153	UCMP	218171	w			E2	Harrington_E1_E2_UCMP_	6/29/2016	yes	y

# Workflow





# Step 1. Selecting Specimens

## Specimens in batches

- Scan first in the same specimen container, assign specimen numbers later

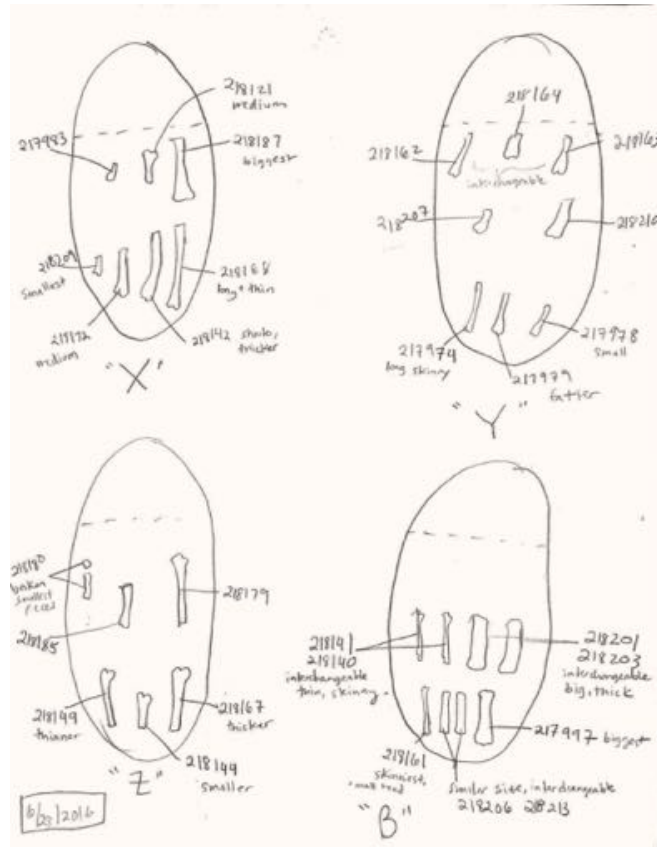


## Specimens in individual vials

- Need to pay attention to specimen ID within one scanning container



# Step 2. Map and Pack



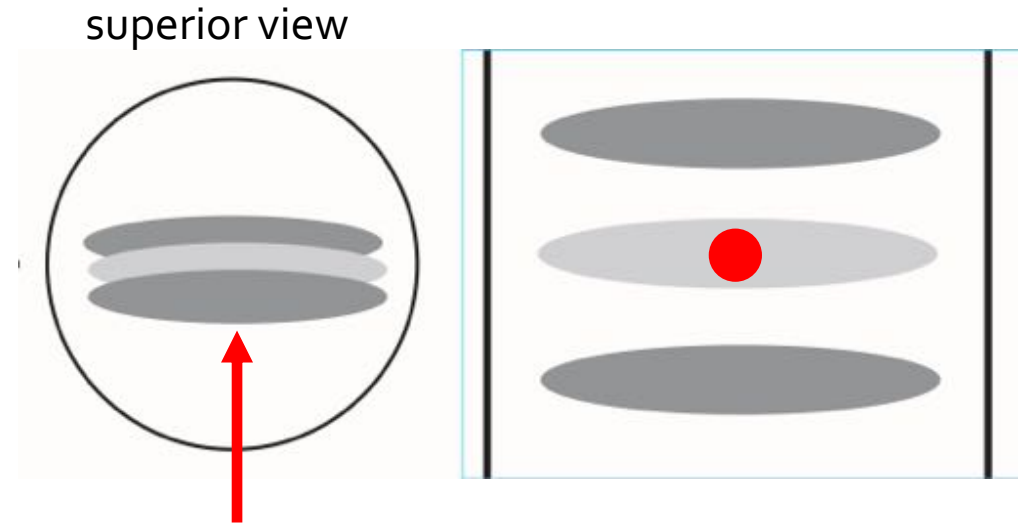
# Packing:

- Balance of efficiency and maintenance of identification
- Fossils placed in labeled pill caps placed in a milkshake straw stuffed with cotton, outside of straw labeled
- Straw placed in a vial with clay (ease of loading into scanner, seems to lessen effects of vibrations)



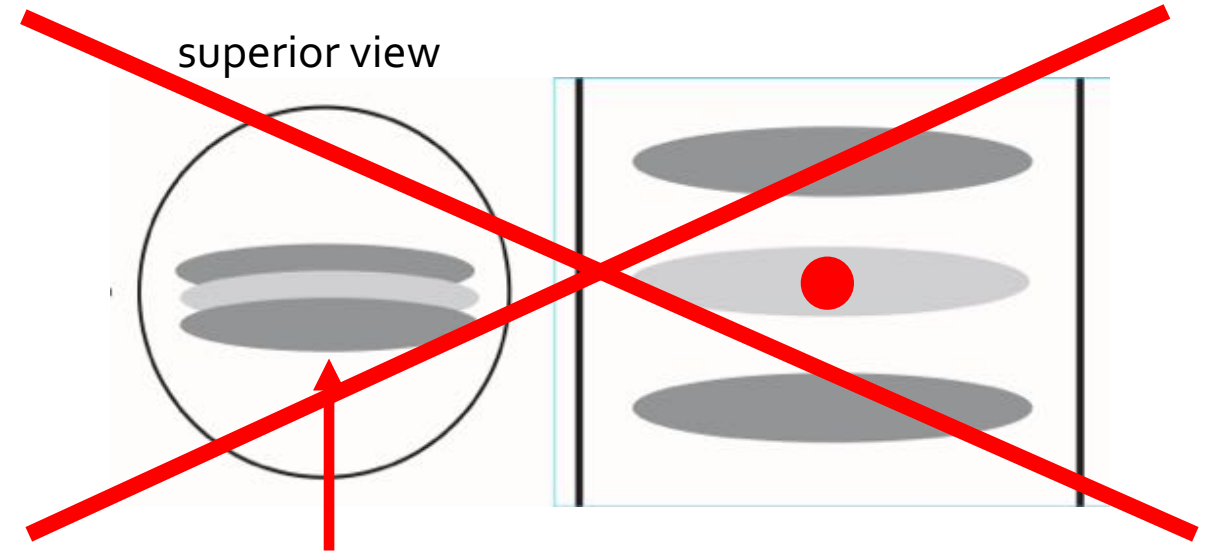
# Packing:

- Balance of efficiency and maintenance of identification



# Packing:

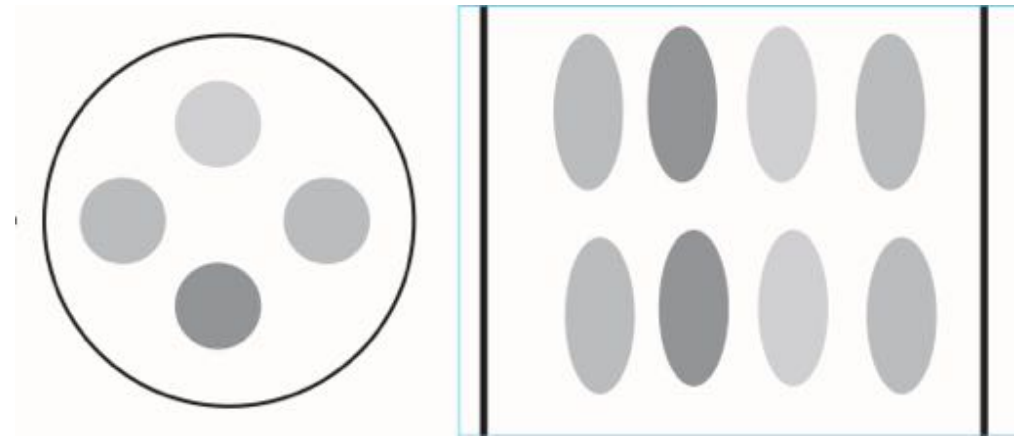
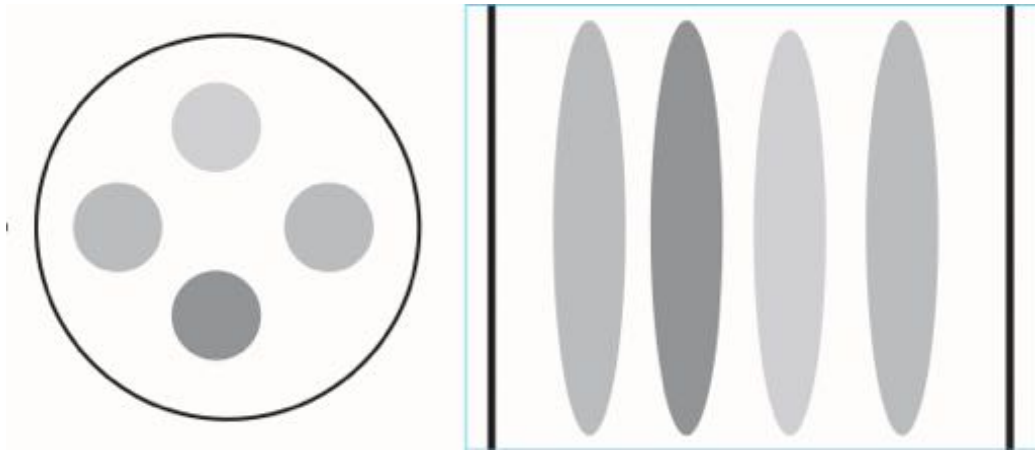
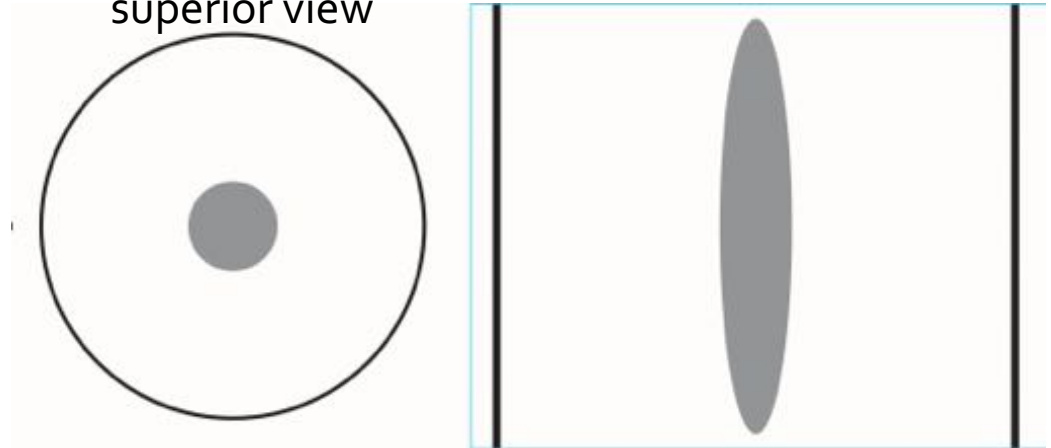
- There are considerations for how specimens should be packed



# Packing:

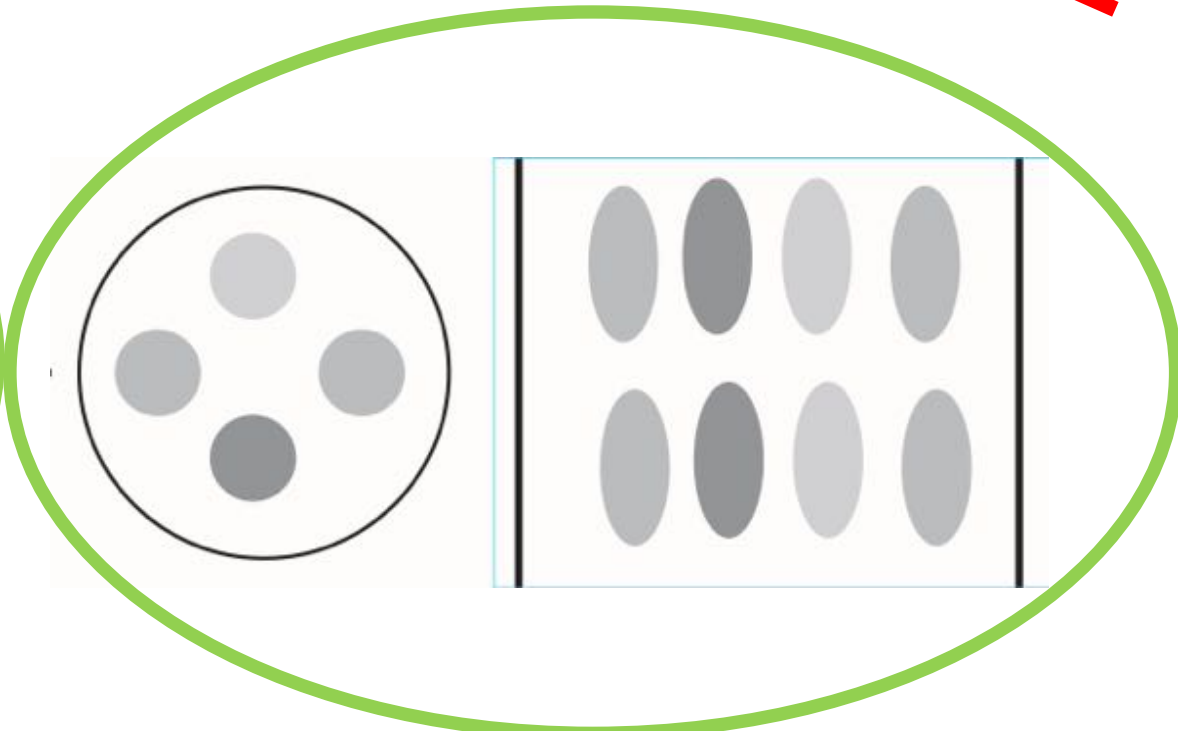
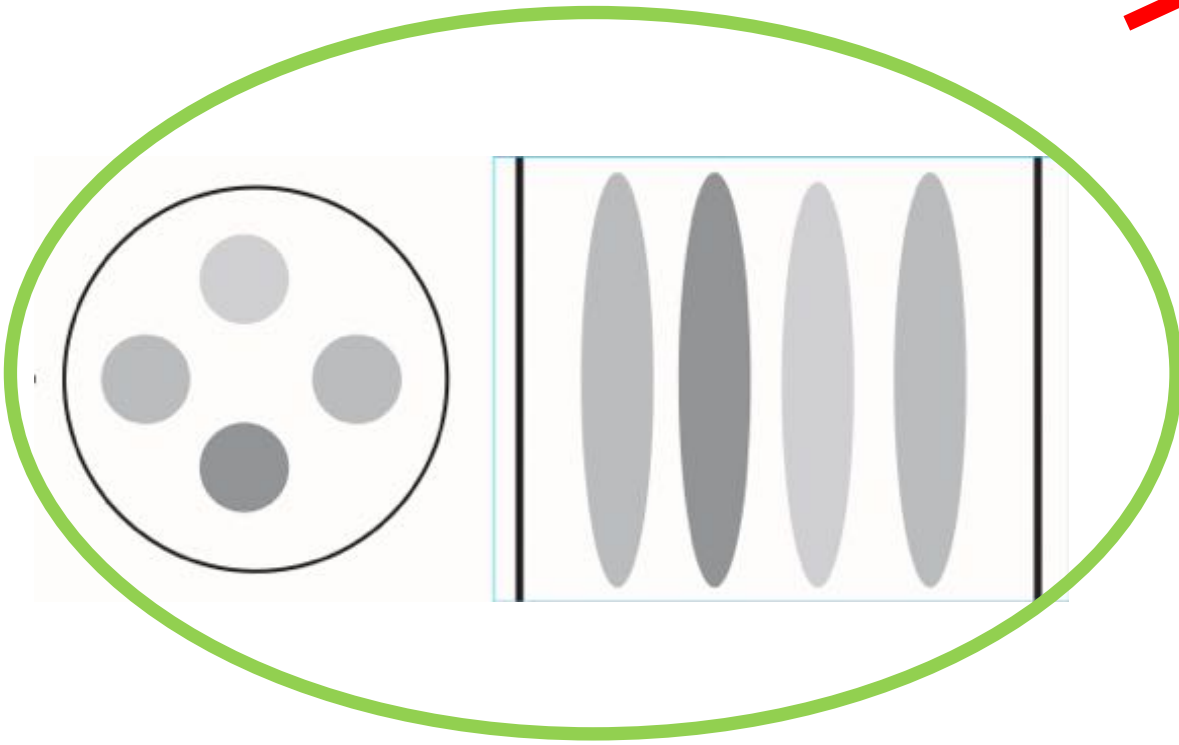
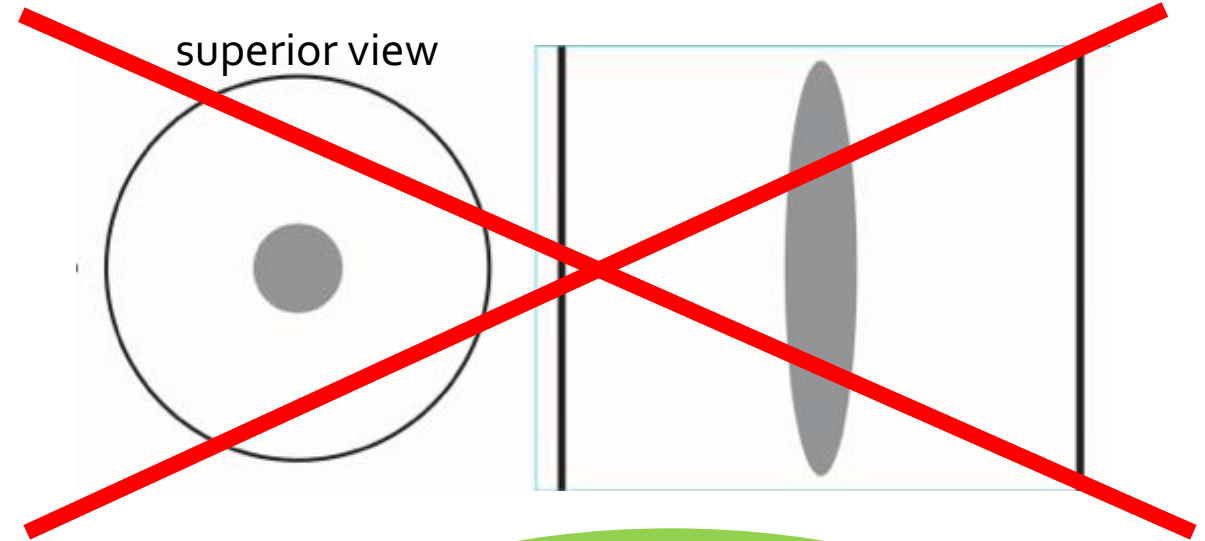
- There are considerations for how specimens should be packed

superior view



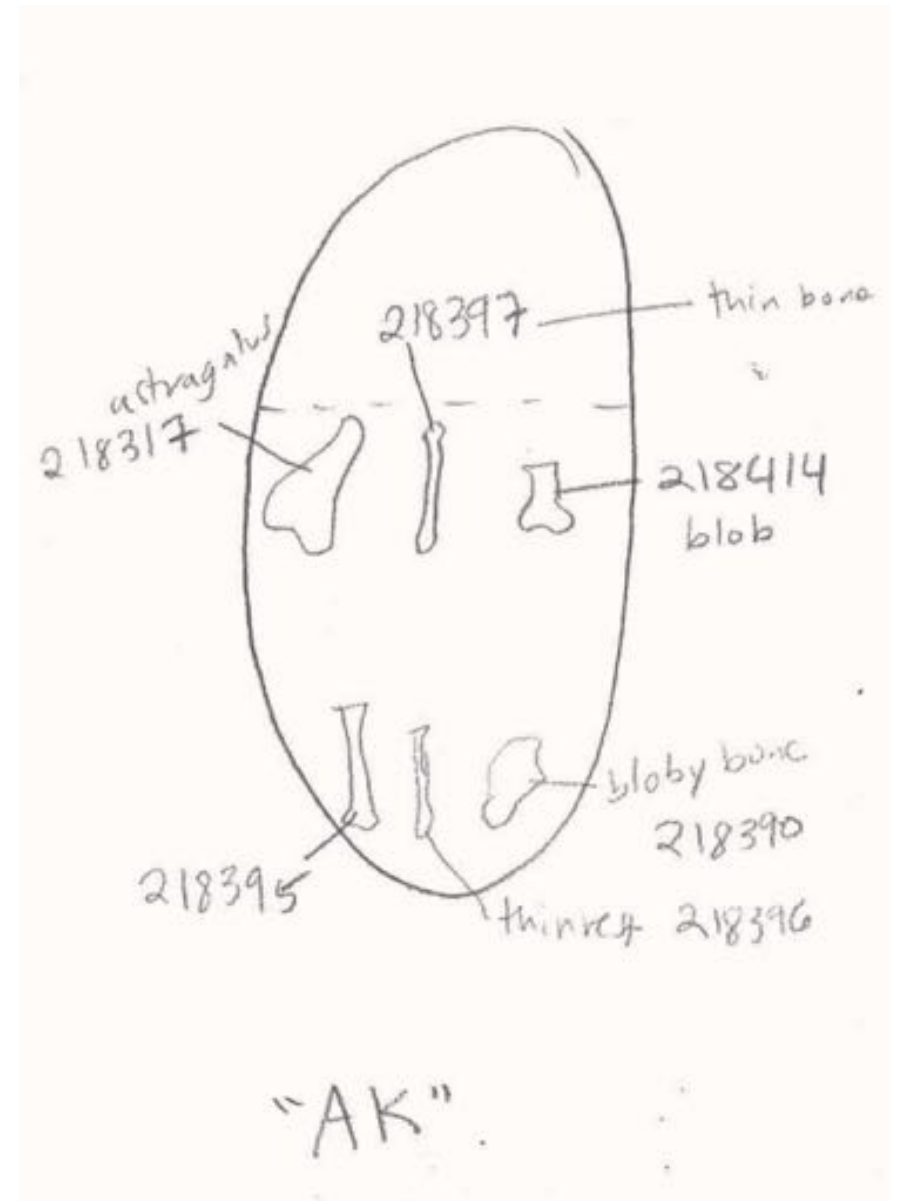
# Packing:

- There are considerations for how specimens should be packed



# Mapping

- Prioritize identification, accuracy
- Maps were photographed and uploaded to Google Drive ("insurance")





# Step 3. Micro CT Scan

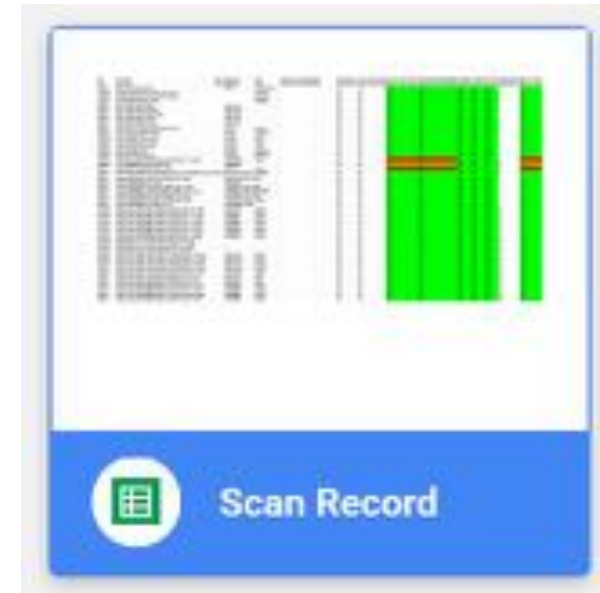
- Naming of files should be consistent
  - Ex:  
Harrington\_AK1\_UCMP\_omomyid\_  
3bones
- Keeping of good scanning records begins here
  - Ex: lab scan records, project-specific scan records



# Step 3. Micro CT Scan

## Example scan record

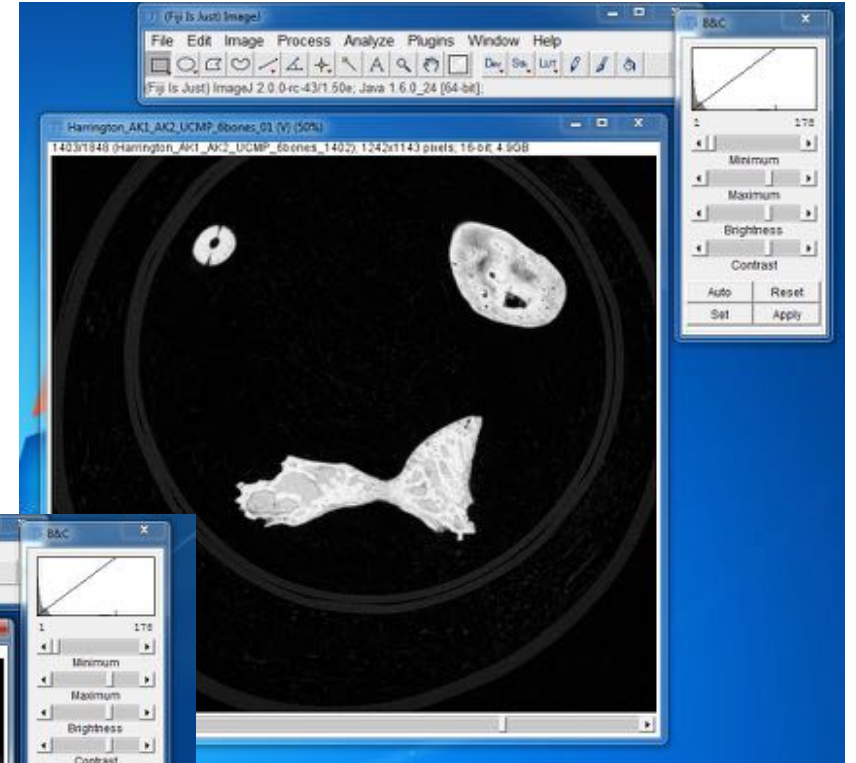
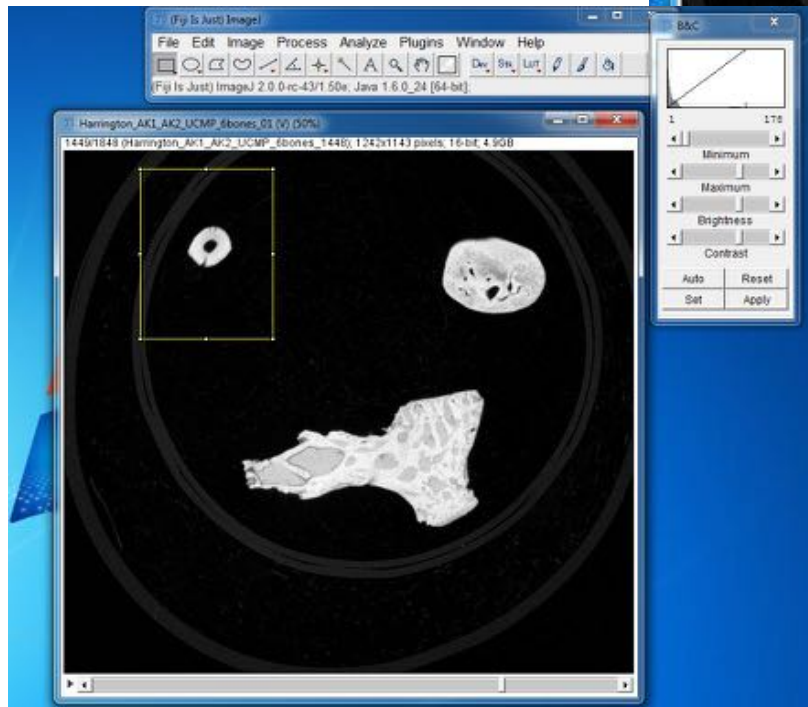
- Every critical step is indicated by a y/n column
- Example: unpacked, layer, scan name, scan date, scan record, cropped, metadata copied, transferred for processing, transferred to Boyer drive, uploaded to MorphoSource



1	Institution	Specimen	unpacked	Genus	Species	Element	Side	Layer	Scan name	scan date	scan record?	cropped
132	UCMP	218163	y					Y3	Harrington_Y1_Y2_Y3_UCMP_	6/29/2016	yes	y
133	UCMP	218164	y					Y3	Harrington_Y1_Y2_Y3_UCMP_	6/29/2016	yes	y
134	UCMP	218144	y					Z1	Harrington_Z1_Z2_UCMP_6boi	6/29/2016	yes	y
135	UCMP	218149	y					Z1	Harrington_Z1_Z2_UCMP_6boi	6/29/2016	yes	y
136	UCMP	218167	y					Z2	Harrington_Z1_Z2_UCMP_6boi	6/29/2016	yes	y
137	UCMP	218179	y					Z2	Harrington_Z1_Z2_UCMP_6boi	6/29/2016	yes	y
138	UCMP	218180	y					Z2	Harrington_Z1_Z2_UCMP_6boi	6/29/2016	yes	y
139	UCMP	218285	y					Z2	Harrington_Z1_Z2_UCMP_6boi	6/29/2016	yes	y
140	UCMP	218161	y					B1	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
141	UCMP	218206	y					B1	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
142	UCMP	218213	y					B1	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
143	UCMP	217997	y					B1	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
144	UCMP	218141	y					B2	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
145	UCMP	218140	y					B2	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
146	UCMP	218201	y					B2	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
147	UCMP	218203	y					B2	Harrington_B1_B2_UCMP_6bo	6/29/2016	yes	y
148	UCMP	217976	y					E1	Harrington_E1_E2_UCMP_6bo	6/29/2016	yes	y
149	UCMP	217981	y					E1	Harrington_E1_E2_UCMP_6bo	6/29/2016	yes	y
150	UCMP	217980	y					E1	Harrington_E1_E2_UCMP_6bo	6/29/2016	yes	y
151	UCMP	218123	y					E2	Harrington_E1_E2_UCMP_6bo	6/29/2016	yes	y
152	UCMP	218124	y					E2	Harrington_E1_E2_UCMP_6bo	6/29/2016	yes	y
153	UCMP	218171	w					F2	Harrington_E1_F2_UCMP_6bo	6/29/2016	yes	y

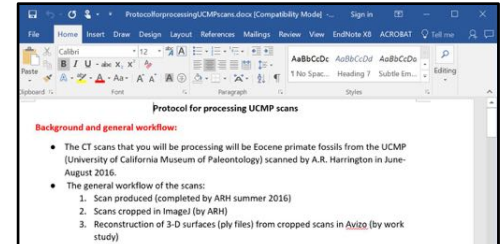
# Step 4. Digital processing

- Image J
  - Check for scan/reconstruction quality
  - Identify specimens
  - Crop out region of interest (ROI)
  - Save as tiff stack with specimen name
    - Ex:  
UCMP218281\_0000.tif

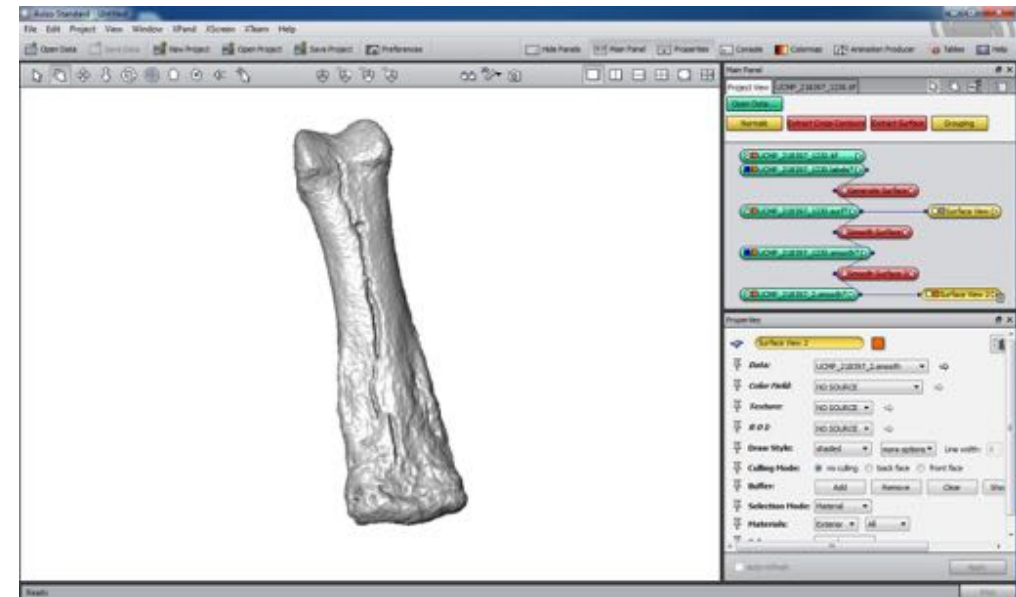
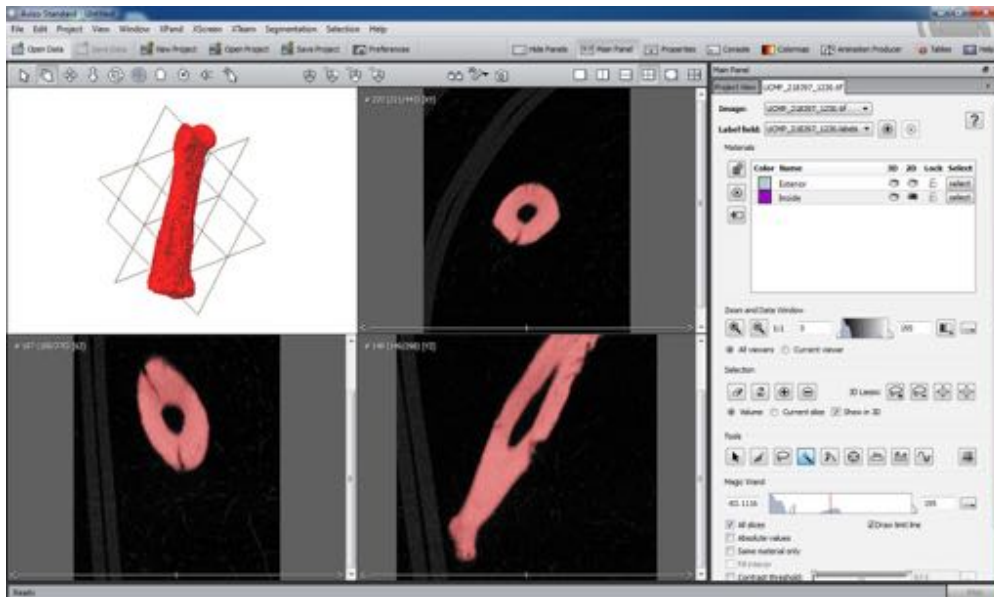


# Step 4. Digital processing

- Avizo
- Making mesh files from the tiff stacks
- Products: 2 mesh files, 2 jpeg images



Institution	Specimen	Unpublished Genus	Species	Element	Side	Layer	Scan name	Scan date	scan record?	cropped?
UCMP	218163					Y3	Harrington_Y1_Y2_Y3_UCMP	6/29/2016	yes	
UCMP	218164					Y3	Harrington_Y1_Y2_Y3_UCMP	6/29/2016	yes	Y
UCMP	218144					Z1	Harrington_Z1_Z2_UCMP_800	6/29/2016	yes	Y
UCMP	218149					Z1	Harrington_Z1_Z2_UCMP_800	6/29/2016	yes	Y
UCMP	218147					Z1	Harrington_Z1_Z2_UCMP_800	6/29/2016	yes	Y
UCMP	218179					Z2	Harrington_Z1_Z2_UCMP_800	6/29/2016	yes	Y
UCMP	218180					Z2	Harrington_Z1_Z2_UCMP_800	6/29/2016	yes	Y
UCMP	218205					Z2	Harrington_Z1_Z2_UCMP_800	6/29/2016	yes	Y
UCMP	218161					B1	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	218206					B1	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	218213					B1	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	217987					B1	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	218141					B2	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	218140					B2	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	218201					B2	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	218203					B2	Harrington_B1_B2_UCMP_800	6/29/2016	yes	Y
UCMP	217976					E1	Harrington_E1_E2_UCMP_800	6/29/2016	yes	Y
UCMP	217981					E1	Harrington_E1_E2_UCMP_800	6/29/2016	yes	Y
UCMP	217960					E1	Harrington_E1_E2_UCMP_800	6/29/2016	yes	Y
UCMP	218123					E2	Harrington_E1_E2_UCMP_800	6/29/2016	yes	Y
UCMP	218124					E2	Harrington_E1_E2_UCMP_800	6/29/2016	yes	Y
UCMP	218171					E3	Harrington_E1_E3_UCMP_800	6/29/2016	yes	Y



# Step 5a. MorphoSource upload

- Upload to a project with information on fields such as:
  - Institution code, specimen number, specimen repository URL, institution, locality
  - Publication status, copyright, description, bibliographic references, grants, scanning facility, scanning parameters (voxel size, amperage, volts, and projections)



VIEW AS LIST NEW SPECIMEN

Group by: [Specimen Number](#) | [Genus](#) | [Species](#)

Order by: [Specimen number](#) | [Taxonomic name](#)

## Specimen Information

Before creating a new specimen, please check if a specimen  
Enter any *individual* part of the catalog number, either the



MORPHO SOURCE BY DUKE UNIVERSITY

ABOUT BROWSE DASHBOARD UNIVERSITY OF CALIFORNIA MEDIA CART STATS

UCMP-218397 NEW MEDIA GROUP

Media Group: M12837, 3 media files

File Name	Format	Size
M12837-21714, Zipped TIFF Stack	ZIPP image series ZIP file	28.74 MB
M12837-21715, Raw Surface Mesh	3D Mesh (Polygon File Format)	25.81 MB
M12837-21715, used for media preview	Smooth Surface Mesh 3D Mesh (Polygon File Format)	20.53 MB

# Step 5b. Unpacking specimens

- With care and in reference to the maps and 3D digitized specimens



# Step 6. Return physical specimens, work on and share digital specimens with collaborators



# Acknowledgements

- iDigBio & workshop organizers for invitation to participate
- NSF

