Challenges and Obstacles to Digitizing Small Paleontology Collections

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UNIVERSITY OF WYOMING

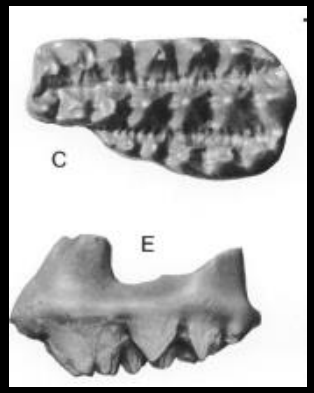
University of Wyoming Fossil Vertebrate Collection

Mesozoic Vertebrates (Dinosaurs and Marine Reptiles)

W. H. Reed

E. D. Cope O. C. Marsh

Mesozoic and Paleogene Mammals



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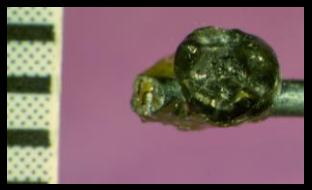

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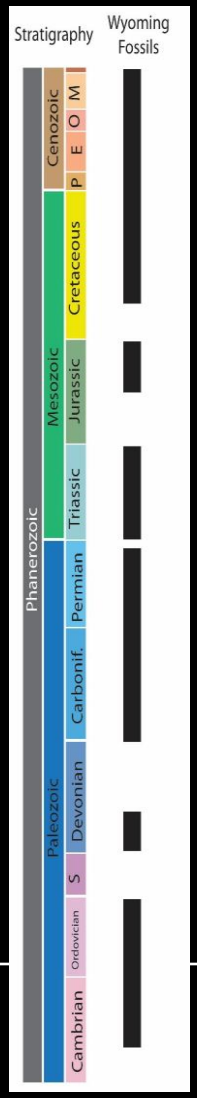

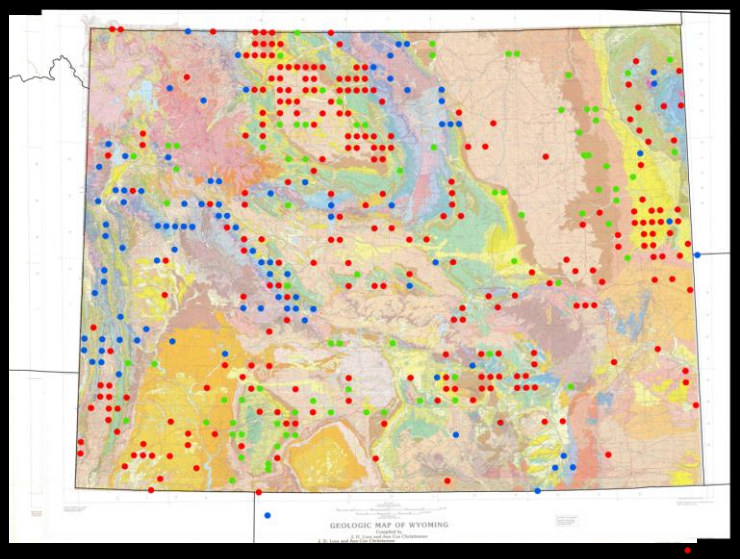

- 40,000 specimens
- 2.6 Billion Years
- 2,600 Localities
- 1,100 Genera, ~400 Families, ~150 Orders

Challenges

- Paleo- Related
  - Fossils are extremely variable
  - Adaptive Workflows and Multiple Methods
- Small Collections- Related
  - Limited Personnel
  - Limited Funds

Fossils are extremely Data-Rich

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Life
Behavior

Morphology
Pathology
Isotopes
Tooth Wear

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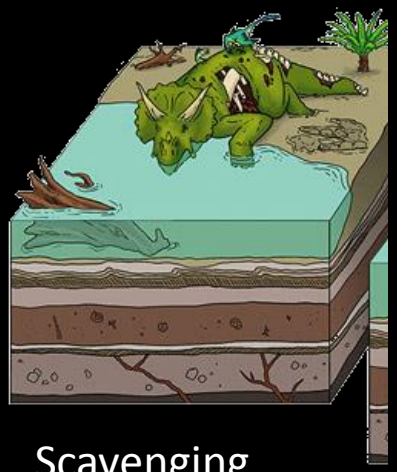
Death/ Decay/
Scavenging



Scavenging
Weathering
Bioerosion
Epibionts
Breakage
Trampling

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Death/ Decay/
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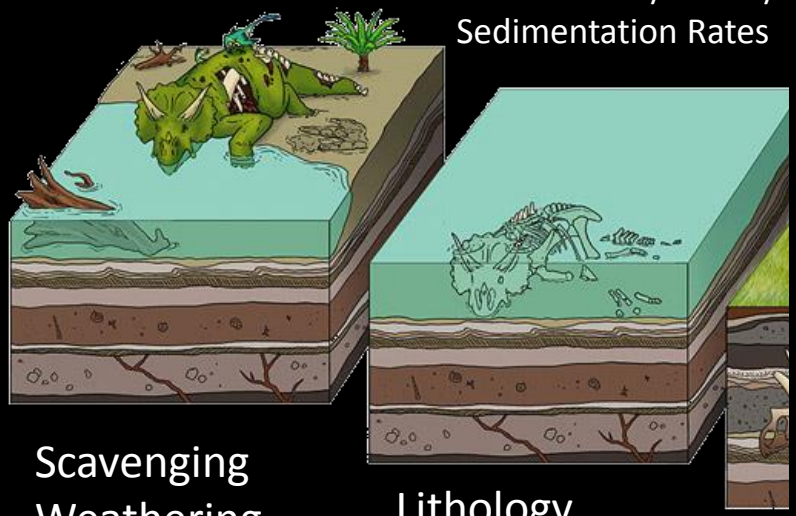
Environment/ Rivers/
Sedimentation Rates



Scavenging
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Lithology
Orientation
Rounding
Corrosion

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Geochemistry
Microbes
Geology

Minerals
Permineralizati
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Excavation
Paleoecology

Field Notes
Field Maps
Associations
Maps
Preps/ Tools

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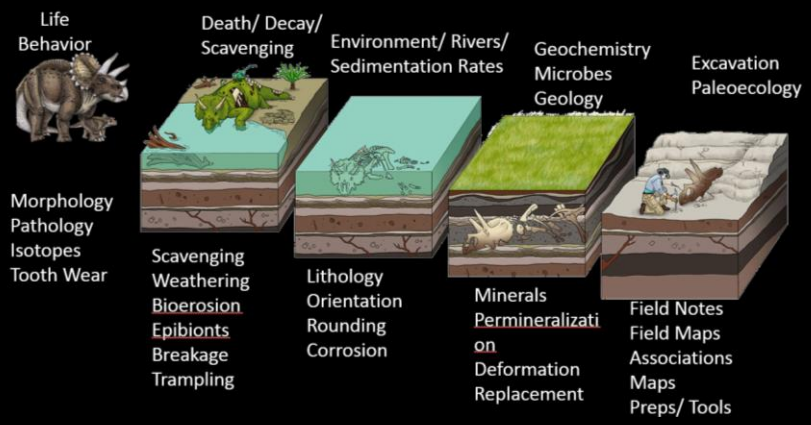

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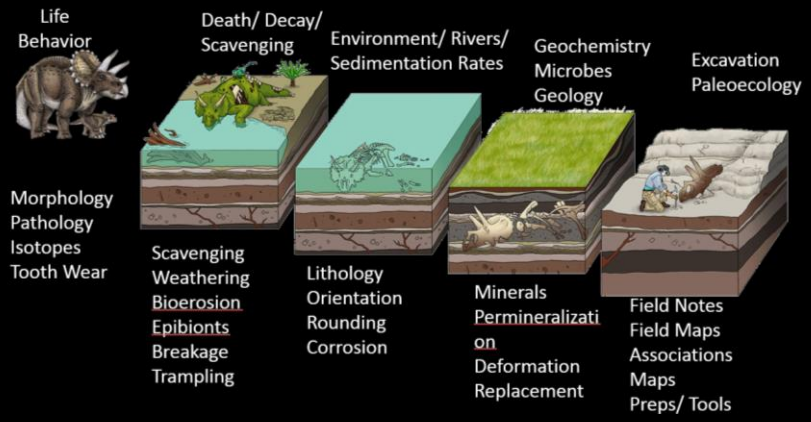

Fossil Preparation

Lab Notes
Consolidate
Tools

Storage

Location
Method
Loans

Research

Types
Analyses

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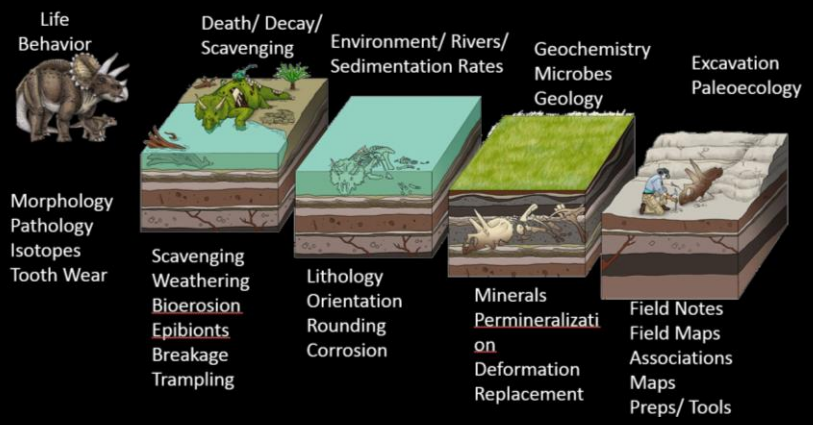

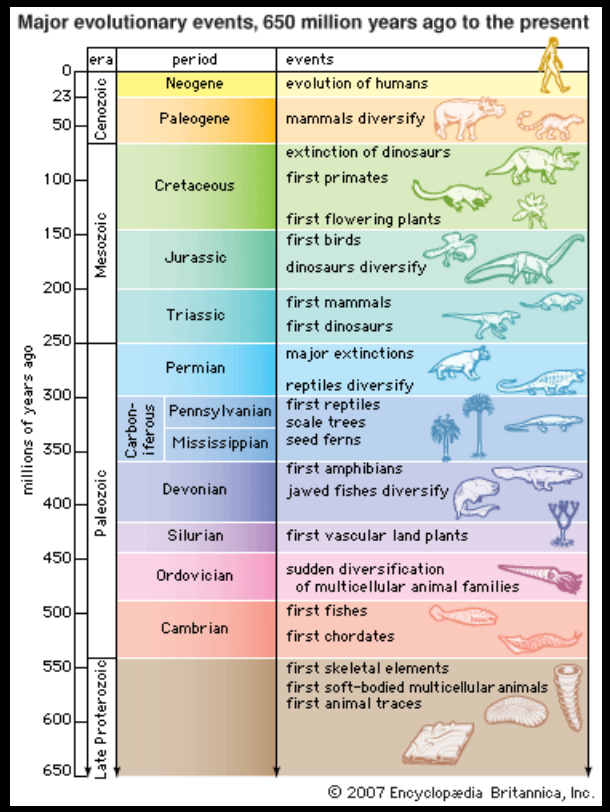

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Fossils are not 3D or 4D but 50+D

- Morphology
- Pathology
- Micro-wear
- Meso-wear
- Elemental
- Isotopic
- Minerals
- Scavenging
- Bioerrosion
- Corrosion
- Rounding
- Weathering
- Field Notes
- Quarry Map
- Time Period
- Lithology
- Sediment
- Associations
- Field Notes
- Field Map
- Field #
- Preparations
- Lab Notes
- Lab photos
- Lab #
- Preparators
- Storage
- Georeference
- Identification
- Element Type
- Holotype?
- Publications
- Research Lab
- Loans
- Interactions
- Cast
- File Type
- Consolidants
- Land Owner
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Poses many challenges to consider when attempting to digitize paleo collections?

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Complicated Workflow

Specimen by Specimen: Adaptive Workflow with several techniques/methods

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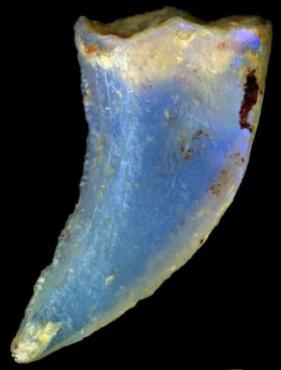
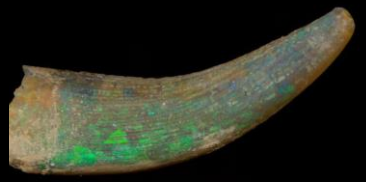
What do I mean?

Fossilization Process

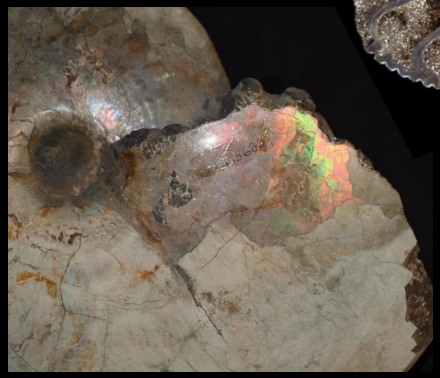
(Variation in Color and Composition)





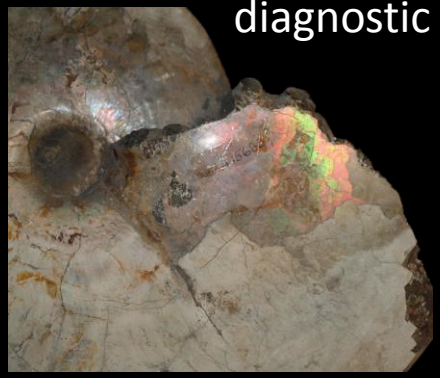


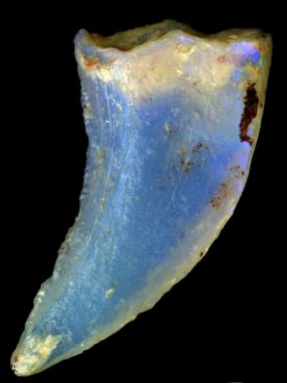


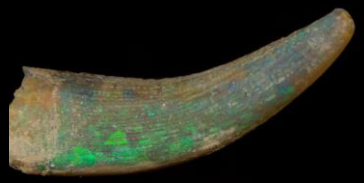

Fossilization Process

(Variation in Color and Composition)

- Varies across bone, skeleton, assemblage, formation, etc…
- Recording or knowledge of what they are
- Different Backgrounds
- Scanning Artifacts
- Consider important features to capture (iridescence, sutures, diagnostic markings?)

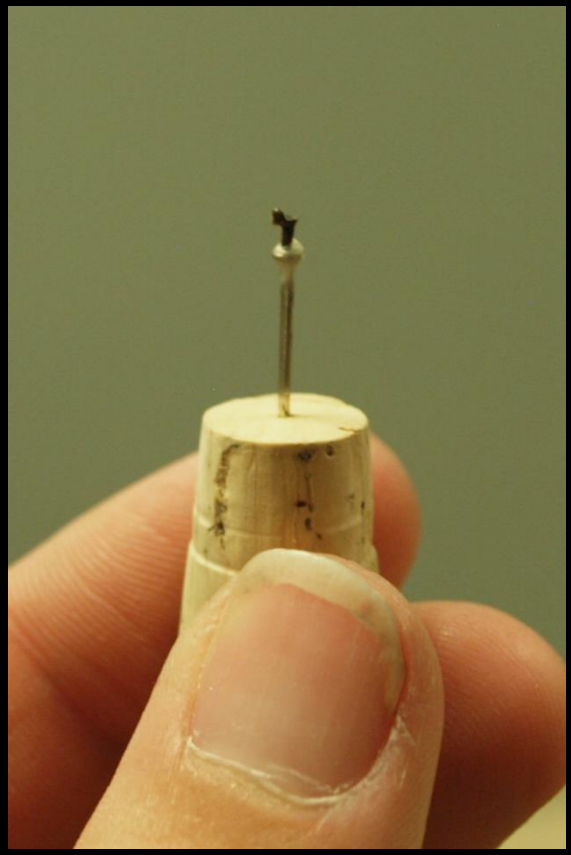






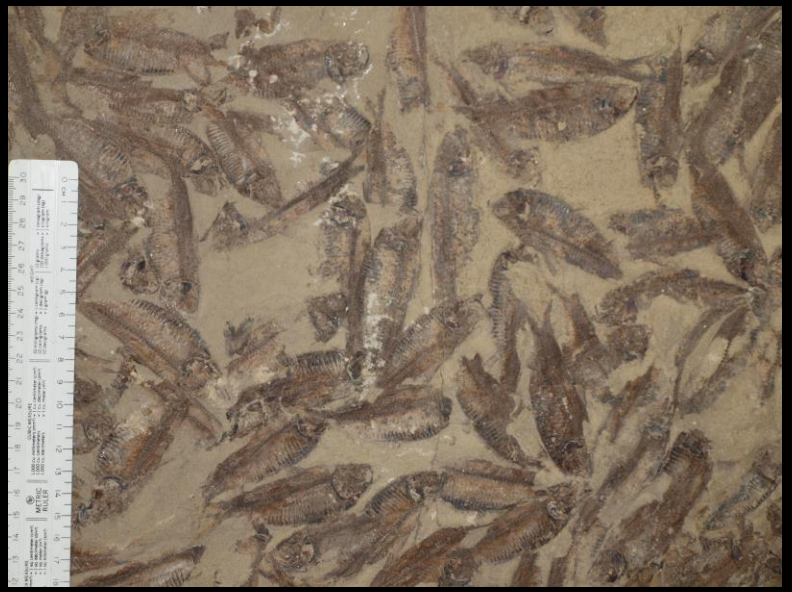
Size Variation

- Extremely Variable
- Dinosaurs to Diatoms
- Matching technology to specimen
- Requires multiple scans/photos
- All the specimen? Part of the specimen?



Shape Variation

- Varies across bone, skeleton, assemblage, formation, etc…
- Extreme Shape variation
- Flat specimens
- How Capture all of it? Do we try?
- 3D scans..stitching



Identification

- Often Difficult
- Not Possible/Diagnostic
- Outdated Nomenclature
- Multiple Specimens
  - Slab
  - Jacket
  - Changes during Prep/research
- Not Linnaean (Morphotypes)

Specimens/Bones/Lots

- How to Best Digitize?
  - Whole Specimen
  - Individual Bones
  - Assemblage?
  - By individual
- Often Changes
  - 3 Femurs identified from one specimen??

Preparations

- Varied Preparation methods and storage methods
- requires consideration when digitizing

Special Features

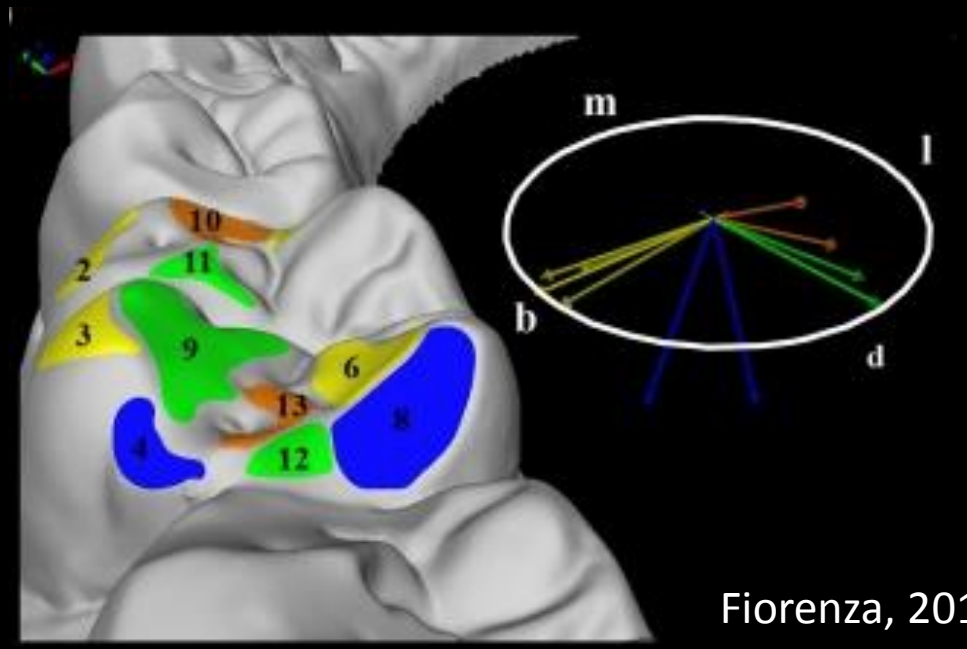
- Post Death Modifications
  - Cultural: Cutmarks
  - Scavenging: Bitemarks
  - Taphonomic: Weathering
  - Epibionts
- Pathologies
- Other important characteristics

Research

- Holotypes
- Paratypes
- Lithotypes
- Morphotypes

- Analyses noted and Digitized

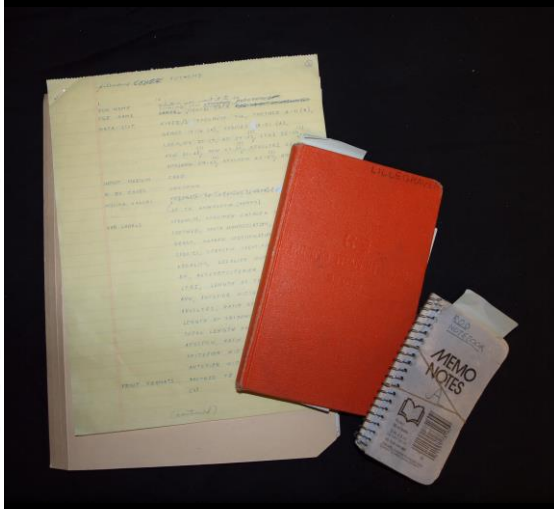
- Researchers have very different needs and requirements for the specimens…no standardized way

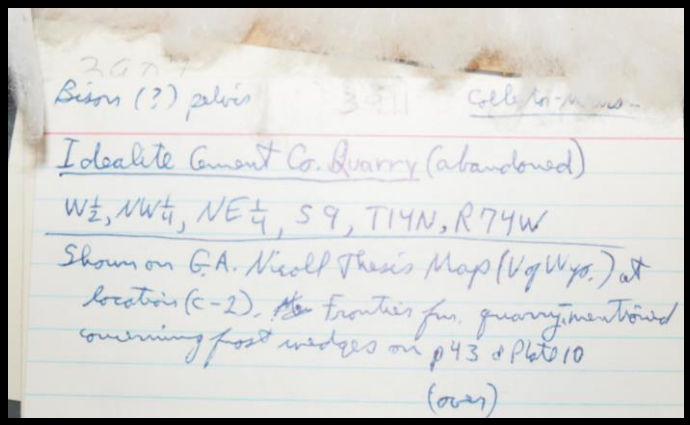


Fiorenza, 2011

Metadata

- Field Data
  - Notes
  - Maps
  - Photos
- Preparation Data
  - Notes
  - Maps
  - Photos
- Curation Data
  - Photos
  - Card Catalogs
  - Identification Notes
- Research Data
  - Analyses
  - Datasheets





- Color
- Composition
- Size
- Shape
- Identifications
- Specimen/Lot Bones
- Special Features
- Preparations
- Metadata

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Challenges

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- Small Collections- Related
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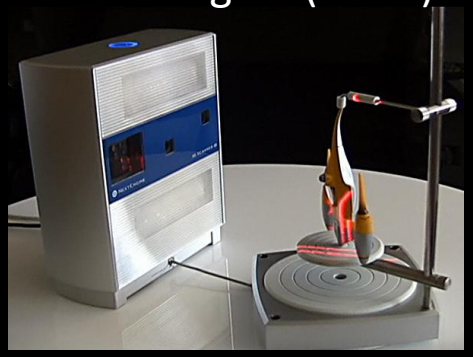
Digitization Requires Multiple Methods: EXPENSIVE

Micro-CT

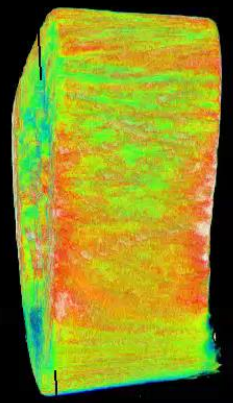
SEM

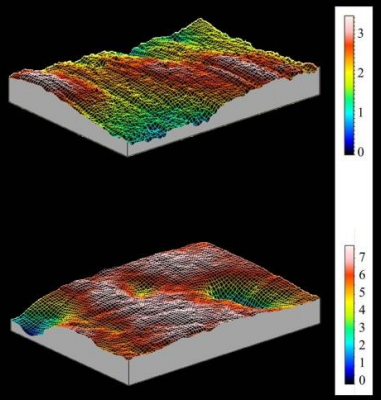
Next-Engine (Laser)



Photogrammetry

Smaller **Larger**





Obstacle: Cheaply Digitizing (3D Scanning) across multiple scales

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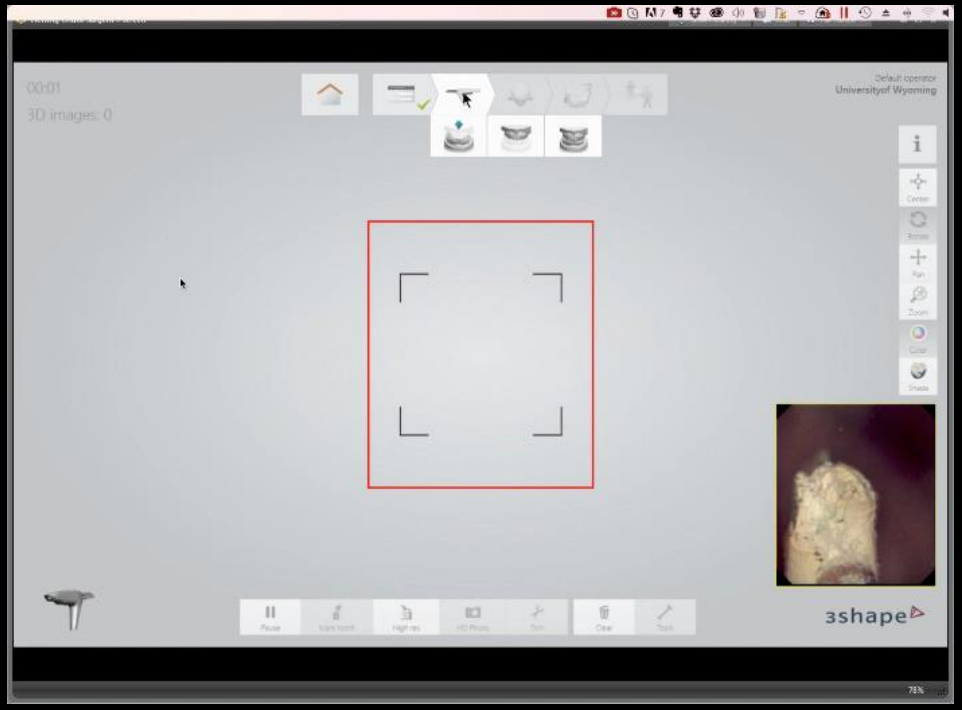

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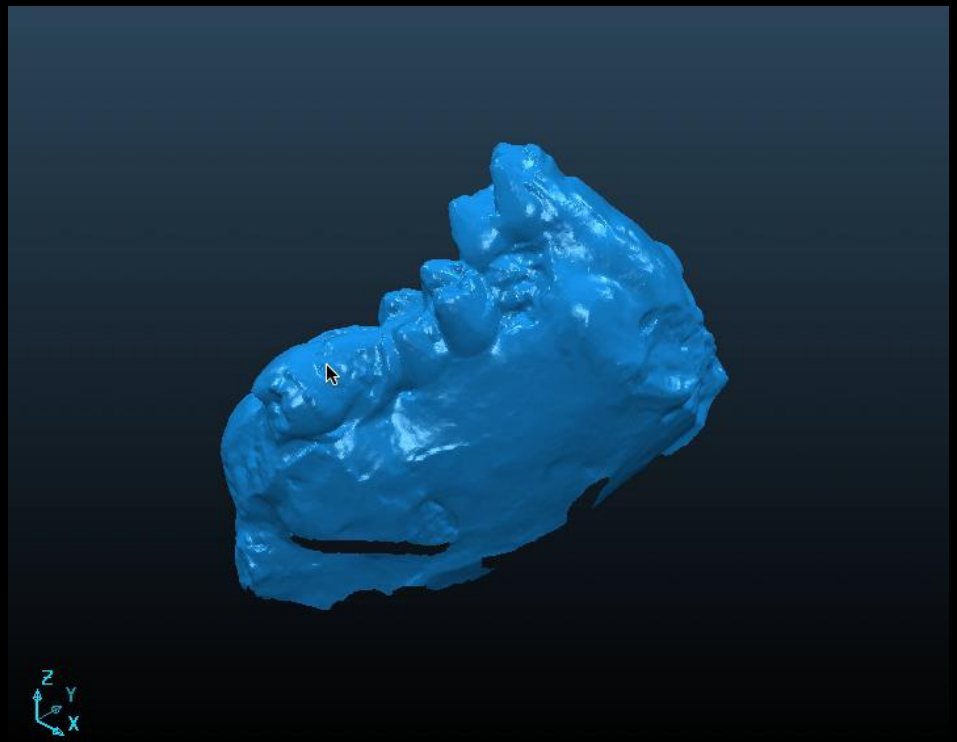

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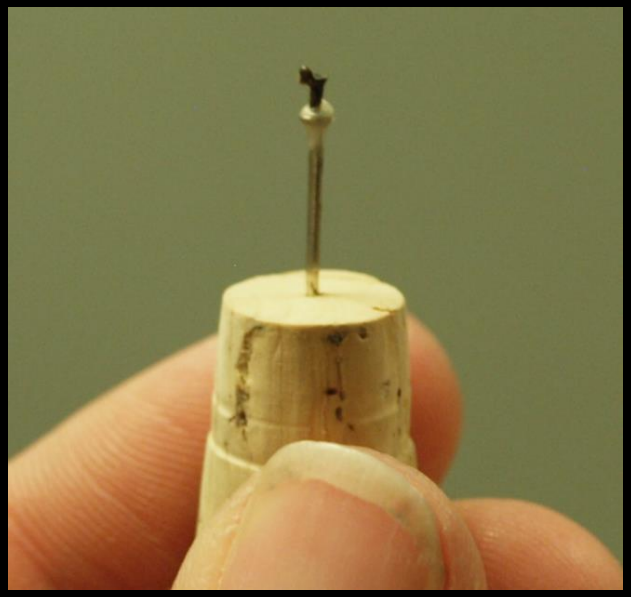

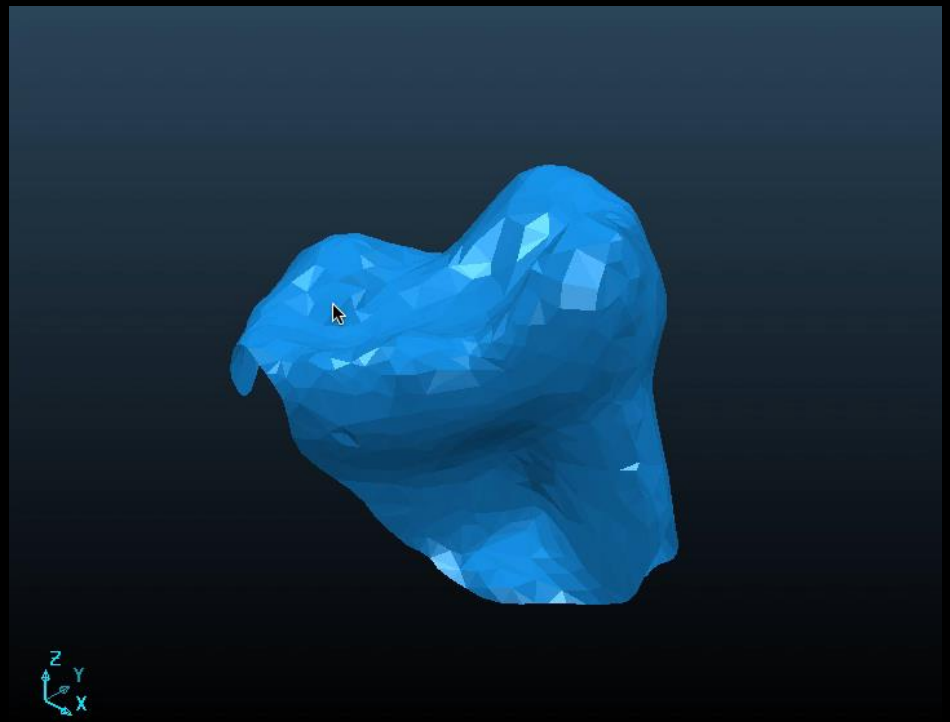

Obstacle: Specialized Personnel

- Adaptive workflows
  - Imaging Backgrounds
  - Matching imaging/scanning technique with specimen
  - Adjusting to limit spectral artifacts
  - Knowledge of important features to Digitize
  - Work with a variety of scanning methods and techniques
- Knowledge/Experience
  - Identification of Specimens
  - Software Experience
  - Use of specialized equipment/software

Obstacle: Limited Funds

- LIMITED Specialized Personnel
  - Can work with Adaptive workflows
  - Work with multiple techniques/digitization methods
  - Expensive…few of them
  - Volunteers…requires a lot of training!
    - Volunteer Retention
- LIMITED Specialized Equipment
  - More than 1 type of imaging/scanning devise
  - Expensive! Constraints on Purchasing Power
  - Technical Software…or lots of it
  - Data Storage Issues

Goal of Digitization in Small Collections?

- Remote Research?
- Search tool for visits?
- Internal Purposes only?>
- Outreach?
- Digitize all or limited # specimens?

- Make it Worth the Effort

- Consider Future Use?
  - What will be important/obsolete 5, 10, 20 years into future

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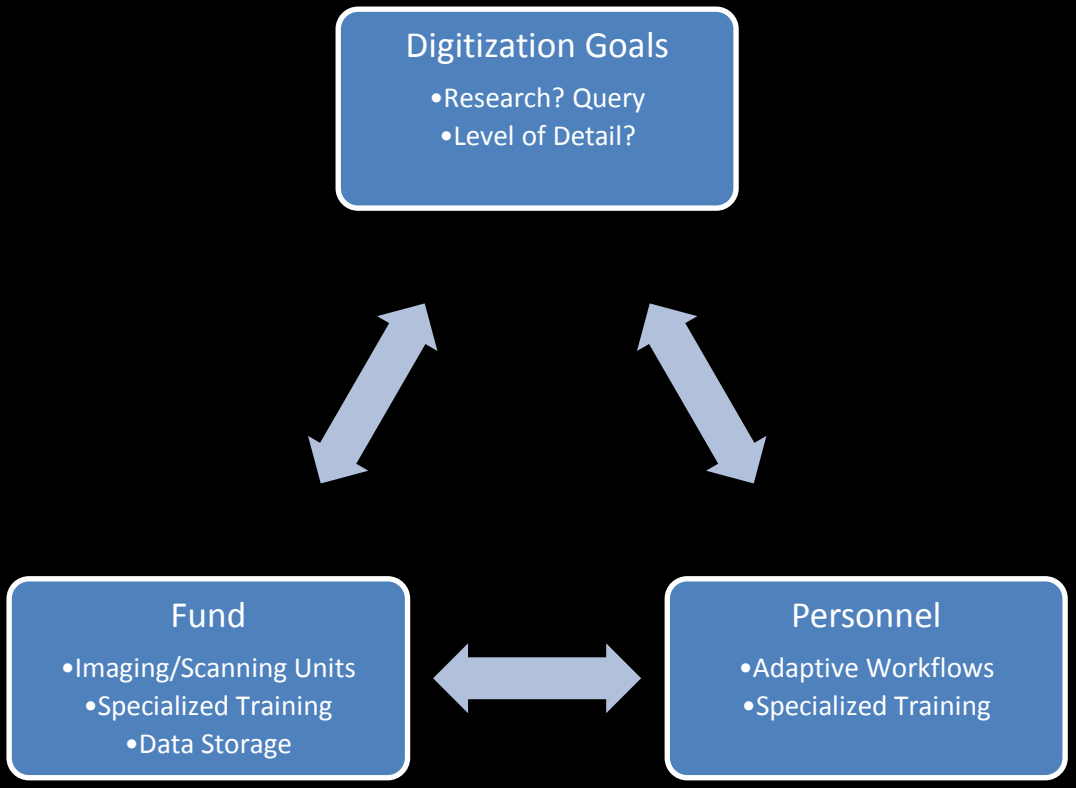
Goal Effects: Level of Effort, Time, Money, Detail

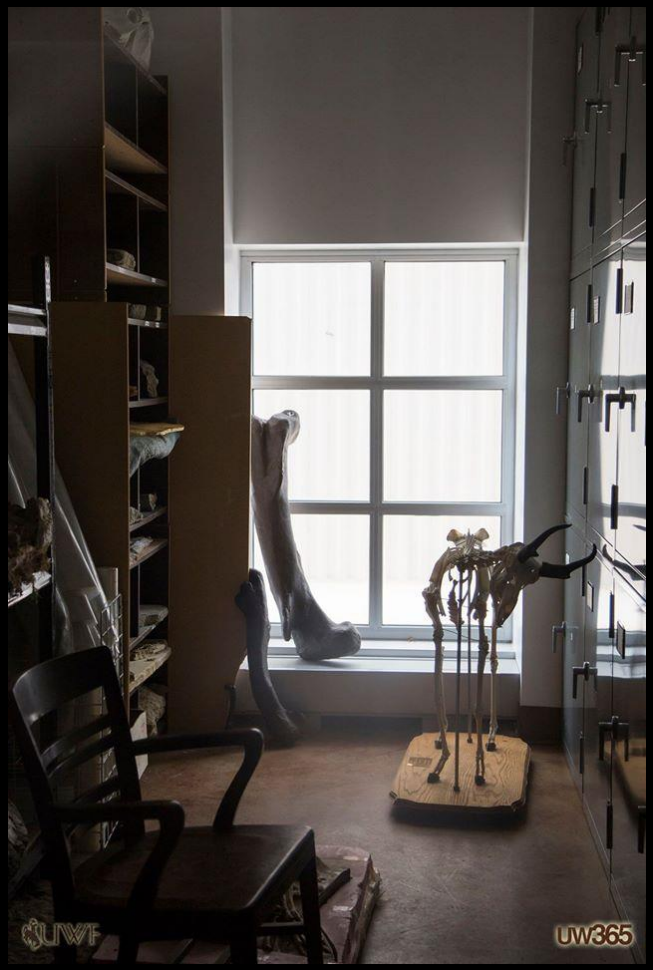
Balance of Resources



Worth it!

Archaeotherium mortoni
'Terminator Pig'

Thank you!



iDigBio
Integrated Digitized Biocollections

NSF

GEOLOGY & GEOPHYSICS

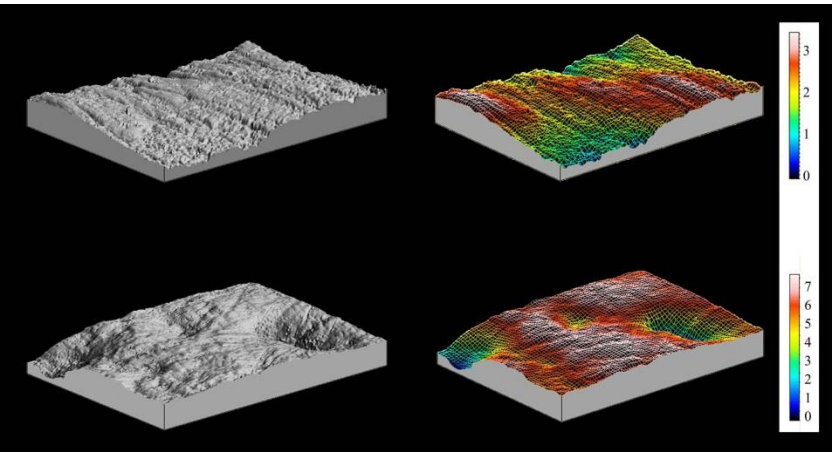
University of Wyoming
UW
Geological Museum
Since 1887

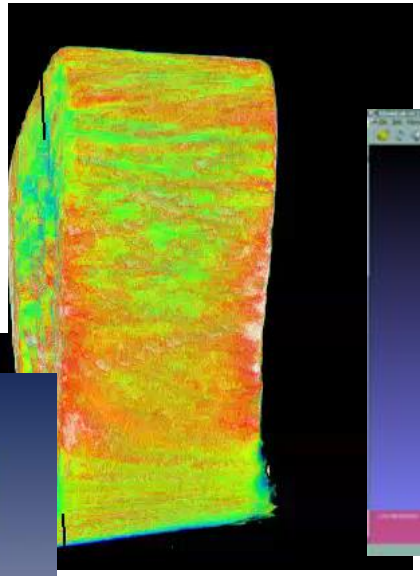
UW | University of Wyoming

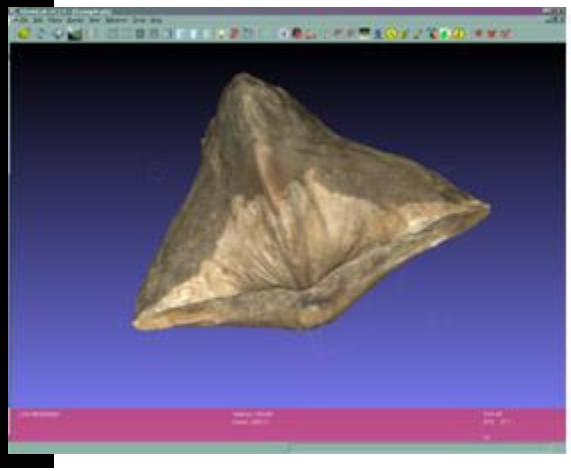
UW

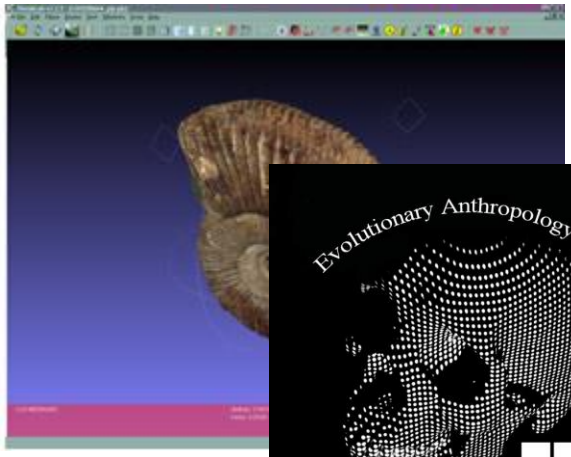
Thank you!

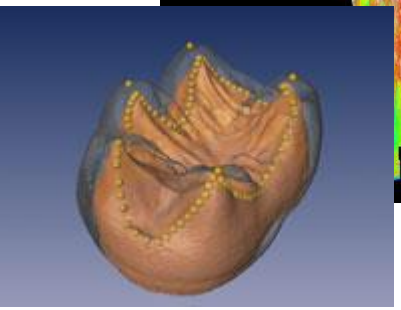
Future Vision for Collections> Surface Characterization

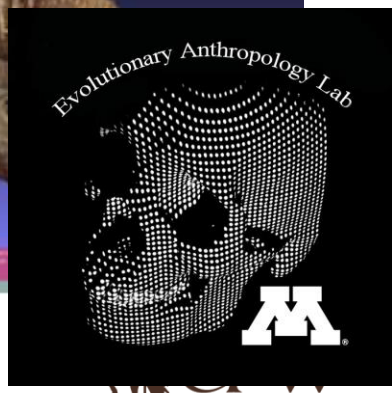




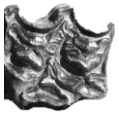








Fossils are the MOST Informative Geologic Specimen: So much information…..but so much information



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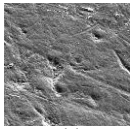
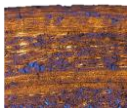
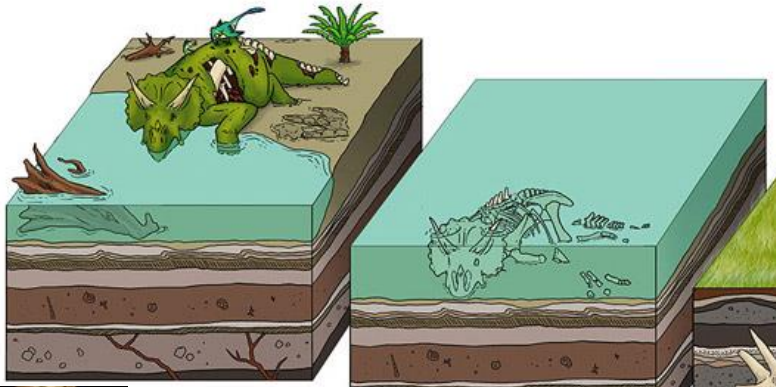


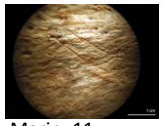
McLaughlin, 08



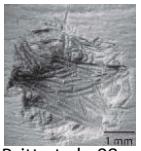
Kohler et al., ‘12



ND Geological Survey, Becky Barnes Artist.



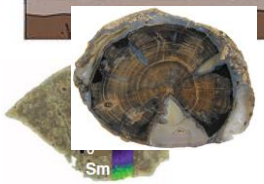
Marin, 11



Britt et al., 08

Noto et al., ‘11

Behrensmeyer, 78



Koenig & Rogers, 09

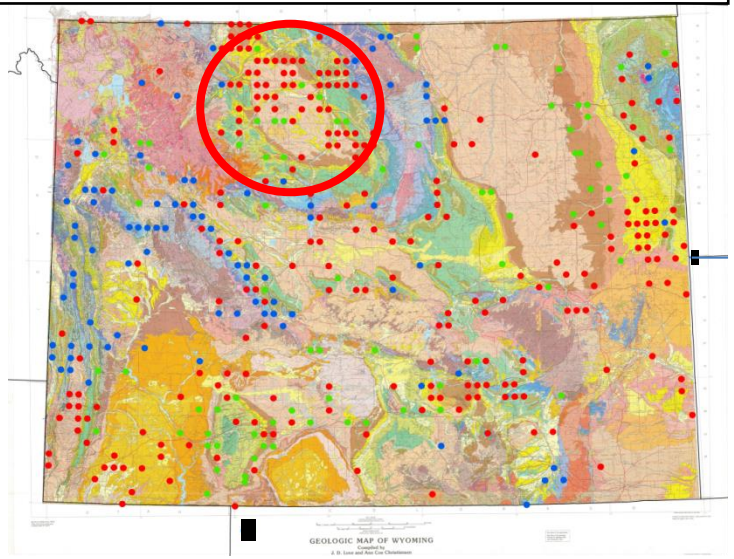
Curation

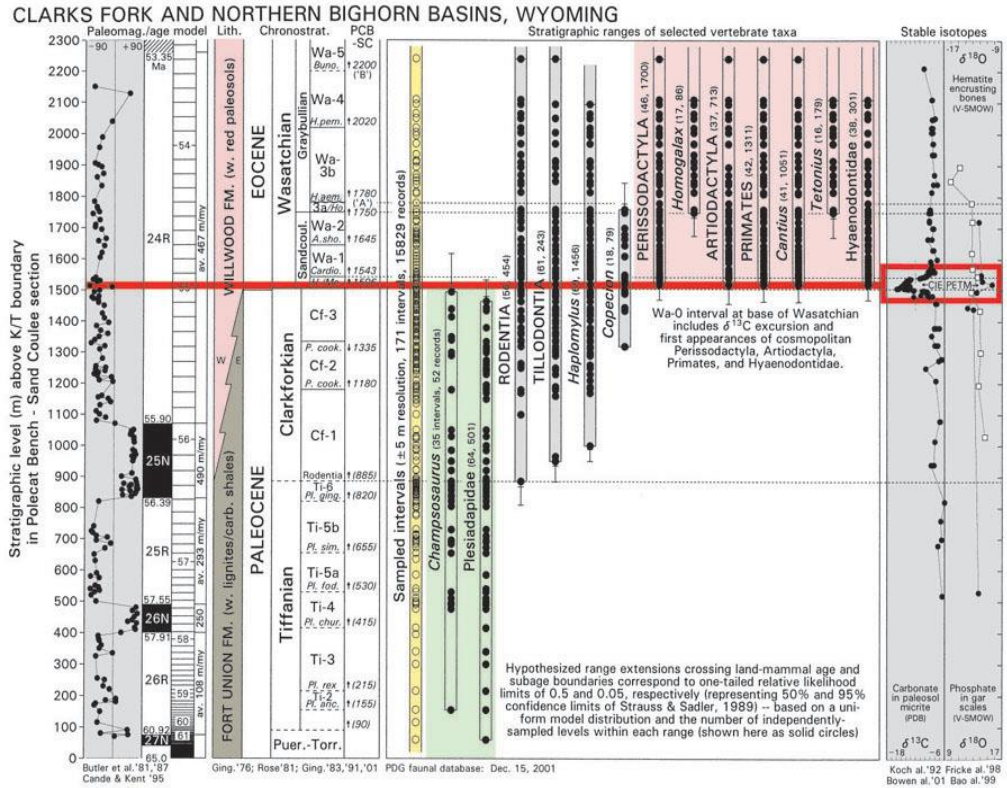
Use this slide as ALL interior slides.

Environment and evolution through the Paleocene–Eocene thermal maximum

Philip D. Gingerich

Museum of Paleontology and Department of Geological Sciences, The University of Michigan, Ann Arbor, MI 48109 1079, USA

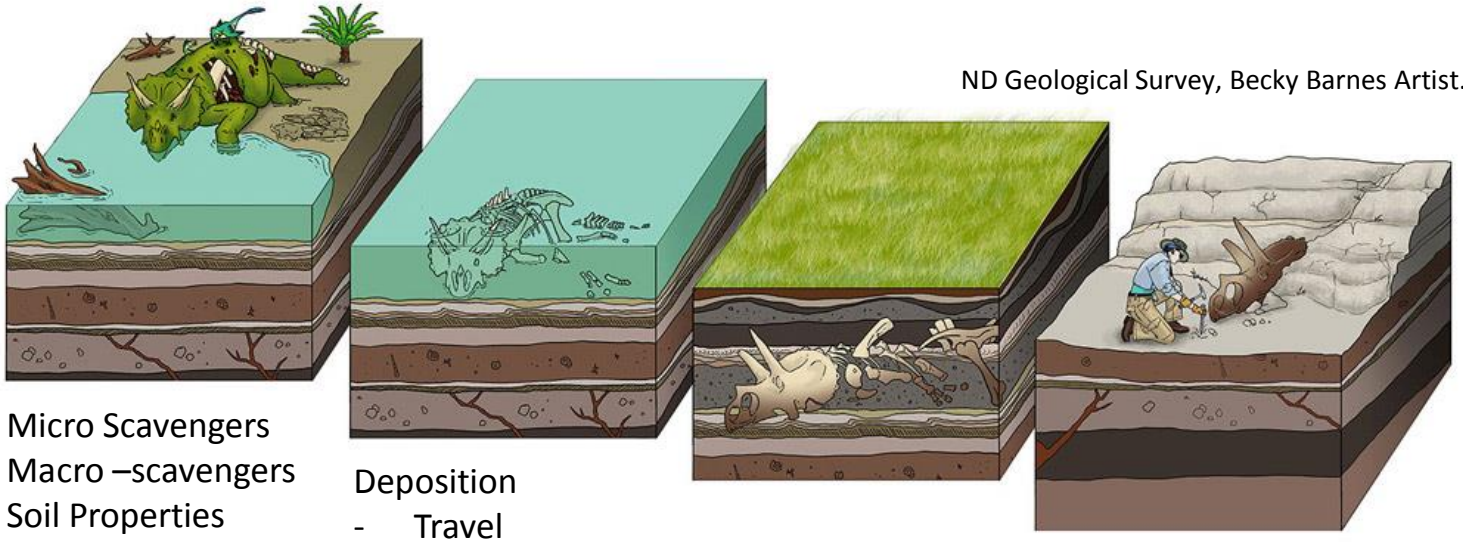




Gingerich (2006)

Fossils are the MOST Informative Geologic Specimen: So much information…..but so much information

Biology
Behavior
Reproduction
Feeding
Stable Isotopes

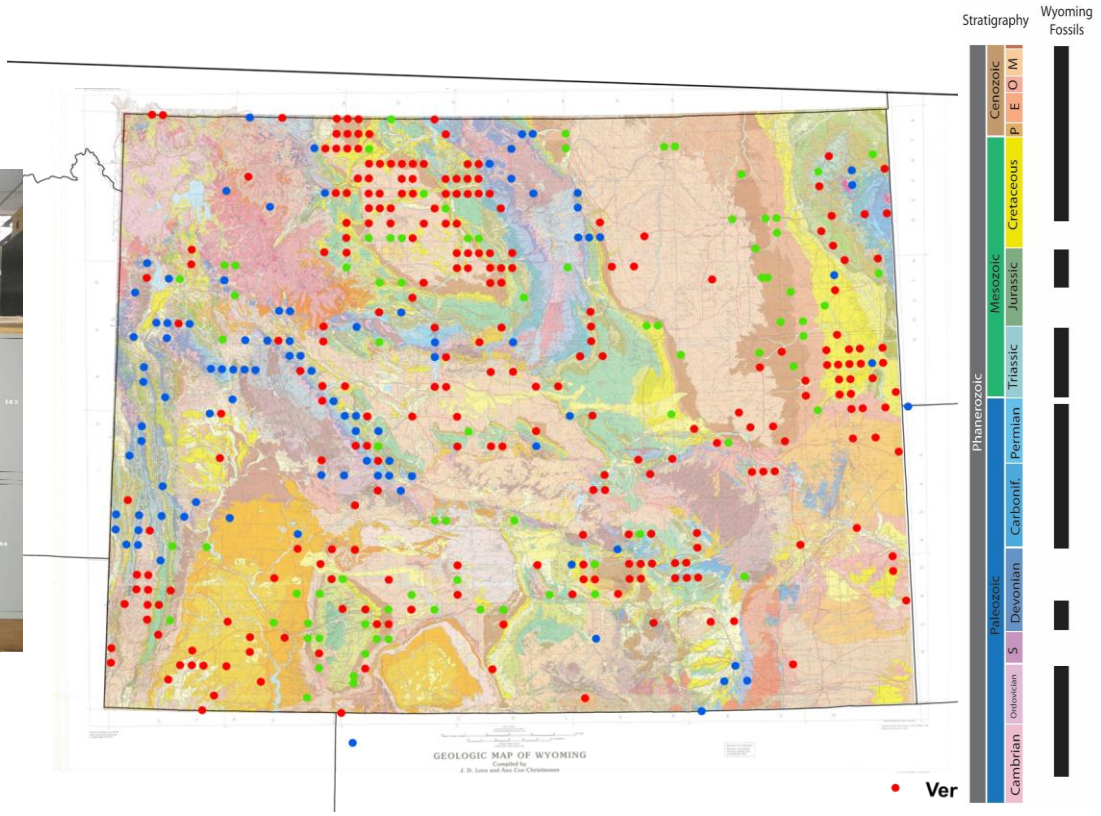


ND Geological Survey, Becky Barnes Artist.

Micro Scavengers
Macro –scavengers
Soil Properties
Precipitation

Deposition
- Travel Distance
- Environment
- Sedimentation rates
- Aqeous Chemistry

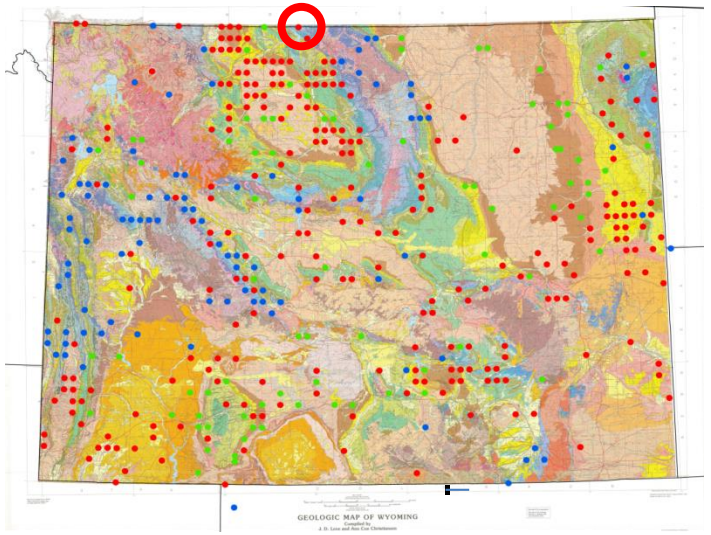
University of Wyoming Fossil Vertebrate Collection



Mycobacterium tuberculosis Complex DNA from an Extinct Bison Dated 17,000 Years before the Present

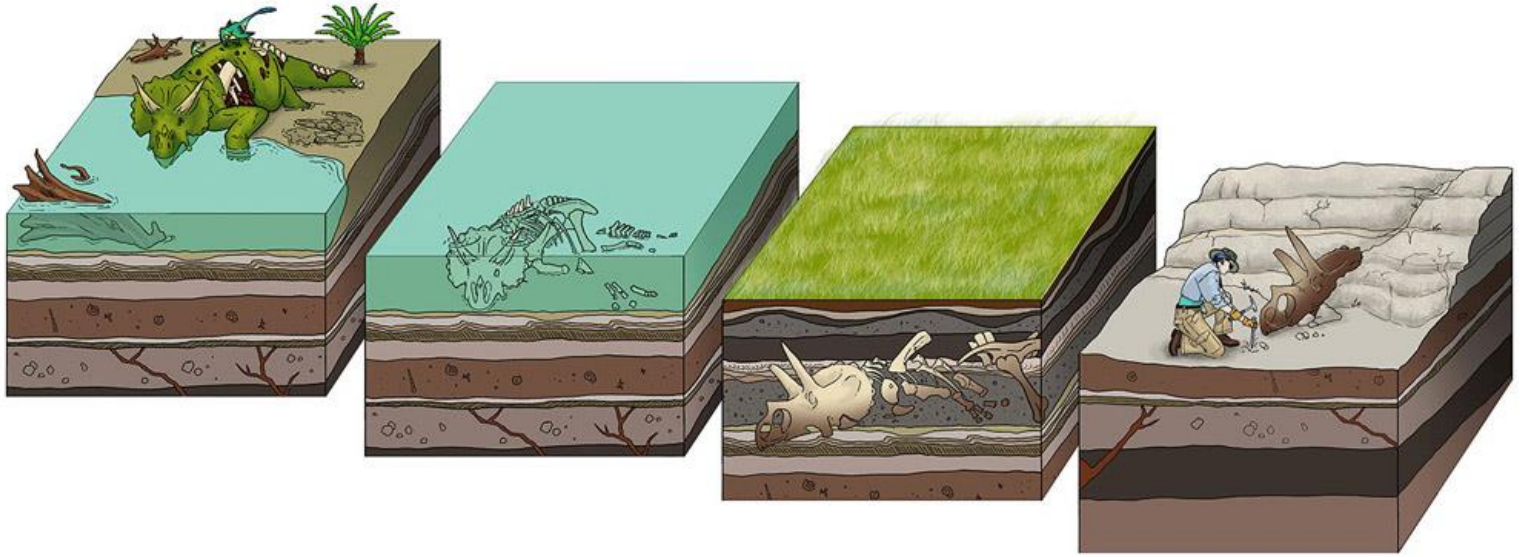
Bruce M. Rothschild,[1,2,3,4] Larry D. Martin,[4] Galit Lev,[5] Helen Bercovier,[5] Gila Kahila Bar-Gal,[5] Charles Greenblatt,[5] Helen Donoghue,[3] Mark Spigelman,[5] and David Brittain[6]

[1]Arthritis Center of Northeast Ohio, Youngstown, [2]Department of Internal Medicine, Northeastern Ohio Universities College of Medicine, Rootstown, Ohio; [3]The Carnegie Museum, Pittsburgh; [4]University of Kansas Museum of Natural History, Lawrence, Kansas; [5]Department of Bacteriology, Royal Free Hospital and University College London, London; [6]Veterinary Sciences Division, Department of Agriculture and Rural Development, Belfast; and [7]Kuvin Center for the Study of Infectious and Tropical Diseases and Ancient DNA, Hadassah Medical School, Hebrew University, Jerusalem

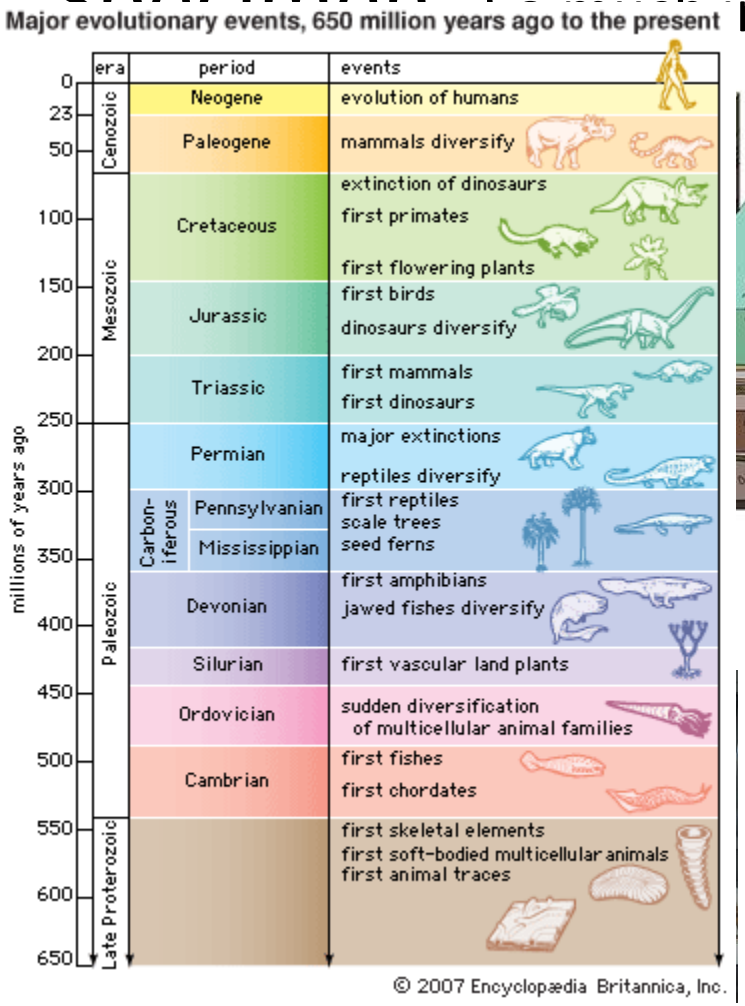


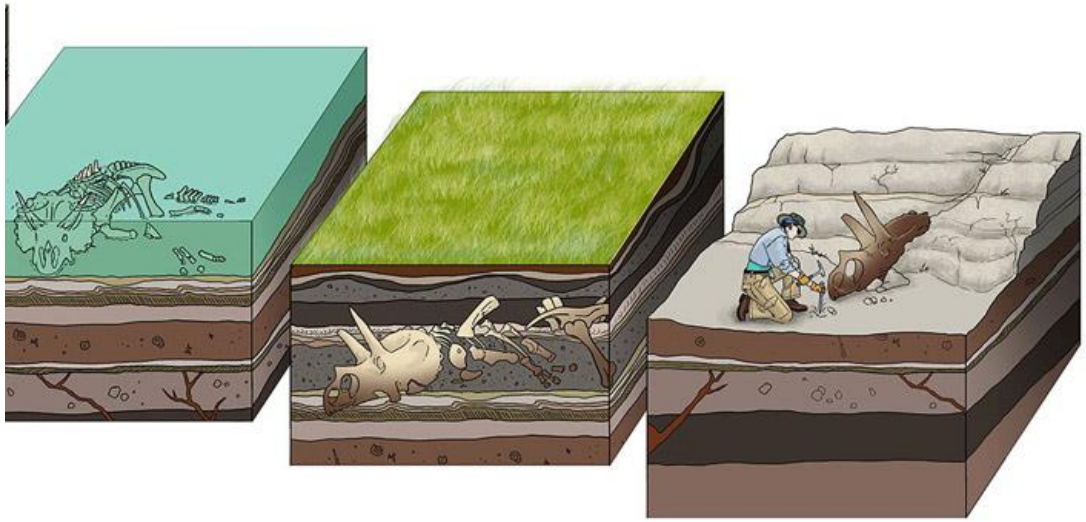
Rothschild, 2003

Fossils are the MOST Informative Geologic Specimen: So much information…..but so much information



Fossils are the MOST Informative Geologic Specimen: so much information…..but so much information



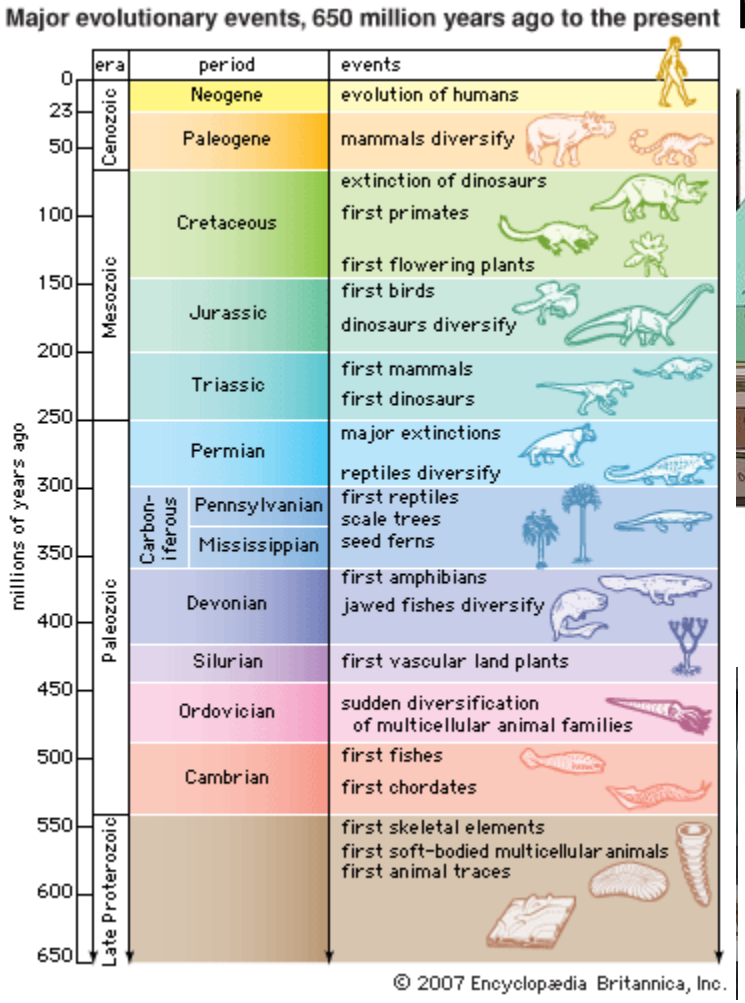


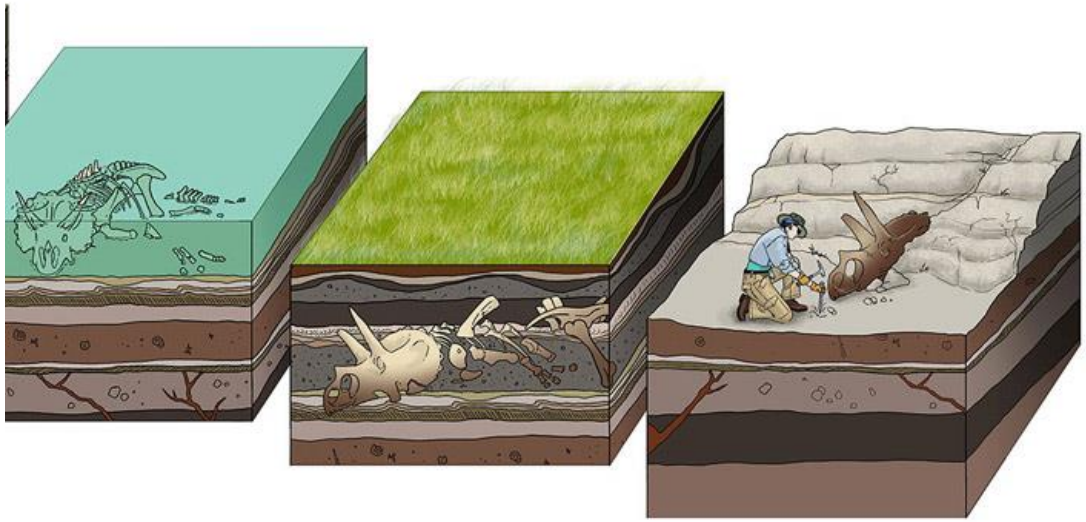
Considerations when Digitizing Paleontological Collections

- 50+D…Types of Information
- Purpose of Digitization (Quick Identification, Research, Outreach?)
- Making Efforts Worth It
- Digitize for Future Purposes

- All in the context of Small-Collections: Challenges

Fossils are the MOST Informative Geologic Specimen: so much information…..but so much information





Not 3D..Not 4D, but 50+D!

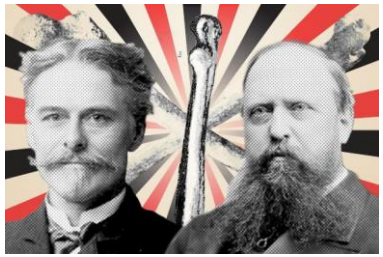
Small Collections have all and concentrated

University of Wyoming Fossil Vertebrate Collection

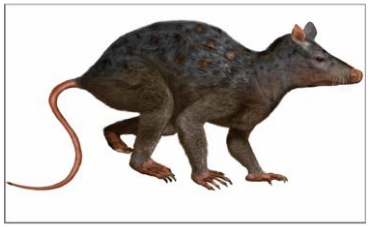
Mesozoic Vertebrates (Dinosaurs and Marine Reptiles)

W. H. Reed

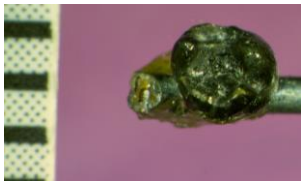
E. D. Cope O. C. Marsh



Mesozoic and Paleogene Mammals



Alphadon halleyi,



University of Wyoming Fossil Vertebrate Collection

Collection Specs.

- Started in 1887
- > 40,000 specimens
- 50 Holotypes
- Teaching Collection

Mesozoic

- 10 Collections
- 3 Thesis Collections

Cenozoic

- 46 Collections
- 15 Thesis Collections

Challenges

- Paleo- Related
  - Fossils are extremely variable
  - Adaptive Workflows and Multiple Methods

- Small Collections- Related
  - Limited Personnel
  - Limited Funds

Fossils are extremely Data-Rich

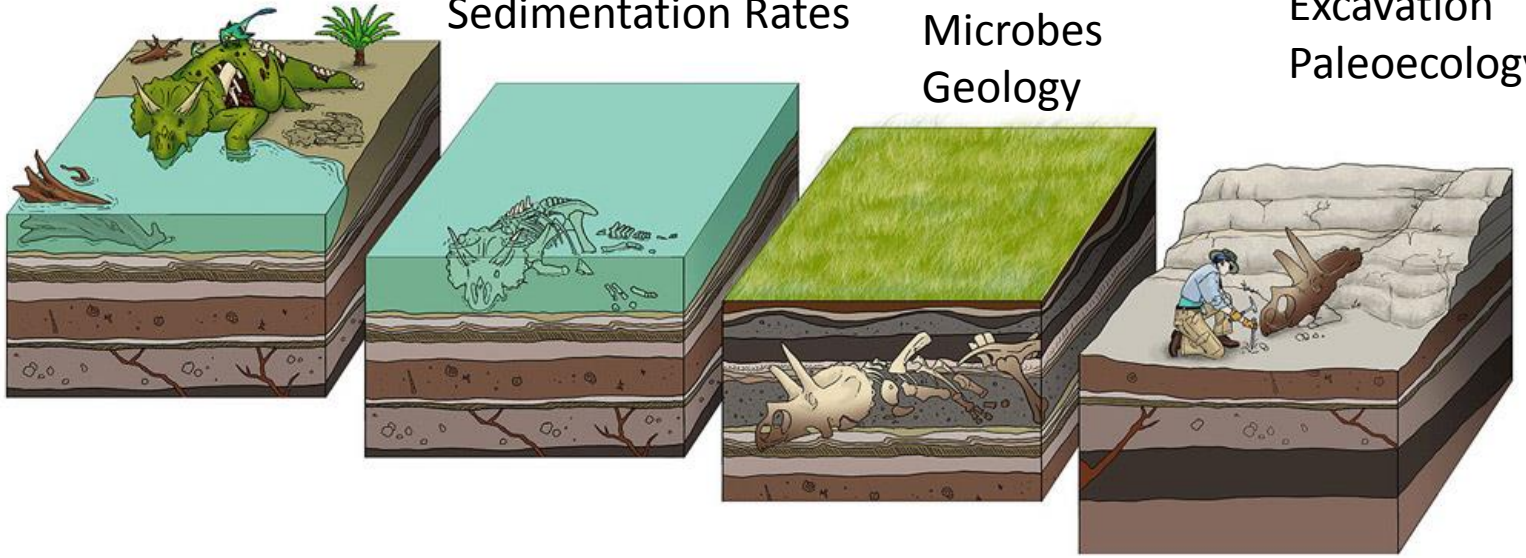
Life
Behavior

Death/ Decay/
Scavenging

Environment/ Rivers/
Sedimentation Rates

Geochemistry
Microbes
Geology

Excavation
Paleoecology



Fossils are extremely Data-Rich

Life
Behavior

Morphology
Pathology
Isotopes
Tooth Wear

Death/ Decay/
Scavenging

Scavenging
Weathering
Bioerosion
Epibionts
Breakage
Trampling

Environment/ Rivers/
Sedimentation Rates

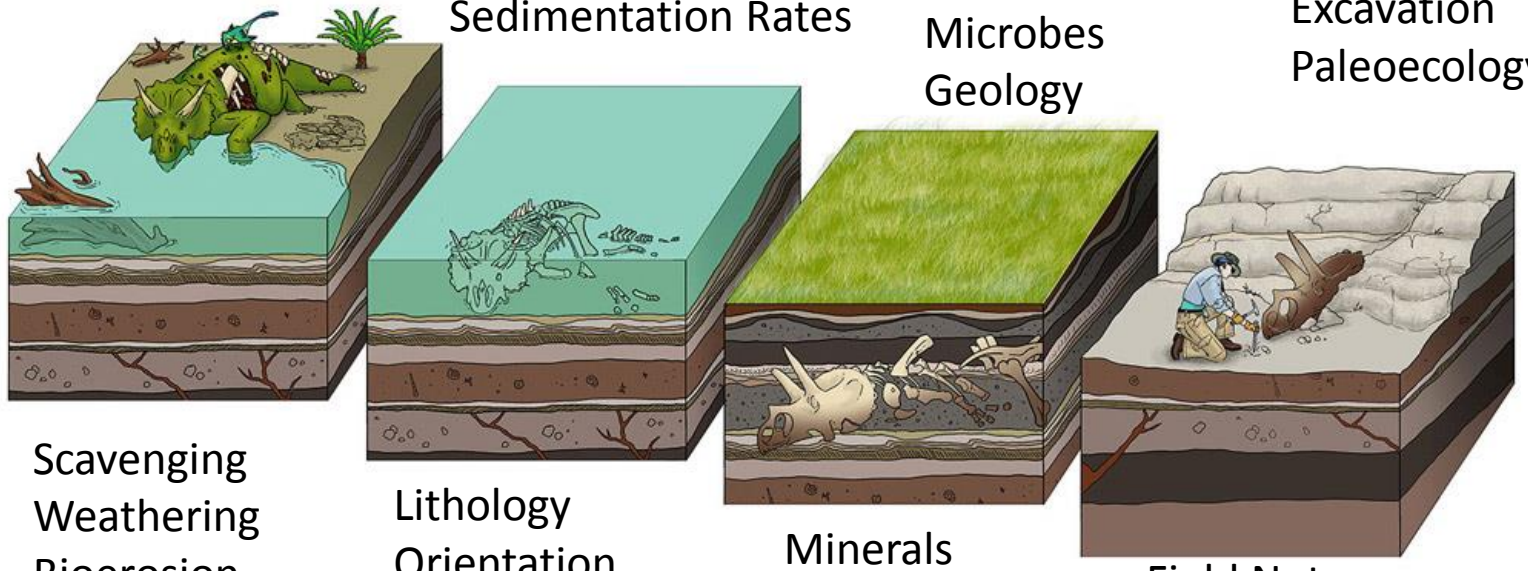
Lithology
Orientation
Rounding
Corrosion

Geochemistry
Microbes
Geology

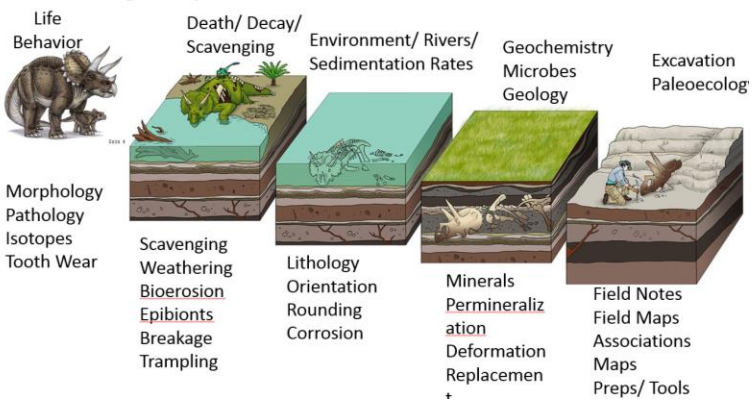
Minerals
Permineralization
Deformation
Replacement

Excavation
Paleoecology

Field Notes
Field Maps
Associations
Maps
Preps/ Tools



Fossils are extremely Data-Rich



Fossil Preparation

Storage

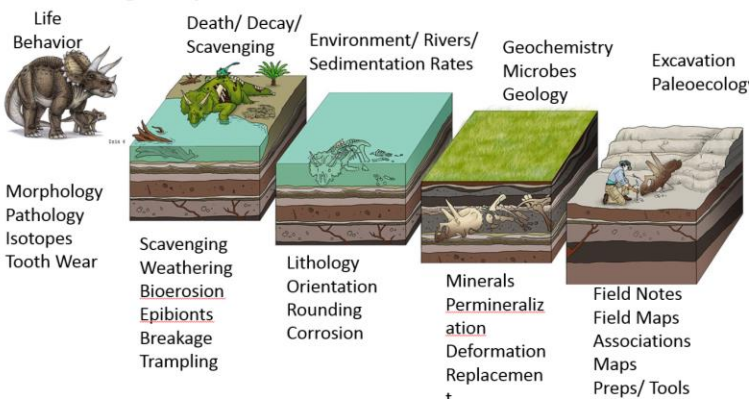
Research

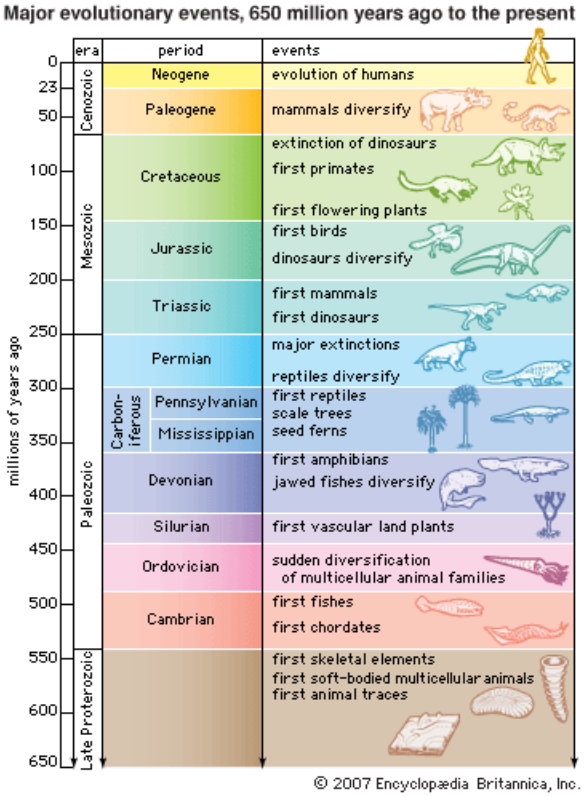
Lab Notes
Consolidate
Tools

Location
Method
Loans

Types
Analyses

Fossils are extremely Data-Rich





Fossil Preparation

Lab Notes
Consolidate
Tools

Storage

Location
Method
Loans

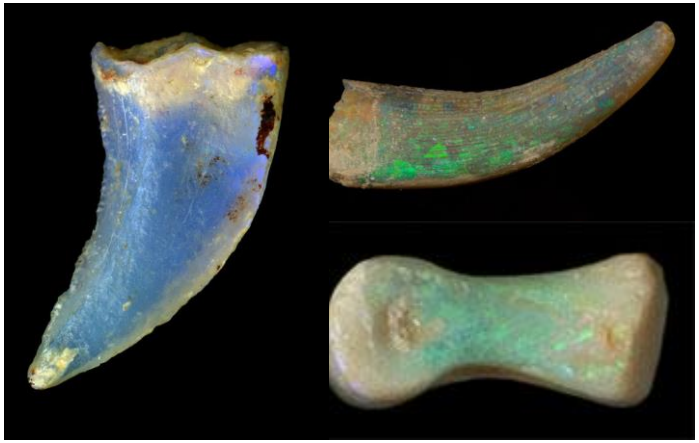
Research

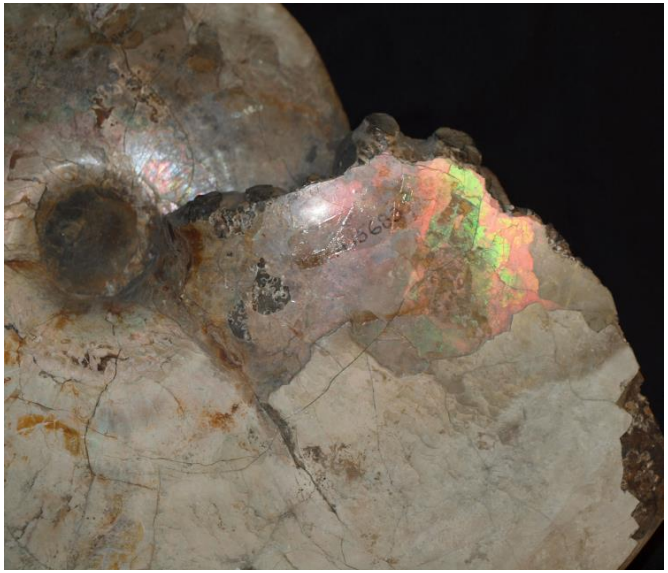
Types
Analyses

Fossils are not 2D or 3D but 50+D

- Morphology
- Pathology
- Micro-wear
- Meso-wear
- Elemental
- Isotopic
- Minerals
- Scavenging
- Bioerrosion
- Corrosion
- Rounding
- Weathering
- Field Notes
- Quarry Map
- Time Period
- Lithology
- Sediment
- Associations
- Field Notes
- Field Map
- Field #
- Preparations
- Lab Notes
- Lab photos
- Lab #
- Preparators
- Storage
- Georeference
- Identification
- Element Type
- Holotype?
- Publications
- Research Lab
- Loans
- Interactions
- Cast
- File Type
- Consolidants
- Land Owner
- Camera Info
- Scanner Info
- Dates
- Horizon
- Determination
- Notes
- Trampling
- Sorting
- Orientation
- Strike/Dip
- Condition?
- Breakage

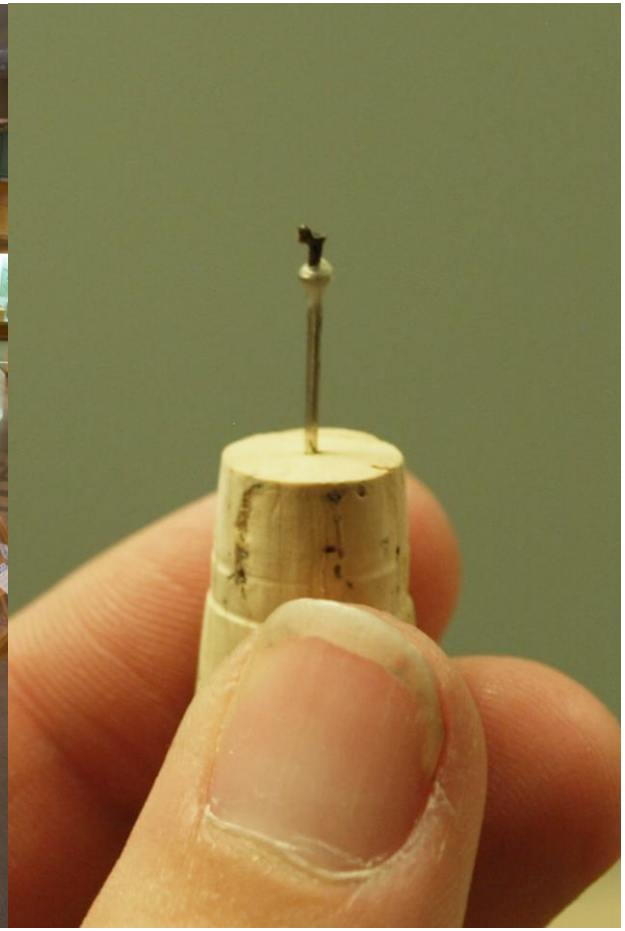
Fossilization Types





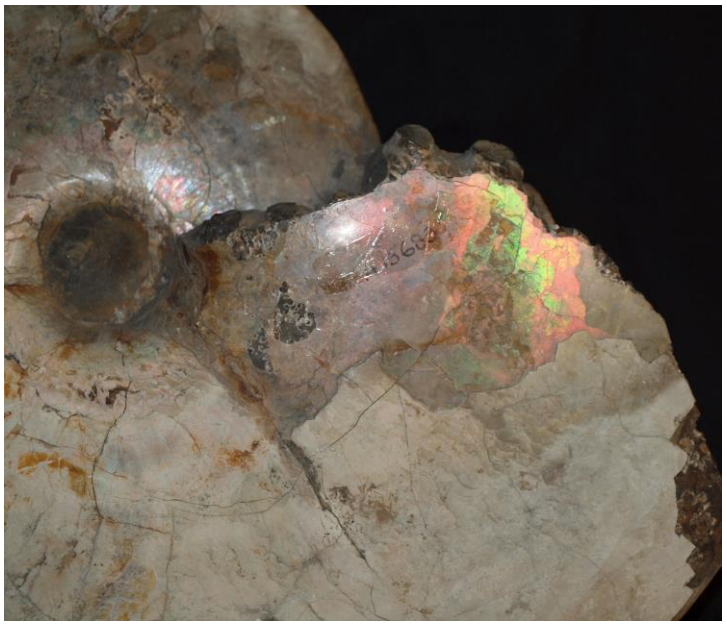
Size Variation

- Extremely Variable
- Dinosaurs to Diatoms
- Matching technology to specimen
- Requires multiple scans/photos
- All the specimen? Part of the specimen?



Color Variations

- Varies across bone, skeleton, assemblage, formation, etc…
- Different Backgrounds
- Scanning Artifacts
- Consider important features to capture (iridescence, sutures, diagnostic markings?)



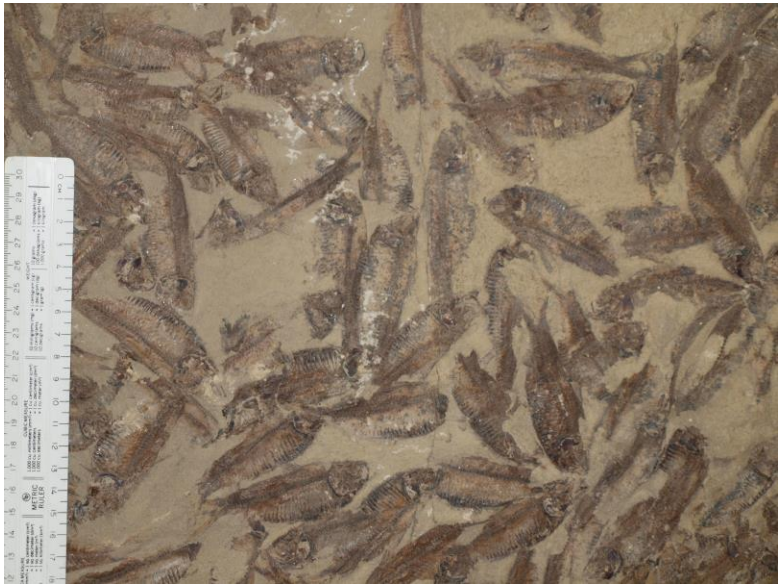
Composition Variation

(permineralization, replacement, films, mold/cast, mummification, etc..)

- Varies across bone, skeleton, assemblage, formation, etc…
- Different Spectral Properties
- Scanning Artifacts
- Recording or knowledge of what they are

Shape Variation

- Varies across bone, skeleton, assemblage, formation, etc…
- Extreme Shape variation
- Flat specimens
- How Capture all of it? Do we try?
- 3D scans..stitching



Identification

- Often Difficult
- Not Possible/Diagnostic
- Outdated Nomenclature
- Multiple Specimens
  - Slab
  - Jacket
  - Changes during Prep/research
- Not Linnaean (Morphotypes)

Specimens/Bones/Lots

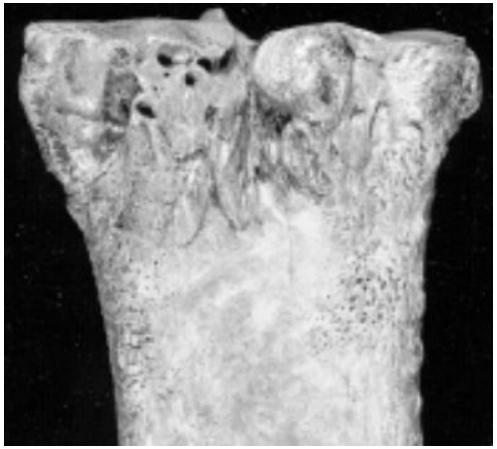
- How to Best Digitize?
  - Whole Specimen
  - Individual Bones
  - Assemblage?
  - By individual
- Often Changes
  - 3 Femurs identified from one specimen??

Preparations

- Varied Preparation methods and storage methods
- requires consideration when digitizing

Special Features

- Post Death Modifications
  - Cultural: Cutmarks
  - Scavenging: Bitemarks
  - Taphonomic: Weathering
  - Epibionts
- Pathologies
- Other important characteristics



Research

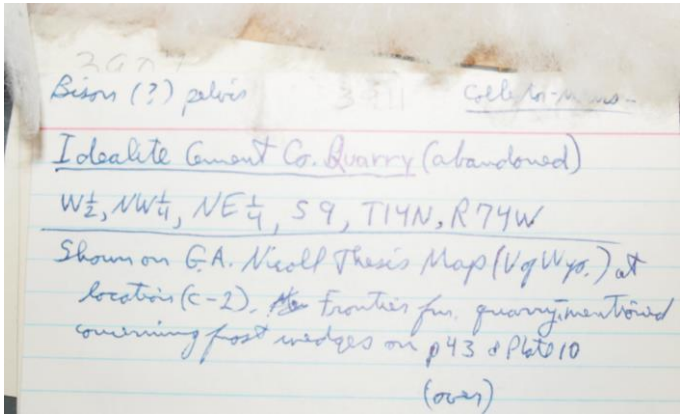
- Holotypes
- Paratypes
- Lithotypes
- Morphotypes

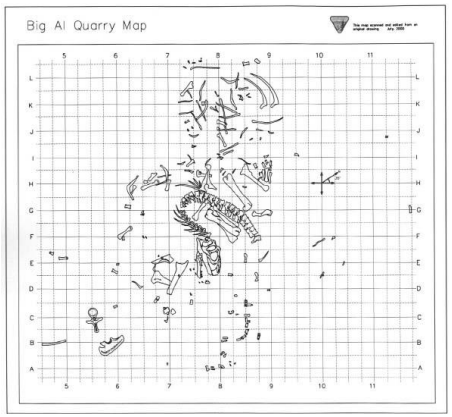
- Analyses noted and Digitized

- Researchers have very different needs and requirements for the specimens…no standardized way

Metadata

- Field Data
  - Notes
  - Maps
  - Photos
- Preparation Data
  - Notes
  - Maps
  - Photos
- Curation Data
  - Photos
  - Card Catalogs
  - Identification Notes
- Research Data
  - Analyses
  - Datasheets





Complicated Workflow

- Color
- Composition
- Size
- Shape
- Identifications
- Specimen/Lot Bones
- Special Features
- Preparations
- Metadata

Specimen by Specimen: Adaptive Workflow with several techniques/methods

Challenges

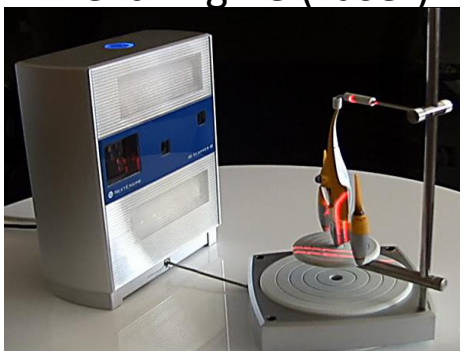
- Paleo- Related
  - Fossils are extremely variable
  - Adaptive Workflows and Multiple Methods
- Small Collections- Related
  - Limited Funds
  - Limited Personnel
- Considerations
  - Digitization Goals? Doing it Right? Future Research?

Multiple Digitization Methods

Micro-CT

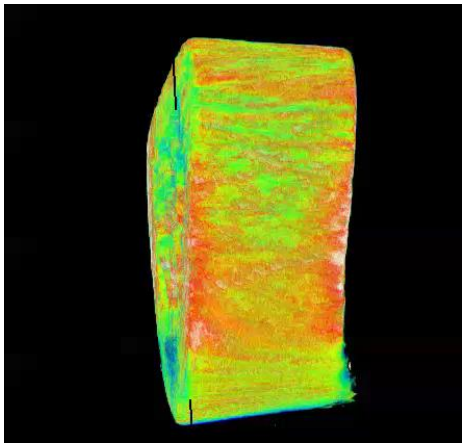
SEM

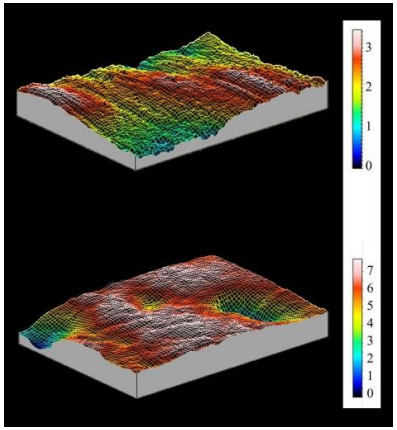
Next-Engine (Laser)



Photogrammetry

Smaller — Larger

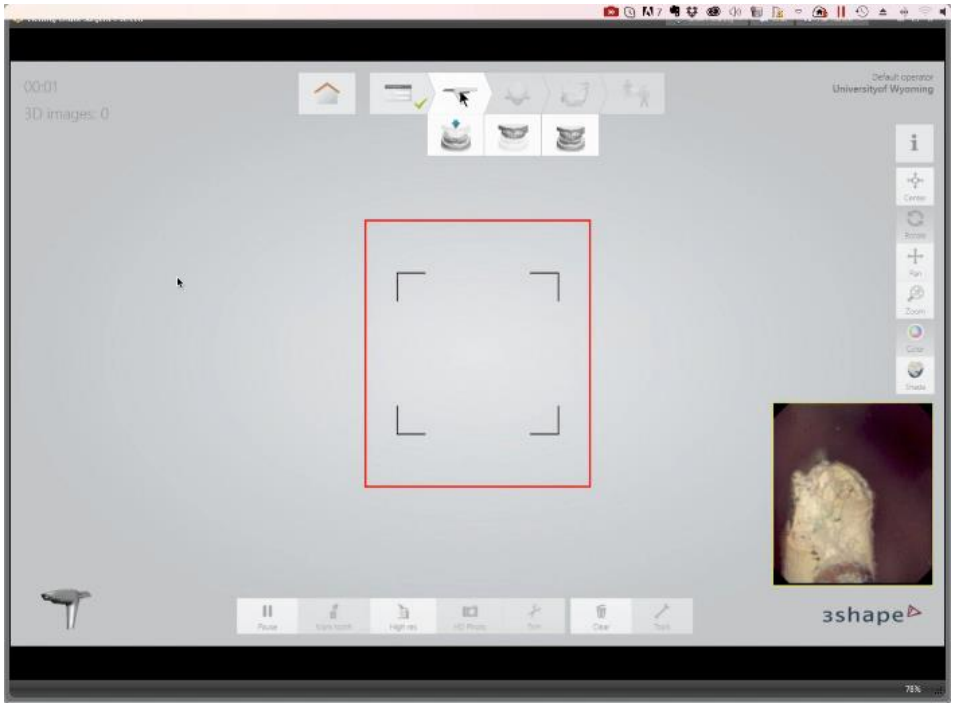




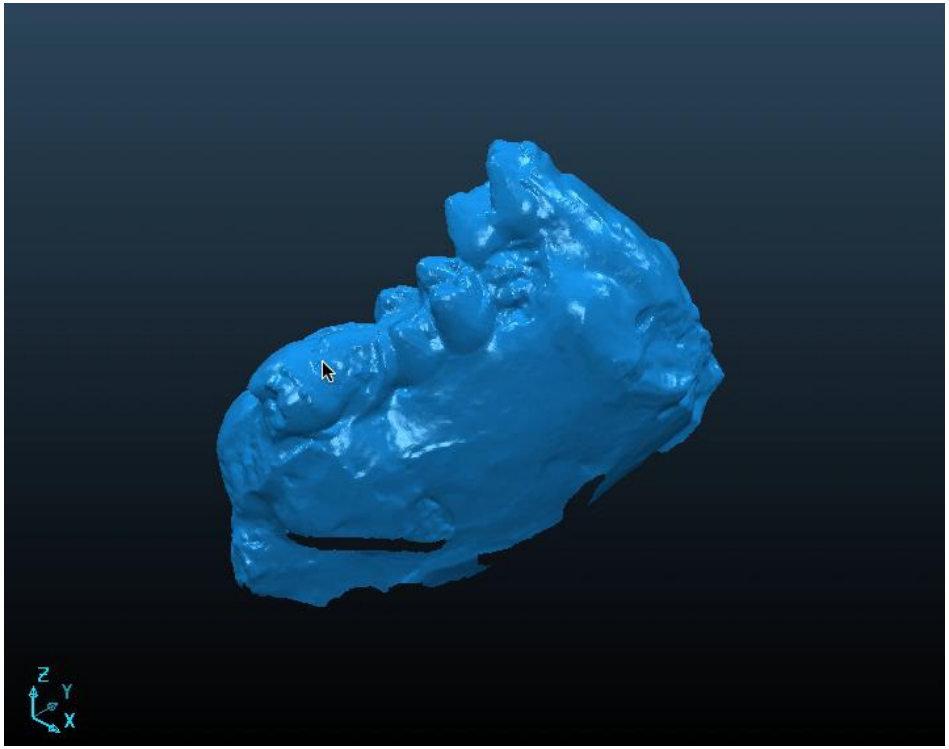
Expensive!

Challenge: Digitization Methods for Teeth

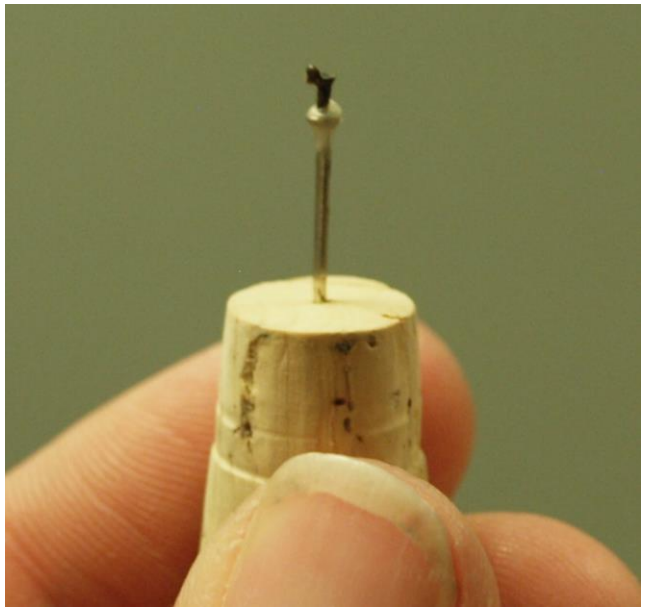
Challenge: Digitization Methods for Teeth

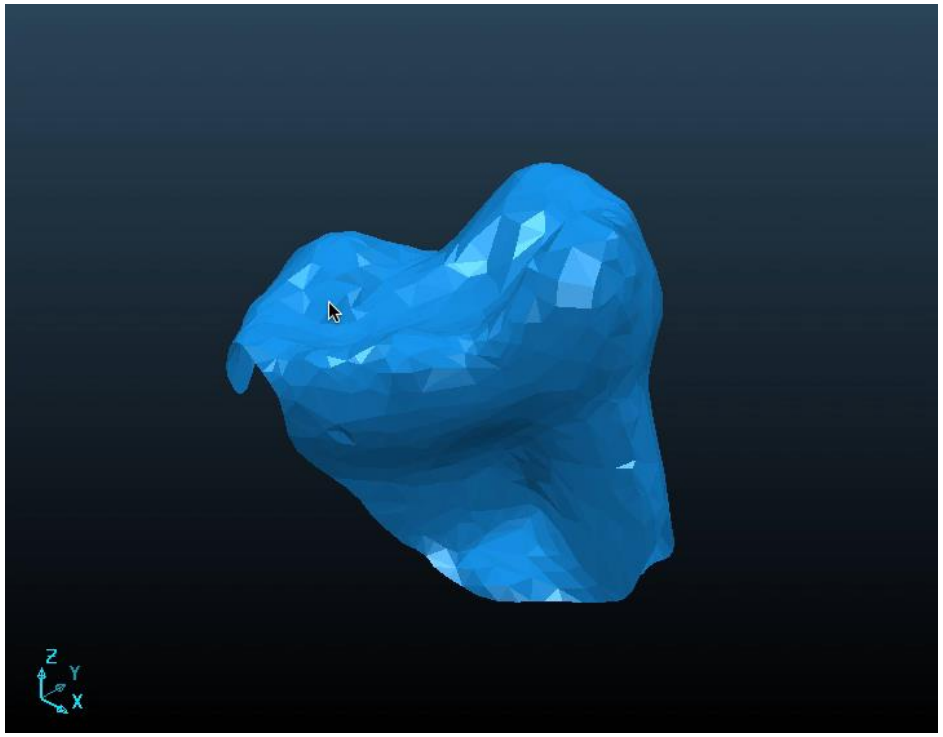


Digitization Methods for Teeth



Digitization Methods for Teeth





Specialized Personnel

- Adaptive workflows
  - Imaging Backgrounds
  - Matching imaging/scanning technique with specimen
  - Adjusting to limit spectral artifacts
  - Knowledge of important features to Digitize
  - Work with a variety of scanning methods and techniques
- Knowledge/Experience
  - Identification of Specimens
  - Software Experience
  - Use of specialized equipment/software

Limited Funds

- Specialized Personnel
  - Can work with Adaptive workflows
  - Work with multiple techniques/digitization methods
  - Expensive…few of them
  - Volunteers…requires a lot of training!
    - Volunteer Retention
- Specialized Equipment
  - More than 1 type of imaging/scanning devise
  - Expensive! Constraints on Purchasing Power
  - Technical Software…or lots of it
  - Data Storage Issues

Compromises