



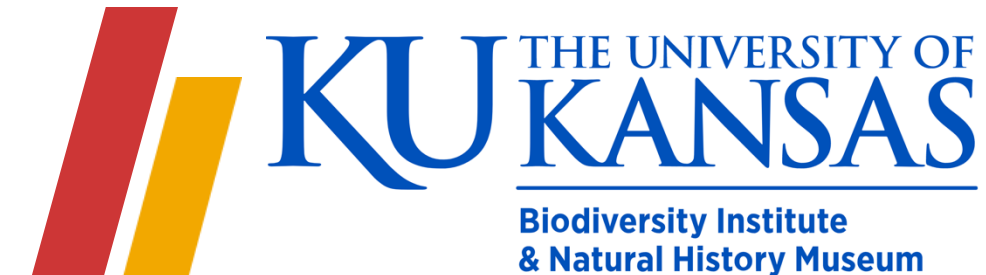
AABA 2025

94th Annual Meeting of the
American Association of Biological Anthropologists

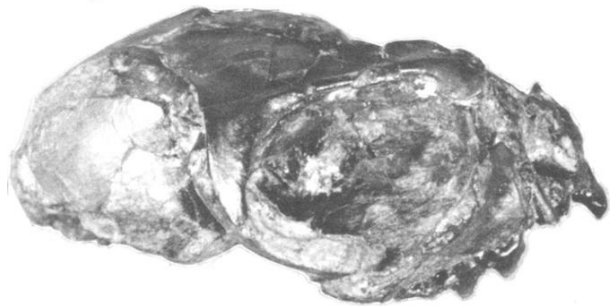
March 12-15, Baltimore, MD, Baltimore Marriott Waterfront

Assessing dental evolution in the anaptomorphine *Tetonius* – *Pseudotetonius* (Omomyidae) lineage using quantitative and qualitative methods

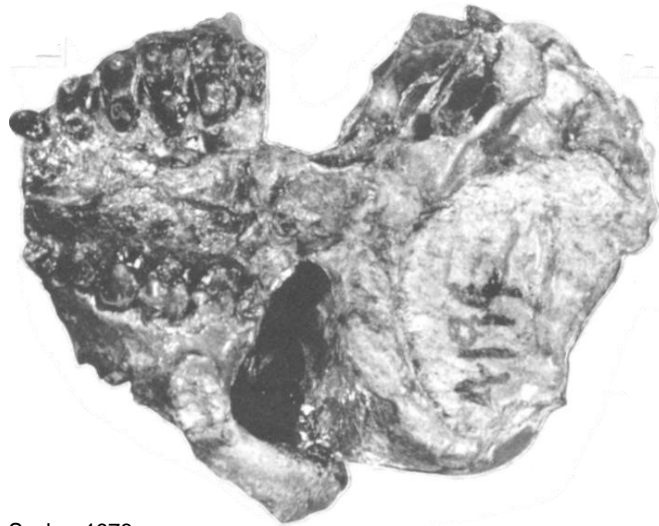
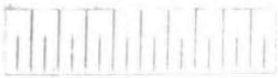
Kathleen Rust^{1,2}, Kristen Tietjen², & K. Christopher Beard^{1,2}
Department of Ecology and Evolutionary Biology¹ & Biodiversity Institute and
Natural History Museum², University of Kansas



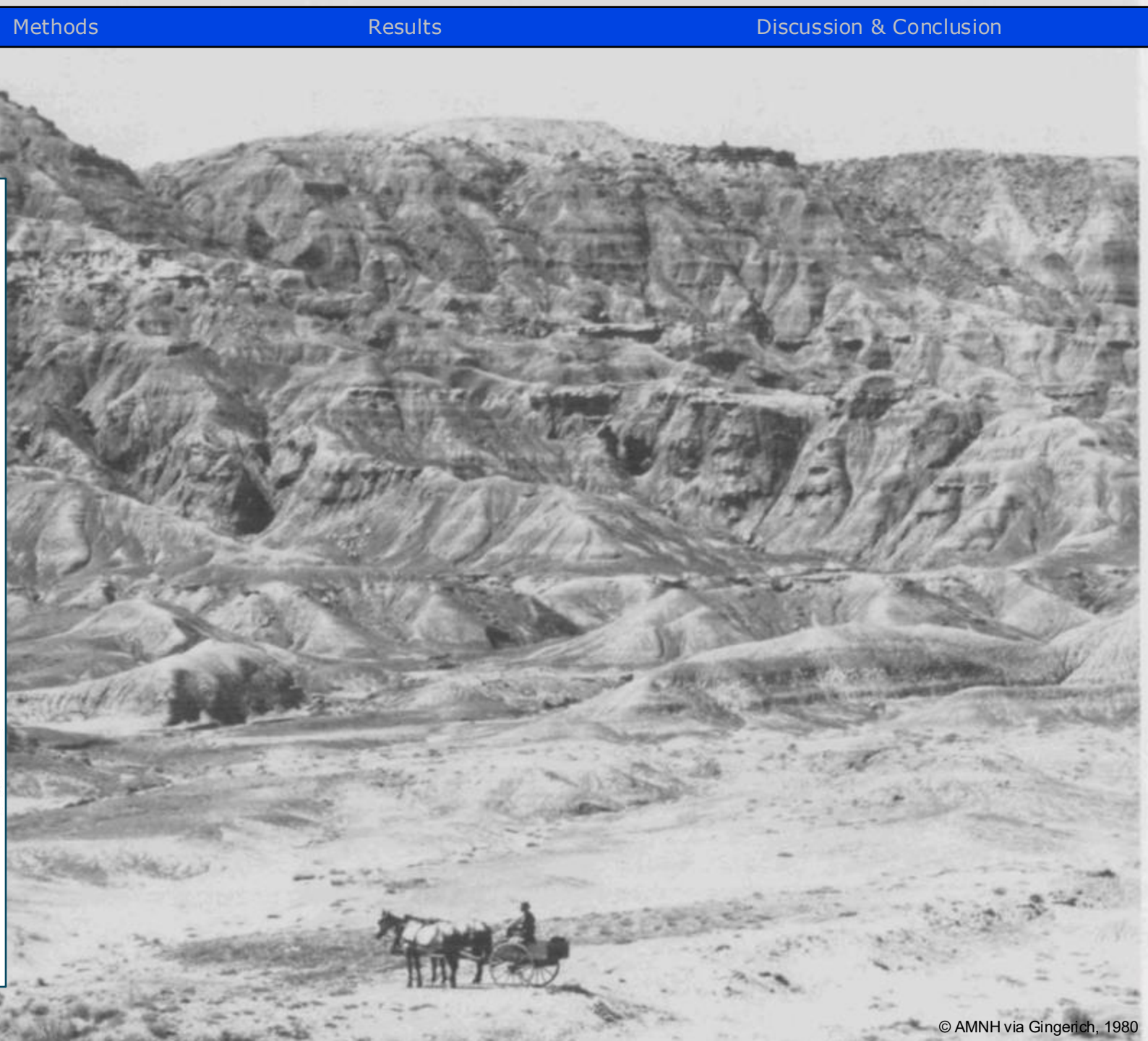
AMNH 4194

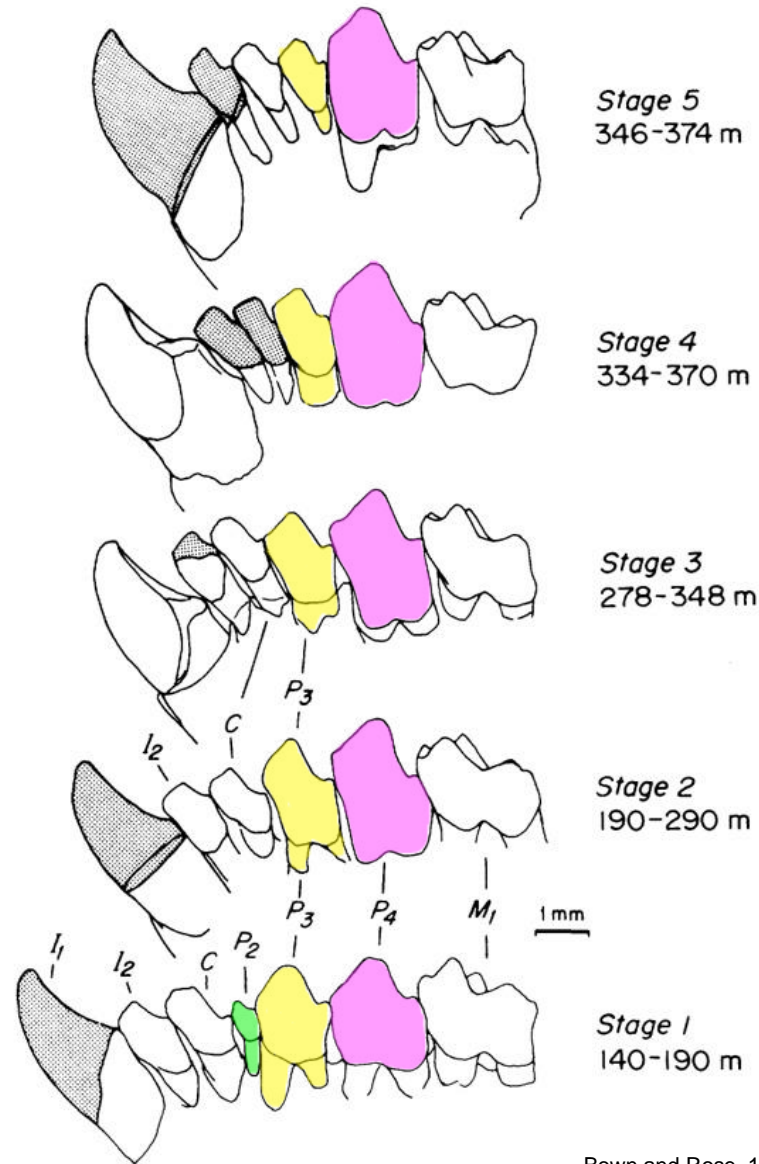


10mm

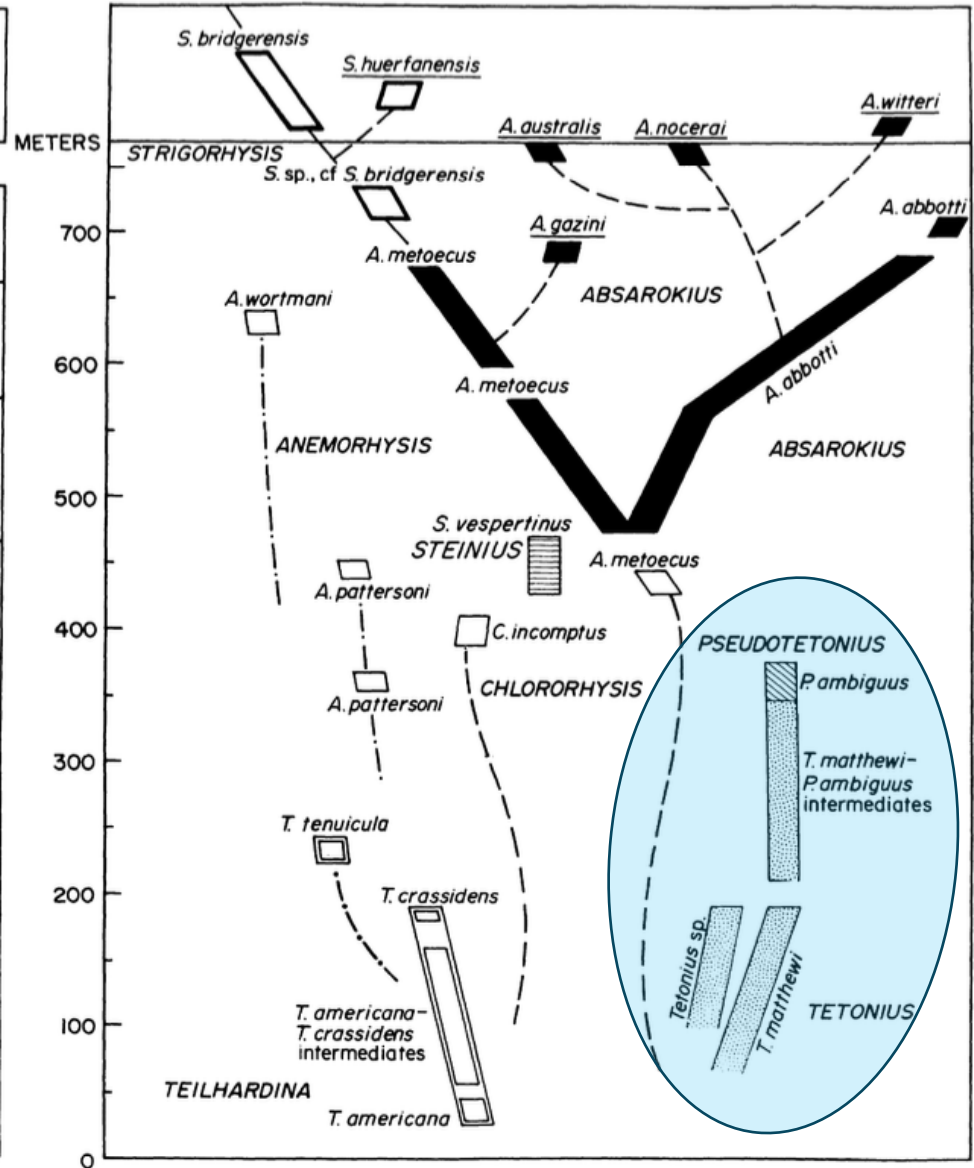
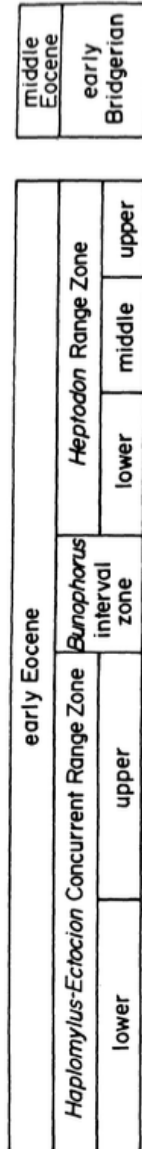


Szalay, 1976





Bown and Rose, 1987



Hypotheses Tested & Research Questions:

H₀: The maxillary antemolar dentition do not exhibit change in shape or morphology through time (i.e., meter level)

H_a: The maxillary antemolar dental morphology and/or shape changes through time

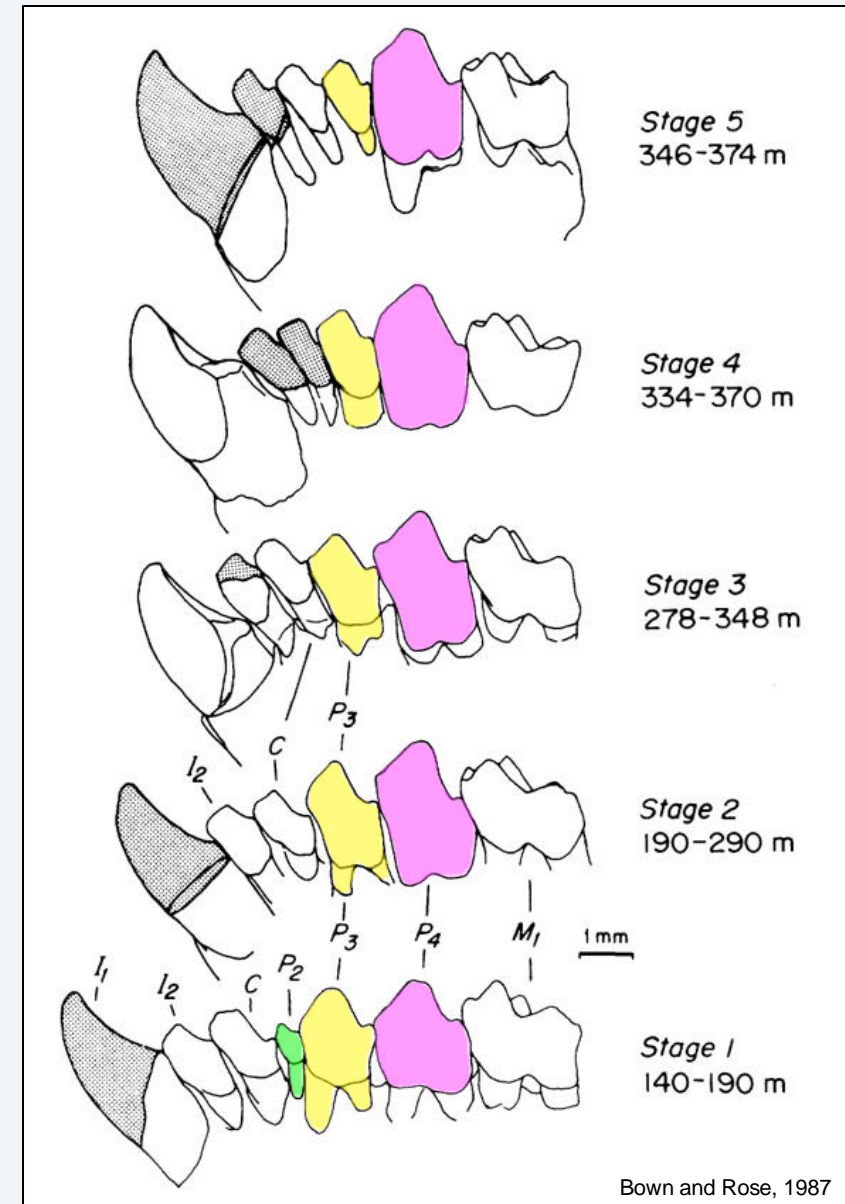
H₀: Observed changes in the maxillary antemolar dentition follow the same pattern of morphological and shape evolution as those in the lower antemolar dentition

↳ uppers & lowers = evolutionarily integrated

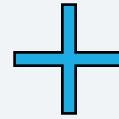
H_a: Observed changes in the maxillary antemolar dentition do not conform to the the same patterns of morphological and/or shape evolution as those in the lower antemolar dentition

↳ uppers & lowers = independent modules → mosaic evolution

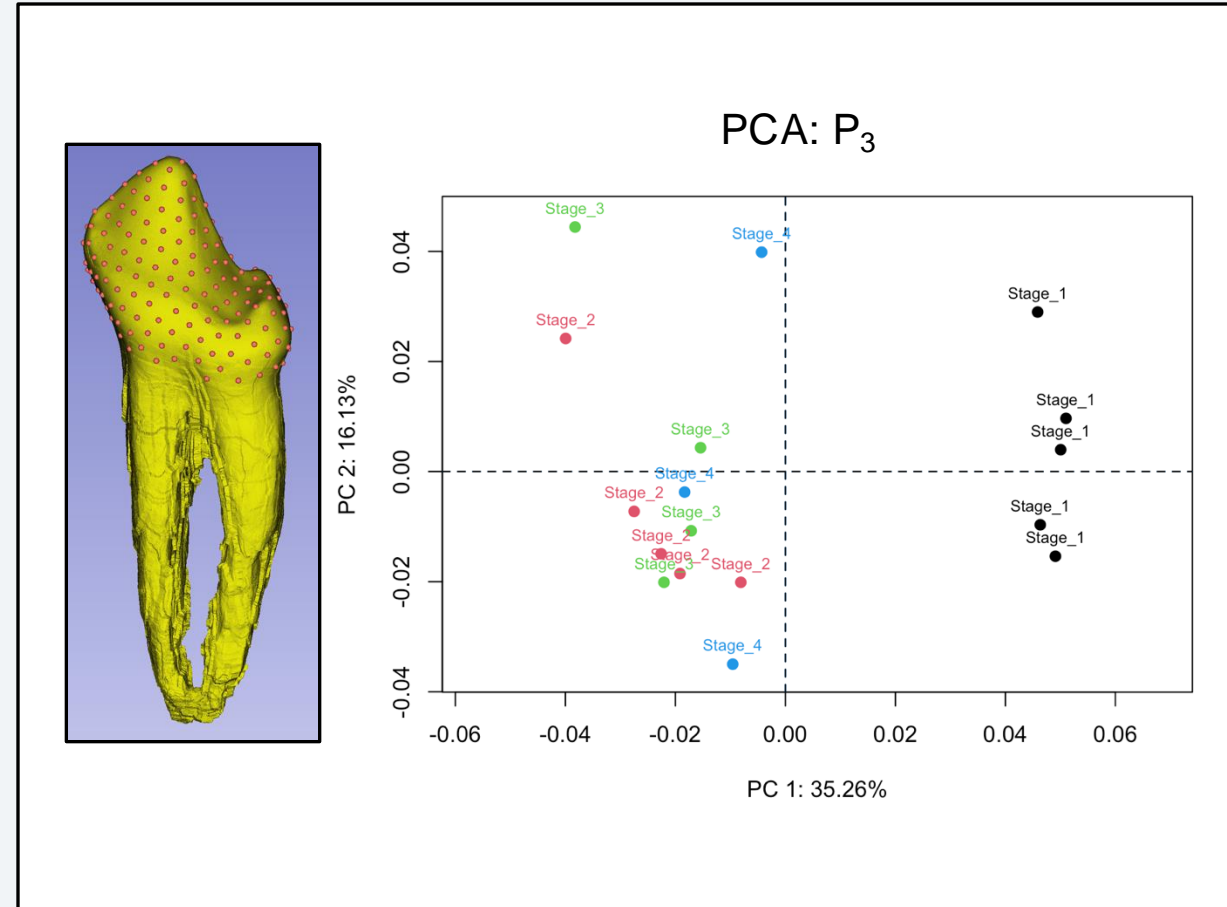
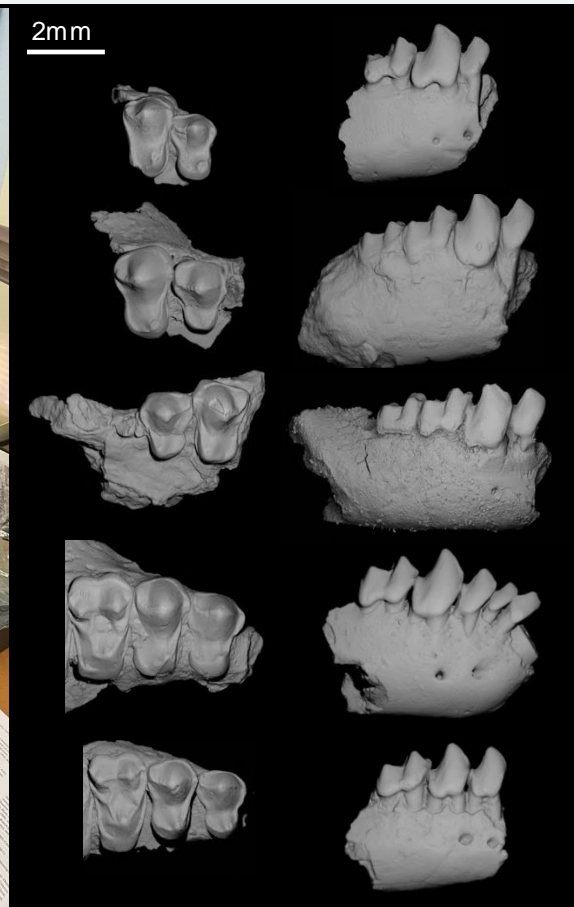
Can we apply the same morphological schema established by Bown and Rose (1987) for the lower antemolar dentition to the upper antemolar dentition to temporally (phylogenetically?) place genotype *T. homunculus* (AMNH 4194)?



**Qualitative Methods:
Comparative anatomical analyses**



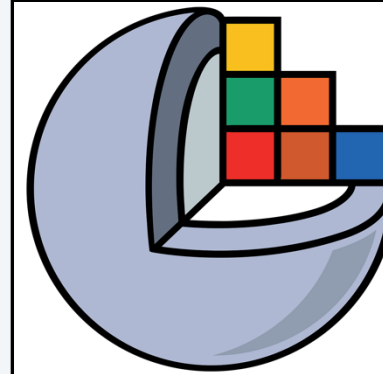
**Quantitative Methods: 3-D
Geometric Morphometric analyses**



Quantitative Methods: data collection and digital preparation

1. Collections visits, physical loans, digital loans
 - ~100 loaned specimens spanning meter levels 140-390
 - Partial maxillae & dentaries: P^3 , P^4 , P_3 , P_4
2. μ -CT scanning
 - Nikon XT H 225
3. Digital preparation
 - I. Segmentation
 - II. Digital restoration, retro-deformation
4. 3DGM shape analysis preparation:
 - I. Fixed, homologous landmarks (7-14 LMs)
 - II. DeCAL: semi-landmark placement procedure (200-400 semi-LMs)
 - III. Generalized Procrustes Fitting

Murat Maga, PhD
University of Washington

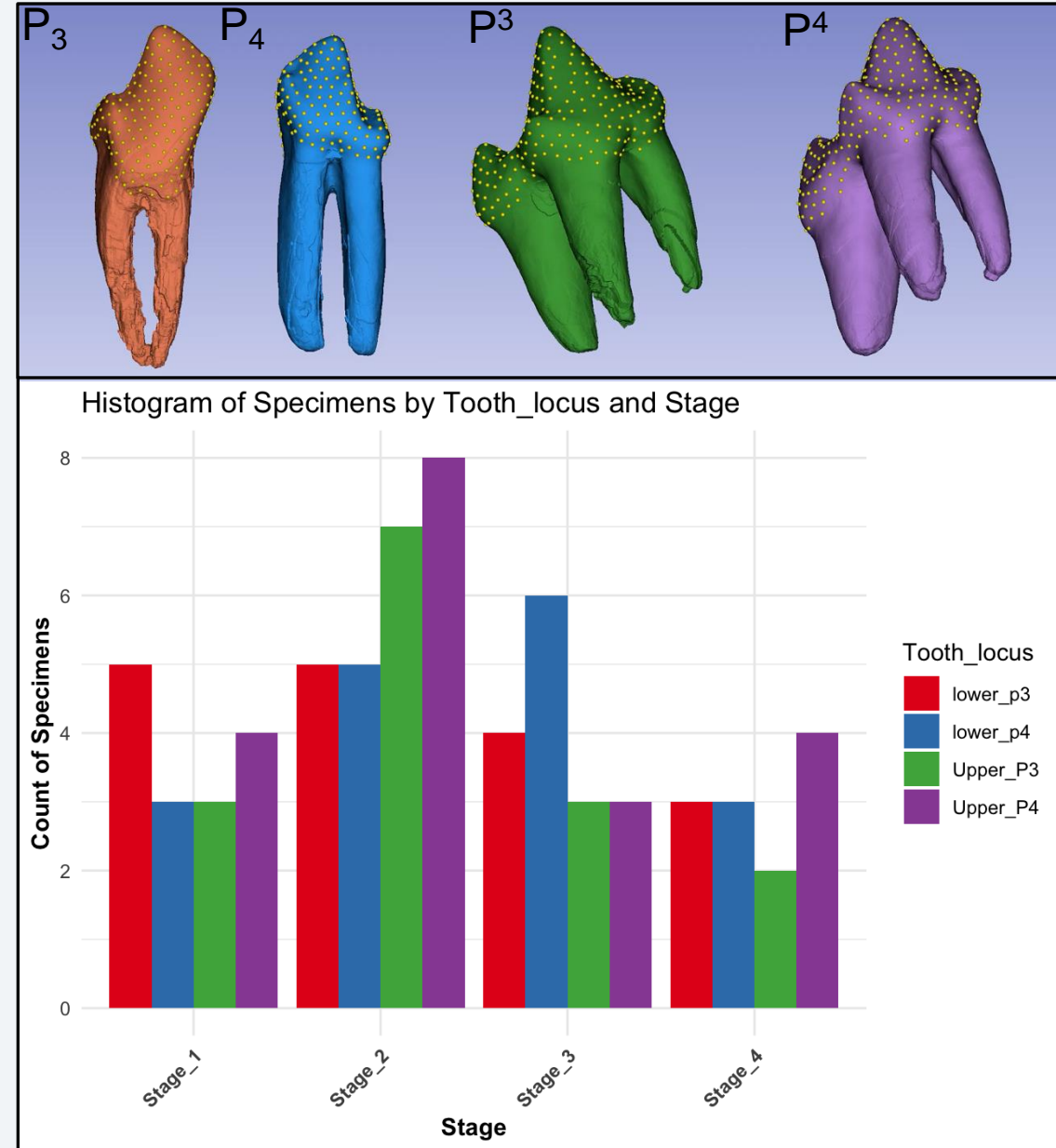


3D Slicer



Quantitative Methods: data collection and digital preparation

1. Collections visits, physical loans, digital loans
 - ~100 loaned specimens spanning meter levels 140-346
 - Partial maxillae & dentaries: P³, P⁴, P₃, P₄
2. μ-CT scanning
 - Nikon XT H 225
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Quantitative Analyses: 3D Geometric Morphometrics

- Generalized Procrustes analysis
- Principal components analysis
- Procrustes MANOVA
 - Shape ~ Stage
- Morphological disparity
 - Shape variance pairwise comparisons by stage



zarquon42b/
Morpho



R-package providing a toolset for (3D-based)
Geometric Morphometrics

6

Contributors

7

Issues

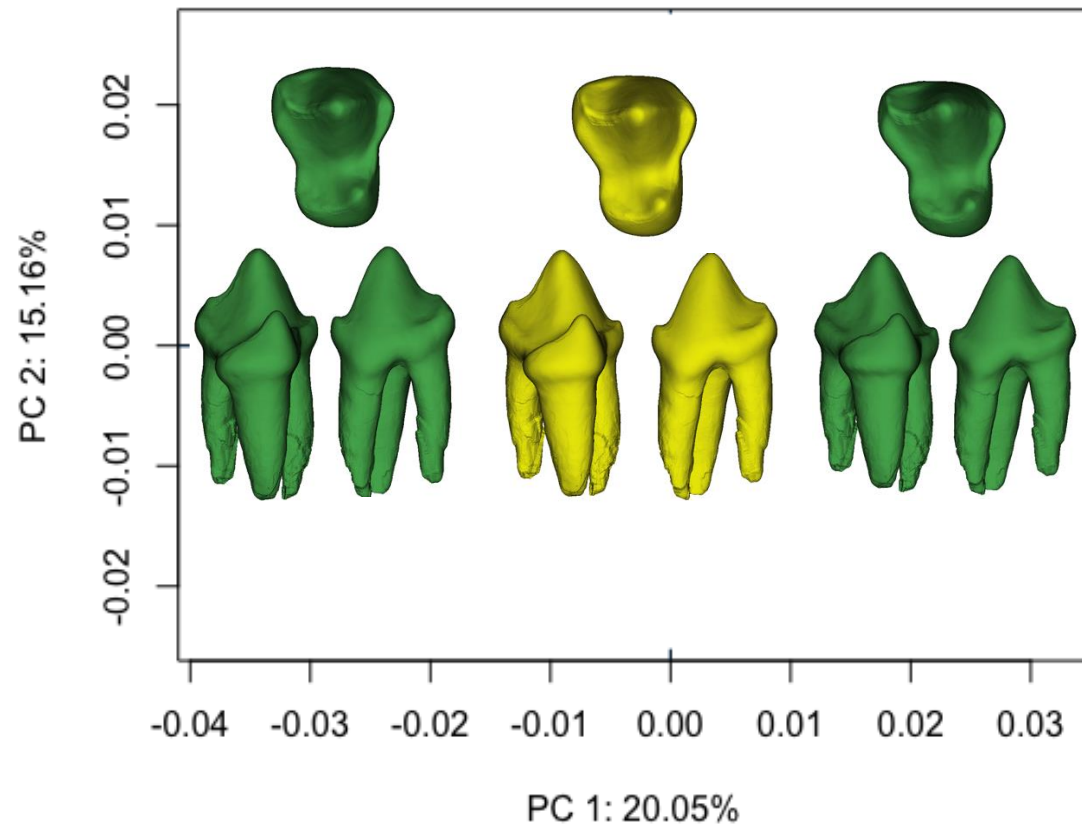
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Stars

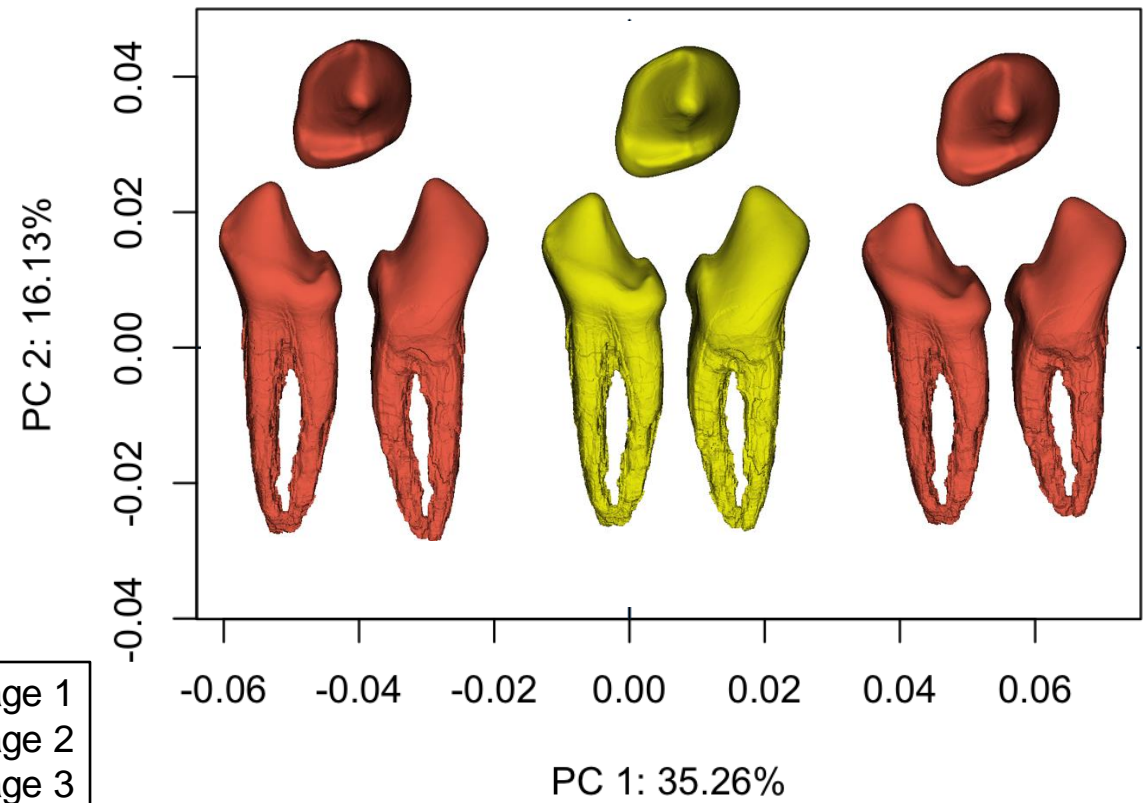
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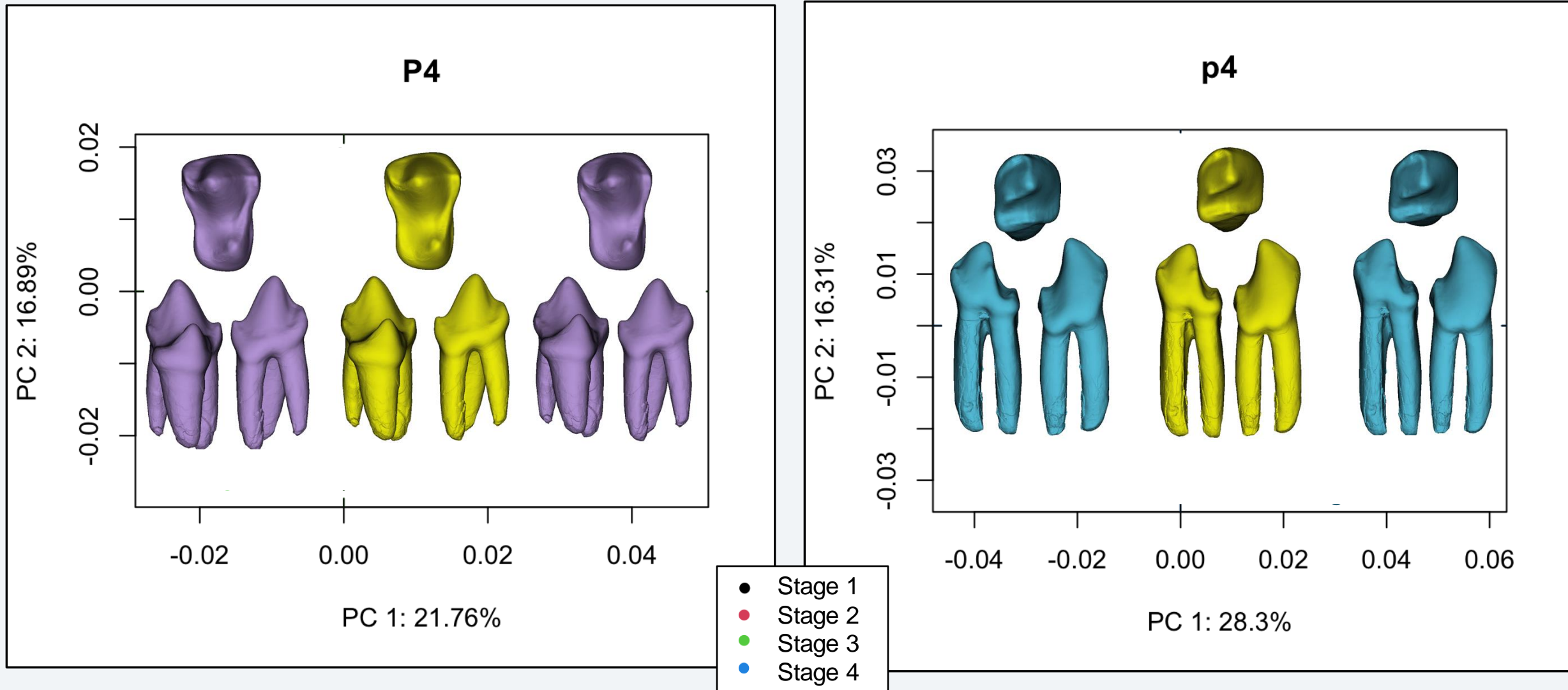
Forks



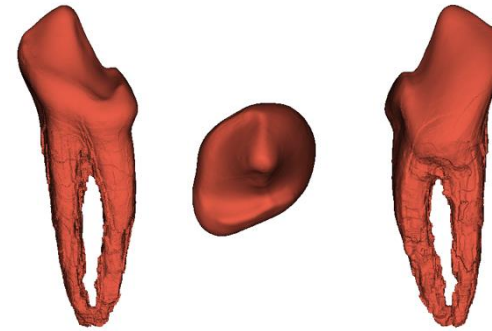
GDGM PCA Results: P^3 & P_3 **PCA Upper P3**

- Stage 1
- Stage 2
- Stage 3
- Stage 4

PCA Lower p3

GDGM PCA Results: P^4 & P_4 

Procrustes ANOVA: P₃



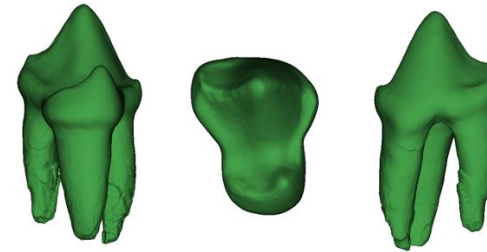
Shape ~ Stage					
	Df	R ²	F	Z	Pr(>F)
Stage	3	0.44899	3.531	3.7888	0.001
Residuals	13	0.55101			
Total	16				

Shape ~ Stage + Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.44899	3.7861	3.9745	0.001
Size	1	0.07666	1.9392	1.7755	.037
Residuals	12	0.47435			
Total	16				

Shape ~ Stage + Size + Stage * Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.44899	4.2835	4.2375	0.001
Size	1	0.07666	2.1940	2.0542	.021
Stage : Size	3	0.15990	1.5255	1.6723	.044
Residuals	9	0.31446			
Total	16				

Shape ~ Size					
	Df	Rsq	F	Z	Pr(>F)
Size	1	0.08213	1.3421	0.96014	0.4
Residuals	15	0.91787			
Total	16				

Procrustes ANOVA: P³



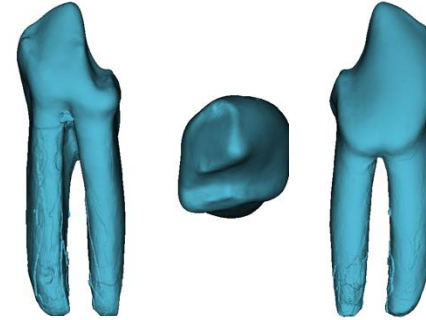
Shape ~ Stage					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.28995	1.4973	2.2744	0.01
Residuals	11	0.71005			
Total	14				

Shape ~ Stage + Size + Stage * Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.28995	1.7329	2.7748	0.002
Size	1	0.14363	2.5753	3.2682	0.003
Stage : Size	3	0.176	1.0519	0.2231	0.408
Residuals	7	0.39041			
Total	14				

Shape ~ Stage + Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.28995	1.7064	2.9197	0.002
Size	1	0.14363	2.5359	3.2136	0.003
Residuals	10	0.56641			
Total	14				

Shape ~ Size					
	Df	Rsq	F	Z	Pr(>F)
Size	1	0.13077	1.9557	2.4676	0.003
Residuals	13	0.86923			
Total	14				

Procrustes ANOVA: P₄



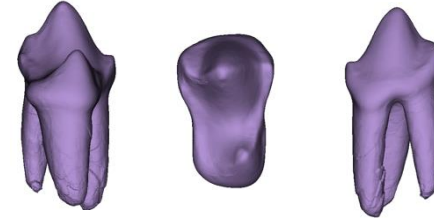
Shape ~ Stage					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.36078	2.2576	2.8594	0.004
Residuals	12	0.63922			
Total	15				

Shape ~ Stage + Size + Stage * Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.36078	2.8962	3.2886	0.002
Size	1	0.08463	2.0381	1.8934	0.034
Stage:Size	3	0.22241	1.7854	2.1079	0.019
Residuals	8	0.33218			
Total	15				

Shape ~ Stage + Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.36078	2.3853	2.9476	0.004
Size	1	0.08463	1.6786	1.4632	0.074
Residuals	11	0.55459			
Total	15				

Shape ~ Size					
	Df	Rsq	F	Z	Pr(>F)
Size	1	0.0996	1.5487	1.2539	0.092
Residuals	14	0.9004			
Total	15				

Procrustes ANOVA: P⁴



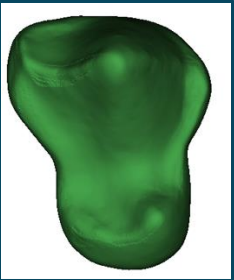
Shape ~ Stage					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.21869	1.3995	1.6488	0.051
Residuals	15	0.78131			
Total	18				

Shape ~ Stage + Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.21869	1.3964	1.62254	0.05
Size	1	0.05048	0.9671	0.02887	0.494
Residuals	14	0.73083			
Total	18				

Shape ~ Stage + Size + Stage * Size					
	Df	Rsq	F	Z	Pr(>F)
Stage	3	0.21869	1.3248	1.28865	0.099
Size	1	0.05048	0.9175	-0.11202	0.549
Stage : Size	3	0.12555	0.7606	-0.86266	0.804
Residuals	11	0.60527			
Total	18				

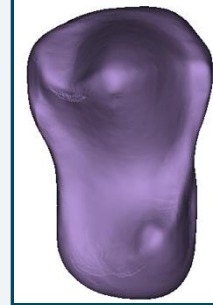
Shape ~ Size					
	Df	Rsq	F	Z	Pr(>F)
Size	1	0.06802	1.2406	0.77518	0.222
Residuals	17	0.93198			
Total	18				

Morphological Disparity



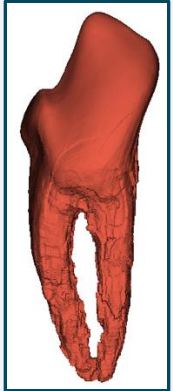
P³: Procrustes variances for defined groups

Stage_1	Stage_2	Stage_3	Stage_4
0.00060934	0.0008382	0.00065044	0.00079491



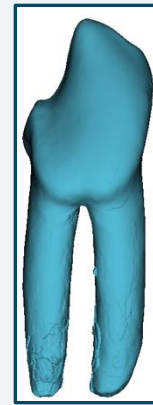
P⁴: Procrustes variances for defined groups

Stage_1	Stage_2	Stage_3	Stage_4
0.00063531	0.00101134	0.00064534	0.00056335



P₃: Procrustes variances for defined groups

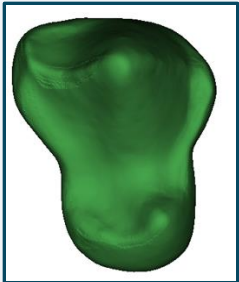
Stage_1	Stage_2	Stage_3	Stage_4
0.00145583	0.00135613	0.00187184	0.00218816



P⁴: Procrustes variances for defined groups

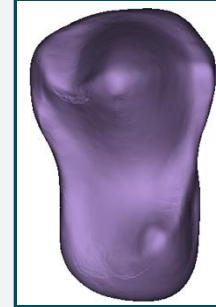
Stage_1	Stage_2	Stage_3	Stage_4
0.00081927	0.00099154	0.00095481	0.0017282

Morphological Disparity



P³: Procrustes variances for defined groups

Stage_1	Stage_2	Stage_3	Stage_4
0.00060934	0.0008382	0.00065044	0.00079491



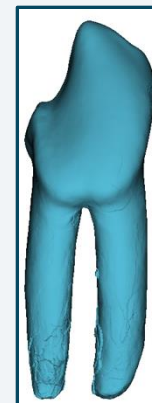
P⁴: Procrustes variances for defined groups

Stage_1	Stage_2	Stage_3	Stage_4
0.00063531	0.00101134	0.00064534	0.00056335



P₃: Procrustes variances for defined groups

Stage_1	Stage_2	Stage_3	Stage_4
0.00145583	0.00135613	0.00187184	0.00218816

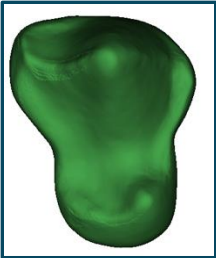


P⁴: Procrustes variances for defined groups

Stage_1	Stage_2	Stage_3	Stage_4
0.00081927	0.00099154	0.00095481	0.0017282

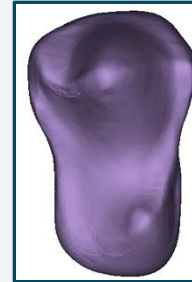


Morphological disparity: Pairwise Comparisons



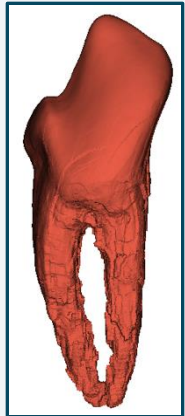
P-values associated with pairwise differences

	Stage_1	Stage_2	Stage_3	Stage_4
Stage_1	1			
Stage_2	0.086	1		
Stage_3	0.786	0.15	1	
Stage_4	0.31	0.749	0.375	1



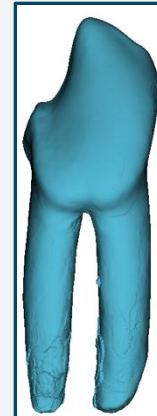
P-values associated with pairwise differences

	Stage_1	Stage_2	Stage_3	Stage_4
Stage_1	1			
Stage_2	0.104	1		
Stage_3	0.973	0.166	1	
Stage_4	0.777	0.051	0.77	1



P-values associated with pairwise differences

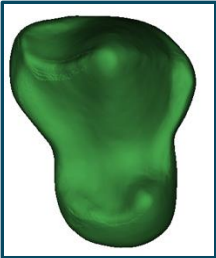
	Stage_1	Stage_2	Stage_3	Stage_4
Stage_1	1			
Stage_2	0.806	1		
Stage_3	0.305	0.186	1	
Stage_4	0.093	0.046	0.481	1



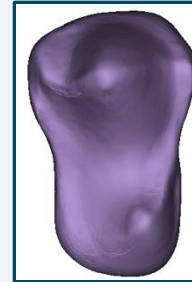
P-values associated with pairwise differences

	Stage_1	Stage_2	Stage_3	Stage_4
Stage_1	1			
Stage_2	0.558	1		
Stage_3	0.6	0.87	1	
Stage_4	0.002	0.011	0.009	1

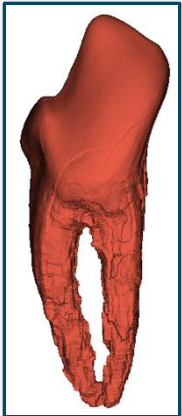
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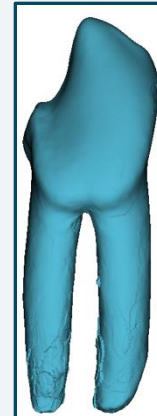
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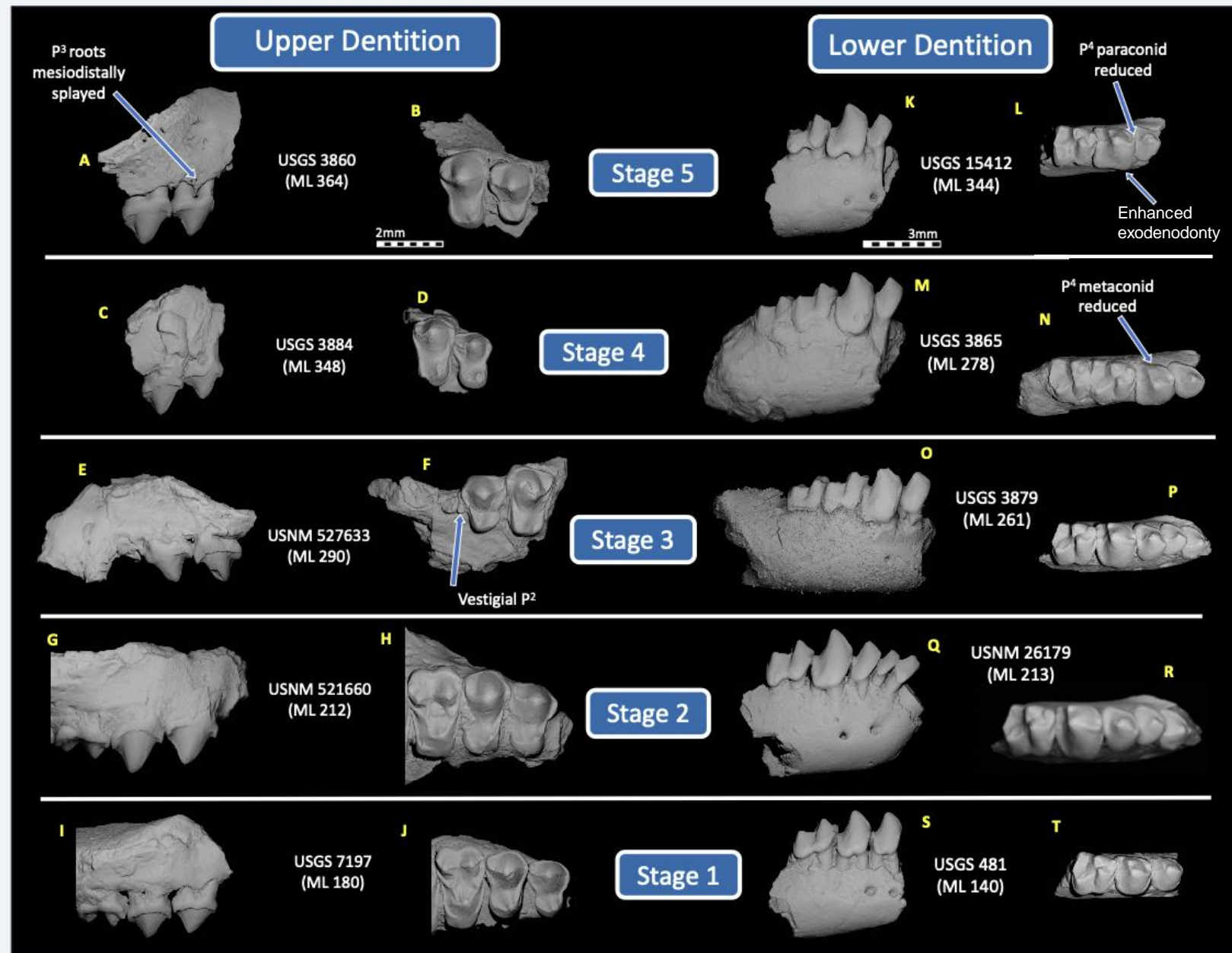
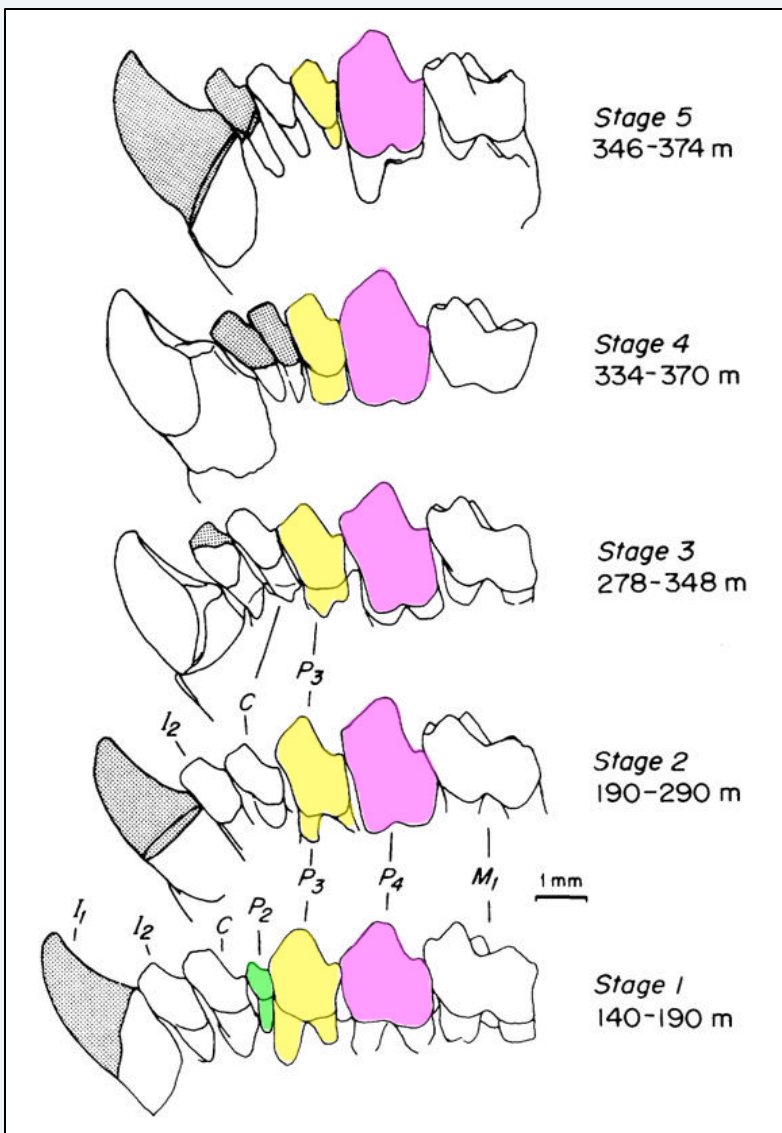


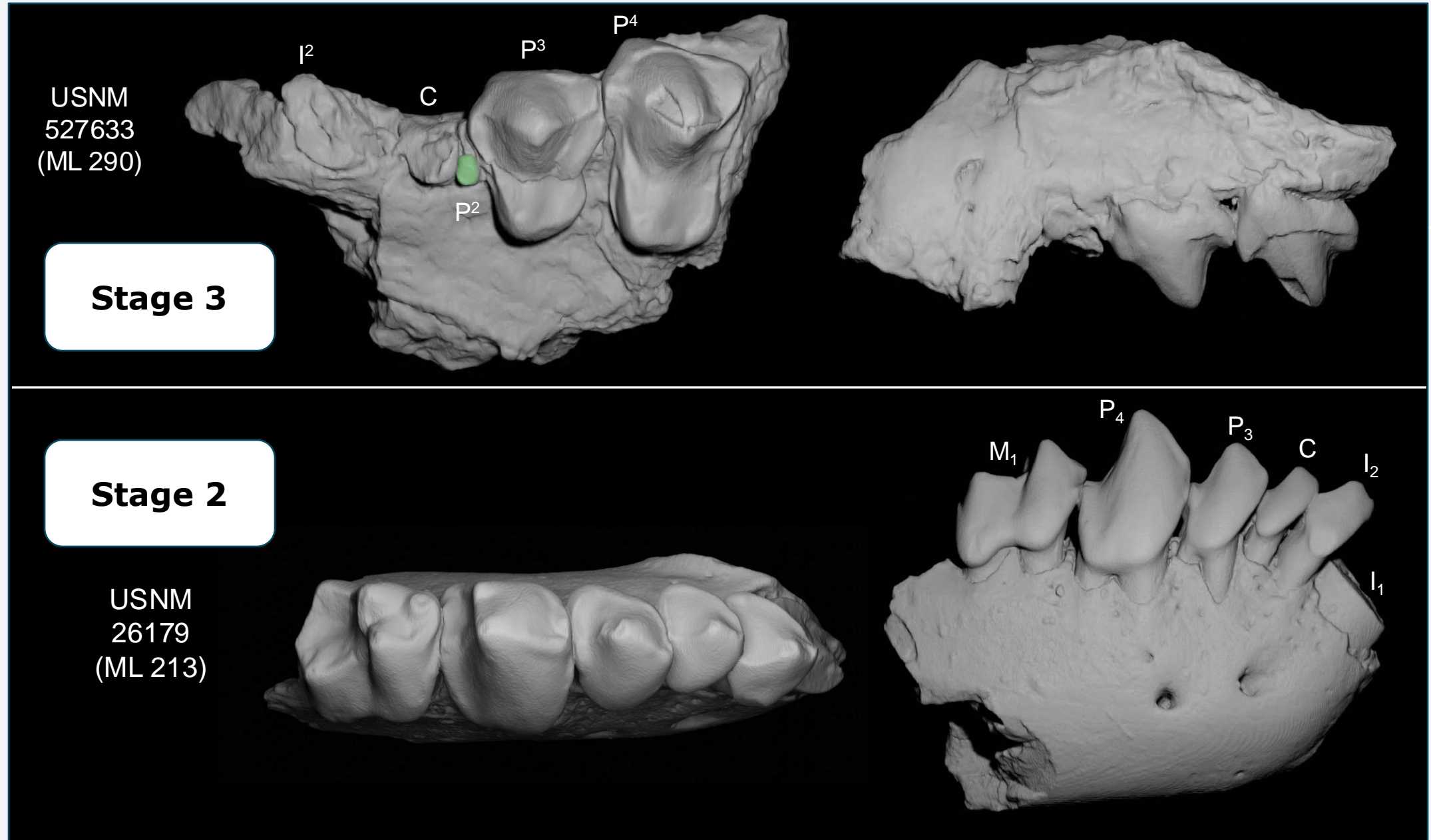
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Qualitative Results: Comparative Morphology





Hypotheses Tested & Research Questions:

H₀: The maxillary antemolar dentition do not exhibit change in shape or morphology through time (i.e., meter level)

H_a: The maxillary antemolar dental morphology and/or shape changes through time

H₀: Observed changes in the maxillary antemolar dentition follow the same pattern of morphological and shape evolution as those in the lower antemolar dentition

- uppers & lowers = evolutionarily integrated


H_a: Observed changes in the maxillary antemolar dentition do not conform to the the same patterns of morphological and/or shape evolution as those in the lower antemolar dentition

- uppers & lowers = independent modules → mosaic evolution

Q1: Can we apply the same morphological schema established by Bown and Rose (1987) for the lower antemolar dentition to the upper antemolar dentition to temporally (phylogenetically?) place genotype *T. homunculus* (AMNH 4194)?

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H₀: Observed changes in the maxillary antemolar dentition follow the same pattern of morphological and shape evolution as those in the lower antemolar dentition

- uppers & lowers = evolutionarily integrated

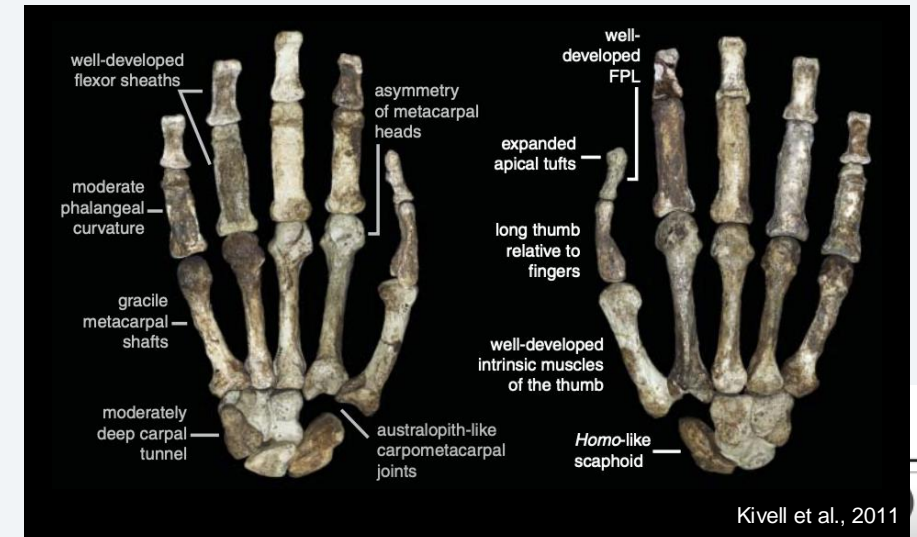
H_a: Observed changes in the maxillary antemolar dentition do not conform to the the same patterns of morphological and/or shape evolution as those in the lower antemolar dentition

- uppers & lowers = independent modules → mosaic evolution

Q1: ~~Can we apply the same morphological schema established by Bown and Rose (1987) for the lower antemolar dentition to the upper antemolar dentition to temporally (phylogenetically?) place genotype *T. homunculus* (AMNH 4194)?~~

Discussion

- Disparate patterns & rates of crown shape evolution between upper and lower antemolar dentition
 - Retention of vestigial P² above ML 190
 - Variances of shape = Differences in pattern, tempo
- Directional morphoclines per tooth locus
 - Lowers → Reduction of cusps/complexity
 - Lowers → mesiodistal pinching and distolingual lobe
 - Uppers → mesiodistal compression
 - Both → “pinched”
- New lens to interpretation of Bown & Rose’s morphological schema
 - Polymorphisms in an evolving population
 - Implications for systematic taxonomy
 - *Tetonius* outside the BHB?
- Integration, modularity and mosaicism

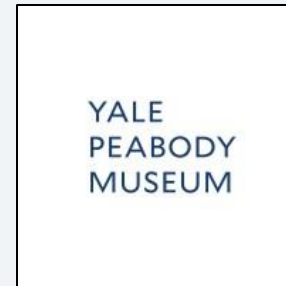


Future Directions

- Additional specimens representing “Stage 5”
- What is the driver of dental evolution in this clade?
 - Selective pressure related to diet
 - Dental topographic analyses
 - Maxillofacial reorganization,
 - Reduction of mid-face & rostrum
 - Product of purported evolutionary trade-off b/w vision and olfaction (in “real time”)?

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