Gabriel S. Yapuncich
Vision Statement

Research goals

The overarching goal of my research program is to reconstruct the patterns of primate evolution through a detailed understanding of morphology, and to understand to what extent morphological changes reflect adaptive processes and/or shifts in selective pressures in the primate lineage. In order to leverage as much information as possible from paleontological specimens, my research also focuses on methodological advancements in body mass prediction and shape characterization. My research requires the collection, study, and description of primate fossil material. I also collect comparative data from extant taxa and evaluate how morphology varies with behavior, function, and phylogeny. This statement describes my current research, explains how these projects relate to one another, and outlines short-term and long-term goals for my future research.

Refining and developing methods of body mass prediction in fossil taxa

Body mass is a fundamental aspect of an organism that is often used as an ecological proxy due to its covariance with multiple ecological characteristics (e.g., diet, life history, and locomotor behavior). The fundamental nature of body mass means that the process of predicting body mass is a foundational analytical tool for researchers in broad range of biological fields, including vertebrate paleontology (e.g., Gingerich et al., 1982; Conroy, 1987; Dagosto and Terranova, 1992; Delson et al., 2000), bioarchaeology (e.g., Ruff et al., 2005; Pomeroy and Stock, 2012), and forensic sciences (e.g., Robbins Schug et al., 2013; Schaffer, 2016). To date, a large amount of my research has focused on refining and expanding the methodological approaches of body mass prediction. This includes development of novel prediction equations based on postcranial dimensions (Yapuncich et al., 2015); these equations have been demonstrated to generate reasonable accurate predictions for a wide variety of taxa. I have evaluated alternative workflows for calculating prediction error, a widely used metric of predictive accuracy (Yapuncich, in revision). Most recently, I have applied previously published prediction equations to a novel test sample of human juveniles to determine their reliability when applied to small-bodied hominins (Walker et al., in revision). These studies and future research in this area improve our ability to reconstruct body mass in fossil species, which facilitates greater understanding of their ecology. The study by Harrington et al. (2015) is a good example of such improvement, as different predicted body masses have strong impacts on inferred levels of encephalization in early euprimate species.

Short-term goals (*indicates active research projects):

- Evaluation of the impact of longitudinal body mass on predictive accuracy (Glander, 2006; Laub et al., 2015)*
- Development of morphometric body mass prediction equations from a juvenile reference sample for bioarchaeological and paleoanthropological application*. This is an ongoing collaboration with Drs. Chris Walker (NC State University), Steve Churchill (Duke University), and Noël Cameron (Loughborough University)

Long-term goals:

- Application of novel body mass prediction equations to recently discovered fossil hominins (*A. sediba* and *H. naledi*), in collaboration with Drs. Walker, Churchill, and Cameron
- Development of machine-learning algorithms for body mass prediction in fossil primates, similar to methods proposed by Grabowski et al. (2015) for application to fossil hominins

<u>Comparative evolutionary morphology</u>

While my research surrounding body mass prediction helps to improve estimation of a common comparative baseline for extant and extinct fossil species, my work also details the relationship between morphological variation and functional differences in primates. Particularly in primate anatomy, there is a rich literature describing variation in morphological features between taxa, and this variation is often linked to functional differences (e.g., in locomotor behaviors, in dietary behaviors) between the same taxa. However, there are several issues with the classic assessments of these features: 1) they are often only qualitatively, but not quantitatively, described, which makes it difficult to evaluate additional specimens in the same comparative paradigm, 2) these features have often only been assessed in a relatively small sample of extant or extinct species, and 3) comparisons have often not taken into account phylogenetic autocorrelation between species (i.e., these features have not been evaluated with modern phylogenetic comparative methods). Many of my collaborations with Dr. Doug Boyer have aimed to alleviate these issues; these projects include evaluation of the size and shape of the medial tibial facet of the talus (Boyer et al., 2015a) and quantification of the position and depth of the groove for the *flexor hallucis longus* muscle on the talus (Yapuncich et al., in revision). This work has important implications for understanding the evolution of primate postural behaviors. Because this approach has proven to be a very fruitful framework for re-evaluating classical descriptions of morphological variation, I anticipate continuing to employ this approach for other postcranial features, such as the size of the posterior trochlear shelf on the talus.

Since quantifying complex morphologies is a central part of my research, I have also helped develop geometric morphometric methods that automatically align and compare digital representations of teeth and bones (Boyer et al., 2015b; Gao et al., in review). Automated shape analyses greatly benefit morphologists, permitting researchers to sample more extensively (with increased sample sizes) and more intensively (with more point-to-point correspondences or landmarks). Ultimately, these methods aim to increase the information content of morphology and to permit morphometrics to utilize a high-throughput workflow, both advancements that Houle et al. (2010) argue are prerequisites for the broad success of phenomics. I am specifically interested in the ability of automated shape characterization to accurately reconstruct phylogenetic relationships. While relationships between living taxa can be determined from genetic information, we only have morphology to determine the phylogenetic relationships of fossil taxa.

Short-term goals:

- Quantifying and developing a functional interpretation of the posterior trochlear shelf of the primate talus*
- Using curvature of synovial joint surfaces to predict locomotor behavior in fossil primates

Long-term goals:

- Evaluating the ability of automated shape analyses to reconstruct phylogenetic relationships solely from morphology*
- Applying alternative ordination methods to high-dimensional morphometric data

<u>Discovery and description of new fossils</u>

I have been an active paleontological fieldworker for the past six years, and I plan to be for the foreseeable future. My fieldwork has focused on mammalian assemblages from Paleogene deposits in the Western Interior of North America, ranging from the Eastern Crazy Mountains Basin in Montana to the southwestern Green River Basin in Wyoming. Fieldwork is a crucial component of research for me, as it generates the raw material for study and incrementally increases our ability to reconstruct paleoenvironments. It also has the added benefit of being a restorative exercise – an invigorating break from laboratory-based research. My short-term goals in this area focus on description of recently discovered material of early euprimates and their potential close relatives. My long-term goals include establishing a field site in the Powder River Basin of northeast Wyoming, an area with sedimentary exposures that overlap temporally with those of the Bighorn Basin. Material from the Powder River would serve as an important comparative sample for testing hypotheses of provincialism and dispersal in early Eocene faunal assemblages during the Laramide orogeny.

Short-term goals:

- Description of first known postcranial elements of a plagiomenid, a supposed stem dermopteran, from Paleocene deposits in the northern Bighorn Basin, Wyoming (Secord, 2008; Yapuncich et al., 2011)*
- Description of postcranial elements of the earliest euprimates from the earliest Eocene of the southern Bighorn Basin, Wyoming
- Description of newly discovered skeletons of adapiform primates from the middle Eocene of the southwestern Green River Basin, Wyoming

Long-term goals:

- Reconstructing paleoecology of fossil assemblages, particularly regarding the role of niche partitioning in sympatric primate species (Yapuncich et al., 2016)*
- Fieldwork in the early Eocene deposits of the Powder River Basin of Wyoming in order to test hypotheses of provincialism and beta-diversity in mammalian fossil assemblages.

Collection curation

As a curator, I believe that I could make significant contributions to collection management on two important levels: efficient internal management of the collection and increasing access to the collections for external users. The first level concerns the organizational structure that permits the curatorial staff to efficiently manage the collection. Ideally, the museum’s internal database would be simple and intuitive to use, and would allow staff to keep track of specimens and their associated metadata, including information such as current location (in-house or on loan), overall usage, state of preparation, associated data (e.g., locality, collector, additional notes), and derivative data (e.g., photographs, digital models). The maintenance and growth of the internal database are critical for the health of the museum’s collection, and achieving these objectives would be a key component of my curatorial approach.

I believe that my prior non-academic work experience is relevant in this regard. After graduating from college in 2004 with a bachelor’s degree in English literature, I managed a large, independent video rental store for three years (sadly, these types of institutions are now relics of a bygone technological era). Our store, which specialized in documentaries and foreign films, had over 20,000 unique items that were continuously out on loan. The business required two large, searchable databases with associated metadata: the inventory (films with director, year, etc.) and the customers (individuals with addresses, phone numbers, etc.). As manager, I was responsible for maintaining these databases, adding additional inventory on a weekly basis, contacting customers with delinquent loans, and maintaining the organization of the physical inventory. As disparate as the “specimens” may be, I believe there are many similarities between the skills I developed in a commercial setting and the skills that are required in a curatorial position.

Additionally, I believe there is aspects of a commercial inventory management system that could readily be applied to managing museum collections. For example, rather than being handwritten or printed text, specimen labels could include QR codes, which are small, two-dimensional grids capable of encoding more than 4,000 alphanumeric characters (Figure 1).

Figure 1. Example of QR code

Because QR codes are capable of storing a large amount of information, much of the specimen’s associated metadata could be digitally attached to the physical specimen (e.g., taxonomic information, stratigraphic and locality information, etc.), rather than relying on a handwritten or printed specimen ID number for reference. Alternatively, the QR code could encode the URL for the specimen in institutions's online database, which already contains much of the relevant metadata.

In addition to storing a large amount of information, QR codes are easily readable with smartphones or tablets. With this type of inventory management system in place, collections staff or visiting researchers could simply scan a specimen's label with a smartphone and pull up all available metadata. Through expansions of the internal database, a researcher would immediately be able to know if a specimen has been fully or partially digitized, and if what types (e.g., digital photographs, microscopy, computed tomography). For collections staff, the speed of the system might permit yearly audits of the collection, which would help identify specimens that are misplaced or lost. I strongly believe that more fully integrating the physical collections with digital databases would be an innovative shift that would improve the experiences of both internal and external users.

The second level concerns the management of the interface between the collection and its user base. A primary goal of any curator should be to maximize user access to the collection, in order to demonstrate that the collection is valuable resource and deserving of continued funding. Traditionally, increasing user access has meant increasing the number of external visitors to the museum. However, the development of digital imaging technologies and the growth of online repositories means there are alternative routes to increasing user access. I believe that it is in the best interest of any museum to begin large-scale digitization initiatives to transform their collections into virtual museums. Such initiatives might include any number of digitization technologies, including laser scanning, structured light scanning, and computed tomography. Digital models collected with these modalities could then be uploaded to digital repositories such as MorphoSource.org (hosted by Duke University). I am currently digitizing a large collection of cadaveric primate specimens housed at the Duke University Lemur Center. When digitization is complete, microCT scans characterizing more than 125 complete skeletons will be made publically available through Morphosource. I hope to continue similar, large-scale digitization efforts.

As collections migrate to online repositories, the metrics used to gauge user access will also have to change. The number of downloads, rather than the number of visitors, would become the most relevant metric for museum collections. A collection of hominin fossils hosted by MorphoSource for K-12 education provides an excellent example of the reach of online repositories. Since its creation in May 2015, digital models from this collection have been downloaded more than 1300 times (an average of 40 times per specimen). Researchers and educators from all over the world can either utilize these models directly or 3D print them for a more tactile experience. To me, it seems clear that leveraging the worldwide reach of digital repositories was the potential to fundamentally shift the scope of a collection's potential user base.

Objectives regarding science communication

I believe that effective science communication requires researchers to engage in several different vectors of communication. The first vector is the most intuitive: transmitting results from one's own research to the broader scientific community. This requires publishing original research papers and attending professional conferences, and benefits greatly from collaborative research projects with scientists at other institutions. I am extremely proud to have worked with nearly all the faculty members in the Evolutionary Anthropology department at Duke University, ranging from behavioral ecologists to forensic anthropologists. Furthermore, since collaboration and integration are key components of how I conduct my research, I feel that it is important to extend similar ideals of openness and transparency to how my research is disseminated. To that end, I have made an effort to publish raw data in appendices and to make digital models of specimens available through online repositories such as MorphoSource.

The second vector concerns the transmission of domain-specific expertise, essentially the communicating the process of scientific research to others, rather than the particular results. This can partially be accomplished in the methodology sections of research articles, but it also requires active mentorship of junior researchers, including post-docs and graduate students. At both Brooklyn College and Duke University, I have mentored a number of undergraduate students, and their work has culminated in joint authorship on several abstracts and publications. I hope to continue to serve as a mentor or dissertation committee member for graduate students.

The third vector concerns the transmission of enthusiasm for scientific process and discovery to the broader public. I have taught introductory science courses to undergraduate students who do not plan on becoming scientists, and it can be difficult to maintain their interest over the course of the semester. From my own experience as a student, I recognize that those individuals who spoke about their subject matter with passion and enthusiasm had a much greater impact on me than those who merely covered the required material. Accordingly, I always try to bring as much energy as possible to my lectures. I believe there is no downside to this approach, as a high level of enthusiasm from the professor can raise the interest level of most students. At Duke University, multiple students have told me that they decided to become Evolutionary Anthropology majors because they took the introductory course with me. I believe this vector is particularly unique for curators, as museums have a much more diverse set of patrons than university classrooms, and I would be honored and excited to have the opportunity to spark interest in new subjects among people that are younger (and older!) than typical undergraduates.

Finally, the fourth vector focuses on effective communication with supervisors. Essentially, a curator should serve as a strong advocate for the value of the collection that they are managing, for the research that the collection enables, and for the importance of future initiatives to improve the collection. Successful communication along this vector is crucial for ensuring that the vertebrate paleontology collection remains a vibrant and valued resource.

I believe that I am well suited for effective communication along all of these vectors. I will continue to publish original research articles to communicate with the broader scientific community. In order to subsequent generation of scientists, I will take an active role in the mentorship of graduate students at nearby universities. I believe that my enthusiasm for research will permit me to communicate effectively with non-scientists, as it has in classroom settings.

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