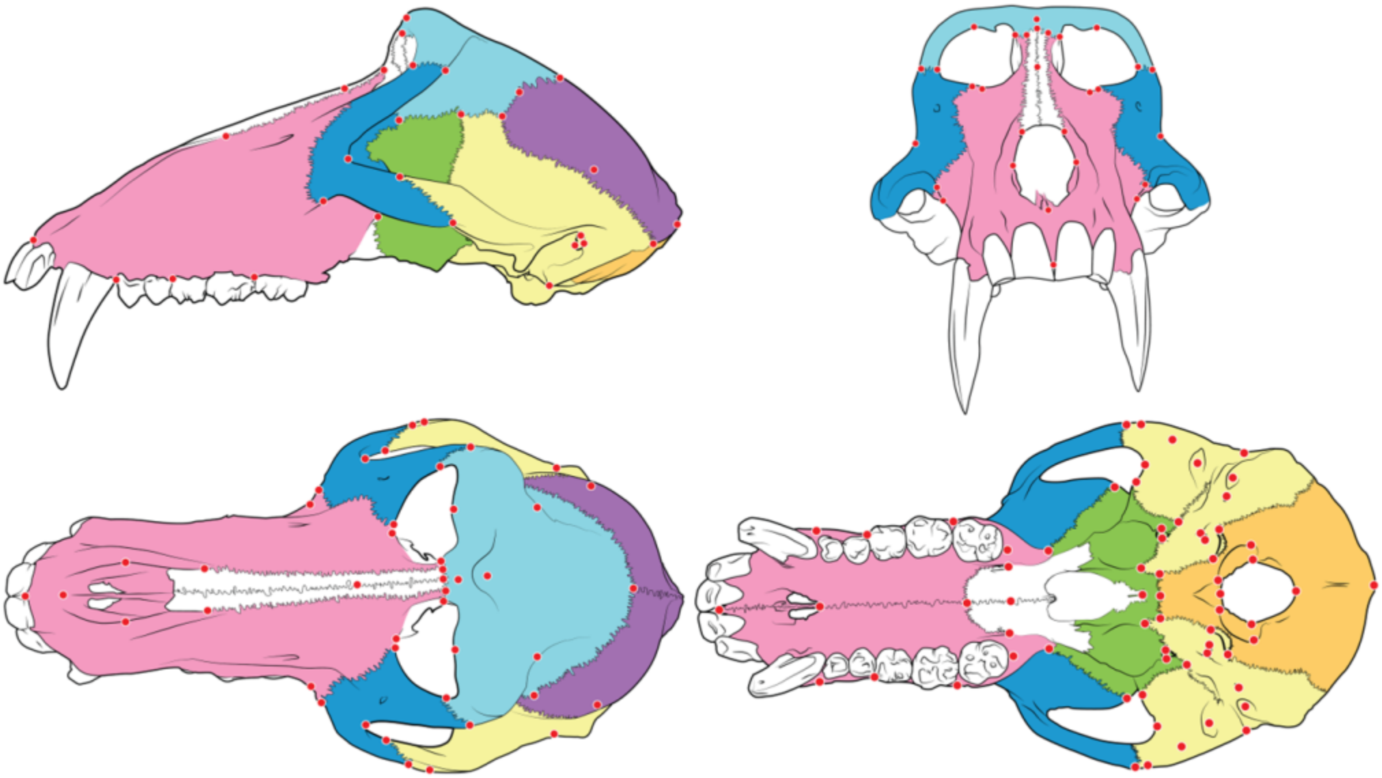
Which regions of the skull contain the most information about genetic relatedness in monkeys?

The primate fossil record is plagued by issues with assessing phylogeny (genetic relationships among species) due to the fact that fossilized specimens are composed entirely of rock and contain no DNA. Paleontologists studying the primate fossil record therefore typically use craniodental (skull and teeth) morphology (shape) to infer genetic relatedness. However, sometimes different regions of the skull send conflicting signals, and it has been unclear which cranial regions are most useful and accurate for inferring phylogeny. It has been previously proposed that cranial regions that mature and fuse together earlier during development, those that are more structurally complex, and/or those that experience lower levels of chewing stress may be more stable, and therefore more indicative of underlying genetic relationships than those that develop later, are more structurally simple, or are under high levels of chewing stress (such as those around the teeth and jaw). We sought to test these hypotheses and identify the most informative cranial regions in primates for use in future studies for which DNA evidence is not available.

Here, we collected 3D data on the morphology of 15 different regions of the skull in 14 species of Old World monkeys (e.g., baboons, macaques, and guenons). We compared differences in 3D shape for each cranial region among species to previously published genetic data to determine which cranial regions' morphology most closely matched the genetic relationships among species. These cranial regions would be the most useful for future studies looking to infer genetic relationships from primate fossil specimens that contain no DNA.



Cranial regions from which 3D shape data were collected and compared to published genetic data in 14 species of Old World monkeys. Figure by Brent Adrian.

Of all the cranial regions compared here, the 3D shape of the cranial base (basicranium) was found to most accurately reflect the underlying genetic relationships among species. Therefore, it is recommended that future studies of fossil Old World monkeys focus on cranial base morphology when attempting to reconstruct phylogeny of fossil species. Contrary to previous hypotheses, cranial regions that are more structurally complex or under low levels of stress were not found to be any more accurate at indicating genetic relatedness than structurally simple regions or those that experience high levels of stresses.

There are several possible reasons why the shape of the cranial base might reflect genetic relationships more accurately than other regions. First, the cranial base ossifies (becomes bone) early in the developmental process, with some portions of it ossifying prior to the infant's birth or soon thereafter. Bones of the cranial vault, on the other hand, don't fully ossify until mid-childhood. Second, the cranial base develops on a relatively stable template of cartilage. Whereas, many other regions of the skull develop on a more flexible template made up of membranes, which is more susceptible to environmental and dietary influences. Both of these factors contribute to stability in the shape of the basicranium, resulting in patterns of shape variation that reflect genetic relatedness rather than variations caused by external influences.

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Publication

The relative correspondence of cranial and genetic distances in papionin taxa and the impact of allometric adjustments.
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