work as miners at much higher altitudes. In order to gain insight into the factors of O_2 transport that permit them to live and work in this hypoxic environment, we studies 20 male Quechuas of Ollaque, Chile, at 3900 meters (26.7 ± 1.1 yrs). Resting pulmonary function and hypoxic (HVR) and hypercapnic (HCVR) ventilatory drives as well as progressive exercise tests on a cycle ergometer to exhaustion were performed. Vital capacities were 5.1 ± 0.1 liters while steady-state diffusion capacities for CO were 36.9 ± 2.6 cc/m/torr. Hemoglobin values were 18.3 ± 0.36 gm/dl. Isocapnic and poikilocapnic HVR's were similar at -0.17 ± 0.05 (V_E, L/min/SaO_2, %) while HCVR was 15.7 ± 2.5 (V_E, L/min/P_ACO_2 torr). During steady-state exercise of 600 kpm/min subjects reached an oxygen consumption (VO_2) of 1.7 ± 0.1 L/min, a ventilatory equivalent (V_E/VO_2) of 33.2 ± 1.02, a DLCO of 71.2 ± 4.5 cc/m/torr with heart rates of 169.6 ± 6.8 bpm and SaO_2 of 84.7 ± 2.8%. At maximum exercise there was no subsequent arterial oxygen desaturation (SaO_2 = 87.0 ± 1.0%) while V_E/VO_2 was increased to 44.5 ± 3.4 with a VO_2 of 3.4 ± 0.3 L/min and heart rate of 200 ± 16 bpm. In spite of blunted resting HVR, other factors (high HCVR, exercise DLCO, and V_E/VO_2) may play a role in maintaining SaO_2 and oxygen delivery during high levels of exercise. These data will be compared to those collected in a subsequent study in a Himalayan high altitude native population, the Sherpas. (This study supported by NSF grant, values are mean ± S.E.M.).

Comparison of intraspecific craniometric variability in Homo, Pan and Gorilla. P. T. SCHOENEMANN, Dept. of Anthropology, University of California, Berkeley, CA 94720.

Physical anthropologists have long recognized the extent of morphological variation present in *Homo sapiens*, yet few studies have directly compared the extent to which human variability differs from the variability found in other species. Theoretical considerations indicate that genotypic (and therefore phenotypic) variation should decrease under directional selection. Since *Australopithecus afarensis* is much more similar cranially to the modern African apes than to modern humans, it is likely that humans have diverged to the greatest extent from the common human-chimpanzee-gorilla ancestor. Certainly there has been strong selection for increasing brain size (and hence cranial size) in hominids during the last 2 million years. One might therefore expect humans to be less variable cranially than the African apes. Experimental selection experiments in mice and *Drosophila*, however, indicate that phenotypic variation does not necessarily decrease with directional selection, and may even increase.

In order to investigate the question of comparative variability in African apes and humans, craniometric data for *Pan paniscus*, *Pan troglodytes*, *Gorilla gorilla*, and *Homo sapiens*, was gleaned from the literature. Data for males only was used in order to avoid the effects of sexual dimorphism. The coefficient of variation (CV) was used for these interspecific comparisons to minimize the effect of size. Because extant African apes are limited geographically to only a part of Sub-Saharan Africa, two comparisons were run: one using human CV's derived from a pooled estimate of variance including all geographical regions, and another using human CV's derived from a within-geographical-region estimate of variance.

Comparisons utilizing the pooled human data indicate that, as a species, humans do not appear to be less variable craniofacially than the other African apes. Further, humans in fact appear to be more variable in measures of cranial breadth. Comparisons utilizing the within- geographical-region estimates indicate that human geographical groups are somewhat less variable in facial-masticatory measurements, but entirely comparable variability exists in measures of the cranial vault. This analysis indicates that, to the extent these measurements are genetically controlled, genotypic variance has not decreased (with respect to the African apes) in the face of directional selection.

This analysis raises at least 2 questions of significance concerning human and African ape evolution. 1) Why are measures of cranial breadth so variable in humans, considering that this dimension is quite heritable? This may indicate that some balancing mechanism is maintaining variation. 2) Mitochondrial DNA studies have indicated the possibility of a bottleneck in human evolution with respect to the African apes. If the rates of mtDNA evolution are constant in these species, the bottleneck must have been both recent and transient (since variation does not appear to have been greatly reduced in modern humans). Alternatively, mtDNA rates may not be constant in humans and African apes.

Protein, an important energy source in human evolution. M.J. SCHOENINGER, Harvard University Cambridge, MA 02138; and J.L. BADA, University of California at San Diego, La Jolla, CA 92093

As Harrison et al. pointed out, dietary flexibility "is one of the most far-reaching adaptive properties of Homo sapiens" (Human Biology, 1964:416). One of us (MS) has investigated several different prehistoric dietary adaptations (maize agriculturalists, Eskimo hunters, goat/sheep pastoralists) using natural abundance of 15N/14N in bone collagen as a tracer for diet. These results indicate that humans incorporate more 15N in collagen relative to diet than do other animals. The fractionation of 15N/14N between diet and collagen could occur: 1) as dietary proteins are broken down in the gut to small peptides and free amino acids; 2) during nitrogen transfer (transamination) in the liver prior to nitrogen entering the urea cycle for nitrogen excretion and carbon entering the citric acid cycle for energy production; or 3) during synthesis of body proteins. Our in vitro experiments using collagen indicate that nitrogen fractionation may occur in breakdown of dietary protein. Macko et al. (Geochim. Cosmochim. Acta 1986 50:2143-2146) report major fractionation during in vitro transamination. Analysis of maternal and fetal proteins by Tuross and Fogel (pers. comm.) suggests that no significant fractionation occurs during protein synthesis. We interpret these results to imply that in humans relatively more of the lighter nitrogen isotope is excreted. Thus, more of the amino acid carbon backbone enters the citric acid cycle. Humans may be able to utilize a larger amount of dietary protein as an energy source than is true for most other mammals with the probable exception of Carnivores.