Cross-References

- ▶ Agrarian Landscapes: Environmental Archaeological Studies
- ▶ Agricultural Practice: Transformation Through Time
- ▶ Agroforestry: Environmental Archaeological Approaches
- ▶ Amazonian Dark Earths: Geoarchaeology
- ▶ Anthropogenic Environments, Archaeology of
- ▶ Anthropogenic Sediments and Soils: Geoarchaeology
- ▶ Archaeological Chemistry: Definition
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- ▶ People as Agents of Environmental Change
- ▶ Site Formation Processes
- ▶ Taphonomy, Regional
- ▶ Taphonomy: Definition
- ▶ Urban Dark Earth

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Beans: Origins and Development

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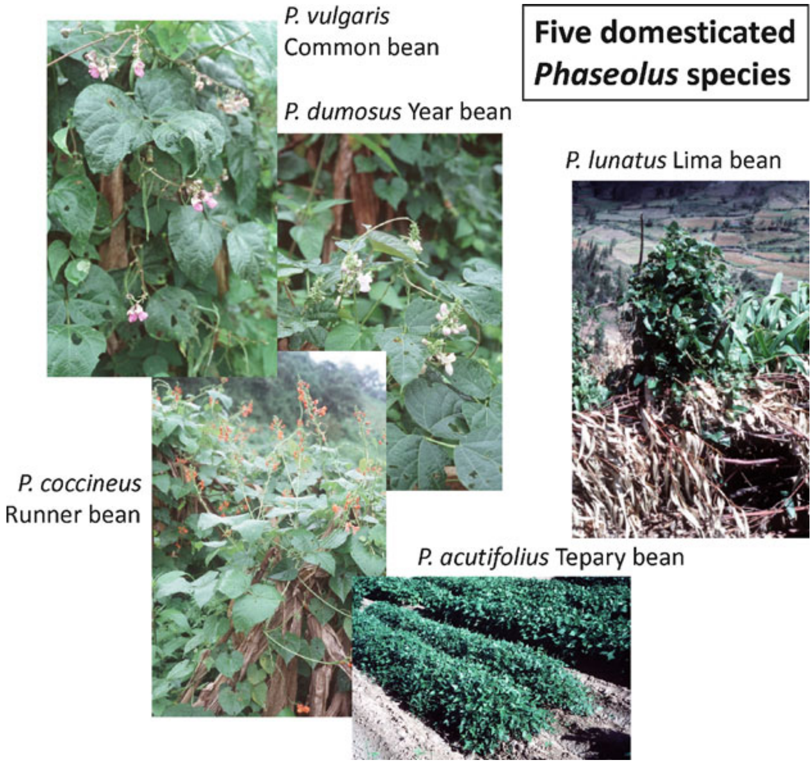
Basic Species Information

The genus *Phaseolus* comprises some 70–80 species (Freytag & Debouck 2002), distributed exclusively in the Americas (Delgado Salinas et al. 2006) but with a clear focal point in Mexico and Central America. This region contains the largest number of species of the genus; it also harbors a very diverse range of environments in which the genus *Phaseolus* radiated following the last major tectonic event, namely, the appearance of the Transverse Volcanic Axis in Mexico. It is in this diverse landscape that five *Phaseolus* species were domesticated (Fig. 1). Of these five species, common bean (*P. vulgaris*) is by far the one with the broadest geographic distribution (Fig. 2) and largest agronomic, nutritional, and economic impact. Other domesticated species are

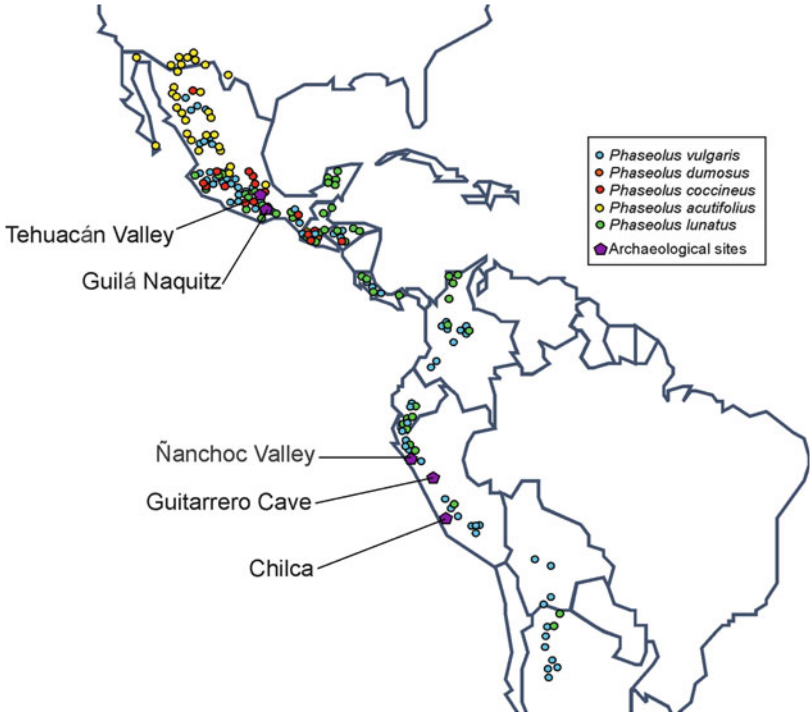


Beans: Origins and Development, Fig. 1 Five domesticated *Phaseolus* species. Lima bean is phylogenetically more distant from the other four species

runner bean (*P. coccineus*), tepary bean (*P. acutifolius*), lima bean (*P. lunatus*), and year bean (*P. dumosus*). In addition to the Mesoamerican domestications, two additional domestications took place in the Andes, one each for common bean (southern Andes, between southern Peru and northwestern Argentina) and lima bean (western Ecuador).

The five domesticated *Phaseolus* species have overlapping, yet distinct, geographic distributions, ecological adaptations, life histories, and reproductive systems (Table 1 and Fig. 2). Common bean grows in mesic environments (i.e., at intermediate temperatures [yearly average of 24 °C] and rainfalls [around 600 mm/year]) at the transition between dry, deciduous, and pine forests. This species is annual with cycle lengths for most varieties from 80 to 120 days. Its reproductive system is primarily autogamous.

Nevertheless, bursts of outcrossing can take place occasionally, which can significantly affect the distribution of genetic diversity within and among populations (Papa et al. 2005; Zizumbo-Villarreal et al. 2005). Runner bean is the domesticated bean species with adaptation to the coolest (and humid) environments. Its tuberous root system, in addition, provides a way for plants to survive winter frosts as new stems can regrow from the roots. Thus, this species is also perennial, surviving for several years. It is an allogamous species, which relies obligatorily on foraging by carpenter bees and humming birds for seed production (Búrquez & Sarukhán 1980). In contrast with runner bean, tepary bean originated in warmer, arid environments. It is a short-lived (part of its drought adaptation) annual species, with a highly selfing (even cleistogamous) reproductive system. Lima bean is perhaps the species with the broadest adaptation of all five domesticated species. It is generally grown in warmer, more humid environments. It is a long-lived, annual species with a mixed autogamous-allogamous reproductive



Beans: Origins and Development, Fig. 2 Geographic distribution of the wild progenitors of the five domesticated *Phaseolus* species and sites with the oldest *Phaseolus* archaeobotanical remains (see Table 2)

Beans: Origins and Development, Table 1 Comparative of five domesticated *Phaseolus* species

	Common bean	Year bean	Runner bean	Tepary bean	Lima bean
Growth habit	Upright bush to climbing; includes bush determinate	Climbing	Mostly climbing; some bush, including bush determinate	Prostrate bush	Upright bush to climbing; includes bush determinate
Reproduction	Predominantly selfing	Predominantly outcrossing	Predominantly outcrossing	Selfing, cleistogamous	Selfing to outcrossing
Adaptation	Mesic	Mesic to cool	Cool, humid	Hot, dry	Selfing to outcrossing
Number of domestications	2	1	1 or 2	1	2
Locations of domestication	West-central Mexico	Guatemala	Mexico	Northwest Mexico	Mesoamerica and Ecuador/N. Peru

system. Finally, as a stabilized hybrid between common and runner beans, the year bean has intermediate characteristics between these two parental species.

Domestication has induced drastic changes in the two most domesticated *Phaseolus* species, common and lima bean. These two species show the full array of traits characteristic of crop domestication (the "domestication syndrome"). In these seed-propagated crops, two domestication traits stand out. Compared to their wild progenitors, domesticated varieties show a reduction or elimination of seed dormancy and dispersal. As a consequence, domesticated common and lima beans have ready germination and limited grain loses from premature pod shattering. In addition, in contrast with wild ancestors, which have exclusively a climbing, viny growth habit with indeterminate branches, these two domesticates' growth habits range from viny to a more compact growth habit with fewer and shorter branches. In some cases, domesticated varieties have a bush growth habit and determinate branches. This trend to smaller plants correlates with a more precocious life cycle, an essential characteristic of most agricultural production systems. Additional changes included gigantism (increase in organ size, especially pods and seeds); development of photoperiod insensitivity, which broadened latitudinal adaptation; acquisition of broad phenotypic diversity for the principal harvested organ pods and especially seeds (e.g., the colorful array of domesticated bean seeds) as a result of selection for novelty; and reduction in toxic compounds, such as the cyanogenic glycosides in lima bean. The inheritance of the domestication syndrome has been investigated in common bean (Koinange et al. 1996). The results show that the inheritance of the domestication syndrome in common bean was relatively simple genetically; few, major genes were responsible for a majority of the phenotypic variation (i.e., domestication traits have a generally high heritability). In addition, these genes are distributed on few chromosomes, and several crucial genes seem to be loosely linked. This genetic architecture would allow a relatively speedy evolution under domestication, provided selection was applied regularly and with sufficient strength (Gepts 2004).

Timing and Tracking Domestication

Molecular analyses in wild and domesticated forms of the various domesticated *Phaseolus* species have provided a picture of "hyperdomestication" in the genus. Not only are there five different domesticated species, but two species – common and lima bean – have been domesticated twice (Fig. 1). Common bean was domesticated in western Mexico and the southern Andes (Kwak et al. 2009; Kwak & Gepts 2009; Chacón et al. 2005). Likewise, lima bean was domesticated in Mexico and Ecuador (Gutiérrez-Salgado et al. 1995; Serrano-Serrano et al. 2012). In both species, these two domestications occurred in distinct geographic regions from already diverged wild progenitors (named the Mesoamerican and Andean gene pools). Runner bean was domesticated once (and possibly twice) in Mexico (Angioi et al. 2009). In contrast, both tepary and year bean were domesticated only once, in northwestern Mexico and Guatemala, respectively (Schinkel & Gepts 1988, 1989; Freytag & Debouck 2002; Blair et al. 2012). Within species, some traits have appeared multiple times, adding to the picture of hyperdomestication. One example in common bean is the multiple origin of the determinacy, which originated independently four times in the Andean gene pool and once in the Andean gene pool, based on DNA sequence data of the gene responsible for the determinacy phenotype (Kwak et al. 2012). This sequence or a related one is also responsible for the presence of determinacy in Mesoamerican and Andean lima beans and in runner bean.

The overall picture created by these domestication studies is one in which farmers have actively shaped the domesticated diversity of beans at multiple taxonomic levels and times and in different areas of the Americas where the genus *Phaseolus* originated. Rather than relying on a single domesticate such as in maize, farmers have adopted different bean species for cultivation in different environments and have further selected – presumably independently – similar phenotypic variation. This may have been made possible by the relatively young age of the genus *Phaseolus* (4–5 Ma; Delgado Salinas et al. 2006) such that the domestication potential was maintained in part of the genus, while allowing for the development of differential adaptation among species (Kwak et al. 2012).

Archaeological and linguistic data point to the antiquity of bean cultivation both in Mesoamerica and Andean South America. The first archaeobotanical remains of *Phaseolus* were identified in Peru in the nineteenth century (de Candolle 1882). Since then, additional remains have been obtained in both regions (Table 2 and Fig. 2), the oldest of which suggests a presence of domesticated forms by 8,000 years B.P. (^{14}C age) in Peru but only 2,300 years B.P. (^{14}C age) in Mexico. Glottochronological analyses show that

Beans: Origins and Development, Table 2 Oldest archaeobotanical remains of *Phaseolus* spp.

Location	Taxon (status)	Type	^{14}C Age (year B.P.)	Age (year cal. B.P.)	Source
Andes					
Ñanchoc Valley, Peru	*Phaseolus sp.* (domesticated)	Starch grains from teeth calculus	8,210–6,970	8,600–7,000	Piperno & Dillehay 2008
Chilca, Peru	*P. lunatus* (domesticated)	Pod, non-carbonized	5,600	6,400	Kaplan & Lynch 1999
Guitarrero Cave, Peru	*P. vulgaris* (domesticated)	Seed, non-carbonized	4,300	5,000	Kaplan & Lynch 1999
Mesoamerica					
Oaxaca Valley, Mexico	Phaseolinae (wild)	Seed and pod, non-carbonized	7,600	8,300	Kaplan & Lynch 1999
Tehuacán Valley, Mexico	*P. vulgaris* (domesticated)	Pod, non-carbonized	2,285	2,300	Kaplan & Lynch 1999
Tehuacán Valley, Mexico	*P. acutifolius* (domesticated)	Seed, non-carbonized	2,360	2,400	Kaplan & Lynch 1999
Tehuacán Valley, Mexico	*P. coccineus* (domesticated)	Seed, non-carbonized	410	500	Kaplan & Lynch 1999

the oldest language for which a term for bean has been identified is a Proto-Mayan language (3,400 B.P.; Brown 2006).

The fact that the oldest age available was obtained from micro-remains rather than macro-remains and the glottochronological data suggests that current dates for bean domestication are most likely underestimates. Furthermore, many of the remains originated in very arid areas, outside the distribution of wild progenitors and putative domestication areas determined by genetic means (e.g., west-central Mexico for one of the two common bean domestications: Kwak et al. 2009). Thus, a more active search for archaeobotanical micro-remains (starch grains, phytoliths) in late pre-agricultural or early agricultural contexts should be pursued.

Cross-References

▶ Agriculture: Definition and Overview
▶ Andes: Prehistoric Art
▶ Andes: Prehistoric Period
▶ Archaeobotany of Early Agriculture: Macrobotany
▶ Archaeobotany of Early Agriculture: Microbotanical Analysis
▶ Domestication Syndrome in Plants
▶ Domestication: Definition and Overview
▶ Flannery, Kent Vaughn
▶ Genetics of Early Plant Domestication: DNA and aDNA
▶ Maize: Origins and Development
▶ Mesoamerica: Complex Society Development
▶ Mesoamerica in the Preclassic Period: Early, Middle, Late Formative
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▶ Mesoamerica: Subsistence Strategies by Region
▶ Mexico's Heritage
▶ Phytolith Studies in Archaeology
▶ Plant Domestication and Cultivation in Archaeology
▶ Plant Processing Technologies in Archaeology
▶ Squash: Origins and Development

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Basic Biographical Information

Mary Carolyn Beaudry is an anthropological archaeologist who has specialized in historical archaeology, mainly in the eastern United States, and has made broad theoretical and practical contributions to household archaeology, the archaeology of gender and inequality, and archaeological material culture studies.

Beaudry received her first degree in Anthropology from the College of William and Mary (1973) and her M.A. (1975) and Ph.D. (1980) in Anthropology from Brown University. Beaudry was advised at Brown by James Deetz, who made a long-lasting impact on her research: an influence most visible in her doctoral thesis, *"Or What Else You Please to Call It": Folk Semantic Domains in Early Virginia Probate Inventories* – which used probate inventories to study the material culture of Virginian households in the seventeenth and eighteenth centuries.