The first horticultural plant propagated from seed in New Zealand:
Lagenaria siceraria

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Introduction

Amongst the plants that the first Polynesians to settle New Zealand over 1000 years ago brought with them, was a member of the family Cucurbitaceae. Most food plants that survived translocation from their tropical home into our temperate climate are propagated using vegetative methods. The most important of these food plants were the kūmara (*Ipomoea batatas*) and taro (*Colocasia esculentum*), with two others, the yam (*Dioscorea elata*) and ti pore (*Cordyline terminalis*), providing minor sources of plant food. The lone cucurbit, the first plant ever propagated from seed by people in New Zealand soils, was the bottle gourd, *Lagenaria siceraria*.

My interest in bottle gourds began when two colleagues and I were asked to assist in locating plant materials that might be used for the reconstruction of the Makotukutuku Wharepuni at Te Papa (Burtenshaw *et al*., 1999). I was interested in the fact that the original wharepuni (sleeping house) in the Makotukutuku Valley was home to pre-European Māori gardeners. As a horticulturist, I was interested in what these people were growing there. Foss Leach (1979), whose archaeological team excavated the wharepuni site and one of the garden mounds in the garden area, reported that kūmara and gourds were grown in the garden area, and that the stone mounds were used specifically for gourd cultivation.

As in Eastern Polynesian, hue (pronounced *hoo–e*) is the Māori name for bottle gourd although ipu is the more common name in Hawaii (Maingay, 1985). Wenewene and kowenewene are other names used on the East Coast of the North Island (Best, 1976). In contemporary usage I have heard the name tahā also applied to the fruit of the plant. This derives from the names for water storage gourd (tahā wai) and containers for preserved meat (tahā huahua). Originally the word tahā was applied to a gourd with a narrow mouth (Maingay, 1985).

Rampant growth of *L. siceraria* 'Italian Edible' in the author's garden.

Ngai Tahu legend tells how the Moeraki boulders (Te Kai Hinaki) are the round food baskets and gourd water containers from the great canoe Arai Te Uru that foundered in a storm near Matakaea (Shag Point). Irregular shaped rocks further south on Katiki Beach are described as kūmara that also washed ashore from the canoe (Anderson, 1998). Waitahā (the water carriers), one of the first iwi to inhabit the South Island, share their name with one of the Māori names for gourd water containers.

The gourd is honoured in Māori myth with a personified form or parent, Pū-tē hue, who was one of the offspring of Tane. Pū-tē hue remarked "The seeds within me shall provide water vessels for my descendents, some of those seeds are of the male sex and will not bear fruit" (Best, 1976, p.245).

The description by Colenso (1880, pp.15-16) of hue provides an excellent summary of the plant, its cultivation and use in Aotearoa and is worthy of repeating in full as most subsequent writers on the subject, including Elsdon Best, refer to it:

"The third food plant cultivated by them [Māori] was a fine one of the gourd family, called by them the *hue*. This noble and highly useful plant was annually raised from seed, and was their only one so propagated: and, curiously enough, of this plant, though yielding seed in great plenty, there was only one species and no varieties. Its seeds, before sowing, were wrapped in a few dry fern fronds, (*Pteris* [*Pteridium*] *esculenta*), and steeped in running water for a few days. It was to them of great service, furnishing not only a prized and wholesome vegetable food (or rather fruit) during the whole of the hot summer days while it lasted, and before their *kumara* were ripe for use, but was also of great use in many other ways. It was always a pleasing sight to see it growing in a suitable soil, as it grew fast and looked so remarkably healthy with its numerous leaves, large white flowers and fruit, the latter often of all sizes, from that of a cricket ball up to that of a globular, pear-shaped, or spheroidal

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A gourd nearing maturity hanging from a supporting trellis.

figure, capable of holding several gallons. As an article of food it was only used when young, and always cooked – baked like the *kumara* and *taro*, in their common earth-oven – and eaten, like them, both hot and cold. Prodigious numbers of them were formerly daily consumed in the summer season. It was from this plant that the Maoris obtained all their useful vessels, for holding water, oils, cooked animal food, etc. This was done by carefully drying and hardening the fully mature fruits with the heat of the sun and fire, and just as carefully scooping out all the contents, through a small hole made near the stalk end. In the very small calabashes so made, they kept their perfumed oils, and rouge, for anointing; of the medium sized and large ones they made useful dishes, and all their common water calabashes. While the few very largest were neatly manufactured into pots for holding preserved and potted birds. For this purpose the stalk end was cut off, and it was ingeniously fitted with a hollow cylindrical neck of carved hard wood, cut out of one piece, and always made large enough to admit a man's hand through it; this was firmly fixed on above, while below, the rotund vase was also fitted with three (or four) legs to stand on, and to keep it off the ground. These big vessels were always prized and taken great care of, sometimes they were named and some lasted a whole generation or longer, and were handed down as heirlooms."

Best (1976) reports that Māori in the Bay of Plenty state that the gourd was introduced to Aotearoa long before kūmara and taro, and postulates this may well be a fact because seed might more easily survive long ocean voyages.

A range of gourds of different shapes and sizes curing on drying racks.

Taxonomy

The bottle gourd or hard-shelled gourd has the Latin binomial *Lagenaria siceraria* (Molina) Standley. This combination was first published in 1930 and the basionym is *Cucurbita siceraria* Molina (1782). *Lagenaria* comes from the Greek *lagenos* and Latin *lagena* for "bottle" and *siceraria* from the Latin, *sicera* meaning "drinking vessel". It has numerous vernacular names, most of which relate to cultivar differences in the shape of the fruit. Common names include white-flowered gourd, calabash gourd, the names given below in the section on folk taxonomies and many others.

Following Jeffrey (1990), *Lagenaria* belongs in the subfamily Cucurbitoideae, tribe Benincaseae and the sub-tribe Benincasinae (Figure 1). Other species within this sub-tribe include the wax-gourd (*Benincasa hispida*), watermelon (*Citrullus lanatus*), poisonous gourd (*Diplocyclos palmatus*), squirting-cucumber (*Ecballium elaterium*), angled loofah (*Luffa acutangula*) and smooth loofah (*L. aegyptiaca*).

There are five other species in the genus *Lagenaria* that grow wild in Africa. These other species are tropical perennials, have a much thinner shell and are not usually used as containers. Heiser conducted trials with three of these species (*L. abyssinica*, *L. sphaerica* and *L. brevifolia*) and produced hybrids with *L. siceraria* that produced vigorous but infertile plants. The hybrids produced only male flowers with no pollen (Heiser, 1979).

The fact that the other five species of *Lagenaria* are all African is the main evidence that *L. siceraria* originated in Africa. This follows Vavilov's theory that the centre of origin of a plant is to be found where it exhibits greatest diversity (Vavilov, 1928). However, this principle has been rejected by later biogeographers (Cain, 1944; Croizat *et al*.,1974; Nelson and Platnick, 1981).

There are two recognised subspecies of *L. siceraria* (Table 1) (Kobiakova, 1930; Heiser, 1973). Heiser produced the most recent classification of subspecies based on morphological differences in leaves, flowers and seeds. He dispensed with Kobiakova's use of fruit shape and fruit colour characters because in his experience a wide range of fruit shape and colour occurs independent of subspecies. The subspecies *L. siceraria* ssp. *siceraria* is found mainly in Africa and the Americas. It has leaves with generally smooth or unruffled margins, unlobed or rounded-lobed; flowers small to medium-sized; sepals or calyx lobes short and broad; and seeds usually dark in colour and less than twice as long as broad. The Asian

subspecies (*L. siceraria* ssp. *asiatica*) has leaves that are somewhat saw-toothed on the margins and sharply three to five lobed; larger flowers than in the other subspecies, with long slender calyx lobes; and light coloured seeds that are usually more than twice as long as broad. There has been no authoritative investigation as to the subspecies that occurs in Eastern Polynesia, New Zealand and Oceania in general, although the genetic fingerprinting research mentioned below may well provide an answer to this question.

Lagenaria siceraria has medium sized chromosomes with mostly median centromeres, but three pairs have secondary constrictions (Singh, 1990). Somatic studies from India give a base gametic chromosome number of x = 11. The eleven pairs of chromosomes or 2x = 2n = 22 chromosome number occurs in both Asian and African subspecies (Maingay, 1985). It has been postulated that present forms of *Lagenaria* may be secondary polyploids that evolved from an ancestor with base numbers x = 5, as 5 + 5 +1 = 11 (Verghese, 1971).

A number of genes expressing characters such as pest resistance, fruit shape and fruit colour have been described for *L. siceraria* (Cucurbit Genetics Cooperative, 1979). Research continues in India and China where the plant is still used as a food crop, but the focus tends to be on cucurbits as a group and the bottle gourd is usually included only coincidentally (Singh, 1990). Genetic engineering introducing DNA from bottle gourd into watermelon has resulted in changes to skin colour, fruit shape and seed colour (Xiao *et al*., 1999).

Genetic analysis conducted by Andrew Clarke of the Allan Wilson Centre for Molecular Ecology and Evolution at Massey University, has produced promising results, discovering genetic markers that can be used to determine differences at the cultivar level (A. Clarke, pers. comm.). This work is currently in progress.

Folk taxonomies

Māori consider hue to be a single variety but have different names for the different sizes and shapes of the fruit. Best (1976) listed thirteen different names Māori used to describe different sizes and shapes of the fruit. This is a logical method of categorising a plant whose fruit are so varied and is still the contemporary vernacular way of distinguishing bottle gourds. Classification based on fruit morphology is typical of folk taxonomies associated with *L. siceraria* in other countries.

Fruit shape is not reliable for scientifically classifying *L. siceraria* into botanical subspecies. Heiser (1973) found the shape of the fruit appeared to be equally diverse in all areas of the world except with some, such as the Maranka, a fruit form originating in Africa. However, among contemporary gourd growers and artists it is fruit shape that is the main character by which gourds are distinguished. There is a relationship between seed size and fruit size, with larger seed usually producing large sized gourds. A long-time gourd grower and artist says that fruit shape can also often be anticipated from the shape of the seed (Polglaze, pers. comm.).

A good example of a modern folk taxonomy is the American Gourd Society's attempt to standardise the names of the more familiar shaped gourd fruit (American Gourd Society, 2003). The Society has proposed four main fruit shape types, with common descriptive names for gourd shapes within each main type:

1. Basket type, including cannonball, basketball, tobacco box, canteen, bushel basket, Japanese basket and Acoma/Hopi rattle.
2. Bottle type, including miniature bottle, martin house, penguin or powder horn, Indonesian, lump-in-neck, hardshell wartie and Chinese bottle.
3. Dipper type, including short-handled dipper, mid-sized dipper, extra-long handled dipper, club and Maranka.
4. Trough/Siphon/Snake type, including banana, snake and zucca.

This popular classification system is useful for those who grow, trade and craft gourd fruit, but ignores floral or foliage differences used in botanical taxonomy. Some genes or alleles responsible for different fruit shapes have been identified. Under the conventions of the *International Code of Nomenclature for Cultivated Plants* (also known as the *ICNCP* or *Cultivated Plant Code*) (Trehane *et al*., 1995), each of the named fruit shapes within each type, such as "Club" and "Maranka", are separate cultivars because self-fertilised offspring produce the same shaped fruit as the parent.

Cultivation and description

Being a tropical plant and an annual with a long growing season, hue required skilled cultivation by Māori in order to produce mature fruit for useable vessels. Seeds were soaked in water and sown at the correct phase of the moon in a humus-filled basket. This was placed in the ground near a fire or kept warm with hot stones to promote early germination. Young plants were set out in small hollows, often with small stones around them to store heat from the sun. Once established, plants were earthed up and fertiliser in the form of wood ash was added to the soil around them.

A 5-6 month warm growing period is required for fruit to mature fully. This has been a problem for me in Lower Hutt over the 2000/2001 and 2001/2002 growing seasons. During the spring and early summer seasons an unusual succession of cool southerlies kept temperatures down and my plants established slowly. Without rapid early establishment bottle gourd does not produce a good crop of mature fruit.

Leave the gourds attached to the vine until the fruit stem turns brown. Even after most of the leaf has died the fruit may still be maturing if the fruit stalk is green. After harvest you need to store the gourds out of the weather for another six months to allow for “curing”. The outer green epidermis will decay and the gourd will lose 90% of its weight as water evaporates from the fruit. You will hear the seeds rattling inside when your gourd is fully dry. At this stage the remnants of the epidermis can be washed and brushed from the hard shell.

In a fertile garden soil and given a warm temperate to subtropical climate, a bottle gourd plant will spread over a considerable area. This makes it a difficult subject for research trials as it requires a large area to grow a range of cultivars. The climbing vine will grow up and over any structure or tree in its way.

The first plants I grew in 1998 of a cultivar of the Asian subspecies, *L. siceraria* 'Italian Edible', had covered a medium sized grapefruit tree and an adjacent raspberry enclosure by February. Growth was more vigorous than that of pumpkin (*Cucurbita pepo*) I have grown, but plants can be trained up a sturdy trellis. Fruit formed hanging down from a trellis will produce a straight neck gourd, whereas fruit that set on the soil surface will often have a bent neck producing a fruit with a more interesting appearance. On average, each plant spreads over 25m^2. Other people have recorded similar growth spread (Maingay, 1985). Once several plants grown in close proximity, start to spread and intertwine it is difficult to track the stem of individual plants. My plants of 'Italian Edible' grown in 1998 had a main stem that measured more than 30m long at the end of the growing season. Adventitious roots are also produced at the nodes particularly when these touch the soil. There is variation in vigour, with smaller fruiting gourds tending to be less vigorous (Heiser, 1979).

Like the vine shoot, the root system is wide spreading. The roots are white to pale cream, and smooth and circular in cross-section. The taproot can penetrate down to 60-80cm, but the bulk of the root system spreads out and inhabits the topsoil (15-30cm, depending on soil depth). In a friable soil one would expect the root spread and mass to at least match those of the top growth, as for most cucurbits (Weaver and Bruner, 1927). I have found no reference to mycorrhizal fungi associated with *L. siceraria* roots.

Botanical description

The *Lagenaria* vine stem is deeply grooved and angular (weakly five-sided) in cross-section. There are five longitudinal ridges which are deep on the main (1-3cm thick) stems, but smooth out toward the growing tips where the stems are 1cm thick. The stems are softly pubescent with jointed, gland-tipped hairs. The main stem branches out to 5-6 main laterals.

Leaves are simple, heart shaped or 3-5 lobed. The leaf base is cordate to sagittate, and the leaf tip generally acuminate. The leaf veins have five main laterals arising palmately from the attachment of the petiole. The first few leaves emerging after the seed leaves are often irregular in shape. Given optimum growing conditions mature leaves range in size from 10-30cm in length and 8-35cm in width. The edges are entire or irregularly dentate (mostly with the African subspecies) to strongly serrated (more common in the Asian subspecies). The leaf surface is covered in dense soft hairs (pubescent) and the foliage has a strong musky odour.

A distinctive feature of all species of *Lagenaria* is the presence of two pore-like glands at the junction of the leaf and petiole (Heiser, 1979). These extra-floral nectaries and glandular leaf teeth are common in members of the Cucurbitaceae, and are the source of a persistent musky smell. Extra-floral nectaries are generally regarded as a primitive pollination feature that function to attract beetles and other insects that swarm over the plant to feed, incidentally carrying pollen from the staminate to pistillate flowers. Heiser (1979) showed beetles to be responsible for most of the pollination of gourds he grew. It has been suggested that these glands and glandules may also have a role in secreting substances, such as cucurbitacins, that deter mammalian herbivores from eating the plant (Metcalf and Rhodes, 1990).

The white flowers of the bottle gourd open in the evening.

The tendrils are modified leaves and they arise from the leaf axils. The tendrils are bifid and assist the plant to attach itself for climbing. They are very strong and easily support heavy gourds. One type of New Zealand gourd has been observed to produce 3 or 4 tendrils from each leaf axil (Maingay, 1985).

The flowers are solitary and borne on long peduncles arising from the leaf axils. Peduncles are usually solitary in leaf axils but are quite often paired. The bottle gourd is usually monoecious although it is sometimes described as being dioecious (Chakravarty, 1990).

Occasional unisexual plants can be produced, although I have never observed this. Hermaphrodite flowers with both stamens and ovaries as well as flowers with 4 or 6 petals have been reported (Maingay, 1985). Maingay suggests this may have been an aberrant polyploid form, but again, I have not observed this in the six years I have been growing bottle gourds.

The staminate flowers are carried on peduncles 10-35cm long and 3-5mm thick. The flowers are held above the foliage and present a spectacular sight on a midsummer evening. The five petals join to form a bell-shaped corolla that is united with the calyx to form a perianth tube. The calyx lobes alternate with the petals. These sepals can vary in length, width and apices. They can sometimes be almost leaf-like in appearance. The calyx edges also have glandules along them. The petals are obovate with finely undulate margins. Their apices vary from blunt to acute, and are fringed to entire. A dense pubescence is longer toward the mid-rib of each petal. The corolla can vary in diameter from 5-14cm, with the Asian subspecies generally producing larger flowers in the 7-14cm range, while the African/American subspecies are within the 5-12cm range. Staminate flowers have 5 stamens. Two pairs are fused forming two double-lobed compound stamens and the remaining one is single. A nectary, which is found only in staminate flowers, is located at the base of the stamens at the bottom of the perianth tube.

The pistillate flowers are quite distinct from the staminate flowers with the inferior ovary showing potential fruit shape early. The interior of the ovary is divided into 3 locules. The single short style terminates in 3 thick bi-lobed stigmas. The peduncles of pistillate flowers are shorter and thicker than those in staminate flowers, from 2-16cm long and 4-6mm wide.

A ratio of at least 5:1 of male to female flowers was observed by Maingay (1985). Male flowers generally appear several days before female flowers, and the ratio will change somewhat through the flowering season.

Lagenaria siceraria seed displays a wide range of morphological variation and this variation is important for distinguishing subspecies. The colour of the seed coat varies between cultivars. Colour ranges from a shade of pale yellow or white, to brown through to dark reddish brown, with darkest colours being more prevalent in *L*. *siceraria* ssp. *siceraria*. Maingay (1985) utilised Munsell Soil Colour Chart (1990) soil colours to describe seed coat colours to good effect.

Presence and absence of ears at the proximal end of the seed is another distinguishing character. Seeds of some of the African types lack ears, but have side wings instead. The seed surface also has lines or tracks which may be almost absent, prominent, or densely pubescent. The width and length of seed varies between cultivars and the seed index, the ratio of seed width divided by seed length, is an important character for distinguishing subspecies.

Lagenaria siceraria has epigeal germination where the cotyledons emerge above the seed sowing medium before the foliage leaves develop. A soil temperature of 15 to 20° C is required for optimum germination but some cultivars, in particular the "New Zealand cultivars", seem to germinate at lower temperatures. This may be an adaptive character worthy of further investigation.

Botanically, the fruit is a pepo or inferior berry. The size and the shape of fruit vary tremendously between cultivars. One Japanese cultivar I grew, *L*. *siceraria* var. *macrocarpa*, produced a mature fruit 50mm long by 30mm wide, but spherical shaped fruit can be up to 2m wide and snake type fruit can be 3m long. The colour of the fruit can vary from pale or light green to dark green, and with striping of different shades of green on some cultivars. Kobiakova (1930) used fruit colour as a character difference between the subspecies, with dark green being more prevalent in the African/American subspecies and pale greens in the Asian. The distinctive ridged Maranka or dolphin cultivar, which has a dark green fruit colour when fresh, is African in origin and exhibits leaf, floral and seed characters typical of *L*. *siceraria* ssp. *siceraria*.

Conclusion

All horticultural plants have their story and the full story of how people used *Lagenaria siceraria* in Aotearoa, the rest of Polynesia and throughout the world requires many more words. For a fascinating account of the plant's history I recommend Heiser's *The Gourd Book* (1979), but for now I will conclude this article by summarising the gourd's main uses by Māori in New Zealand.

The first plant propagated from seed by people in New Zealand was valued as a food plant. The young fruit resemble a hairy zucchini and were cooked in hangi. However, it also provided Māori with a wide range of containers, floats, musical instruments, tops and masks. While the Lapita Culture brought pottery to Western Polynesia, by the time the latter wave of Polynesian migrants reached Eastern Polynesia islands, where sources of suitable clay were in short supply, pottery making techniques were forgotten. Hence the importance of a plant that could annually produce a range of different sized containers.

The most well known Māori containers were the water storage gourd (tahā wai) and containers for preserved meat (tahā huahua). The hard shells of the mature fruit were also used for food bowls, ritual containers, floats for fishing nets and to help children to learn to swim, musical instruments, spinning tops and masks. Although I have seen no direct reference to their use as bailing

instruments during canoe trips, this does seem an obvious use. Medium sized gourds that would fit over the head were occasionally used as masks in the same manner as other Polynesian peoples.

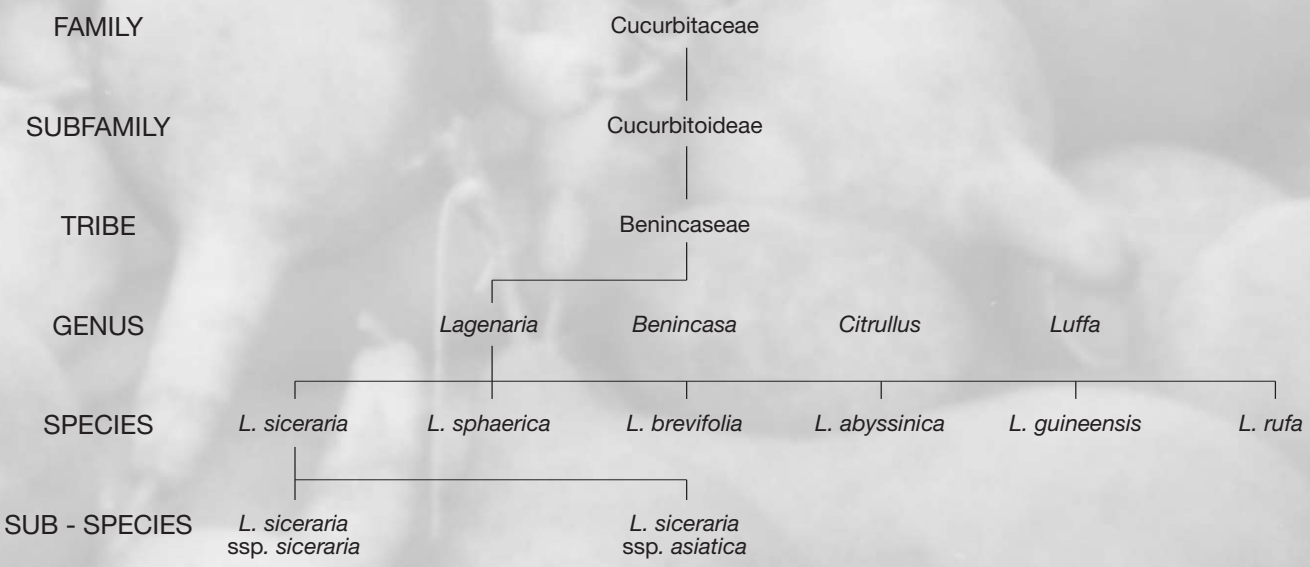
The excellent resonating properties of the dried gourd shell is well known from Africa where it is used for a range of flutes, drums and stringed instruments to India where they are used as the resonating chamber of the sitar and other musical instruments. Māori use hue to make flutes and bullroarers. Bullroarers were made by firmly attaching a cord through the neck of a smaller gourd drilled with one or two holes. The gourd was whirled through the air on the end of the cord to create a roaring sound. Dried gourds filled with pebbles were also used as rattles by children.

I have come a long way since taking an interest in the hue that Māori gardeners once grew in the Makotukutuku Valley. There is much more to tell, particularly about the ethnobotany of the bottle gourd. For now it is enough to record for our horticultural history, the fact that *Lagenaria siceraria* was the first plant people propagated from seed in Aotearoa.

Table 1. Summary of morphological differences between *Lagenaria siceraria* subspecies.

Character	***Lagenaria siceraria* ssp. *siceraria***	***Lagenaria siceraria* ssp. *asiatica***
Leaf	Smooth or unruffled margins, not lobed or rounded-lobed	Saw-toothed on the margins and sharply three- to five-lobed
Flower	Corolla diameter 50-120mm; sepals or calyx lobes short and broad	Corolla diameter 70-140mm; long slender calyx lobes
Seed	Usually dark in colour, less than twice as long as broad	Light coloured, usually more than twice as long as broad
Origin range	Africa and the Americas	Mainly Asia

Figure 1. Taxonomic relationships of *L. siceraria*



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