

Order PROCELLARIIFORMES

A rather distinct group of some 80–100 species of pelagic seabirds, ranging in size from huge to tiny and in habits from aerial (feeding in flight) to aquatic (pursuit-diving for food), but otherwise with similar biology. About three-quarters of the species occur or have been recorded in our region. They are found throughout the oceans and most come ashore voluntarily only to breed. They are distinguished by their hooked bills, covered in horny plates with raised tubular nostrils (hence the name Tubinares). Their olfactory systems are unusually well developed (Bang 1966) and they have a distinctly musky odour, which suggest that they may locate one another and their breeding places by smell; they are attracted to biogenic oils at sea, also no doubt by smell. Probably they are most closely related to penguins and more remotely to other shorebirds and waterbirds such as Charadriiformes and Pelecaniiformes. Their diversity and abundance in the s. hemisphere suggest that the group originated there, though some important groups occurred in the northern hemisphere by middle Tertiary (Brodkorb 1963; Olson 1975).

Structurally, the wings may be long in aerial species and shorter in divers of the genera *Puffinus* and *Pelecanoides*, with 11 primaries, the outermost minute, and 10–40 secondaries in the Oceanitinae and great albatrosses respectively. The tail varies in length, being forked in *Oceanodroma*, forked to pointed in other forms, usually with 12 rectrices but up to 16 in fulmars. The tarsi are light and cylindrical in aerial forms; strong and laterally compressed with legs set far back in aquatic ones. The front toes are webbed; hind toe small or absent. The proventriculus is long and glandular; the gizzard small and twisted; and the small intestine often spiral in *Pterodroma*, presumably to aid absorption of the unusual lipids in their food. Chicks are helpless and covered in down, with two coats except in some Oceanitinae. Some larger species have a darker immature plumage, and the female is often darker than the male in the great albatrosses. The male is usually larger than the female, though smaller in the Oceanitinae and some other small species. Otherwise there is little difference in appearance with sex or age, except that young birds may have more pronounced pale or dark edges to the feathers. Many have simple counter-shaded markings that often appear to have given rise to uniformly dark or, less often, to pale derivatives; some species in most groups are dimorphic or polymorphic. The more complex groups have often developed distinctive markings of the extremities.

Breed more or less colonially on offshore islands, coastal cliffs, or on hills and deserts inland, where they perform complex vocal and aerial displays. The nest is a simple scrape or cup in a burrow or natural hole, sometimes under vegetation. The s. albatrosses build large cone-shaped nests in the open; may be lined with any debris available in the area. Smaller species visit it only at night, though larger ones and those breeding on remote islands may come to nests in the open by day. Parents incubate for spells of several days in turn and generally leave the chick alone soon after it hatches, only returning at long intervals to feed it by regurgitation. In consequence the chick is vulnerable to introduced predators and some species are now greatly reduced and at least two are now extinct. Some species also periodically liable to have unsuccessful breeding seasons. Many young or even old birds may be wrecked ashore and die when they meet bad weather or suffer shortage of food on migration or in the winter. Though it has been claimed that they are also vulnerable to all sorts of pollution, the evidence is weak (Bourne 1976). There is at present anxiety about the effect of some fishing methods, such as long-lining, which may be endangering species such as the great albatrosses.

All species feed at sea on a variety of fish, cephalopods and small marine invertebrates, either socially or alone; larger species may scavenge all sorts of offal or prey on other birds. Most, except perhaps *Pelecanoides*, can digest the complex lipids formed by some marine animals (Clarke & Prince 1976), and may eject them to soil the plumage of their enemies with lethal results (Swennen 1974). Some species can digest wax (Obst 1986). Many now take wastes from whaling and fishing operations (Fisher 1952). All have long life-cycles in proportion to their size; they disperse on fledging and then prospect for nest-sites for 2–12 years in their youth. They usually lay a single large white egg annually; though a successful breeding cycle may be completed in less than a year in at least one tropical species, *Puffinus lherminieri*, it may take 2 years in larger southern ones. Before laying, the birds court for weeks or months, then go to sea for feeding. Incubation lasts 6–8 weeks, and fledging 2–9 months. Once the fat chick fledges it fends for itself, even in species that immediately make a long migration, sometimes to the opposite hemisphere.

Tendency for failed breeders and non-breeders to begin moult before successful breeders. Five strategies of wing-moult in breeding adults: (1) In albatrosses, remiges replaced in staffelmauser interrupted while breeding; in nearly all other species, primaries moulted outwards; possibly simultaneously in some diving-petrels. (2) In most subantarctic and temperate species, moult begins soon after breeding and is completed shortly before next breeding season. (3) In most tropical species, moult aseasonal, between breeding attempts; resumption of breeding apparently depends on when moult completed. (4) In trans-equatorial migrants, wing-moult delayed until they reach non-breeding quarters, where it is completed; moult rapid but no satisfactory evidence for flightlessness. In

some species, body-moult also in winter quarters; in others, at breeding grounds. (5) In some species of high latitudes, rapid moult completed in summer when they breed; some begin moult long before breeding finished.

The history of the classification of the Order is very confused, as is seen by comparing Timmermann's (1965) discussion of their Mallophagan parasites with that by Klemm (1969) of their leg muscles and that by Harper (1978) of their proteins, but it is now widely agreed that the Order is best divided into four families: Diomedeidae or large to huge aerial albatrosses; Procellariidae or medium-sized, mainly aerial but sometimes aquatic, petrels, shearwaters and prions; Hydrobatidae or small to tiny, aerial storm-petrels; and Pelecanoididae or small aquatic diving-petrels.

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Family PROCELLARIIDAE fulmars, petrels, prions, shearwaters

The family Procellariidae represents the main radiation of medium-sized 'true petrels', characterized by having united nostrils with a median septum and the outer functional primary at least as long as the next. It tends to be dominant among the birds of the Southern Ocean, though in the n. hemisphere the Charadriiformes are more numerous. The giant-petrels *Macronectes* have also developed as large scavengers and predators, showing some convergence in appearance and behaviour with the Diomedidae. The Procellariidae may be divided into four main groups with some intermediate species, which makes it hard to draw distinctions between them.

(1) The fulmars *Macronectes*, *Fulmarus*, *Thalassoica*, *Daption* and *Pagodroma* consist of seven species of surface predators and filter-feeders of rather varying structure and appearance (Voous 1949) that breed in high latitudes but may migrate along cool currents into much lower ones. *Fulmarus* appears to have colonized the n. hemisphere in the Tertiary. Six of the seven species are essentially confined to our region.

(2) The gadfly-petrels *Pterodroma* are a large series of some 30 agile species; 16 breed in our region and another six occur rarely or rather rarely. Their short sturdy bills are adapted for seizing soft prey at the surface, and their twisted intestines, for digesting marine animals with an unusual biochemistry, which are also found throughout the warmer oceans (Imber 1985). They show complex markings of face and wings that must serve as interspecific recognition-marks (Murphy & Pennoyer 1952). Some species placed in this group have an intermediate structure and intergrade with all other groups distinguished here: *Pterodroma (Lugensa) brevirostris*, which moves S in winter, has distinctly big eyes like *Pagodroma*; *Halobaena caerulea* has a plumage similar to that of prions; *Bulweria* has some structural resemblance to shearwaters. At present it is difficult to determine their precise relationships.

(3) The prions *Pachyptila* are a specialized group of six (perhaps five) very numerous species, all in our region, that show a progressive adaptation of a small, agile, cryptically coloured, fulmarine form for filter-feeding on zooplankton. There has been dispute over their classification (Cox 1980; Harper 1980) but the arrangement discussed by Fleming (1941) seems best except that the Broad-billed Prion *P. vittata* appears to intergrade with Salvin's Prion *P. salvini* through *macgillivrayi* of Ile St Paul; so they may be better treated as subspecies of the same species.

(4) The shearwaters *Procellaria*, *Calonectris* and *Puffinus* include some 20 agile species with long bills adapted to catch prey more or less under water throughout the warmer seas (Kuroda 1954); 13 species breed in our region, some migrating into the n. hemisphere; six others are chance or perhaps regular visitors. From the fossil record (Brodkorb 1963; Olson 1975); they seem to have been particularly common in the great Tethys Ocean of the middle latitudes of the n. hemisphere in the Tertiary, so this development of aquatic habits may have occurred there without competition from penguins with a subsequent return S by the more successful forms.

General features of the family are: body, ovate, or elongate in shearwaters; wings, long and narrow, 11 primaries, p10 longest, p11 minute; 20-29 secondaries, short, diastataxic; tail, short, 12 feathers; bill, heavy (*Macronectes*), slender (shearwaters), broad (prions) or stubby (gadfly-petrels), hooked, formed of several horny plates; nostrils in dorsal tube of varying length; legs set far back, laterally flattened but round in gadfly-petrels; three toes, webbed, hind toe vestigial, raised. Oil-gland feathered. Peculiar musky odour. Sexes similar, male usually larger than female. Plumage, black or grey above, white below, or all dark; light and dark morphs in some species. Juveniles and immatures usually like adults.

Cosmopolitan throughout the oceans, essentially pelagic; more abundant in cool or cold waters rich in plankton and mostly away from ice. Swim well but usually aerial except when feeding or resting. Fly with alternate swooping and flapping action close to the surface but often arcing high in some gadfly-petrels. Gait on land, a shuffling crouch, being unable to walk properly with feet set so far back; generally avoid open areas on land, being thus vulnerable to predators. Nest colonially; for the most part in burrows and cavities in all sorts of terrain, sometimes far from the sea and in mountainous areas but some species, e.g. *Macronectes*, nest on open ground. Hole-nesters usually nocturnal at colonies, when often extremely vocal, though generally silent at sea. Migratory and dispersive. Some species divide the year between s. and n. hemisphere, often migrating in large flocks that may settle on the sea in huge dense rafts. Feed mostly on fish, cephalopods and crustaceans obtained by flight-feeding, plunge-diving, surface feeding, surface-diving and underwater pursuit; hydroplaning (Murphy) is a characteristic method used particularly by prions.

Probably all defend small nesting territories to which they return regularly while undisturbed; certainly so in some hole- and burrow-nesting forms. Agonistic and sexual behaviour of nocturnal, hole-nesting species very poorly known but generally seem to have little specialization for visual displays. Tactile actions such as allopreening and billing used but olfactory and vocal communication is probably important. Breeding is usually seasonal, generally with synchronized laying, often after a pre-laying exodus but some may not nest annually; some have shorter

cycles or nest continually. For the most part, little attempt to make substantial nests. Eggs, ovate, mat, white. Clutch-size, invariably one; single-brooded; no replacement laying. Incubation by both sexes in alternate spells of 1-11 days. Single median brood-patch. Incubation period, 45-55 days. Eggshells probably always trampled in nest. Young, semi-altricial, nidicolous; hatched in down. Rarely left alone in nest for first 1-2 weeks. Cared for and fed by incomplete regurgitation by both parents. Nestling period generally shorter in cliff- and ledge-nesting species than in hole-nesters. Young attain greatest weight, often well above that of adult, some days before fledging, by which time weight has been reduced to about the same as an adult, but no clear evidence that young are totally deserted for last few days in nest. Adults and young of most species liable to eject stomach-oil in defence. Young independent at fledging. Maturity reached at minimum of 3-4 years, in some 6-12 years.

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Procellaria alba Gmelin, 1789, *Syst. Nat.* 1: 565; based on 'White-breasted Petrel' of Latham, 1785, *General Syn. Birds* 3: 400 — Turtle and Christmas Islands, Pacific Ocean; restricted to Christmas Island by Murphy, 1952, *Am. Mus. Novit.* 1580: 32.

MONOTYPIC

FIELD IDENTIFICATION Length 35 cm; wingspan 83 cm; weight 269 g. Medium-sized dark-brown and white gadfly petrel with sharply demarcated dark hood and typical *Pterodroma* jizz; small headed and slender bodied, with longish gently wedge-shaped tail (held tightly folded in normal flight giving pointed rear-end); long narrow wings with carpals held well forward, outerwings bowed down and swept back tapering to long fine points (or held gently spread, giving rounded hand); short rather delicate bill; buoyant arcing flight. Very similar in size and shape to Herald Petrel *P. arminjoniana*. Plumage similar to Tahiti Petrel but with varying white chin and throat, and underwing, wholly dark except for white submarginal patch. Sexes alike. No seasonal plumage changes. Juveniles inseparable.

DESCRIPTION ADULT. Upperparts, uniform sooty-brown, appearing blackish at sea. Head, neck and upper breast, sooty brown forming blackish hood sharply demarcated from white lower breast, belly and undertail. Dorsum and hood become browner with wear. Varying white patch on

chin and throat, often difficult to see. Always appear strongly hooded. Sooty brown of hood continues narrowly along flanks joining small sooty-brown patch on thighs. Rest of breast, belly and vent, clean white. Under tail-coverts, white; lateral coverts narrowly barred sooty brown, combining with blackish undertail to form narrow dark rim round tip of tail. At distance, underwing appears wholly blackish like dorsum; when closer, marginal, lesser and median coverts, uniform sooty brown except for narrow white submarginal patch along leading-edge of innerwing, centred just behind elbow; extent of patch varies; always present but often difficult to see. Greater coverts and remiges, greyish black, slightly paler than rest of lining (palest on bases of primaries) and more glossy and reflective; when strongly lit, these tracts may appear momentarily as diffuse silvery flash on bases of primaries and fainter diffuse silvery stripe along trailing third of innerwing. Dark dorsum, hood and underwings contrast sharply with white underbody, giving generally black-and-white appearance. Bill, black; short and stubby though rather delicate for genus;

strongly hooked; nostrils conspicuously raised over basal quarter of upper mandible. Iris, dark brown. Legs and basal halves of feet, flesh-coloured, distal halves, black.

SIMILAR SPECIES Closely resembles **Tahiti Petrel** *P. rostrata*; see that text for details. Light and intermediate morphs of **Herald Petrel** superficially similar: dorsum slightly paler and greyer and, on some, white of chin and throat may extend to lores and even forehead, giving white-faced appearance (forehead, lores and cap uniform blackish in Phoenix); in light morph, breast band greyer and appears less strongly defined; in intermediate morphs, grey breast band extends farther onto white belly and flanks in series of smudges, making dark head and neck appear less sharply demarcated from white of underbody; under tail-coverts and vent-feathers have dark grey tips forming wider dusky border round undertail, often extending to vent forming dark rear-end (vent and under tail-coverts mostly white on Phoenix); on underwing, all light and intermediate morphs have large skua-like white patch at base of primaries, which extends inward along bases of greater secondary coverts as bold tapering white line (on Phoenix, wholly dark except for white submarginal patch). Some intermediate morph **Kermadec Petrel** *P. neglecta* also have superficially similar pattern of plumage but separated by large white skua-like patch on base of primaries on underwing and diagnostic white primary shafts forming skua-like white flash on upperwing. Herald and Kermadec Petrels do not have generally black-and-white appearance of Phoenix. Light morph **Soft-plumaged Petrels** *P. mollis* about same size as Phoenix and also with dark underwings but distinctly grey above with contrasting dark open M across upperwing. **Magenta Petrel** *P. magentae* much larger with more thickset build and larger chunkier bill; upperparts slightly paler and distinctly greyer (sooty grey not sooty brown); underwing lining wholly dark (without submarginal patch of Phoenix).

Highly pelagic gadfly petrel restricted to tropical waters. Avoid land except when breeding. Flight similar to that of other medium-sized *Pterodroma* (closely resembles that of Herald Petrel), with characteristic pendulum-like progression

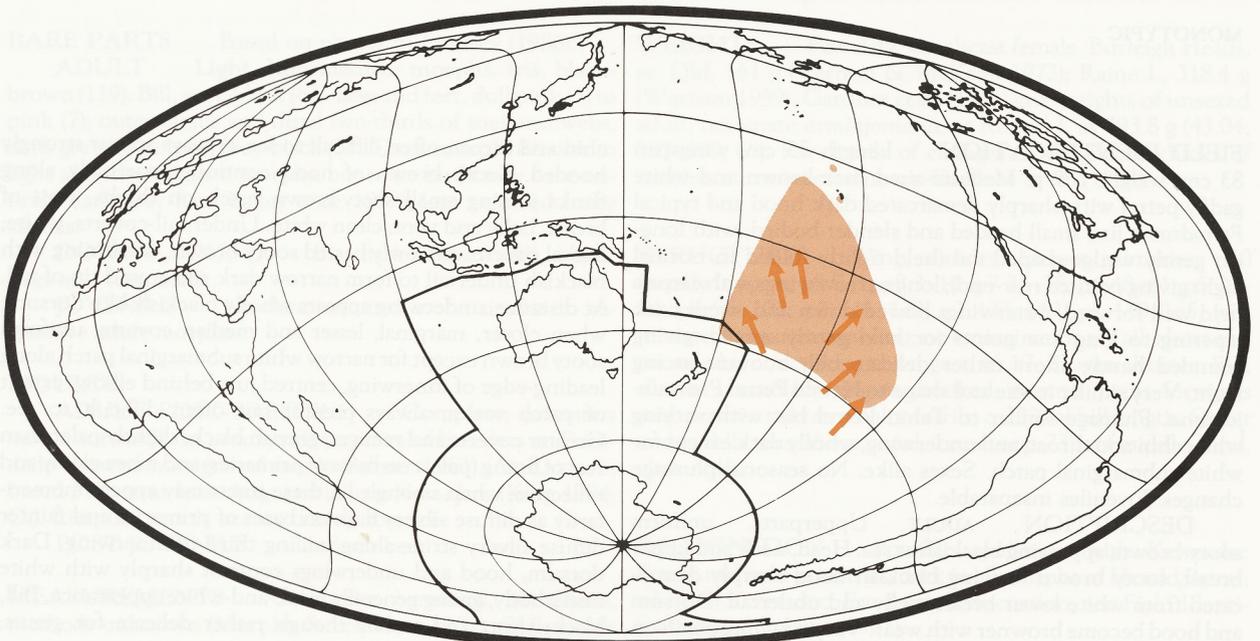
in series of steep bounding arcs, which become higher in strong winds. Arcing flight broken by occasional brief bursts of leisurely flapping and sudden changes of course. Breeding birds forage in pelagic waters. Feed by surface-seizing, dipping and pattering. Usually solitary at sea but occasionally form small parties of up to 20 birds. Avoid ships. Nest on surface; gregarious at colonies where parties of birds circle over breeding areas from mid-afternoon and into night. As far as known, silent at sea. At breeding colonies, birds frequently utter 'a strange, shrill warble ending with a low bubbly, gurgling sound' associated with pursuit flights over colonies (Donaghlo in Murphy *et al.* 1954).

HABITAT Marine, pelagic. Habitat preferences poorly known; observed over waters of surface-temperature 24.7 °C and salinity 35.3 ‰ in n. hemisphere (Gould 1983). May forage over cooler nutrient-rich waters, especially when breeding; decline in numbers and breeding failure on Christmas I. (Pac.) during El Niño Southern Oscillation, when sea surface-temperature high and food supply poor (Schreiber & Schreiber 1984). Probably travel several hundred kilometres from breeding islands to feed (Ashmole & Ashmole 1967); abundant N of Christmas I. over Equatorial Countercurrent at 7°N (Mörzer Bruyns 1965). Readily fly over land on breeding islands (Gallagher 1960).

Breed on atolls, coral islets and volcanic islands free of cats and large species of rats; nest in scrapes under trees, bushes or low vegetation (Gallagher 1960; Holyoak & Thibault 1984). Fly in glides and high arcs over sea (King 1967). Feed from on or just below surface; do not swim underwater (Ashmole & Ashmole 1967). Rest on water in lagoon at Christmas I. (Gallagher 1960).

May have bred at Raoul I., Kermadec Is, and been exterminated by feral cats.

DISTRIBUTION AND POPULATION Tropical and subtropical central Pacific Ocean. Breed extraliminally on Line, Phoenix, Marquesas, Pitcairn Is., Tuamotu and Tonga (King 1967). Possibly once bred Raoul I., Kermadecs (Oliver),



but status there uncertain (King 1967). Probably to be found in waters near breeding islands (Pratt *et al.* 1987). Recorded on Equator between 149–156°W (Pitman 1986). Extend N to Hawaii (Gould 1983); three tentative sightings in Fijian waters (Jenkins 1986). Rare vagrant to A'asia; no records Aust.

NZ. One collected 1913 Raoul I., Kermadec Is (Sorensen 1964); four ashore 7 Mar. 1913 (Oliver); Curtis I., unsubstantiated report of single live bird, 21 May 1982 (Lovegrove 1982).

MOVEMENTS Little information. No fixed breeding season but seen as far as 25°N in central Pacific (Gould 1983). Well-digested state of food brought to chicks suggests large foraging distances when breeding (Ashmole & Ashmole 1967). Four prospecting birds recorded Kermadec Is (Oliver).

PLUMAGES

ADULT (Definitive basic). Presumably includes juvenile. **HEAD AND NECK**, black-brown (greyish 19), save for white patch on chin and throat with varying dark brown-grey (brownish 83) speckling at borders. Feathers, white with varying dark brown-grey (brownish 83) tips; as tips wear, size of throat patch increases. **Interramal region**, black-brown (greyish 19). **UPPERPARTS**, black-brown (c19); feathers have slightly greyer frosted tips. **TAIL**, black-brown (c119); feathers have concealed paler bases and inner webs. **UPPERWING**, black-brown (119); all feathers have dark-brown (121A) shafts, appearing blackish (82) at angle. **UNDERPARTS**. Upper breast, sides of lower breast, flanks and axillaries, dark greyish brown (greyish 119A), slightly greyer when fresh. Rest, white; under tail-coverts have brownish grey (79) mottled bars and dark-grey (c83) shafts; mottling heavier on lateral under tail-coverts. **UNDERWING**. Greater under wing-coverts and primaries, dark grey-brown, with paler gloss in some direct lights, especially near bases of primaries. They merge to white bases, generally concealed by under wing-coverts. Usually small white stripe near front edge of underwing, extending both sides of junction of humerus and ulna; feathers, white with patchy dark-grey areas. These absent on two specimens examined; unknown if this is individual variation or caused during preparation of skin. Rest of under wing-coverts, black-brown (119).

BARE PARTS

ADULT, (POSSIBLY JUVENILE) Iris, dark brown (21). Bill, grey-black (c82); at least some adults have narrow whitish bands at base of unguis. Top of outer toe, distal two-thirds of toes and webs, black; rest of feet and legs, flesh-pink (NZRD, NMNZ).

MOULTS Based on Sreiber & Ashmole (1970), who also give information on breeding season.

ADULT POST-BREEDING Period at sea between

breeding season probably largely occupied by moult; duration of primary moult less than seven months. No primary moult recorded during incubation or while chicks small; few adults handled while chicks large, so possibility that moult of some adults starts before chicks fledge cannot be excluded.

POST-JUVENILE, SUBSEQUENT MOULTS No information.

MEASUREMENTS (1) Combined locations, skins; methods unknown; information on Murphy's measuring methods in account of Common Diving-Petrel (Murphy & Pennoyer 1952). (2) Skins (NMNZ).

	MALES	FEMALES
WING	(1) 276.6 (4.79; 267-285.5; 39)	276.4 (6.51; 265-291; 39)
8TH P	(2) 183	186
TAIL	(1) 112.3 (3.09; 106.5-118.5; 39)	112.9 (3.46; 106.4-119.7; 39)
BILL	(1) 27.8 (0.72; 26.6-29.7; 39)	27.9 (0.96; 25.5-29.3; 39)
TARSUS	(1) 33.9 (0.83; 32.2-35.4; 39)	33.5 (0.80; 32.1-35.3; 39)
TOE	(1) 44.9 (1.03; 43.4-47.3; 39)	44 (1.35; 41.5-46.5; 39)

WEIGHTS At Christmas I. (Pac.) 269 g (n=10) (Ashmole & Ashmole 1967).

STRUCTURE (Only two examined). Wing, long and narrow. P10 longest; p9 4, p8 14–18, p7 34–35, p6 57, p5 82–86, p4 103–118, p3 126–147, p2 150–167, p1 165–182. Tail, strongly rounded, 12 feathers, t1–t6=26. Bill, short; nasal tubes one-quarter of length, directed forwards. Outer toe, longest, middle toe 95–100% of length, inner 82%.

DIR

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Tahiti Petrel *Pterodroma rostrata*

- 1. Adult, ventral
- 2. Adult, dorsal
- 3. Adult, head

Phoenix Petrel *Pterodroma alba*

- 4. Adult, ventral
- 5. Adult, dorsal
- 6. Adult, head

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