Lecture 3

Modes of Life

Animals and plants are highly dependent on their immediate environment to satisfy their vital needs for feeding and reproduction. Within populations, natural selection favours the forms best adapted to the physico-chemical and biological conditions which dominate their environment. Thus recognition of the adaptive characters of fossil organisms and an understanding of their significance forms an important part of the reconstruction of fossil environments. This is the aim of functional morphology. Broadly, the function of various structures can be reconstructed from the morphology of the hard parts preserved by fossilization.

Knowledge of the workings and mode of life of present-day organisms is obviously fundamental to the interpretation of fossil species. As in so many aspects of the earth sciences, the present is, to a certain extent, the key to the past.

I. Mobility

How an organism feeds, protects itself against its enemies and reproduces itself is controlled to a great extent by its mobility, and one can base a broad classification of living beings on this (Fig. 1).

1. Aquatic .Organisms

a) Benthos

Benthic organisms or benthos live in a very close relationship to the bottom. Epibiontic forms live on the surface of the sediment while endobiontic forms live within it, either buried or in holes.

i) Sessile Benthos

The adults of sessile species are fixed to, or sit on, the substrate or another organism (epizoans, epiphytes). Since they do not move, they are completely under the influence of their environment. They are thus excellent environmental indicators.

There are many adaptations to a fixed mode of life:

Some organisms simply sit on the surface of the unconsolidated sediment (Fig. 2) by means of spines (productid brachiopods) or on their shell (Liassic gryphaeids, whose left valve, in contact with the bottom, is shaped like a cradle to raise the animal above the mud, while the right valve acts as an operculum);

In many other organisms are fixed to the substrate (Fig. 3):

- *by a flexible stalk;* for example: most aquatic plants, brachipods, fixed echinoderms (blastoids, crinoids etc.), some Crustacea (goose-necked barnacles) etc;

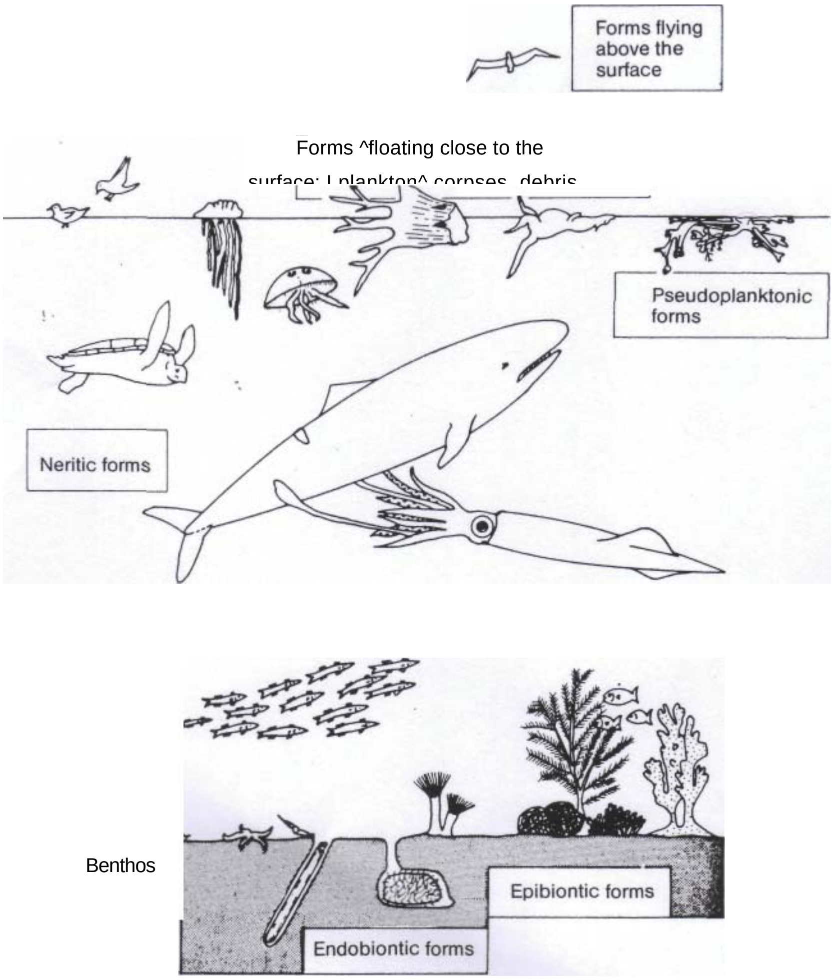

Fig. 1. Classification of marine organisms according to their mobility. (Ager in Babin 1971)

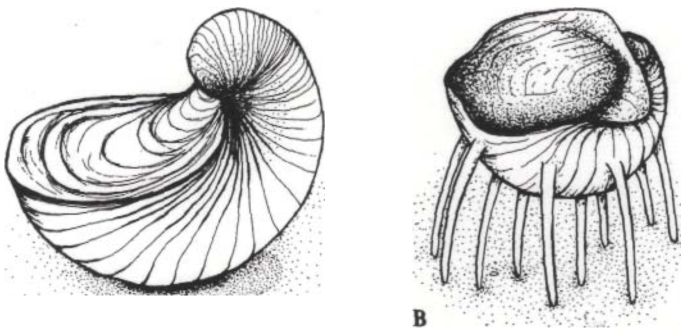

Fig.. 2A,B. Sessile benthic forms living on a mobile substrate. A bivalve *(Gryphaea arcuata,* LiasiB brachiopod (Upper Palaeozoic productid)

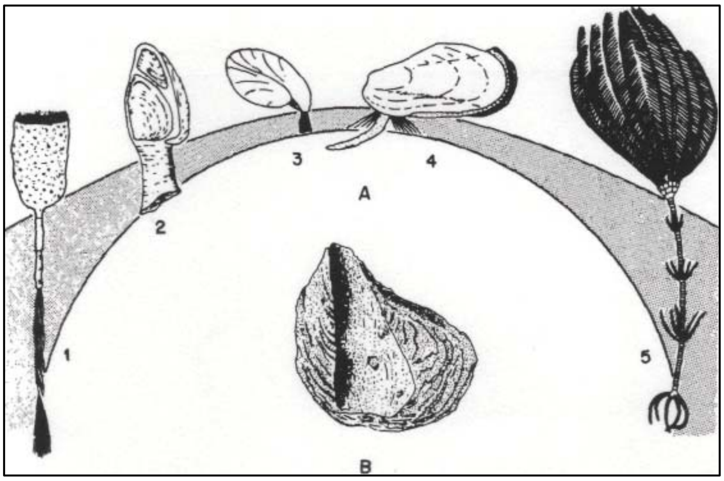

Fig. 3A, B. Methods of fixation of sessile benthos. A by a flexible organ: *1* siliceous sponge *(Hyalonema);2* cirripede crustacean *(Lepas; 3* brachiopod *(Magadina);4* bivalve *(Modiolus); 5* crinoid *(Cenocrinus).* (Zeigler 1972); B by theirshell: valve of a Sparna-cian *Ostrea uncifera* showing the impression of its attachment area. (Plaziat 1970)

- *by part of their shell or skeleton* which welds itself to the substrate and mimics its shape; for example: sponges, corals, bryozoans, anne lids (serpulids), bivalves (oysters, rudistids), Crustacea (barnacles), etc.;
- *by a specialised organ;* for example: the exothecal lamellae of archaeocyathids, the byssus of bivalves etc.

In general, a fixed mode of life favours the development of external skeletons, shells and carapaces, as a means of protection against predators.They frequently have a radial symmetry (sponges, coelenterates, echino-derms), and their distribution takes place by means of free larvae.

ii) Vagile Benthos

The movement of vagile or free species is limited by their contact with the substrate, which effectively controls their search for food. They move in several different ways:

- *by contractions of their body muscles;* for example: worms;
- *by a contractile foot;* for example: many molluscs (gastropods);
- *by appendages for locomotion;* for example: the parapodia of annelid worms, arthropod feet (trilobites, limulids, Crustacea);
- *by propulsion organs;* for example: cephalopod jets, fins of benthic fish (skates and rays, Palaeozoic armoured fish), bilaterally symmetri cal shells of some bivalves (pectinids), etc.;

- *by specialised structures;* for example: the ambulacral system and spines of echinoderms.

Animals which move actively are generally bilaterally symmetrical.

in) Infauna

The infauna includes organisms which burrow into unconsolidated sediments (Fig. 4) or bore into hard substrates (Figs. 17, 36). They are also described as endobiontic. They come from several different zoological groups: worms, molluscs, Crustacea, echinoderms. This mode of life requires certain morphological adaptations:

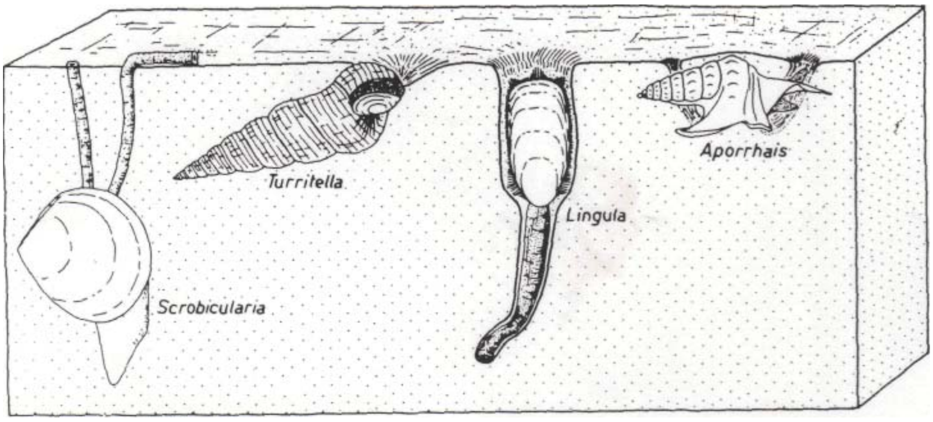

Fig. 4. The endofauna of Recent mobile bottoms: brachiopod *(Lingula)*, bivalve *(Scrobicularia)*, gastropods *(Aporrhais, Turritella)*. (Zeigler 1972)

- *a trend towards the reduction of carapaces and shells* whose protective role has become unnecessary because of the burial of the animal; for example: wood-boring (teredinids) or rock-boring bivalves (pholads);
- *the development of a siphon,* a fleshy, tubular extension of the body of certain molluscs (bivalves, gastropods) which passes water through the pallial cavity. In the bivalves (Fig. 5), the formation of a notch in the pallial line, the sinus, shows where it enters the valves. The shell also becomes elongated in an antero-posterior direction and frequently gapes around the siphon;
- *a change in the ambulacral areas* on the upper surface of the test of irregular echinoderms into branchiae (petaloid ambulacra) (Fig. 6).

If body fossils are not present, the infauna leaves traces of its activity in the sediment which have great palaeoecological interest (p. 40).

b) Nekton

Nektonic organisms or nekton live in the body of the sea where they move actively in search of food. They move by means of swimming organs:

- *the fins of aquatic vertebrates;* in fish and some tetrapods (ichthyosaurs, dolphins, whales) the body is propelled by the caudal fin; else where, this function is carried out by paired structures changed into paddle-like fins by the elongation or increase in number of joints (plesiosaurs, turtles, seals) (Figs. 9, 116);
- *the jet and funnels* of cephalopods;
- *the caudal fan and swimming appendages* of decapod Crustacea.

The bodies of animals well adapted to swimming often have a spindle-shaped hydrodynamic profile (fish, reptiles, mammals). This is a remarkable example of morphological convergence (Fig. 7).

c) Plankton

Planktonic organisms or plankton live free in the sea and are passively swept about by it. Depending on whether they are animal or vegetable, they are known as zooplankton or phytoplankton. In general, planktonic species do not have organs to help them move. Because of their low body density, they are able to float. This low body density can be achieved in several different ways (Fig. 8):

- *by a very small size;* many forms are microscopic; for example: the protista, the larvae of various metazoans, etc.;

by the absence (medusids) *or the reduction of the skeleton* (the perforated shells of radiolaria; the reduced shells of heteropod and ptero-pod gastropods);

by expanding the body, thus increasing its surface area; for example: the calcareous spines of globigerinids and some coccolithophorids; the appendages of certain acritarchs; the development of appendages and bristles on crustacean larvae, etc.;

by the secretion of small droplets of oil; for example: the coccoid family of green algae which give rise to algal hydrocarbons; *by gas-filled floats;* for example: some algae (sargassids), graptolites etc.; *by high tissue water retention;* for example: medusids, some tunicates etc.

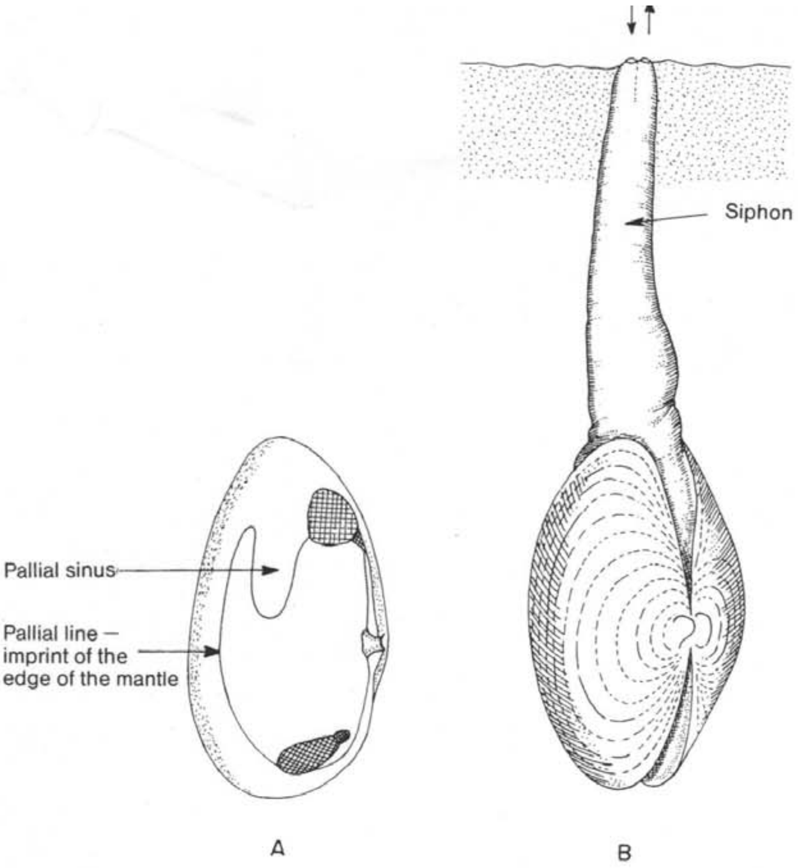

Fig. 5A, B. Adaptation to a burrowing mode of life in the bivalves *(Mya arenaria)*: **A** internal view of the left valve; **B** animal in position of life. (Modified after Boué and Chanton 1958)

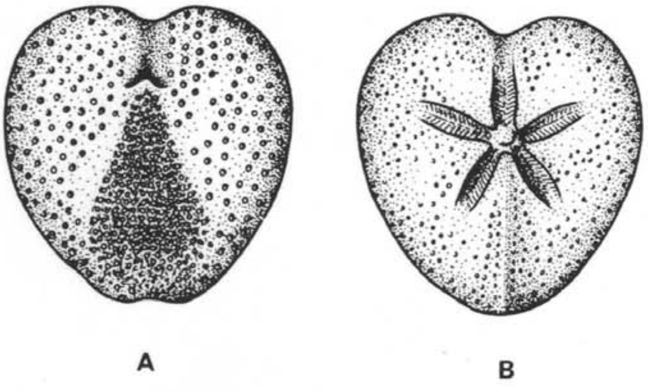

Fig. 6A, B. Adaptation to a burrowing mode of life in the irregular echinoids *(Micraster* – Upper Cretaceous). **A** jawless oral face; **B** apical face with petaloid ambulacra. (Devilliers 1973)

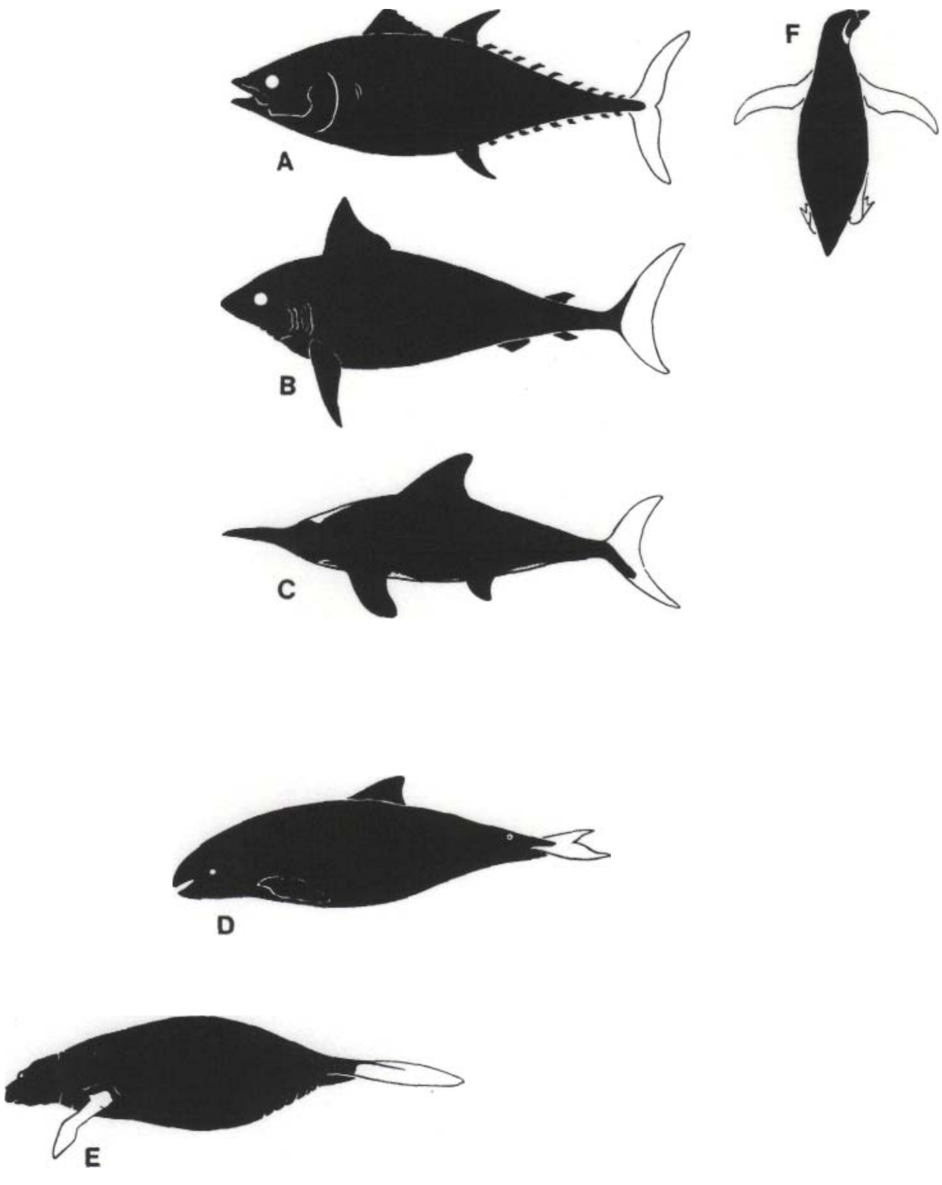

Fig. 7A—F. Hydrodynamic shapes of the bodies of swimming vertebrates. A bony fish (tuna: *Thunnus);* B cartilaginous fish (shark: *Lamna);* C reptile (Jurassic ichthyosaur); D mammal (porpoise: *Phocaena);* E mammal (sea-cow: *Trichechusj;* F bird (penguin: *Spheniscus).* (Gutmann 1966)

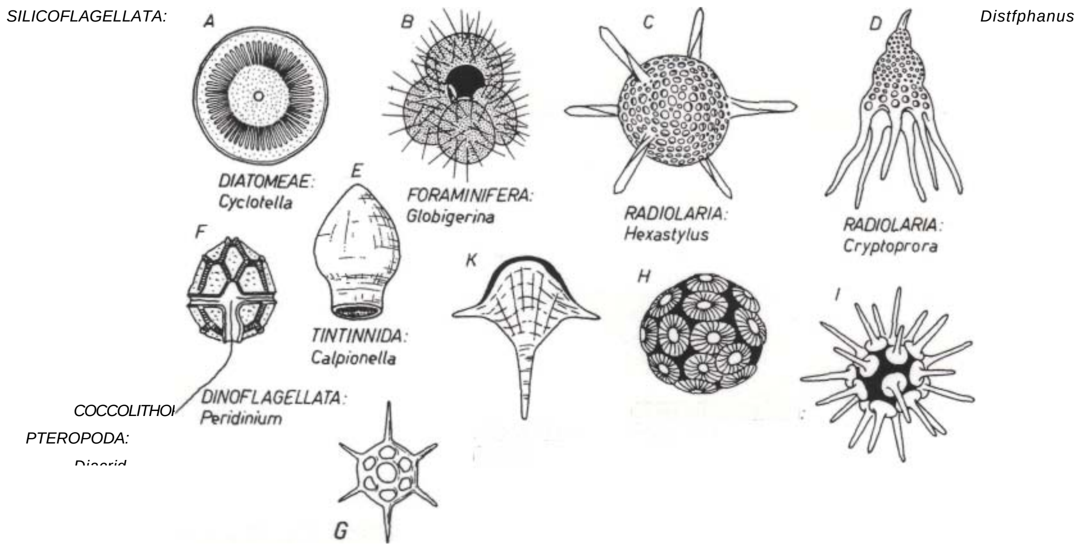

Fig. 8. Recent and fossil planktonic organisms. (Zeigler 1972)

The plankton play an important role in the food chain of present-day seas and lakes. Their small size and their reduction in skeletal development means their importance has often been underestimated.

Nekton and plankton are also grouped as pelagics since, unlike the benthos, they are independent of water depth.

d) Pseudoplankton

The term pseudoplankton groups together sessile organisms which occasionally fix themselves to floating objects (algae, wood, shells, etc.) (Fig. 117). Like the plankton, they are subject to the play of the currents. They come from many groups of organisms: coelenterates (hydrozoans), bryozoans, annelids (serpulids), molluscs (bivalves, gastropods), arthropods (cirripede crustaceans), echinoderms (crinoids), etc. When the floating support is not fossilised, pseudoplanktonic species can easily be confused with benthic forms and this can lead to inaccurate environmental interpretations.

2. Land Organisms

The ability to live on land is one of the great developments in the history of life. During the Palaeozoic, plants and several groups of animals (arthropods, gastropods, vertebrates) in turn colonised the continents. Air breathing and protection against desiccation were among the many adaptations required by this change in environment.

A fixed mode of life is found only among autotrophic organisms which take their nourishment directly from the soil. This is so for the plants. In the animals, however, the search for food requires active travel on the ground or in the air.

a) Movement on Land

Travel on land can occur in various ways:

a *crawling* by means of contraction of the body muscles (worms, caterpillars) or by the use of a specialised organ such as the foot of the gastropods;

a walking with articulated appendages; for example: the arthropods and the vertebrates.

Tetrapod vertebrates, with pentadactyl extremities, provide good examples of adaptation to different modes of travel (Fig. 9):

- *running*, helped by a more erect posture combined with a reduction in the number of digits (horses);
- *climbing* by the acquisition of claws, adhesive pads or by the ability to oppose the digits to make grasping structures (primates, some marsu pials);
- *jumping* using an articulated hind limb with three sub-equal segments (frogs, kangaroos, rabbits);
- *burrowing* by shortening and enlarging the fore-limbs (moles).

Elsewhere, among tetrapods which have returned to an aquatic mode of life, the pentadactyl extremity can be changed into swimming paddles by an increase in the number of joints or digits (ichthyosaurs,plesiosaurs, cetaceans etc.).

b) Flight

The development of wings has occurred in the arthropods (insects) and the vertebrates.

The two pairs of wings in insects are a membraneous expansion of the dorsal side of the thorax.

Vertebrate wings are altered fore-limbs (Fig. 9). In flying reptiles (pterosaurs) and bats (cheiropterans), they consist of a web of skin, supported by one or several digits. In contrast, in the birds, the lifting surface of the wing is made of the arms covered in feathers.

They are lost in parasitic species.

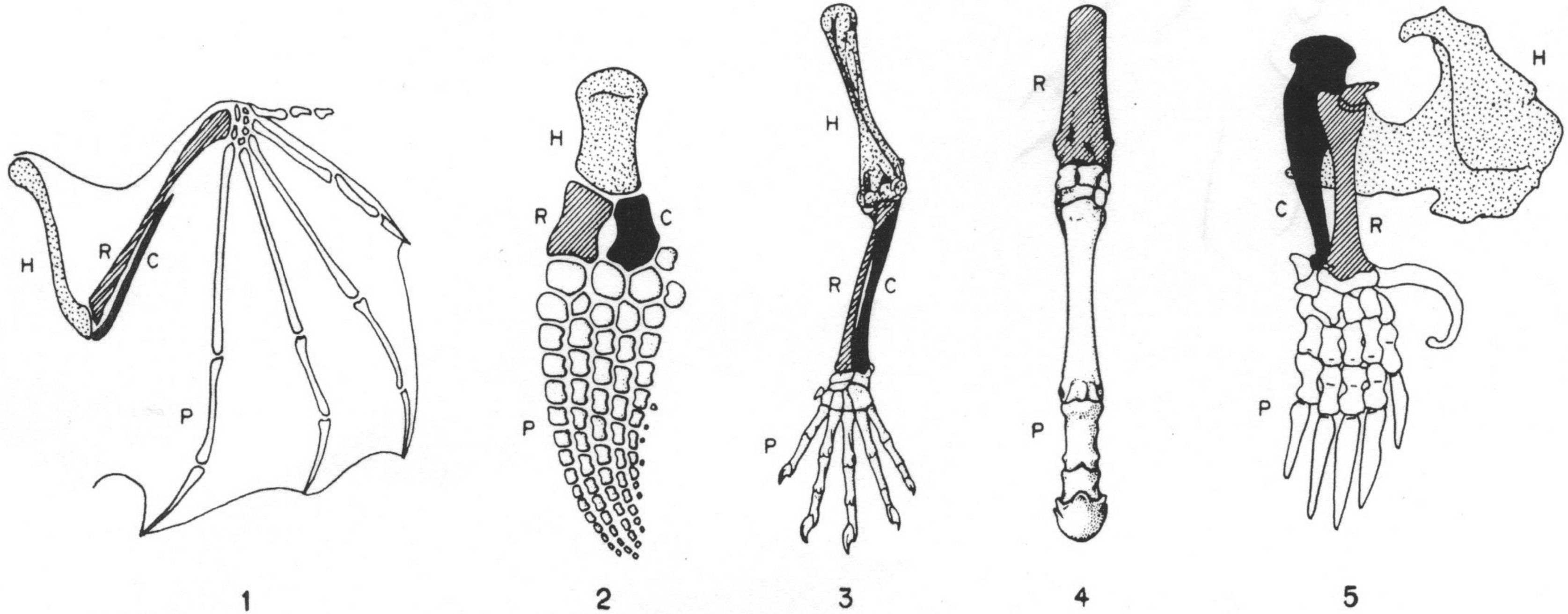

Fig. 9. Adaptations of fore-limbs in tetrapod vertebrates. *1* for flight (bat); *2* for swimming (ichthyosaur); *3* for gripping (opossum); *4* for running (horse); *5* for burrowing (mole). *H* humerus; *R* radius; *C* cubitus; *P* phalanges (finger- and toe-joints). (*1* and *5* from Grasse 1967, *2, 3* and *4* from Devilliers 1973)