1. FROM LAKE TO DIAGRAM

1.1. What are Cladocera?

Cladocera (water fleas) are microscopic crustaceans (class Branchiopoda) that inhabit all kinds of freshwater environments and can be very abundant in some basins, whereas there are only a few marine species. Some freshwater cladocerans are planktonie (e.g. Daphniidae and Bosminidae) and form an important component of the zooplankton community, both as phytoplankton grazers and prey items for other animals. There are also littoral cladocerans that live in the macrophytic zone (zone of aquatic vegetation), both on plants and on bottom sediments (e.g. Chydoridae). Some species are purely benthic (living on the bottom) while others can live in the profundal zone outside the macrophytic zone. Most cladocerans eat algae, bacteria and detritus, however there are also three predatory species in Europe *(Leptodora kindti, Bythotrephes longimanus and Polyphemus pediculus)*.

The classification and taxonomy of Cladocera is in a constant state of change and revision. Here we present the classification of 4 suborders Haplopoda, Ctenopoda, Anomopoda and Onychopoda within the order Cladocera (p. 18), recently supported by Olesen et al. (2003). However, the division into families and subfamilies given here is relatively conservative, especially regarding the family Macrothricidae (cf. e.g. Dumont & Silva-Briano 1998) and mainly follows Flössner (2000). The author names for all of the taxa described in this book are presented in a list (p. 18) and are only provided within the text for undescribed species.

Research upon Cladocera began in Europe and most of the European chydorid fauna had been described by the early 20th century and is therefore well-known, unlike the fauna of other continents. As the early descriptions and inspection of species were superficial, it was thought for a long time that there are mant' cosmopolitan species. However, in the late 20th century it became obvious that most cladocerans are not actually cosmopolitan in nature, but instead that there are groups of closely related species. This situation inspired David G. Frey to write the immortal sentence "Besides death and taxes, one of the accepted certainties of our modern world has been that nearly all subglobular individuals of *Chydorus* belong to the species *sphaericus*." (Frey 1980). During recent decades plenty of new species have been described all over the world.

The present atlas concentrates purely upon the remains of cladocerans from central and northern Europe. During examination of the presented material and European cladoceran literature it became obvious that even in this restricted area there might be morphological variation within species. It is possible that in the future some species will be shown to be groups of species or morphotypes. Some European species also occur in North America and the remains appear identical (cf. Sweetman & Smol 2007). However, the present book should be used in the identification of North American cladoceran remains with caution, keeping in mind that there may still be undescribed closely-related species with morphological differences invisible in exoskeletal remains. Furthermore, as the ecological preferences of some species that occur in both continents have been shown to differ, e.g. *Alona costata and A. rustica* (Fkissner & Frey 1970), only European information should be used in ecological interpretations of the results from Europe.

Cladocerans have two reproduction strategies. For most of the open-water season there are only asexually reproducing (parthenogenetic) females which clone themselves. During autumn an environmental stress, i.e. the oncoming winter, triggers sexual reproduction. Males and sexually reproducing (gamogenetic) females appear. After copulation and fertilization the female produces one or more resting eggs that remain dormant throughout the winter until the spring when new parthenogenetic females hatch from them. In some families, e.g. Sididae, the resting eggs are released freely into the water, whereas in others, e.g. Daphniidae, Bosminidae and Chydoridae, the resting egg/eggs of the sexual female are enveloped by a modified shell (carapace), known as an ephippium (p1. ephippia) which protects the egg/eggs.

As males and ephippial females are present only in autumn, their proportion of the yearly population (and of all the remains in sediments) is much smaller than that of parthenogenetic females. Abundances also decrease from subarctic areas with a relatively short open-water season towards southern Europe where the active period is long and cladocerans can live through winter and even reproduce parthenogenetically during winter. Therefore, male remains and ephippia can be very rare in mild climates in Europe.

The cladoceran body consists of chitinous exoskeleton and soft tissues. Fig. A shows the outer view of a cladoceran belonging to the family Chydoridae (the inner organs are invisible). The body consists of a head covered by a headshield, the main body

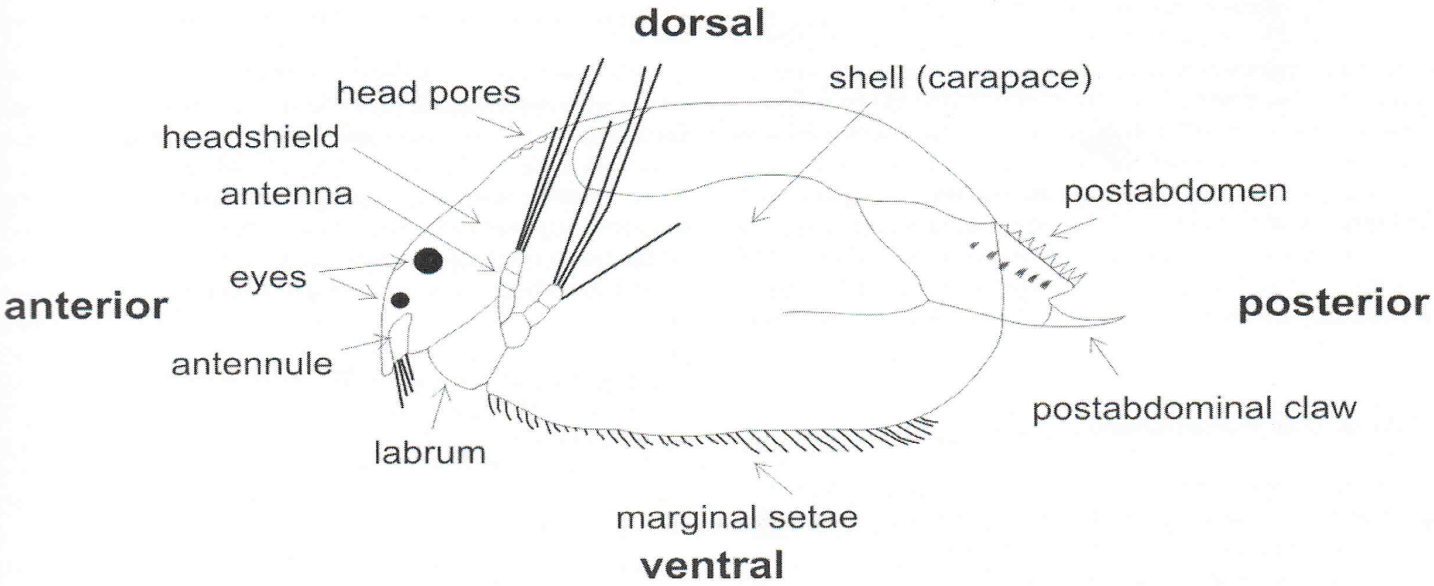

Fig. A. An intact cladoceran (Chydoridae, *Alona costata),* showing the main body structure characteristic of most cladocerans, e.g. head with antennae,
antennules and eyes, as well as a labrum, main body and postabdomen ending in 2 postabdominal claws. The interna) organs are not shown. The soft tissues,

eyes and labrum decompose after death, however the chitinous parts of the exoskeleton (headshield, shell, postabdomen and postabdominal claws) of orany species are preserved (best in families Chydoridae and Bosminidae) in aquatic sediments. In other families there are less - although fortunately at least some - remains that are preserved.

A labrum exists between the anterior head and shell. The eyes and labrum do not preserve in subfossil remains. There are marginal setae on the ventral margin of the body and usually also these are detached. Most of these main characters are found in all cladocerans (with exceptions), although there is variation between farni-bies and species, for example, in planktonie Daphniidae the antennae have developed into long swimming appendages and Bosminidae have large, long antennules.

The animals have to molt regularly, i.e. shed their old exoskeleton and build a new one, as they grow. The stage between molts is called an instar. There are a number of immature, juvenile intars (usually 2-4) before maturity in both sexes, the number varying between families or genera. After molting the chitinous parts 3f the exoskeleton are detached and shed.

1.2. From living animals to subfossil remains

When an animal Bies, its soft tissues decompose and the chitinous body parts become detached in the same manner as during molting. There is great variation in the preservation of chitinous remains. For example, only the heavily chitinized claws of *Acantholeberis curvirostris* are preserved, whereas the delicate, thinly postabdomen decomposes, as well as the test ot the animal. However, remains of the families Bosminidae and Chydoridae are exceptionally well preserved making them valuable for palaeolimnological research. Chydoridae (chydorids) are especially valuable as the remains of the numerous species can be identified to the species level and there are different ecological preferences among the species, allowing them to be used as palaeoecological indicators.

The chitinous remains of dead animals settle to the lake bottom, together with molted remains and are finally deposited in the sediment. Due to the selective preservation, species composition and relative abundance of species preserved in sediments do not reflect the exact assemblages of species living in the lake during one or more open-water seasons. However, in order to reconstruct environmental changes through time using the palaeolimnological approach, it is necessary to try to identify the remains of as urany species as possible so that the picture created is as accurate as possible. Furthermore, it is not possible to reconstruct the exact number of individuals because a single individual may molt several times during its life span. In addition to bioturbation, in most basins there is always redeposition on the sediment surface for several years before the final sedimentation, this results in the fact