

# 17 The Non-Aquatic Ape: The Aquatic Ape Theory and the Evolution of Human Drowning and Swimming

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## SUMMARY

From an analysis of the evolutionary processes that have led to the features that have diminished humans' adaptation for survival in the water, it appears that from a traditionally biological point of view we are indeed, like the apes, poorly adapted. However, the percentage of humans that actually die from drowning is relatively low – the result of other, counteracting, adaptations, namely, our cognitive and manual abilities. A central question of the Aquatic Ape Theory debate, not hitherto addressed, is therefore: did the aquatic ape already possess these abilities, including those of transferring to conspecifics, especially offspring, the necessary knowledge? Indications from comparative morphology, physiology and ethology, and from palaeoanthropology, appear to offer a negative answer to this question. The analysis, therefore, does not support the AAT.

## INTRODUCTION

This chapter attempts to test the Aquatic Ape Theory (AAT) against a number of data (including personal observations) that permit us to roughly reconstruct the evolutionary background to swimming and drowning in modern humans. The data derive mainly from comparative zoology, palaeontology, evolutionary biology, anatomy, physiology and psychology (see Figure 17.1). Like other arguments for and against the AAT, mine, though based on quite hard data, may legitimately be considered as speculative. However, my general conclusion will be that there is little evidence in favour of the theory. This chapter will not discuss the adaptationist, the purely palaeontological or the methodological issues associated with the AAT (which are discussed elsewhere in this volume).

## MAN AND WATER: THE PARADOX

Remarkably, most humans and all apes swim less well and drown much more readily than virtually all other animals, including monkeys. How has this come about? Before that question can be answered, drowning has to be defined. Somewhat simplified, it can be defined as a disturbance

of the relations between the individual, water and air. Tracing the evolutionary background of human drowning may elucidate the intriguing comparative zoological observations mentioned above. Also, it may facilitate an assessment of the AAT and clarify our basic relations with water which are, at first sight, somewhat ambivalent.

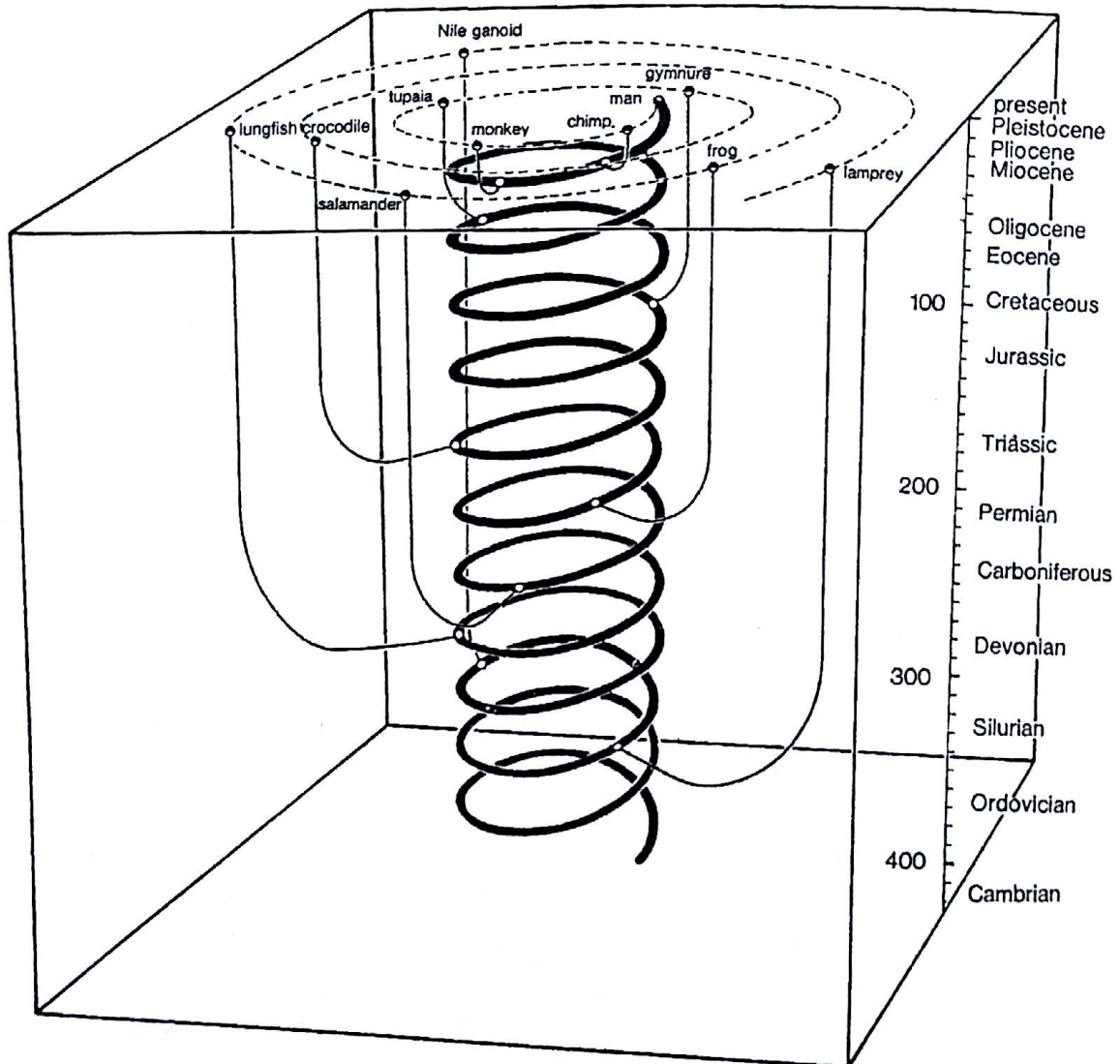


Figure 17.1 Schematic representation of the value of observing modern animals for elucidating the evolutionary history of humans. The upper face of the cube indicates the present, the lower parts of the cube the past, and the heavy spiral man's phylogeny. The species mentioned in the upper face have changed less than others and are taken to be indicative of conditions in our ancestors; yet they are also the end-result of an evolutionary process, as indicated by the lines leading from the heavy spiral to the upper surface. The series of modern species, therefore, merely provides a reflection of man's phylogeny as indicated by the broken-lined spiral in the upper face. The names mentioned here refer to species whose proneness to drowning is discussed in this chapter; the ancestral species are indicated by the white dots. The geological time scale is graded into millions of years.

On the one hand, humans can be considered to show *hydrophilia*: we all started life immersed in water for nine months, while for the rest of our lives we are hardly able to survive a few days without it. In addition, psychoanalysts, and poets in their wake, have stressed man's nostalgic longing for submersion in water, especially the sea, interpreting this as a symbol of our comfortable stay in the womb and as a deeply ingrained, biologically determined, ancient memory of the ocean in which life originated many millions of years ago (see e.g., Fliess, 1961; Ferenczi, 1968; and Richards, this volume, chapter 6). Indeed, it has been claimed that the composition of our blood still reflects that of the primeval ocean at the time when our aquatic ancestors evolved into terrestrial ones, some 300 million years ago (Grayson, 1988; for older references, see Wind, 1973). And are we not fond of playing with water and taking showers? Are we not able to conquer oceans by our advanced modern technology?

On the other hand, humans can be considered to show *hydrophobia*. Except in a warm bath, most humans when immersed feel rather threatened by the surrounding water. In fact, humans survive total or partial immersion in water for a much shorter period than most other organisms, including the majority of animals. Accidental human drowning occurs at least 160,000 times per year throughout the world.\* And if the concept of drowning is broadened, many more people may be considered to die by 'drowning' – by their own body fluid, present in the lungs during the terminal stages of various diseases.

To put these somewhat puzzling and paradoxical phenomena into a proper perspective, we need to know their origins and evolution. These can crudely be reconstructed on the basis of Darwinian principles. In order to trace the evolutionary history of human drowning, the most probable reconstruction of the level and nature of our ancestors' adaptation to an aquatic environment will briefly be reviewed.

## LIFE AND WATER

Water is present in all living organisms, and the more primitive ones usually live in an aquatic environment. Accordingly, it is generally assumed that life originated in water. Our vertebrate ancestors are likely to have remained largely aquatic until some 250 million years ago, and to have been good swimmers until some 50 million years ago. As far as the non-human primates are concerned, most modern prosimians and monkeys observed so far (and, for that matter, most terrestrial mammals) appear able to swim very well, mainly as a means of crossing small tracts of water (rarely exceeding a few hundred metres) or recovering food, or

\* Based on Miles (1968), who estimated the number at that time to be 140,000. Extrapolating on the basis of the increase in world population, 160,000 is a low estimate.

just for playing.\* These observations and similarities in morphology and ecology suggest that our monkey-like ancestors possessed the same swimming abilities. In contrast, the apes appear to be afraid when in water, and in fact (except, maybe, for some gibbons) they drown very readily, either sinking motionless or panicking.

Humans, assisted by sophisticated equipment, can dive deeper and for a longer time than any other mammal; and even without any equipment most humans are able to *learn* swimming and diving as well as the monkeys. However, without such technology and without having been taught to swim, humans drown about as readily as the apes do, and many humans are unable to swim. Therefore, considerable changes in the level of biological water adaptation must have occurred during human phylogeny.

Clearly, this level had already begun to decrease in Devonian times (some 300 million years ago) with the evolution of fish into amphibians, the most dramatic drop having been during primate evolution. Assuming that modern monkeys provide a model for our monkey-like ancestors, and apes for the hominids, this change must have occurred with the Oligocene splitting of the monkey and the ape-hominid lineages (Figure 17.1). From that time onwards our forebears' poor, ape-like water adaptation could only have been compensated for if they had possessed human-like technological and communication (that is teaching) abilities. Palaeoanthropology, however, suggests that these abilities evolved much later; for instance, rafts could hardly have been constructed prior to the invention of tool-making, 2 to 3 million years ago.

## LOSS OF WATER ADAPTATION

What may have been the causes and the consequences of this 300-million-year-long decrease in water adaptation? In evolutionary-biological parlance, this question is formulated as: Did this loss have any selective advantage, or was there a relaxation of the selective pressures that favoured water adaptation? A satisfactory answer could only be given

\* The extant tree-shrews and prosimians are terrestrial, but are generally able to swim; see Figure 17.4 (a) and Sprankel (1961) for tree-shrews; e.g., Eisenberg and Gould (1970) for some tenrec genera, and Walker (1967) for fossil lemurs. *Lemur fulvus* does swim, but *L. catta* probably does not (Tattersall, 1973); *Galago senegalensis* and *G. crassicaudatus* have never been seen in water (G.A. Doyle, personal communication, 1972). Many Old and New World monkeys, including immature individuals (Koford, 1963), although mainly arboreal, are frequently seen to take to the water and seem to enjoy swimming even in cold water (Coon, 1963). Though Kummer (1971) assumed that baboons do not swim, swimming was observed by van Lawick (1972). For swimming in Old World monkeys, see Kern (1964), Gartlan and Brain (1968), Frisch (1968), Schultz (1969), Gautier-Hion (1971), Stern and Oxnard (1973), Judge (1974); for New World monkeys, see Schultz (1969). Also see Table 4.3, this volume.

if we knew fully the morphology, physiology, behaviour and ecology of all our ancestors, as well as the complicated network of selective pressures that shaped them. Though this, unfortunately, is impossible, a number of probabilities can be formulated. The fact that the water adaptations of most vertebrates, even the terrestrial ones, are better than those of man and apes, suggests that the possession of these adaptations has a positive selective value for them, and that the same applies to most of our vertebrate ancestors.

The relatively minor reduction in water adaptation during the evolution from the first air-breathing vertebrates to our monkey-like ancestors was probably mainly the result of a relaxation of the selective pressures favouring a purely aquatic way of life. This was a consequence of ecological pressures – that is, the opening up of a new niche: the terrestrial one. Yet even this frequently involved contact with water and the need to cross it – for instance, to get to food or mates, to flee, or simply to reach the land after accidentally having got into the water. Monkeys, indeed, show the abilities needed to meet these requirements.

How, then, could the prehuman hominids like *Australopithecus* afford *not* to have such abilities? Compensation was probably offered by their intelligence and social behaviour, enabling them, even before the invention, for example, of any floating device, to learn to avoid deep water; to locate, communicate and remember the position of fords and intermingling tree-tops that permitted crossings; to look for branches and logs for floating on and for bridging smaller streams. The poor water adaptation of the modern apes may be explained by some of these mechanisms as well; in addition, its negative selective value would seem to be smaller in the apes' habitat, a tropical forest, than in a savannah habitat, which is generally considered to have been the cradle of the hominids.

Having thus delineated the general causes and consequences of the gradual decrease in water adaptation during evolution from the early vertebrates to man, I will now try to reconstruct the more specific ones – that is, the largely interacting anatomical, physiological, behavioural and environmental changes that have contributed to the process.

## BUOYANCY

It is clear that, to prevent drowning, the individual in water must be able to continue breathing, which implies that the entrance of the airway should, at least occasionally, reach above the water level. The ability to breathe in water, then, depends on the individual's buoyancy and the position of the airway entrance. Buoyancy is determined by the density of the body relative to that of the surrounding water. Unfortunately, body density cannot be inferred from fossil remains, and so our ancestors'

buoyancy is difficult to assess. Thus, we have recourse to comparative zoology; the density of modern mammals like cats, dogs, pigs, guinea-pigs and armadillos appears not to differ significantly from that of man – that is, ranging from about 1.02 to about 1.10 times that of water (Table 17.1). Buoyancy differences between mammalian species appear mainly to be determined by differences between the volumes of their bodies' air spaces. Unfortunately, this had not been taken into account in the measurements described in Table 17.1, which therefore possess limited value.

Table 17.1 A summary of animal and human density

Species	Specification	Density (mean or ranges)	Reference
Man <i>Homo</i>	27 adult females, maximal inspiration	0.9635–1.0614	Rork and Hellebrandt (1937)
Man <i>Homo</i>	14 adult males	1.043–1.086	Krzywicki and Chinn (1967)
Man <i>Homo</i>	99 adult males	1.021–1.097	Behnke <i>et al.</i> (1942)
Man <i>Homo</i>	1 infant 31 days old	1.031	Fomon <i>et al.</i> (1963)
Man <i>Homo</i>	1 infant 55 days old	1.061	Fomon <i>et al.</i> (1963)
Man <i>Homo</i>	1 infant of 5260 g	1.040–1.050	Falkner (1963)
Cat <i>Felis domestica</i>	10 adults, fur removed	1.031–1.080	Walser and Stein (1953)
Cat <i>Felis domestica</i>	1 adult	1.097	Noyons and Jongbloed (1935)
Guinea-pig <i>Cavia</i>	23 females	1.040–1.080	Liuzzo <i>et al.</i> (1958)
Sheep <i>Ovis</i>	14 adults	1.040–1.112	Beeston (1965)
Hog <i>Sus</i>	20 adults	1.018	Lynch and Wellington (1963)
Armadillo <i>Dasypus</i>	—	1.060	Bates (1964)
Dog <i>Canis</i>	4 adults	1.074	Kohlrausch (1930)

In all except one (Rork *et al.*, 1937), the air of the respiratory tract and of the fur was considered as not belonging to the body, thereby reducing their value for buoyancy determination. Angus (1971) reports chimpanzee specific gravity to average 1.025, but this figure is likely to be incorrect, because the observations of Hamlin *et al.* (1964) to which she refers concerned only chimpanzee urine. (References in Wind, 1976a.)

The relative volume of air present in the airways and lungs does not differ greatly in the various primates, with one exception: the laryngeal air-sacs present in the apes are of considerable size and could, when inflated, act as a lifebelt. Unfortunately, it is not known whether our ape- and monkey-like ancestors possessed such air-sacs. Anyway, when in water apes quickly sink despite possessing air-sacs, and the gibbon does not inflate his.

Air trapped in the fur does contribute to floating in many mammals. During evolution from the insectivores to man, this contribution must

have gradually decreased because of the concomitant relative and perhaps absolute decrease in average hair length and fur density that accompanied the increase of body size (larger animals have a relatively smaller body surface and hence a relatively smaller heat loss). In addition, gas present in the digestive tract promotes buoyancy. The shift from a largely vegetarian to an omnivorous diet during evolution from our simian ancestors to the hominids suggests that concomitantly the average volume of such gas decreased somewhat, for the gut of vegetarian mammals usually contains more gas-producing bacteria than that of omnivores and carnivores. In conclusion, it seems that during primate evolution buoyancy has slightly decreased.

### BREATHING

In fossilised prehomimid mammalian and reptilian ancestors, as in virtually all modern vertebrates exemplifying them, the airway entrance appears positioned more superior and anterior than in man; that is to say, the muzzle could act as a snorkel-like organ. Their normal position allows most reptiles and mammals – and must have allowed our ancestors – to continue breathing while in water; only a slight neck extension is necessary.

In contrast, a human, unless he has learned to swim or is equipped with special devices, has much difficulty with inspiration when out of his depth in either fresh or sea water. This results from his poor buoyancy and the usual position of the body and that of the airway entrance. The human body position is likely to be upright because the centre of gravity lies caudally to the centre of the upward forces, the former being located in the upper abdomen and the latter in the lower thorax (Slijper, 1962). In addition, the stressful situation of being immersed tends to make the naïve individual assume a vertical position, rather than a supine or prone one by which the nose and mouth could more easily be brought above the surface. The individual's difficulty with inspiration relates to the fact that the buoyancy of the average human in a vertical position is not great enough to lift the nostrils, and *a fortiori* the mouth, above the water level. The familiarity of every swimmer with this inability can easily be illustrated quantitatively. Even in women, whose bodies contain relatively more (low-density) fat tissue than men's, and even during maximal inspiration, body density (including the air in the lungs) is no lower than 0.981 kg per litre. Assuming that the part of the head cranial to a horizontal plane through the nostrils weighs 2.5 kg, representing some 4 per cent of total body weight in adults and even more in children, a body density of at least 0.96 kg per litre would be required to keep the nostrils above the surface (Wind, 1976a).

## ASPIRATION, HYPOTHERMIA AND OSMOLALITY

Accidental entry into deep water is more likely to cause *aspiration* of water – that is, inhalation of water into the larynx and lower airways – in humans than in our ancestors, for at least four reasons.

- (1) Many people in water resort to mouth-breathing because of the exercise, the sudden cooling and their instinctive crying out; and, as just noted, the mouth is even less easily brought above the surface than the nostrils.
- (2) Humans typically show a gap between the choanae and the laryngeal entrance (Negus, 1962; Wind, 1976b) (Figure 17.2).
- (3) Human metabolic rate and ventilatory drive are higher than in our pre-mammalian ancestors who, being cold-blooded (or ectothermic), needed less oxygen than warm-blooded (or endothermic) mammals.
- (4) Cooling of the body by the ambient water readily causes impairment of normal brain metabolism, leading to mental confusion, loss of memory and unconsciousness, and hence to aspiration (Keatinge, 1969).

During human phylogeny, immersion *hypothermia* has increasingly contributed to our drowning proneness, for the following reasons.

- (1) *Homo sapiens* has spread out from his tropical cradle into colder parts of the earth.
- (2) The mean sea and air temperatures have since Oligocene times steadily decreased (Newell, 1971).
- (3) The dense, hairy coat of our earlier mammalian ancestors (see page 269) has disappeared, resulting in a decrease of insulation.
- (4) Man, possibly like other endotherms, shows upon sudden immersion in cold water a reflex deep inspiration (Patrick, this volume, chapter 14) which, in combination with the gap in the airway (Figure 17.2), increased the risk of aspiration.
- (5) During human phylogeny the brain, especially the cortex, has become more susceptible to lack of oxygen and more important for our survival in water, which is more dependent on learned behaviours. In fact, most animals survive total submersion for a much longer time than humans do.

After water has entered the lungs of a mammal, it is not only the decrease in pulmonary gas exchange that threatens the individual's life. In the alveoli (the tiny compartments of the lungs where this exchange takes place) there is very close contact between the blood and the contents of



the alveolar space. Across the thin tissue layer that separates the blood from that space can occur an exchange not only of gases but also of water and substances dissolved in it. Therefore, when aspiration of fresh water occurs, some of it will enter the pulmonary blood vessels and some of the blood ions will pass into the alveolar space. This latter process results from the ion concentration (or osmolality) of human blood being higher than that of fresh water. By the former process, blood becomes diluted and increases in volume; subsequently, the red blood cells become overloaded with water and may rupture. As a result, many physiological functions become seriously impaired.

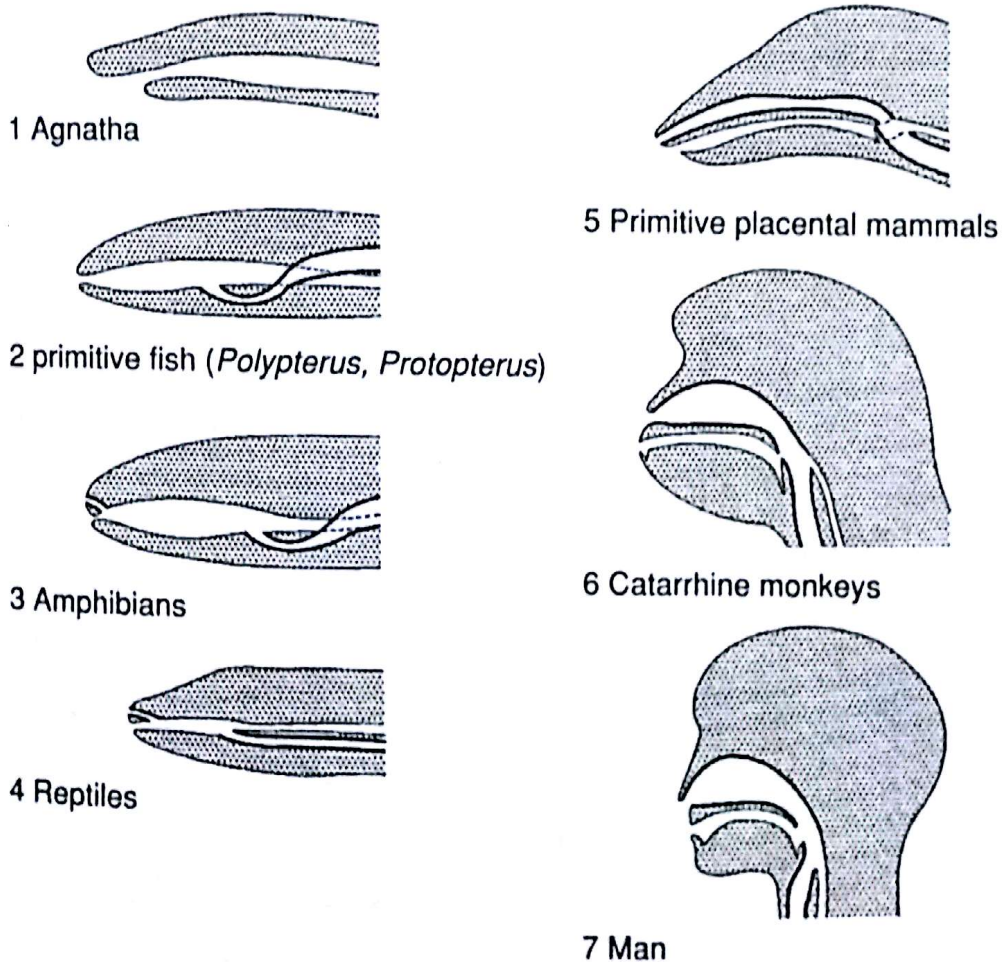


Figure 17.2 Evolution of the human airway as indicated by some representative modern species (from Wind, 1970).

Conversely, aspirated sea water – having an osmolality four times that of human blood – causes the passage of water from the pulmonary blood vessels into the alveolar space and the concomitant passage of the sea-water ions into the blood vessels. Thus, the aspiration of sea water also

results in the impairment of physiological functions, though this is usually less serious than the aspiration of fresh water.

Comparative observations suggest that the concentration of the various types of ions in the blood, as well as the total blood osmolality, of our terrestrial ancestors – and hence the drowning mechanisms described above – were about the same as ours (Wind, 1973). But is our blood not similar to the ocean water of the Devonian, 300 million years ago, when the first terrestrial animals evolved – as suggested by the ‘sea-within-us’ theory mentioned earlier? The answer is no. The oceans have had their present composition for a much longer time, probably for a billion years (MacIntyre, 1970; Holland, 1984; Holland, Lazar and McCaffrey, 1986). Even if we assume that since the start of the water cycle (when evaporation and rain washed ions from the land into the seas) sea water has become four times saltier, the theory does not hold: the inorganic constituents of human blood are not similar to sea water diluted four times (see Figure 17.3). Therefore, in so far as drowning is caused by the osmotic differences described above, it must have been much the same in our terrestrial ancestors as it is in modern man.

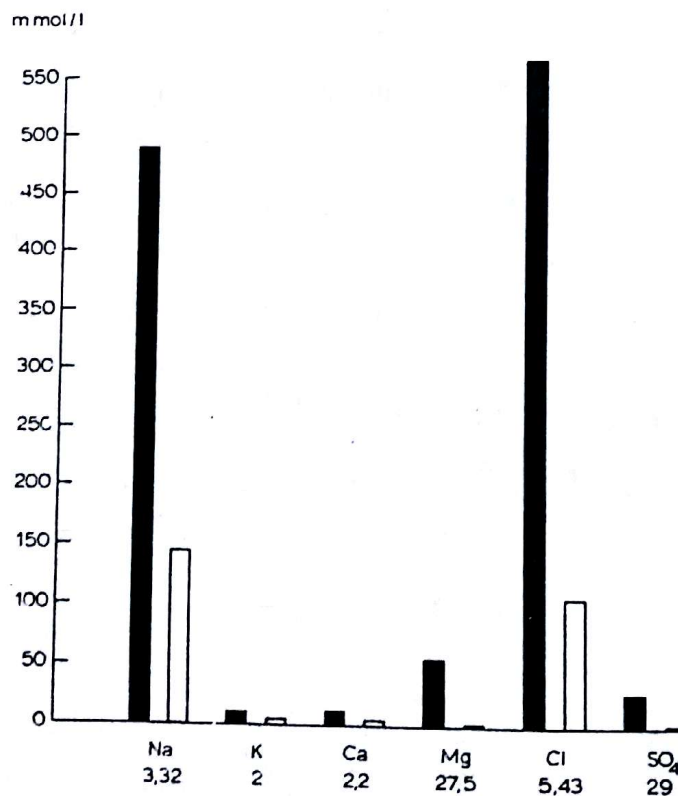


Figure 17.3 Comparison of the concentration of the most common ions present in sea water (black columns) and human blood plasma (white columns).

The sea water/blood ratios, as rendered below the bars, are significantly higher or lower than 4, illustrating that blood plasma cannot be considered as sea water simply diluted four times.

Dying as a result of pulmonary malfunctioning after the penetration of the lungs by water must, for three reasons, have been a more likely event for our mammalian than for our pre-mammalian ancestors.

- (1) In our pre-synapsid (reptilian) ancestors, penetration of the lungs by water must have happened less frequently than in mammals, as already explained.
- (2) The non-mammalian, more saccular, lungs have a much smaller gas-exchanging surface, and in amphibians and fish they function only as auxiliary respiratory organs.
- (3) If our pre-synapsid ancestors had succeeded in removing the aspirated water – for instance, by (primitive) coughing – their lungs could probably have regained their function faster than mammalian lungs would. This can be understood by the fact that the function of the alveoli of mammalian lungs depends, among other things, on the presence of special substances – forming the ‘surfactant’ – which, by lowering the surface tension, prevent the alveoli from collapsing, which they tend to do because of their very small size. So, once the surfactant has been washed out, as occurs with the aspiration of water, the alveoli collapse and gas exchange is severely hampered. This pathology – and especially the irreversible brain damage (resulting from a lack of oxygen lasting for more than a few minutes) and the serious lung infection that often accompany it – explains the bad prognosis of human drowning victims, in spite of all modern medical facilities.

## LOCOMOTION

Survival in water depends not only on the anatomical and physiological properties described above, but also on the ability to move through and out of the water. Locomotion in water is achieved in most vertebrates mainly by undulatory body movements passing from head to tail, or by movements derived from these movements. The ubiquity, in aquatic species, of this mode of propulsion suggests that, in terms of energy cost, it is an extremely efficient one – as is illustrated by its presence in such remotely related organisms as bacteria, protozoans, spermatozoa, and a number of multicellular non-vertebrates. This indicates that the pattern evolved independently several times during evolution, by the mechanism of convergence: similar selective pressures led to this very (if not most) efficient means of locomotion in a liquid environment. In most quadrupedal terrestrial vertebrates, including the primates, this 400-million-year-old motor pattern is still recognisable in walking, in the simultaneous forward and backward moving of the two diagonally positioned limbs.

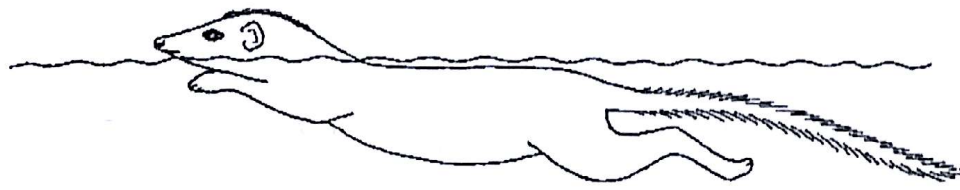
Comparative zoological and palaeontological data indicate that our pre-mammalian ancestors swam by means of these undulatory body movements, greatly assisted by their tails. As regards the modern animals that represent our mammalian ancestors, such as insectivores and non-human primates, when in the water all of them (except the apes) make their usual walking or hopping movements, which appear to result in effective propulsion.

In contrast, the stereotyped walking pattern of man has hardly any propulsive effect in the water. How has this come about? In order to answer this question, I made some observations of a few tree-shrews and a rhesus monkey which had never been in the water before, when they were swimming. They may exemplify, respectively, the condition of our earliest primates and of our monkey-like Oligocene ancestors. Because these animals were moving horizontally, it can be predicted that their forward limb movements encounter substantially less resistance from the water than their backward limb movements. How this happens can be understood by analysing the movements of their limbs during swimming (Figure 17.4).

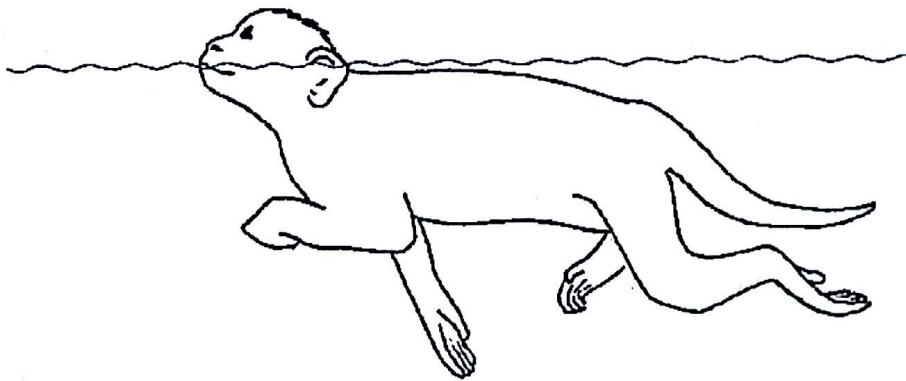
What evolutionary processes, then, have made an equally naïve human, who suddenly finds himself in water higher than his head, barely able to achieve any horizontal displacement? First, this inability can be understood in terms of the loss of the strong muscular tail (which had probably already occurred with the transition from mammal-like reptiles to the first mammals) and the loss of the anatomical and physiological adaptations discussed earlier. Second, and more importantly, the acquisition of the erect posture can explain this inter-primate difference: for man's vertical posture in the water (see page 269) results in the body meeting considerable resistance during horizontal displacement – a resistance that is increased by the relatively flat human body.

An even more important factor in the human inability to swim effectively, however, is the limb adaptations associated with our erect posture: these have reduced the propulsive efficiency of stereotyped walking and, to a lesser extent, of crawling movements, in both the vertical and the horizontal positions. This can be explained by (1) the small ratio of the hands and feet to body size, as compared to the other hominoids; (2) the much reduced range of flexion and extension movements in hands, fingers, feet and toes; (3) the position of the axis of the elbow, with wrist and finger joints not being perpendicular to the walking direction and not being parallel, causing the contra-lateral propulsive forces (if any) to counteract.

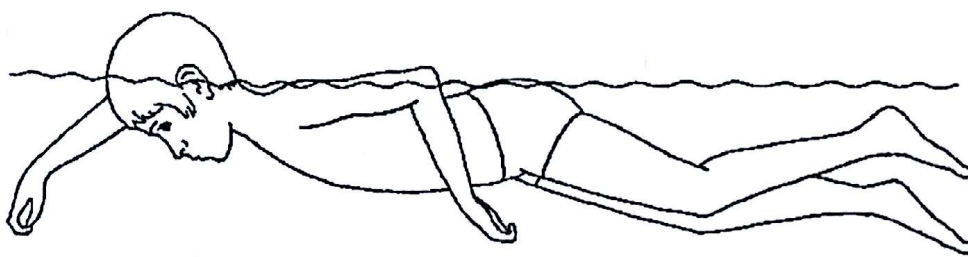
My reason for assuming that this position of the joints is associated with the erect posture is that in virtually all vertebrates, including the synapsids (the mammal-like reptiles), the position of these axes in the limbs that support the body when walking is transverse – that is, perpendicular to



(a)



(b)



(c)

Figure 17.4 Swimming position in (a) the tree-shrew (*Tupaia glis*), (b) the rhesus monkey (*Macaca mulatta*), and (c) man, illustrating that breathing during swimming in pre-Miocene human ancestors must have been much less difficult than in man.

The normal walking movements of these ancestors are likely to have resulted in effective horizontal propulsion, whereas in man this is only possible by quite different locomotor patterns. (a) and (b) are based on original photographs of animals that had never been in the water before.

the longitudinal body axis, or nearly so. Indeed, from a mechanical point of view it is clear that if the axis of the limb joints used during walking was not transverse, the joints would be much more strained and locomotion would cost more energy. In species that have limbs not used for walking, however, there is a relaxation of the selective pressures favouring the transverse position of the axes within these limbs. In addition, during hominid evolution there have been selective pressures favouring this inclination, such as the use of tools, the carrying of infants, food and implements; and maybe also the earlier, suspensory, function of the front limbs, during the arboreal phase of our ancestry.

Humans, like many other mammals which accidentally and for the first time get into water, do not usually show the normal walking pattern, but rather a series of uncoordinated limb and body movements that can best be described as panic movements. These may, to be sure, include some normal locomotor patterns which other mammals soon discover to have a propulsive effect. But such behaviour in man actually adds to his drowning proneness, because it raises oxygen consumption; and it rarely leads him to discover the motor patterns that result in life-saving horizontal or vertical displacement – the swimming strokes. These are usually only acquired after much trial and error. On the other hand, their acquisition is facilitated by (1) the plasticity of human behaviour, usually greater than in animals, meaning that a new motor pattern can more readily be mastered; (2) the accumulation of knowledge and experience as a result of man's intellectual (including linguistic and social) capacities; (3) the extremely movable shoulder joints, which we owe to our arboreal ancestry and which enable humans to practise the breast, butterfly and crawl strokes, all of which considerably decrease the resistance met during the forward stroke. On the other hand, this arm-lifting ability, if utilised during the 'panic phase', may cause the rest of the body to go down.

## HUMAN BEHAVIOUR

In addition to the anatomical, physiological, biochemical and environmental features noted above, other circumstances that contribute to humans' proneness to drowning have to be discussed. These are a series of species-specific behaviours which result, for instance, in alcohol abuse, panic, suicide, traffic accidents (such as shipping disasters), and competition between both individuals and groups. Competition permits people to boost their performances, but can lead to life-endangering behaviour. For instance, the anticipatory capacity of their brains leads many human divers to practise pre-diving hyperventilation. This not only raises the oxygen level of the blood, but it also lowers the carbon dioxide level. Now, it appears that a rise in the carbon dioxide level

rather than a fall in the oxygen level stimulates the respiratory centres in the brain stem so as to cause an irresistible drive to breathe and to surface. However, the increased arterial oxygenation resulting from hyperventilation often insufficiently relieves the tissue (including the brain) hypoxia resulting from continued oxygen usage by the diver; consequently, the carbon dioxide level returns too slowly to the value that normally stimulates the respiratory centre of the brain. Hence, the hyperventilated diver may lose consciousness before noticing that his body needs a fresh supply of oxygen. This mechanism is one of the possible causes of unexplained fatal diving accidents.

### EVIDENCE FROM THE APES?

The curious fact of apes' proneness to drowning, which is quite similar to humans' and, in fact, quite rare in the animal world, needs clarification. Unfortunately, the contribution that the observation of apes can make to the explanation of drowning in our hominid ancestors must, for the time being, remain limited; few experiments have been done because these animals are endangered and precious. It can merely be stated provisionally that the properties that explain apes' proneness to drowning largely coincide with the human ones. The main differences are that in apes (1) the body-covering hairs provide slightly more insulation and buoyancy; (2) hypothermia is less frequent because of the tropical habitat; (3) their behaviour usually involves taking fewer drowning risks than follow from the specifically human behaviours discussed above; and (4) their body density is possibly higher than ours, as suggested by their reportedly quick sinking and by an allometric relationship, in arboreal primates, between the size of the body and that of the limb bones. However, as long as exact data on their body density are lacking, this explanation remains hypothetical.

It may be that apes' usual locomotor movements in the water and, *a fortiori*, their panic movements are as poorly propulsive as man's because of a similar – that is, non-transverse – position of the axes of the front limb joints, due to their terrestrial (knuckle-walking) and arboreal (arm-swinging) locomotor habits.

### 'OCEANIC DESIRES'

As mentioned above (page 265), psychoanalysts and poets have adduced certain arguments in favour of humans' close or, in their terminology, ancient and deep-rooted, ties with water. Unfortunately, science is unable to account for the mental processes behind the back-to-the-ocean and back-to-the-womb associations underlying these arguments. However, one has to realise that (1) the frequency of these associations, even

among those, educated in the Western world, upon whose thoughts the arguments are based, is unknown and therefore its ubiquity is questionable; (2) man is – and even the supposed aquatic ape was – separated from his aquatic, early vertebrate ancestors by millions of generations of non-aquatic species; (3) analogues to these associations have never been demonstrated in modern species representing the ancestral non-aquatic species, while comparative neurophysiology and ethology indicate that their presence is very unlikely indeed; and (4) whether there exists any memory of the intra-uterine submersion manifesting itself in such associations is doubtful.

Much more likely, these associations are the result of typically human mental processes based on a great variety of genes interacting with man's present environment, rather than on hereditary properties retained for millions of years and suddenly becoming apparent in modern humans. Moreover, the associations can more parsimoniously be explained on the basis of (1) an early memory of bathing, which the individual has experienced as pleasant because of the temperature, the relative weightlessness, the usually relaxed situation, and, in so far as the experience took place in childhood, the parental care; and (2) a combination of the typically human metaphorical associations and mental conditions underlying, for instance, escapism.

Finally, one of the alleged physical starting-points of the psychoanalysts and poets is false: as mentioned earlier (page 272), our blood is certainly not similar to the ocean water of the Devonian of 300 million years ago, when the first terrestrial animals evolved.

## THE AAT AND THE SWIMMING BABIES

One of the arguments favouring the AAT has received little attention in the other chapters: the swimming abilities of human infants. The argument is based on two assumptions.

First, that the properties of human infants may be more indicative of those of our ancestors than are those of adults. This assumption derives from Haeckel's 'Biogenetic Law' (1866), postulating that each individual, during his development, 'recapitulates' the evolutionary history of the species. However, this 'Law' only rarely holds, as has been demonstrated by numerous observations and as can be predicted by theoretical evolutionary biology. The properties of living organisms are the result of the operation of genetic variation and natural selection in previous generations; and the selective pressures which have shaped modern developing vertebrates, embryonic and infant, are usually completely different from those that shaped adult ancestral ones. This has resulted in differences in morphology and physiology.



Second, the AAT argument assumes that human infants do indeed swim. To be sure, their usual crawling and kicking limb movements may have some propulsive effect in the water. But the immersed infant will only survive if supported so as to surface for breathing, for this is even more difficult than in adults because of the relatively large infant head. This is illustrated by the frequent reports of babies drowning in shallow water, including bathtubs, and by the extreme neck extension needed for breathing shown even by older children during swimming lessons. Therefore, a baby's 'swimming' should, rather, be understood as a combination of the infant's preference for a horizontal position and his relative weightlessness, which permits his generalised vertebrate motor patterns to be demonstrated. Some mysterious property indicating an aquatic habitat supposedly exploited by some of our hominid ancestors is a much less likely explanation of infant 'swimming'.

## CONCLUSION

A systematic review of the evolutionary background of human proneness to drowning (as summarised in Figure 17.5) shows that the capacity to survive in the water must have gradually decreased during human phylogeny, in so far as it is interpreted in terms of the water adaptations that are usually labelled instinctive, genetic, innate or pre-programmed: in short, the adaptations that are the most obvious in animals and that can be called the biological ones. On the other hand, the capacity to survive can be considered to have increased in so far as it is measured by the adaptations that, in fact, usually prevent man from drowning. To these, environmentally dependent behaviour makes a greater contribution, that is, learning, communicating, applying technology, and so on – in short, the cultural adaptations. These have led humans to avoid water, to learn swimming strokes, to construct floating devices and bridges, and to provide medical care for people rescued from drowning.

Therefore, the paradox mentioned in the introduction to this chapter, already partly elucidated by the disproving of most of the 'hydrophilic' arguments, can now be reduced to the classic *nature–nurture dichotomy*. This too has, in recent decades, been shown to be false: all behaviour, animal as well as human, can be considered the result of an *interaction* of genetically determined (or innate) and environmental processes. It appears that the relative contribution to a specific behaviour of each of the two factors is difficult to quantify; and that at best, when comparing a similar behaviour in different species, it can sometimes be stated that in one species the relative contribution of one of the two factors is more obvious than in the other. (Consider, for instance, flying in insects and 'flying' in man.)

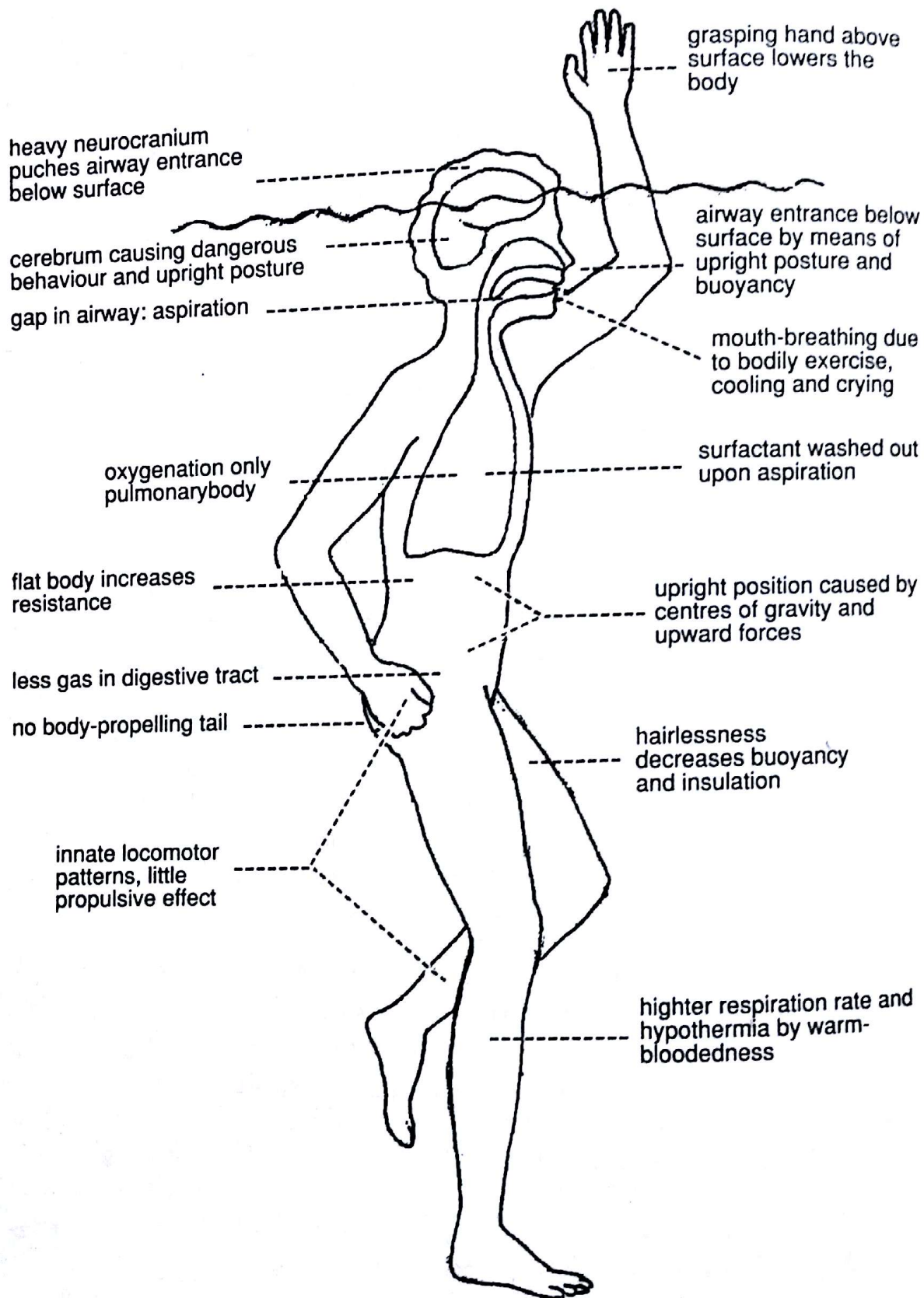


Figure 17.5 Summary of the causes of man's proneness to drowning as they have evolved during his descent from the first vertebrates.

Accordingly, when one tries to quantify the relative contributions of the 'biological' and the 'cultural' water adaptations, one can only say that during human phylogeny there has been a decrease of the former and an increase of the latter. Whether such a shift can be considered as actually having led to a change in the resulting water adaptation level depends on how the latter is defined. When measured by the proportion of the population actually drowning (drowning in one's own body fluids excluded), the human level may well be about the same as our mammalian ancestors' (except, maybe, for the prehuman hominids, where it may have been lower). So the decrease in biological adaptations has probably largely been compensated for by the increase in cultural ones.

Much of the discussion around the AAT can be resolved by taking the nature–nurture issue into account. The central question to be answered, then, by the AAT advocates is: *Could the presumed aquatic apes have learned and taught their offspring their supposed, primatologically extraordinary, swimming and other aquatic skills?* Obviously, a conclusive answer to this question will be rather difficult to find. After all, we do not know anything about the ape's intellectual (or, for that matter, any other) abilities; speculations on its morphology and physiology can only with great audacity be derived from comparative primatology, as long as the first fossil remnant of the aquatic ape is still waiting to be discovered. Therefore, my evolutionary considerations argue against rather than in favour of the theory. This is not to deny, however, that its proposals have had a beneficial – that is, a heuristic – value for palaeoanthropology, in forcing the palaeoanthropological establishment into the often necessary careful reconsideration and reformulation of its own assumptions and ideas. In that sense we should be grateful to Sir Alister Hardy and Elaine Morgan.

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