Life at the Extremes

Frances Ashcroft

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Extract

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INTRODUCTION

In November 1999, the newspapers were dominated by stories of the death of the golf champion Payne Stewart and four others in an air crash. Their Lear jet lost contact with ground control soon after taking off from Orlando, Florida, at an altitude of around 11,300 metres (37,000 feet). Concerned that it might crash in a populated area, US officials scrambled two Air Force fighter planes – to shoot it down, if necessary. They reported that there was no sign of life on board the Lear jet and that the windows were frosted over, which suggests that the aircraft had depressurized and the temperature in the cabin had plunged to that of the outside air. The plane continued on autopilot before finally running out of fuel and crashing in South Dakota, but its occupants would have died far earlier from lack of oxygen. It is not the first time such tragedies have occurred and it is unlikely to be the last, for there is simply not enough oxygen at such high altitudes to support life and the failure of a door or window seal may have fatal consequences.

Like Stewart and his colleagues, many of us live life on the edge, often without even realizing it. We routinely fly around the world at altitudes too high to support life, go sailing in frigid waters, expose ourselves to the dangers of the bends when scuba-diving on holiday, or simply live in places where the winter is so severe that it is not possible to survive outside overnight unaided. Environmental extremes are not the prerogative of the adventurous few – with the help of technology, all of us can tolerate severe conditions with equanimity. Without adequate protection, however, it is a very different matter, and every year, thousands of ordinary people die of cold or heat stress, or succumb to mountain sickness.

Yet despite (or perhaps because of) the danger, people have always been fascinated by life at the extremes. Eight hundred million people in

fifty-nine different nations watched Neil Armstrong set foot on the moon, and the exploits of polar explorers, mountaineers and other adventurers continue to enthral us. We share vicariously in their dangers, and the more narrowly they cheat death, the greater the thrill. There is even a terrible fascination in tragedy. The poignant story of a climber dying alone high up on a mountain, cut off from help by severe weather, yet still able to use his mobile phone to say goodbye to his wife, touches us more than hundreds killed by floods or earthquakes.

The perils of icy winters, freezing waters and scorching summers were recognized in classical times, but in the late nineteenth and early twentieth centuries the advent of balloons, aeroplanes, submarines and deep-sea diving and the growth in polar and mountain exploration, brought new hazards that required a deeper understanding of human physiology if they were to be circumvented. For many people, like deep-sea divers and astronauts, these risks constitute an unavoidable part of their job. But others put their lives in jeopardy for pleasure. Men – and increasingly women – constantly seek new physical challenges. Our own lives are so cushioned from danger and death that we crave adventure. Rather than a traditional holiday sitting on the beach, many people prefer the adrenaline rush of sports such as off-piste skiing, trekking in the high Andes, scuba-diving, bungee-jumping, and paragliding. Our ability to tackle these ventures with comparative safety has evolved from a partnership between physiologists interested in how the human body works and intrepid adventurers seeking to push the limits ever further.

This book describes the physiological response of the body to extreme environments and explores the limits to human survival. It considers what happens when you find yourself locked in the freezer, trapped under the ice, or stranded in the desert without water; why an elite mountaineer can climb Everest without supplementary oxygen, yet if an aircraft depressurized at the same altitude its occupants would lose consciousness in seconds; why astronauts may find it difficult to stand without fainting on their return to Earth; why deep-sea divers suffer from bone disease; and other such puzzles. Solving these problems has presented many challenges for physiologists, both physical and intellectual.

The philosopher Heraclitus once remarked that 'War is the father of all things'. As far as the physiology of extreme environments is concerned, he had a point. Military personnel are routinely exposed to

adverse conditions – in just the last few years, we have seen wars fought in the freezing Balkan winter, the searing heat of the Kuwaiti desert, and the high mountain passes between India and Pakistan. Many investigations of the effects of heat, cold, pressure and altitude on humans were initiated, directly or indirectly, as a result of this military imperative. It is also salutary to realize that it was not primarily for scientific reasons, but rather because of the Cold War, that humans ventured into space.

Sport – a far more acceptable form of competition between nations than war – has also stimulated much interest in human physiology and in recent years sports physiology has developed into a distinct discipline. Most of us take some form of exercise, even if it is only the occasional sprint for the bus. But there is a limit to how fast we can run, even with training, and exercise imposes its own stresses on the body. This rather different, but related, type of extreme is discussed in Chapter Five.

The scientific study of human physiology is based on controlled experiment. Because the potential hazards may be poorly understood, and the limits to survival unknown, animals are often used in initial experiments to identify the type of dangers involved and to obtain an indication of the safety limits for a person. Ultimately, however, there is no substitute for humans and physiologists have often experimented on themselves – and still do. Some of them even used their children. The eminent scientist J.B.S. Haldane once remarked that his father had used him as a guinea-pig ever since he was four years old (although he did not appear unduly discouraged by this experience, for he followed his father into a distinguished career as a physiologist).

There are good reasons why physiologists use themselves and their colleagues as experimental subjects. It is often easier to understand something by experiencing it yourself than from a second-hand description; and, particularly in the past, the work was often dangerous and unpredictable so that many scientists preferred to take a risk themselves, rather than ask a volunteer to do so. It was also quicker – finding a volunteer takes time. The early physiologists needed considerable courage, as well as skill and scientific curiosity. Sitting in a cramped steel chamber filled with pure oxygen while the pressure is increased, knowing that you are doomed to go into convulsions that may cause you permanent damage, but not knowing exactly when it will happen, is a far from pleasant experience. But as discussed in Chapter Two, such experiments were vital for the safety of deep sea-divers.

People may react very differently to physiological stress, and their behaviour under normal conditions is no indication of the way they will perform under stress: tough commandos can succumb rapidly to mountain sickness, yet their more fragile female companions suffer no ill effects. So while it may not be essential for understanding the scientific principles involved, when it comes to practical applications, the experiments must be repeated on a larger number of volunteers. Unfortunately, not all human guinea-pigs have been volunteers. There are a number of infamous cases in which experiments have been carried out on people without their consent. The Nazis used the inmates of Dachau, the Russians reputedly used prisoners of war, the Japanese experimented on the Manchurian population, and convicted criminals have been used by Western governments even in recent times. Although the latter theoretically may have been volunteers, the choice between execution or reprieve and participation in a, possibly dangerous, experiment, is not really a choice. Moreover, in many cases, the subjects were not fully informed of the risks. Many of these experiments were concerned with testing the effects of chemicals or radiation. But not all. Some were designed to enhance our understanding of how humans cope with extreme conditions. As we shall see, there is also a dark side to the study of life.

Human experiments are still needed, for new types of survival suit for cold water immersion must constantly be tested, and space suits are still a developing technology. But today, experiments are conducted under stringent safety conditions, and the limits to life, obtained from accident and experiment, are well documented.

The study of human physiology has obvious practical applications, but for many scientists (perhaps the majority), the real spur is curiosity; they are driven by Kipling's 'six honest serving men' – by 'What and Where and When, and How and Why and Who'. As a consequence, the life of the physiologist, like that of many experimental scientists, is a curious combination of elation and frustration – elation when a pet hypothesis turns out to be correct, and frustration when, for technical reasons, an experiment does not work and the question it was designed to test cannot be answered. All too often, there seems to be too little of the former and too much of the latter. But piecing together a puzzle, solving an intellectual challenge, or finding a new fact, can be very rewarding, and the sharp excitement of discovery is an exhilaration like no other I have experienced. It is this emotional high that sustains you

throughout the long hours needed to obtain the results.

Although many people may find it difficult to appreciate the delights of the scientific life, most will understand the elation of reaching the summit of a mountain, and the sense of achievement that comes from running a marathon. Some physiologists are fortunate because they manage to combine both intellectual and physical adventure. Those seeking to answer questions about how the body works, for example, have often had to go to extreme ends – to the mountain tops, the depths of the sea, the Antarctic icefields, or even into space – to find the answers. The knowledge they gained has been invaluable, for as this book will show, physiology is not just a laboratory science, but something applicable to everyday life. In our battle to survive at the limits a knowledge of physiology, the 'logic of life', is crucial.

Climbing Kilimanjaro

KILIMANJARO IS ONE of the most beautiful mountains in the world. A perfect volcanic cone, it straddles the border between Kenya and Tanzania, rising 5895 metres (19,340 feet) from the African plains. At its feet lies the Amboseli game reserve with its teeming herds of wildebeest, antelope and elephants. Its summit is crowned with icefields of breathtaking beauty. Despite its great height, no mountaineering skills are required to reach the top of Kilimanjaro; it is a walk which takes less than three and a half days from base to summit. Unfortunately, the rapidity of this ascent is fraught with danger for the unwary.

We set off through the rain forest early in the morning. The air was warm, heavy and damp, redolent of the tropics. It smelt like the Palm House at Kew. Our feet made little sound on the soft moist earth of the forest floor. Monkeys swung chattering through the canopy far above us. It was difficult to realize that we were climbing all day as we wound our way though the cool dark shade of the forest. Late in the afternoon we emerged from the trees to find a small triangular hut nestling against the side of the mountain in meadows reminiscent of those of the Alps. The sun winked out and night fell almost instantly, since Kilimanjaro lies on the equator.

Next day we climbed to around 3700 metres, crossing high grasslands and passing through vegetation unique to these altitudes in Africa and South America. Giant Senecio, a relative of the common groundsel, towered above our heads. Immense lobelia flowers, like giant blue candles, stood sentinel beside the path. The thinner air was exhilarating, convincing me that I was immune to mountain sickness.

The following morning it was very cold. As we walked, we left the vegetation behind us and entered a high rock saddle hanging between the twin peaks of Kilimanjaro. To our right stood Mawenzi and to our left the higher Kibo, our ultimate goal. Despite the flatness of the terrain, I felt tired. It seemed a long way across the saddle and even further to the tin huts sited at the foot of the final climb – a giant ash cone.

We spent a third, cold and uncomfortable night at 4600 metres. Sleep was impossible. My head hurt and the world spun around me when I closed my eyes. Despite a lack of appetite, I had forced down lukewarm food and tepid tea (at this altitude, water boils at 80°C), conscious that I would need energy for the coming climb. Now I felt sick. My companions' breath came in jangling gasps interrupted by such long silences that I wanted to shake them awake for fear they had permanently stopped breathing. I waited, shivering, for time to pass.

We rose at two o'clock in the morning to begin the long trek to the summit, for our guide had persuaded us to see dawn break over Mawenzi peak. I now know his real reason for the early start was far more prosaic: we climbed in the dark, so as not to see the enormity of the task that lay before us. The path wound in a shallow zig-zag up a 1200-metre cone of fine grey ash and small stones to the edge of the crater. Even at sea-level, climbing sand dunes is hard work; at this altitude it was torture. For every hard-won three steps up, I slid two steps back. My boots filled with fine abrasive dust. My legs felt unsteady and out of control, so that I staggered wildly, further compromising my progress on the shifting sands. One of my companions collapsed, unable to go further. It is not easy to tell who will succumb to mountain sickness; he was probably the fittest and strongest of our group but now he sat gasping for air like a stranded fish, his only option to descend. We continued, the guide lighting the way ahead with a hurricane lantern held low by his side. Progress was not easy. I fought for breath and struggled to take a few steps between each ever-longer rest. It was only by sheer effort of will and the (quite foolish) determination not to be beaten that I managed the last few hundred feet. I collapsed at the top of the crater rim, my head feeling as if knives were being driven through it, my vision swimming with black dots.

A medley of images danced across my mind. I sat in a dusty Cambridge lecture theatre, shafts of sunlight falling across the desks, listening to a discourse on mountain sickness. What exactly had the lecturer

said? It seemed important but it slipped away as brilliantly coloured zig-zags marched majestically before my eyes. The air shivered and a snow leopard slunk around the edge of the ice floes which sail within the crater of Kilimanjaro. It glared at me with yellow eyes and twitched its tail. I looked away and the sun rose, flooding the sky with a soft pink and orange glow, tinting with gold the edges of the thin clouds, Mawenzi peak a sharp black silhouette against a Botticelli sky. I sat on the top of Kibo's crater rim, the cold wind blowing through my hair, and I knew the illusions were a warning. My brain was slowly shutting down through lack of oxygen. It was past time to leave.

I slithered and slipped drunkenly down the steep slope, suddenly afraid of cerebral oedema, yet fearful of falling forwards and tobogganing uncontrollably downwards if I went too fast. With every step I felt more alive, as oxygen flooded through my brain. I ran the scree, skiing down the mountain in great long slides, slaloming around the rocks and boulders. It took only half an hour to cover the distance I had taken over five hours to climb so painfully.

I was lucky; the previous week two people had died of mountain sickness on the same trek. My own brush with mountain sickness had no permanent effects, but I had been foolish. We had climbed too high too fast: 5895 metres in three and a half days. The high peaks may not be reserved for the gods, but they must be treated with respect.