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PREFACE

WHY SEVEN?

The number seven has always held a central place in myth, music and literature. The world was created in seven days; there are seven notes in the diatonic scale; and, according to Shakespeare, there are seven ages of man. In conceiving this book, I was also drawn to the number seven and so I asked myself: which of the seven chemical elements help us best to understand our world and how it came to be? I also thought about which have had the greatest influence on my life and which I have experienced most directly.

Carbon, which in combination with hydrogen forms the bulk of crude oil, was obvious. So too was iron, the backbone of all industry since the eighteenth-century Industrial Revolution (and without which no oil could be extracted). Silver came next to my mind as the element that made possible photography, one of my lifelong passions. Looking for further inspiration, I found in my library my school copy of the periodic table, which organises the elements according to their chemical properties. As I scanned the chequerboard, from left to right, I passed along the elements, each containing one more proton in its nucleus than the last.[1]

First is hydrogen, vitally important in combination with so many other elements to form the structures of life and, as a result, fossil fuels.[2] But in its own right, hydrogen did not seem world-changing. Passing further along, I came to silicon, sitting directly below carbon as both elements contain four electrons in their outermost shell. I thought back to my time on the board of Intel, the pioneers of the silicon microchip. Their ubiquitous nature in our day-to-day lives – in making possible our digital world

– made silicon another obvious choice for inclusion.

Appearing in its world-changing form at the same time as silicon in the 1940s was titanium, the next element I stopped at. Once it was going to be the miracle element, a dream that did not quite work out. But what most drew me to it was its little-known use as a whitening agent in almost everything that is white. I learnt of this through business with Quebec Iron and Titanium in Canada. It surprised me then, and continues to astound me now.

Traversing the remainder of this line, I passed a number of familiar metals: iron, cobalt, nickel, copper, zinc. All of them are so important but, I wondered, which one actually changed the world. I stuck with my choice of iron and left copper behind; electrical engineering will have its fair share with silicon.

I passed silver, the element of photography, and then in the line below reached gold. Its universal allure led to its use in coins, the basis of currencies for centuries and the foundation of international trade. Gold became a great motivator for global expansion and imperial ambition. But the same attraction has led many to commits acts of immense cruelty. It continues to captivate us today.

Finally, I reached the bottom of the periodic table, six elements in tow. Here I came to uranium, whose nucleus, having accumulated so many protons and neutrons on the journey down the periodic table, is very unstable. That characteristic defined the post-war era on a day in 1945 in a city in Japan, and for that reason it is the seventh element.

Time and again, while writing this book, I have revisited the periodic table, questioning this choice of seven elements and questioning the choice of the number seven. Iron, carbon, gold, silver, uranium, titanium, silicon; each time, *these* seven elements have stood out as having most powerfully changed the course of human history. These seven elements have shaped the vast complexities of our social, economic and cultural existence. These seven elements hold a grip on our emotions – and our history – like no others.

I cannot think of an eighth.

The Essence of Everything

The elements are the source of all human prosperity and a great deal of human suffering. In numerous ways, I have seen both. Over the course of my forty-five years in business, including twelve as the leader of BP, I saw the very best and the very worst that the elements can do for humanity.

As a child, when I asked my father to tell me a story, improbably he really did begin with 'once upon a time …'. That is where the story of the elements begins. If you pointed a very powerful radio telescope out into the sky, you would detect a stream of low-energy radiation coming from every direction. This radiation has been travelling undisturbed through space ever since the first elements were formed some fourteen billion years ago. It is the remnant, or echo, of the Big Bang that gave birth to the Universe.

At first, the Universe was nothing more than a fluid of pure energy. As it expanded and so cooled, particles, which are the basic building blocks of matter – protons, neutrons and electrons – appeared from the fluid. The Universe kept cooling and allowed the particles to fuse together to become helium and deuterium (a heavy form of hydrogen). This process of nuclear fusion would later give birth to all the other elements inside the stars.

I would ask my father to tell me stories about science, but he would not because he did not like the subject. To keep me quiet, he gave me a book of Christmas lectures by the physicist Sir William Bragg, originally delivered at the Royal Institution in 1923. In *Concerning the*

Nature of Things, Bragg describes how atoms of different elements could join to form the vast complexity of the world around us.[1] At some stage, they had then combined to create life itself with its astounding ability to shape our chaotic world. I was amazed that, at a fundamental level, our own lives and even our thoughts are simply the result of these atomic interactions. In the early twentieth century, Bragg and his son Lawrence were pioneers in the field of x-ray crystallography. They used x-rays to look at matter in unprecedented detail.[2] With these 'new eyes', the Braggs transformed our view of the elements, just as John Dalton's atomic theory and Mendeleev's periodic table had done in the century before.[3]

As a teenager growing up in southern Iran, where my father was stationed, I was surrounded by oil and its awe-inspiring industry. I was thrilled by watching the huge machinery which drilled the wells that produced the oil. As I had learnt from Bragg's lectures, oil is composed of hydrogen and carbon. 'Under the proper stimulus and in the presence of oxygen,' wrote Bragg, 'the atoms rush into fresh combination, developing great heat in doing so.'[4] I was fascinated by the process of transformation which produced the energy to transform society. Carbon, in the form of hydrocarbons, brought people heat, light and mobility, and so created freedom and new ways of life.

Nowhere was that more evident than in China. On my first visit in 1979, only three years after the death of Mao, the country was poor, bleak and bland. There were hardly any motor vehicles on the streets, merely a monochrome sea of miserable men and women in grey-green suits travelling by foot or by bicycle. Today China feels like the centre of the world, overflowing with skyscrapers and cars and bustling with people. Hundreds of millions of people have found prosperity in this transformation, a transformation that has been fuelled by carbon-based energy, of which China is now the world's largest consumer.[5]

In Azerbaijan, at the other end of Asia, I saw how hydrocarbons could bring great benefits to a country. The most visible beneficiaries appeared to be the ruling elite associated with allegations of corruption and the abuse of power, but there were real economic benefits to its citizens. The oil pipeline from Baku, the capital of Azerbaijan on the Caspian

Sea, to Ceyhan on the shore of the Turkish Mediterranean, completed in 2005, stretches for a thousand miles, through three countries and the lands of more than a hundred ethnic groups. More than 30,000 contracts were signed to secure the rights of the local people. As a result, the pipeline and the oil that flows through it have provided many benefits to the people of Azerbaijan, tripling the average income over the last decade.[6]

China and Azerbaijan are just two examples of how hydrocarbons, our primary fuel source since the Industrial Revolution, can transform our way of life for the better. But there and elsewhere, I saw carbon bring pollution and pain alongside prosperity.

En route to Anchorage, Alaska, in 1989, I looked out of the window of the plane to see below us the *Exxon Valdez* that had earlier run aground. Oil was flowing out of her side, coating the water and the white ice in satin black. It was an extraordinarily powerful image, which remains with me to this day, of the harmful impact that hydrocarbons can have on the natural world.

Elsewhere, greed, fuelled by carbon, has caused more than physical hurt to people and the environment; it has changed people's very nature, bringing out their darkest side. In the 1990s, I was responsible for a huge Colombian oilfield, located in the foothills of the Llanos Mountains in an area rife with drug lords, paramilitaries and bandits who were drawn to the oil like flies to a carcass. To protect ourselves we built a tall barbed-wire fence and surrounded ourselves with armed guards. People outside the fence soon grew to despise us and kidnappings and attacks became frighteningly common. They saw us profiting from a natural resource that they believed belonged to them, and they wanted a share of the returns to remain in their community. We responded by building taller fences, travelling everywhere by helicopter and bringing in the Colombian army. All sides were overcome with fear, anger and greed, fuelling human division, hatred and ultimately war.[7]

But carbon is not my only focus. Of the ninety-eight naturally occurring chemical elements on the periodic table, there are six others that have most powerfully changed the course of human history: iron, gold, silver, uranium, titanium and silicon. This book traces the story of how they have

enabled progress as well as destruction, of the power they give humans to do good and evil, and of their capacity to shape our future.

Progress

For the greater part of our existence, we lived more like lower-order animals than humans, spending our days on the most basic of activities, searching for food, water and shelter. In that existence, there was no choice: everything was done to survive. About 50,000 years ago, humanity took a 'Great Leap Forward' with a wave of behavioural innovations that included the start of complex language, the first cave art, the origins of religious ritual and the beginnings of barter trade.[8] The timing and the origins of these changes are disputed, but there is little doubt that it was intimately connected to our use of the elements; new ways of carving limestone, creating iron pigments, and controlling wood fires. The creative use of the elements made our survival less burdensome and gave humanity the tools to lay the foundations of civilisation. Beyond this, they have continued to give us the means to do great things, to give us more freedom and to give us more choices in the conduct of our daily lives.

Human progress can be measured by our ability to harness greater amounts of energy and so transform the world far beyond what would be achievable by human strength alone. No energy source has been more potent than carbon, in the form of wood, coal, oil and natural gas. Coal enabled industrial revolutions in Europe and the US, as it gave us the ability to expand our productivity; an amount of coal equal to the weight of an average man can do the same work as that man working for a hundred days. We have used carbon to accomplish extraordinary feats in our endeavours, whether in travel, trade, art, engineering or communication.

Carbon, too, has unlocked the potential of the other elements: with its energy, we have smelted iron, mined gold and enriched uranium. It is the creative force that underpins all others. Carbon's most powerful alliance is with iron. We need only to look around, at the railways, the factories and the skyscrapers, to see how the wealth of industry and the fabric of society are built from iron.

In the most specialist applications, for which iron is too weak or heavy,

futuristic titanium metal has been used to accomplish triumphs of air and sea exploration. But far more pervasive than titanium's use as a metal in supersonic aircraft and deep-diving submarines is its use as bright white titanium dioxide. In that form, titanium is everywhere around us, feeding our obsession with purity, cleanliness and façade. Milk is no purer and shirts are no cleaner as a result of the titanium dioxide that whitens them. It is their whiteness that satisfies some urge within us.

However ubiquitous, we do not normally notice titanium's presence in our regular lives. The same is true of silver in its use in photography. The impact of photography is so significant since it has enabled us to see the world in a way that we would not have otherwise been able to do. It has shown us the vivid reality of the Second World War, the Vietnam War and the Rwandan genocide. It has impacted the way we think about each other, by putting a human face to our leaders, our neighbours and our enemies. Perhaps most powerfully of all, silver has changed the way we think about ourselves. It records our memories, our histories and our relationships not as words or thoughts, but as lasting images.

Silver is much better known, along with gold, as a store of value and medium of trade. Ever since the first coins were minted over two millennia ago, possibly in the ancient city of Sardis, merchants have relied on the standards established by these rare and precious metals for international commerce. Gold and silver have enabled the movement of people and materials and the cross-fertilisation of ideas. They have not only helped to spread the economic benefits of the Earth's elements across the world but have also stimulated human progress.

Silicon is the final element of the story, and perhaps the most transformative of all. It was first used to make objects of beauty in the form of glass beads, vases and mirrors. Later it became a common, utilitarian building material, draped around the outside of skyscrapers, satisfying the human desire for light. But silicon's greatest impact has been in the last half-century as the inner workings of computers. In this 'Silicon Age', we calculate and communicate effortlessly, with instant access to the sum of human knowledge. Silicon's impact on society is perhaps greatest when placed in the hands of the ordinary citizen. As the heart of modern communication, silicon has supported political revolutions in the Arab Spring

and broken down the geographical barriers that have restrained our social interactions for millennia.

Destruction

The elements have created progress, innovation and prosperity, but they have also wreaked great destruction on people and nature. Carbon's destructive force is felt through the indirect consequences of its extraction and consumption. During the Industrial Revolution in Great Britain, the air became thick with smoke and thousands died in mine collapses and explosions. As industrial revolutions followed around the world, the consequences were similar. Only in the last two decades have we come to realise carbon's most insidious effect. Burning hydrocarbons has released billions of tonnes of carbon dioxide into our atmosphere, trapping the energy of the sun and potentially changing the world's climate.

Often the destructive forces of the elements are unleashed by deliberate human action. The strength of iron has made it not only the beneficial tool of peaceful industry, but also the brutally efficient and bloody weapon of war, in swords, guns, ships and tanks. Iron has also been the subject of conflict: for almost a century, the great powers of Europe went to war to obtain control of the vast iron ore and coke reserves of the Ruhr and Alsace Lorraine.

Throughout my career I have seen how oil, the 'black gold', has driven men's passions, desires and greed. The world has become very dependent on oil and therefore anxious about securing reliable supplies of it. Oil confers powers on leaders who control it but is sometimes more of a curse than a benefit to the countries that produce it.

But in the history of the elements, humanity has committed the greatest acts of cruelty in its quest for ownership of gold. Over half a millennium, this precious metal has inspired intense greed, madness and violence, driving people to plunder, kill and enslave.

One element stands above all others in its destructive power. Uranium is the element which defined the post-war era. It is tied to one of the darkest moments in human history: the detonation of an atomic bomb over Hiroshima. From that dark moment came the great hope that we could

use uranium's extraordinary energy for creation rather than destruction. But the great hope of cheap and abundant nuclear-generated electricity has been dogged by dread and fear. Uranium continues to command power on the global stage as we struggle to control the spread of nuclear weapons. By unlocking its power, we have created the potential for our own destruction.

Human choice

So great is the influence of these elements that they have taken on personalities of their own: uranium, the powerful and the fearful; gold, the alluring and hypnotic; and iron, the strong and dependable. But, in a sense, their story is nothing more than the story of seven arrangements of protons, neutrons and electrons, the pattern which gives each element its character. It is tempting to think of these characteristics as inevitable or even uncontrollable. But each element's character is determined by the choices we make. We are in control of our own destiny, and the elements are merely the tools for our progress or our destruction. We are not slaves of the elements; we are their masters.

And so this book is not about the elements *per se*. Rather, it is about how people have harnessed the intrinsic powers of the elements to shape our cultural, economic and social existence, and in doing so have transformed our world. I have seen much of this transformation first-hand, and so this story of seven elements also contains a personal element. It takes you on a journey of my adventures with oil barons in Russia, merchants in Venice, tribesmen in Colombia and computer wizards in Silicon Valley. And along the way, we explore the stories of remarkable times and remarkable individuals – Pizarro, Rockefeller, Carnegie, Curie – and their deep connection with the elements. They changed the course of history. They demonstrated the elements' latent potential to inspire and equip good men to do good and evil men to do evil. Whether we continue to use these elements for common human progress and prosperity, or for individual greed and iniquity, is up to us.

The American physicist Richard Feynman summed it up through a Buddhist proverb: 'To every man is given the key to the gates of heaven; the same key opens the gates of hell.'[9]