The Universe in a Single Atom

The Convergence of Science and Spirituality

His Holiness the Dalai Lama

HARMONY

HIS HOLINESS THE

Dalai Lama

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In each atom of the realms of the universe,
There exist vast oceans of world systems.

The Great Flower Ornament,
an ancient Buddhist scripture

PROLOGUE

I was never myself trained in science. My knowledge comes mainly from reading news coverage of important scientific stories in magazines like *Newsweek*, or hearing reports on the BBC World Service and later reading textbooks on astronomy. Over the last thirty years I have held many personal meetings and discussions with scientists. In these encounters, I have always attempted to grasp the underlying models and methods of scientific thought as well as the implications of particular theories or new discoveries. But I have nonetheless thought deeply about science—not just its implications for the understanding of what reality is but the still more important question of how it may influence ethics and human values. The specific areas of science that I have explored most over the years are subatomic physics, cosmology, and biology, including neuroscience and psychology. Given that my own intellectual training is in Buddhist thought, naturally I have often wondered about the interface of key Buddhist concepts and major scientific ideas. This book is a result of that long period of thinking and of the intellectual journey of a Buddhist monk from Tibet into the world of bubble chambers, particle accelerators, and FMRI (functional magnetic resonance imaging).

Many years after I went into exile in India, I came across an open letter from the 1940s addressed to the Buddhist thinkers of Tibet. It was written by Gendün Chöphel, a Tibetan scholar who not only had mastered Sanskrit but also, uniquely among Tibetan thinkers of his time, had a good command of English. He traveled extensively in British India, Afghanistan, Nepal, and Sri Lanka in the 1930s. This letter, composed toward the end of his twelve-year trip, was amazing to me. It articulates many of the areas in which there could be a fruitful dialogue between Buddhism and modern science. I discovered that Gendün Chöphel's observations often coincide remarkably with my own. It is a pity that this letter did not attract the attention it deserved, partly because it was never properly published in Tibet before I came into exile in 1959. But I find it heartwarming that my journey into the scientific world has a precedent within my own Tibetan tradition. All the more so since Gendün Chöphel came from my native province of Amdo. Encountering this letter so many years after it was written was an impressive moment.

I remember a disturbing conversation I had had only a few years earlier with an American lady who was married to a Tibetan. Having heard of my interest in science and my active engagement in dialogue with scientists, she warned me of the danger

science poses to the survival of Buddhism. She told me that history attests to the fact that science is the “killer” of religion and advised me that it was not wise for the Dalai Lama to pursue friendships with those who represent this profession. By taking this personal journey into science, I suppose I have stuck my neck out. My confidence in venturing into science lies in my basic belief that as in science so in Buddhism, understanding the nature of reality is pursued by means of critical investigation: if scientific analysis were conclusively to demonstrate certain claims in Buddhism to be false, then we must accept the findings of science and abandon those claims.

Because I am an internationalist at heart, one of the qualities that has moved me most about scientists is their amazing willingness to share knowledge with each other without regard for national boundaries. Even during the Cold War, when the political world was polarized to a dangerous degree, I found scientists from the Eastern and Western blocs willing to communicate in ways the politicians could not even imagine. I felt an implicit recognition in this spirit of the oneness of humanity and a liberating absence of proprietorship in matters of knowledge.

The motivation for my interest in science is more than merely personal. Even before I came into exile, it was clear to me and others in the country that one of the underlying causes for Tibet’s political tragedy was its failure to open itself to modernization. As soon as we arrived in India, we set up Tibetan schools for refugee children with a modern curriculum, which included scientific education for the first time. By then I had come to recognize that the essence of modernization lies in the introduction of modern education, and at the heart of modern education there must be a command of science and technology. My personal commitment to this educational project has led me to encourage even the monastic colleges, whose primary role is to teach classical Buddhist thought, to introduce science into their curriculum.

As my comprehension of science has grown, it has gradually become evident to me that, insofar as understanding the physical world is concerned, there are many areas of traditional Buddhist thought where our explanations and theories are rudimentary when compared with those of modern science. But at the same time, even in the most highly developed scientific countries, it is clear that human beings continue to experience suffering, especially at the emotional and psychological level. The great benefit of science is that it can contribute tremendously to the alleviation of suffering at the physical level, but it is only through the cultivation of the qualities of the human heart and the transformation of our attitudes that we can begin to address and overcome our mental suffering. In other words, the enhancement of fundamental human values is indispensable to our basic quest for happiness. Therefore, from the perspective of human well-being, science and spirituality are not unrelated. We need both, since the alleviation of suffering must take place at both the physical and the psychological levels.

This book is not an attempt to unite science and spirituality (Buddhism being the example I know best) but an effort to examine two important human disciplines for the purpose of developing a more holistic and integrated way of understanding the world

around us, one that explores deeply the seen and the unseen, through the discovery of evidence bolstered by reason. I am not attempting a scholarly treatment of the potential points of convergence and difference between Buddhism and science—I leave that to professional academics. Rather, I believe that spirituality and science are different but complementary investigative approaches with the same greater goal, of seeking the truth. In this, there is much each may learn from the other, and together they may contribute to expanding the horizon of human knowledge and wisdom. Moreover, through a dialogue between the two disciplines, I hope both science and spirituality may develop to be of better service to the needs and well-being of humanity. In addition, by telling the story of my own journey, I wish to emphasize to the millions of my fellow Buddhists worldwide the need to take science seriously and to accept its fundamental discoveries within their worldview.

This dialogue between science and spirituality has a long history—especially with respect to Christianity. In the case of my own tradition, Tibetan Buddhism, for various historical, social, and political reasons, the full encounter with a scientific worldview is still a novel process. The implications of what science has to offer are still not wholly clear. Regardless of different personal views about science, no credible understanding of the natural world or our human existence—what I am going to call in this book a worldview—can ignore the basic insights of theories as key as evolution, relativity, and quantum mechanics. It may be that science will learn from an engagement with spirituality, especially in its interface with wider human issues, from ethics to society, but certainly some specific aspects of Buddhist thought—such as its old cosmological theories and its rudimentary physics—will have to be modified in the light of new scientific insights. I hope this book will be a contribution to the critical project of enlivening the dialogue between science and spirituality.

Because my aim is to explore issues of the deepest significance for our contemporary world, I have wished to communicate with the widest possible audience. This is not easy, given the sometimes complex reasoning and argumentation in both science and Buddhist philosophy. In my eagerness to make the discussion accessible, I may on occasion have oversimplified issues. I am grateful to my two editors, my longtime translator Thupten Jinpa and his colleague Jas' Elsner, for their assistance in helping me to articulate my ideas as lucidly as possible in English. I also wish to thank the numerous individuals who have helped them and commented on the various stages of the manuscript. Above all, I am grateful to all the scientists who have met with me, been so generous with their time, and shown such extraordinary patience in explaining complex ideas to a sometimes slow student. I regard them all as my teachers.

I

Reflection

I have spent many years reflecting on the remarkable advances of science. Within the short space of my own lifetime, the impact of science and technology on humanity has been tremendous. Although my own interest in science began with curiosity about a world, foreign to me at that time, governed by technology, it was not very long before the colossal significance of science for humanity as a whole dawned on me—especially after I came into exile in 1959. There is almost no area of human life today that is not touched by the effects of science and technology. Yet are we clear about the place of science in the totality of human life—what exactly it should do and by what it should be governed? This last point is critical because unless the direction of science is guided by a consciously ethical motivation, especially compassion, its effects may fail to bring benefit. They may indeed cause great harm.

Seeing the tremendous importance of science and recognizing its inevitable dominance in the modern world fundamentally changed my attitude to it from curiosity to a kind of urgent engagement. In Buddhism the highest spiritual ideal is to cultivate compassion for all sentient beings and to work for their welfare to the greatest possible extent. From my earliest childhood I have been conditioned to cherish this ideal and attempt to fulfill it in my every action. So I wanted to understand science because it gave me a new area to explore in my personal quest to understand the nature of reality. I also wanted to learn about it because I recognized in it a compelling way to communicate insights gleaned from my own spiritual tradition. So, for me, the need to engage with this powerful force in our world has become a kind of spiritual injunction as well. The central question—central for the survival and well-being of our world—is how we can make the wonderful developments of science into

something that offers altruistic and compassionate service for the needs of humanity and the other sentient beings with whom we share this earth.

Do ethics have a place in science? I believe they do. First of all, like any instrument, science can be put to good use or bad. It is the state of mind of the person wielding the instrument that determines to what end it will be put. Second, scientific discoveries affect the way we understand the world and our place in it. This has consequences for our behavior. For example, the mechanistic understanding of the world led to the Industrial Revolution, in which the exploitation of nature became the standard practice. There is, however, a general assumption that ethics are relevant to only the application of science, not the actual pursuit of science. In this model the scientist as an individual and the community of scientists in general occupy a morally neutral position, with no responsibility for the fruits of what they have discovered. But many important scientific discoveries, and particularly the technological innovations they lead to, create new conditions and open up new possibilities which give rise to new ethical and spiritual challenges. We cannot simply absolve the scientific enterprise and individual scientists from responsibility for contributing to the emergence of a new reality.

Perhaps the most important point is to ensure that science never becomes divorced from the basic human feeling of empathy with our fellow beings. Just as one's fingers can function only in relation to the palm, so scientists must remain aware of their connection to society at large. Science is vitally important, but it is only one finger of the hand of humanity, and its greatest potential can be actualized only so long as we are careful to remember this. Otherwise, we risk losing our sense of priorities. Humanity may end up serving the interests of scientific progress rather than the other way around. Science and technology are powerful tools, but we must decide how best to use them. What matters above all is the motivation that governs the use of science and technology, in which ideally heart and mind are united.

For me, science is first and foremost an empirical discipline that provides humanity with a powerful access to understanding the nature of the physical and living world. It is essentially a mode of inquiry that gives us fantastically detailed knowledge of the empirical world and the underlying laws of nature, which we infer from the empirical data. Science proceeds by means of a very specific method that involves measurement, quantification, and intersubjective verification through repeatable experiments. This, at least, is the nature of scientific method as it exists within the current paradigm. Within this model, many aspects of human existence, including values, creativity, and spirituality, as well as deeper metaphysical questions, lie outside the scope of scientific inquiry.

Though there are areas of life and knowledge outside the domain of science, I have noticed that many people hold an assumption that the scientific view of the world should be the basis for all knowledge and all that is knowable. This is scientific materialism. Although I am not aware of a school of thought that explicitly propounds this notion, it seems to be a common unexamined presupposition. This view upholds a

belief in an objective world, independent of the contingency of its observers. It assumes that the data being analyzed within an experiment are independent of the preconceptions, perceptions, and experience of the scientist analyzing them.

Underlying this view is the assumption that, in the final analysis, matter, as it can be described by physics and as it is governed by the laws of physics, is all there is. Accordingly, this view would uphold that psychology can be reduced to biology, biology to chemistry, and chemistry to physics. My concern here is not so much to argue against this reductionist position (although I myself do not share it) but to draw attention to a vitally important point: that these ideas do not constitute scientific knowledge; rather they represent a philosophical, in fact a metaphysical, position. The view that all aspects of reality can be reduced to matter and its various particles is, to my mind, as much a metaphysical position as the view that an organizing intelligence created and controls reality.

One of the principal problems with a radical scientific materialism is the narrowness of vision that results and the potential for nihilism that might ensue. Nihilism, materialism, and reductionism are above all problems from a philosophical and especially a human perspective, since they can potentially impoverish the way we see ourselves. For example, whether we see ourselves as random biological creatures or as special beings endowed with the dimension of consciousness and moral capacity will make an impact on how we feel about ourselves and treat others. In this view many dimensions of the full reality of what it is to be human—art, ethics, spirituality, goodness, beauty, and above all, consciousness—either are reduced to the chemical reactions of firing neurons or are seen as a matter of purely imaginary constructs. The danger then is that human beings may be reduced to nothing more than biological machines, the products of pure chance in the random combination of genes, with no purpose other than the biological imperative of reproduction.

It is difficult to see how questions such as the meaning of life or good and evil can be accommodated within such a worldview. The problem is not with the empirical data of science but with the contention that these data alone constitute the legitimate ground for developing a comprehensive worldview or an adequate means for responding to the world’s problems. There is more to human existence and to reality itself than current science can ever give us access to.

By the same token, spirituality must be tempered by the insights and discoveries of science. If as spiritual practitioners we ignore the discoveries of science, our practice is also impoverished, as this mind-set can lead to fundamentalism. This is one of the reasons I encourage my Buddhist colleagues to undertake the study of science, so that its insights can be integrated into the Buddhist worldview.

2

Encounter with Science

I was born into a family of simple farmers who used cattle to plow their field and, when the barley was harvested, used cattle to trample the grain out of the husk. Perhaps the only objects that could be described as technological in the world of my early childhood were the rifles that local warrior nomads had probably acquired from British India, Russia, or China. At the age of six I was enthroned as the Fourteenth Dalai Lama in the Tibetan capital, Lhasa, and embarked upon an education in all aspects of Buddhism. I had personal tutors who gave me daily classes in reading, writing, basic Buddhist philosophy, and the memorization of scriptures and rituals. I was also given several *tsenshap*, which literally means "philosophical assistants." Their primary job was to engage me in debate on issues of Buddhist thought. In addition, I would participate in long hours of prayers and meditative contemplation. I spent periods in retreat with my tutors and sat regularly for two hours at a time four times a day in a meditation session. This is a fairly typical training for a high lama in the Tibetan tradition. But I was not educated in math, geology, chemistry, biology, or physics. I did not even know they existed.

The Potala Palace was my official winter residence. It is a huge edifice, occupying the entire side of a mountain, and is supposed to have a thousand rooms—I never counted them myself. In my spare moments as a boy, I amused myself by exploring some of its chambers. It was like being on a perpetual treasure hunt. There were all kinds of things, mainly the belongings of former Dalai Lamas and especially of my immediate predecessor, preserved there. Among the most striking of the palace's contents were the reliquary stupas containing the remains of the previous Dalai Lamas, reaching back to the Fifth, who lived in the seventeenth century and enlarged the

Potala to its present form. Amid the assorted oddities I found lying about were some mechanical objects which belonged to the Thirteenth Dalai Lama. Most notable were a collapsible telescope made from brass, which could be attached to a tripod, and a hand-wound mechanical timepiece with a rotating globe on a stand that gave the time in different time zones. There was also a large stash of illustrated books in English telling the story of the First World War.

Some of these were gifts to the Thirteenth Dalai Lama from his friend Sir Charles Bell. Bell was the Tibetan-speaking British political officer in Sikkim. He had been the Thirteenth Dalai Lama's host during his brief sojourn in British India when he fled in 1910 at the threat of invasion by the armies of the last imperial government of China. It is curious that exile in India and the discovery of scientific culture are things bequeathed to me by my most immediate predecessor. For the Thirteenth Dalai Lama, as I later found out, this stay in British India was an eye-opening experience, which led to a recognition of the need for major social and political reforms in Tibet. On his return to Lhasa, he introduced the telegraph, set up a postal service, built a small generating plant to power Tibet's first electric lights, and established a mint for the national coinage and the printing of paper currency. He also came to appreciate the importance of a modern, secular education and sent a select group of Tibetan children to study at Rugby School in England. The Thirteenth Dalai Lama left a remarkable deathbed testament, which predicted much of the political tragedy to come and which the government that succeeded him failed to understand fully or to heed.

Among the other items of mechanical interest acquired by the Thirteenth Dalai Lama were a pocket watch, two film projectors, and three motorcars—two Baby Austins from 1927 and a 1931 American Dodge. As there were no drivable roads across the Himalayas or in Tibet itself, these cars had to be disassembled in India and carried across the mountains by porters, mules, and donkeys before being put back together again for the Thirteenth Dalai Lama. For a long time these were the only three automobiles in all Tibet—and pretty useless they were, since there were no roads outside Lhasa on which one could drive them. These various items, the telltale signs of a technological culture, exercised great fascination on a naturally curious and somewhat restless boy. There was a time, I remember very clearly, when I would rather fiddle with these objects than study philosophy or memorize a text. Today I can see that these things were in themselves no more than toys, but they hinted at a whole universe of experience and knowledge to which I had no access and whose existence was endlessly tantalizing. In a way, this book is about the path to discovering that world and the wonderful things it has to offer.

I did not find the telescope a problem. Somehow it was quite obvious to me what it was for, and I was soon using it to observe the bustling life of Lhasa town, especially the marketplaces. I envied the sense of abandon with which children of my age could run about in the streets while I had to study. Later I used the telescope to peer into the night sky above the Potala—which offers, in the high altitude of Tibet, one of the most spectacular views of the stars. I asked my attendants the names of the stars and constellations.

I knew what the pocket watch was for but was much more intrigued by how it worked. I puzzled over this for some time, until curiosity got the better of me and I opened up the case to look inside. Soon I had dismantled the entire item, and the challenge was to put it back together again so that it actually worked. Thus began what was to become a lifelong hobby of dismantling and reassembling mechanical objects. I mastered this process well enough to become the principal repairer for a number of the people I knew who owned watches or clocks in Lhasa. In India later on, I did not have much luck with my cuckoo clock, whose poor cuckoo got attacked by my cat and never recovered. When the automatic battery watch became common, my hobby got much less interesting—if you open one of these, you find hardly any mechanism at all.

Figuring out how to use the Thirteenth Dalai Lama's two hand-cranked film projectors was much more complicated. One of my attendants, an ethnic Chinese monk, worked out how to make one of them function. I asked him to set it up so that I could watch the very few films we had. Later we got hold of a sixteen-millimeter electrically powered projector, but it kept breaking down, partly because the generator which powered it was faulty. Around this time, I guess in 1945, Heinrich Harrer and Peter Aufschnaiter, Austrians who had escaped over the Himalayas from a British prisoner of war camp in northern India, arrived in Lhasa. Harrer became a friend of mine, and I would occasionally turn to him to help fix the projector. We could not get many films, but numerous newsreels of the great events of the Second World War made it across from India, giving the story from an Allied perspective. There were also reels of VE Day, of the coronation of King George VI of England and Laurence Olivier's film of Shakespeare's *Henry V,* as well as some of Charlie Chaplin's silent movies.

My fascination for science began with technology, and indeed I saw no difference between the two. When I met Harrer, who was much better with things mechanical than anyone I knew in Lhasa, I presumed his expertise in science was as profound as his command over the few mechanical objects we had in the Potala. It is funny that years later I discovered he had no professional scientific background—at that time I thought all white men had deep knowledge of science.

Inspired by my success in dismantling watches and repairing the projector, I got more ambitious. My next project was to understand the mechanics of the automobile. The man in charge of driving and looking after the cars was called Lhakpa Tsering; he was a bald fellow whose ill temper was legendary. If he accidentally banged his head while working beneath the car, he would become so angry that he would thrash and bang it again. I made friends with him so that he would allow me to examine the engine while he was repairing it and eventually show me how to drive.

One day I sneaked one of the Austins out for a solo drive but had a small accident and broke the left headlight. I was terrified of what Babu Tashi, another man in charge of the cars, might say. I managed to find a replacement headlight, but it was of clear glass, whereas the original had been frosted. After some thought, I found a solution. I reproduced the light's frosted appearance by covering it with molten sugar. I never

knew if Babu Tashi found out. If he did, at least he never punished me.

In one crucial area of modern science, Harrer was most helpful to me; this was world geography. Within my personal library was a collection of English volumes on the Second World War, which gave detailed accounts of the participation in the war by a great many nations, including Japan. My adventures with the movie projector, fixing clocks, and trying to drive a car gave me an inkling of what the world of science and technology might be about. On a more serious level, after I had been invested with the leadership of Tibet at the age of sixteen, I embarked on state visits to China in 1954 and India in 1956, which left a strong impression. The Chinese army had already invaded my country, and I was involved in a long and delicate negotiation searching for an accommodation with the Chinese government.

My first foreign trip, when I was in my late teens, took me to Beijing, where I met Chairman Mao, Chou En-lai, and other leaders of the regime. This state visit included a series of excursions to cooperative farms and major utilities such as hydroelectric dams. Not only was this the first time I was in a modern city with paved roads and cars but it was also when I first met real scientists.

In 1956 I went to India to take part in the 2,500th anniversary of the Buddha's death, whose main event took place in Delhi. Later, the Indian Prime Minister Jawaharlal Nehru became something of a counselor to me and a friend, as well as my host in exile. Nehru was scientifically minded; he saw India's future in terms of technological and industrial development and had a profound vision of progress. After the formal celebration of the Buddha's final passing away, I saw many parts of India—not only the pilgrimage sites like Bodhgaya, where the Buddha attained full awakening, but also major cities, industrial complexes, and universities.

It was then that I had my first encounters with spiritual teachers who were seeking the integration of science and spirituality, such as the members of the Theosophical Society in Madras. Theosophy was an important spiritualist movement in the nineteenth and early twentieth centuries that sought to develop a synthesis of human knowledge, Eastern and Western, religious and scientific. Its founders, including Madame Blavatsky and Annie Besant, were Westerners but spent much time in India.

Even before these official trips, I came to recognize that technology is in fact the fruit, or expression, of a particular way of understanding the world. Science is the basis of these expressions. Science, however, is the specific form of inquiry and the body of knowledge derived from it that give rise to this understanding of the world. So although my initial fascination was with the technological artifacts, it is this—the scientific form of inquiry rather than any particular industry or mechanical toy—that has come to intrigue me most deeply.

As a result of talking to people, especially professional scientists, about science, I noticed certain similarities in the spirit of inquiry between science and Buddhist thought—similarities that I still find striking. The scientific method, as I understand it, proceeds from the observation of certain phenomena in the material world, leads to a

theoretical generalization, which predicts the events and results that arise if one treats the phenomena in a particular way, and then tests the prediction with an experiment. The result is accepted as part of the body of wider scientific knowledge if the experiment is correctly conducted and may be repeated. However, if the experiment contradicts the theory, then it is the theory that needs to be adapted—since the empirical observation of phenomena has priority. Effectively, science moves from empirical experience via a conceptual thought process that includes the application of reason and culminates in further empirical experience to verify the understanding offered by reason. I have long been gripped with a fascination for the parallels between this form of empirical investigation and those I had learned in my Buddhist philosophical training and contemplative practice.

Although Buddhism has come to evolve as a religion with a characteristic body of scriptures and rituals, strictly speaking, in Buddhism scriptural authority cannot outweigh an understanding based on reason and experience. In fact the Buddha himself, in a famous statement, undermines the scriptural authority of his own words when he exhorts his followers not to accept the validity of his teachings simply on the basis of reverence to him. Just as a seasoned goldsmith would test the purity of his gold through a meticulous process of examination, the Buddha advises that people should test the truth of what he has said through reasoned examination and personal experiment. Therefore, when it comes to validating the truth of a claim, Buddhism accords greatest authority to experience, with reason second and scripture last. The great masters of the Nalanda school of Indian Buddhism, from which Tibetan Buddhism sprang, continued to apply the spirit of the Buddha's advice in their rigorous and critical examination of the Buddha's own teachings.

In one sense the methods of science and Buddhism are different: scientific investigation proceeds by experiment, using instruments that analyze external phenomena, whereas contemplative investigation proceeds by the development of refined attention, which is then used in the introspective examination of inner experience. But both share a strong empirical basis: if science shows something to exist or to be non-existent (which is not the same as not finding it), then we must acknowledge that as a fact. If a hypothesis is tested and found to be true, we must accept it. Likewise, Buddhism must accept the facts—whether found by science or found by contemplative insights. If, when we investigate something, we find there is reason and proof for it, we must acknowledge that as reality—even if it is in contradiction with a literal scriptural explanation that has held sway for many centuries or with a deeply held opinion or view. So one fundamental attitude shared by Buddhism and science is the commitment to keep searching for reality by empirical means and to be willing to discard accepted or long-held positions if our search finds that the truth is different.

By contrast with religion, one significant characteristic of science is the absence of an appeal to scriptural authority as a source of validating truth claims. All truths in science must be demonstrated either through experiment or through mathematical proof. The idea that something must be so because Newton or Einstein said so is

simply not scientific. So an inquiry has to proceed from a state of openness with respect to the question at issue and to what the answer might be, a state of mind which I think of as healthy skepticism. This kind of openness can make individuals receptive to fresh insights and new discoveries; and when it is combined with the natural human quest for understanding, this stance can lead to a profound expanding of our horizons. Of course, this does not mean that all practitioners of science live up to this ideal. Some may indeed be caught in earlier paradigms.

With regard to the Buddhist investigative traditions, we Tibetans owe a tremendous debt to classical India, the birthplace of Buddhist philosophical thinking and spiritual teaching. Tibetans have always referred to India as "the Land of the Noble Ones." This is the country that gave birth to the Buddha, and to a series of great Indian masters whose writings have fundamentally shaped the philosophical thinking and the spiritual tradition of the Tibetan people—the second-century philosopher Nagarjuna, the fourth-century luminaries Asanga and his brother Vasubandhu, the great ethical teacher Shantideva, and the seventh-century logician Dharmakirti.

Since my flight from Tibet in March 1959, a large number of Tibetan refugees and I have been extremely fortunate to find a second home in India. The president of India in my early years in exile was Dr. Rajendra Prasad, a deeply spiritual man and respected legal scholar. The vice president, who later became president, was Dr. Sarvepalli Radhakrishnan, whose professional and personal interests in philosophy were widely known. I vividly remember an occasion when, in the middle of a discussion of some philosophical question, Radhakrishnan spontaneously recited a stanza from Nagarjuna's classic, *Fundamental Wisdom of the Middle Way*. It is most remarkable that since Independence in 1947, India has maintained the noble tradition of investing noted thinkers and scientists with the nation's presidency.

After a difficult decade of adjustment, helping to settle the community of around eighty thousand Tibetan refugees in various parts of India, setting up schools for the youth, and attempting to preserve the institutions of a threatened culture, I began my international travels toward the end of the 1960s. In addition to sharing my understanding of the importance of basic human values, advocating interreligious understanding and harmony, and promoting the rights and freedoms of the Tibetan people, I have taken the opportunity during my travels to meet distinguished scientists to discuss my interests, develop my knowledge, and delve ever deeper into my understanding of science and its methods. Even as early as the 1960s, I had discussed aspects of the interface between religion and science with some valued visitors to my residence in Dharamsala, in north India. Two of the most memorable meetings of this period were with the Trappist monk Thomas Merton, who had a deep interest in Buddhism and opened my eyes to Christianity, and the scholar of religion Huston Smith.

One of my first teachers of science—and one of my closest scientific friends—was the

German physicist and philosopher Carl von Weizsäcker, the brother of the West German president. Though he would describe himself as a politically active professor of philosophy who had been trained as a physicist, in the 1930s von Weizsäcker was employed as an assistant to the quantum physicist Werner Heisenberg. I will never forget von Weizsäcker's infectious and inspiring example as a man who constantly worried about the effects—especially the ethical and political consequences—of science. He sought relentlessly to apply the rigor of philosophical inquiry to the activity of science, in order to continually challenge it.

In addition to lengthy informal discussions on various occasions, I was fortunate to receive some formal tutorial sessions from von Weizsäcker on scientific topics. These were conducted in a style not so different from the one-to-one knowledge transmissions that are a familiar form of teaching in my own Tibetan Buddhist tradition. On more than one occasion, we were able to set aside two full days for a retreat when von Weizsäcker gave me an intensive tutorial on quantum physics and its philosophical implications. I feel deeply grateful for his tremendous kindness in granting me so much of his precious time and also for the depth of his patience, especially when I found myself struggling with a difficult concept, which I must admit was not infrequent.

Von Weizsäcker used to insist on the importance of empiricism in science. Matter can be known, he said, in two ways—it can be phenomenally given or it can be inferred. For instance, a brown spot on an apple can be seen with the eye; it is phenomenally given. But that there is a worm in the apple is something we may infer from the spot and from our general knowledge of apples and worms.

In Buddhist philosophy, there is the principle that the means by which a specific proposal is tested should accord with the nature of the subject under analysis. For example, if a proposal pertains to facts about the world that are observable, including one's own existence, then it is by empirical experience that the proposal may be affirmed or rejected. Thus, Buddhism puts the empirical method of direct observation first. If, by contrast, the proposal relates to generalizations that are induced from our experience of the world (for instance, the transient nature of life or the interconnectedness of reality), then it is by reason, primarily in the form of inference, that the proposal may be accepted or rejected. Thus, Buddhism accepts the method of reasoned inference—very much on the model presented by von Weizsäcker.

Finally, from the Buddhist point of view, there is a further level of reality, which may remain obscure to the unenlightened mind. Traditionally, a typical illustration of this would be the most subtle workings of the law of karma, and the question of why there are so many species of beings in the world. Only in this category of propositions is scripture cited as a potentially correct source of authority, on the specific basis that for Buddhists, the testimony of the Buddha has proven to be reliable in the examination of the nature of existence and the path to liberation. Although this principle of the three methods of verification—experience, inference, and a reliable authority—is implicit in the earliest developments of Buddhist thought, it was the

great Indian logicians Dignaga (fifth century) and Dharmakirti (seventh century) who first formulated it as a systematic philosophical methodology.

In this final example, Buddhism and science clearly part company, since science, at least in principle, does not acknowledge any form of scriptural authority. But in the first two domains—the application of empirical experience and reason—there is a great methodological convergence between the two investigative traditions. In our day-to-day life, however, we regularly and habitually use the third method of testing claims about reality. For example, we accept the date of our birth on the verbal testimony of our relatives and in relation to the written testimony of a birth certificate. Even in science, we accept the results published by experimenters in peer-reviewed journals without ourselves repeating their experiments.

My engagement with science was undoubtedly given greater depth through my encounter with the remarkable physicist David Bohm, who had one of the greatest intellects and most open minds I have ever come across. I first met him in England in 1979, during my second trip to Europe, and we both felt an immediate rapport—indeed, I later found out that Bohm too had been an exile, having been forced to leave America during the persecutions of the McCarthy era. We began a lifelong friendship and a mutual intellectual exploration. David Bohm guided my understanding of the subtlest aspects of scientific thought, especially in physics, and exposed me to the scientific worldview at its best. While listening very carefully in a detailed conversation with a physicist like Bohm or von Weizsäcker, I would feel that I could grasp the intricacies of the full argument; unfortunately, when the sessions were over, there was often not a great deal left! My long discussion with Bohm over two decades fueled my own thinking about the ways Buddhist methods of inquiry may relate to those used in modern science.

I particularly admired Bohm’s extraordinary openness to all areas of human experience, not only in the material world of his professional discipline but in all aspects of subjectivity, including the question of consciousness. In our conversations, I felt the presence of a great scientific mind which was prepared to acknowledge the value of observations and insights from other modes of knowledge than the objective scientific.

One of the particular qualities Bohm exemplified was the fascinating and essentially philosophical method of conducting a scientific inquiry by means of thought experiments. Simply put, this practice involves conjuring an imaginary scenario within which a specific hypothesis is tested by examining what consequences it may hold for assumptions normally thought to be irrefutable. A great deal of Einstein’s work on the relativity of space and time was conducted by means of such thought experiments, which tested the understanding of physics that was current in his time. A famous example is the twins paradox, in which one brother remains on earth while another travels on a spaceship at a rate approaching the speed of light. For the brother on the ship, time should slow down. If he were to return ten years later, he would find that his brother on earth would have aged significantly more than he had. The full appreciation

of this paradox requires an understanding of complex mathematical equations, which unfortunately lies beyond my skill.

In my engagement with science, I have always been extremely excited by this method of analysis because of its close parallels with Buddhist philosophical thinking. Before we met, Bohm had spent much time with the Indian spiritual thinker Jiddu Krishnamurti, and even participated in a number of dialogues with him. On numerous occasions Bohm and I explored the ways objective scientific method may relate to meditative practice, which is, from the Buddhist point of view, equally empirical.

Although the basic emphases on empiricism and reason are similar in Buddhism and science, there are profound differences concerning what constitutes empirical experience and the forms of reasoning employed by the two systems. When Buddhism speaks of empirical experience, it has a broader understanding of empiricism, which includes meditative states as well as the evidence of the senses. Because of the development of technology in the last two hundred years, science has been able to extend the capacity of the senses to degrees unimaginable in earlier times. Hence scientists can use the naked eye, admittedly with the help of powerful instruments like microscopes and telescopes, to observe both remarkably minute phenomena, like cells and complex atomic structures, and the vast structures of the cosmos. On the basis of the expanded horizons of the senses, science has been able to push the limits of inference further than human knowledge has ever reached. Now, in response to traces left in bubble chambers, physicists can infer the existence of the constitutive particles of atoms, including even the elements within the neutron, such as quarks and gluons.

When I was a child experimenting with the telescope belonging to the Thirteenth Dalai Lama, I had a vivid experience of the power of inference based on empirical observation. In Tibetan folklore we speak of the rabbit on the moon—I believe the Europeans see a man instead of a rabbit. Anyway, one full-moon night in autumn, when the moon was especially clear, I decided to examine the rabbit with my telescope. To my surprise, I saw what looked like shadows. I was so excited that I insisted my two tutors come and peer through the telescope. I argued that the presence of shadows on the moon was proof that the moon is lit by the sun’s light in the same way as the earth. They looked puzzled but agreed that the perception of shadows on the moon was indubitable. Later, when I saw photographs of lunar craters in a magazine, I noticed the same effect—that within the crater there was a shadow on one side but not on the other. From this I inferred that there must be a light source casting the shadow, just as on the earth. I concluded that the sun must be the source of the light that caused the shadows on the craters of the moon. I was very excited when I discovered later that this is in fact the case.

Strictly speaking, this process of reasoning is neither uniquely Buddhist nor uniquely scientific; rather it reflects a basic activity of the human mind which we naturally employ on a daily basis. The formal introduction to inference as a principle of logic for young trainee monks involves the illustration of how one may infer the presence of fire from a distance by seeing a column of smoke over a mountain pass,

and from fire it would be normal in Tibet to infer human habitation. One can easily imagine a traveler, thirsty after a long day's walking, who feels the need for a cup of tea. He sees the smoke and thus infers fire and a dwelling where he can get shelter for the night. On the basis of this inference, the traveler is able to fulfill his desire to drink tea. From an observed phenomenon, directly evident to the senses, one can infer what remains hidden. This form of reasoning is common to Buddhism and science.

During my first visit to Europe, in 1973, I had the honor to encounter another of the twentieth century's great minds, the philosopher Sir Karl Popper. Like myself, Popper was once an exile—from his native Vienna during the period of Nazi rule—and he became one of the most articulate critics of totalitarianism. So we found much in common. Popper was an old man when I met him, over seventy, with bright eyes and great intellectual sharpness. I could guess how forceful he must have been in his youth from the passion he showed when we discussed the question of authoritarian regimes. In this meeting, Popper was more worried about the growing threat of communism, the perils of totalitarian political systems, the challenges of safeguarding individual liberty, and the sustenance of an open society than he was interested in exploring questions pertaining to the relations of science and religion. But we did discuss problems concerning method in science.

My English was not as good then as it is now, and my translators not so skilled. Unlike empirical science, philosophy and method are much more demanding to discuss. As a result, I benefited less perhaps from my opportunity to meet Popper than I did from meetings with figures like David Bohm and Carl von Weizsäcker. But we struck up a friendship, and I saw him again whenever I came to England, including a memorable visit in 1987 for tea at his house at Kenley in Surrey. I have a particular love of flowers and gardening, especially of orchids, and Sir Karl took great pride in giving me a tour of his own lovely garden and greenhouse. By this time I had discovered how great Popper's influence was in the philosophy of science, and especially on the question of scientific method.

One of Popper's principal contributions lay in clarifying the relative roles of inductive and deductive reasoning in the postulation and proof of scientific hypotheses. By induction, we mean building to a generalization from a series of empirically observed examples. Much of our everyday knowledge of the relations of cause and effect is inductive; for instance, on the basis of repeated observations of the correlation between smoke and fire, we make the generalization that where there is smoke there is fire. Deduction is the opposite process, operating from the knowledge of general truths to particular observations. For example, if one knows that all the cars produced in Europe after 1995 use only lead-free gas, when one hears that a particular car belonging to a friend was made in 2000, one can deduce that it must use lead-free gas. Of course, in science these forms are much more complex, especially deduction, because it involves the use of advanced mathematics.