STRATEGIC ORIENTATIONS FOR INNOVATION

SURFING TOWARDS THE FUTURE

CHILE ON THE 2025 HORIZON

NATIONAL COUNCIL ON INNOVATION FOR COMPETITIVENESS

2013

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AN INVITATION TO CHILE

The pages of this book contain the results of many meetings, dialogues and discussions. They reflect the privilege of having been given the mission of thinking about our country and its future from the space that innovation opens up; in other words, from what is new and necessary to become better integrated into a world of accelerated changes that is complex, competitive and globalized.

We have had to navigate in waters riddled with recipes, methodologies and models, and we have done so in a style that may be puzzling at first, because it challenges the way we usually think about innovation. This is precisely why it took us a while to reach our destination, because our country deserved that the commitment of taking responsibility for what is essential to our future ought to be done at an appropriate pace—not limited by the contingency—and with a broad view of the horizon.

We can say, without fear of exaggerating, that we are living at a unique historical moment: a change of era. And, in this context, no country has its future assured. The most successful ones will be those most capable of "reading" reality and designing more efficient mechanisms to deal with the transformations. But this competitive scenario is also characterized by the duty to assume our responsibility, as a human race, for the survival of the planet, which has long been deteriorating due to the pace and intensity of our interventions.

As we face these challenges, our actions and our policies—but above all, our ways of relating with each other and our imagination and ability to invent the future—will play an increasingly relevant role. In this era, "innovate or die" appears to be much more than a motto.

For us, as Chileans, the most fundamental and urgent change is cultural. We are being called upon to generate new attitudes, new practices and new styles that may help us overcome the blindness, fears, comforts, tranquilizing illusions and other moods that prevent us from taking risks, making commitments, and assuming a central role with a single certainty: that innovation must become the cornerstone of our country's full development .

We wish to infect our compatriots with this sense of urgency for a cultural change, and this is the goal of this publication. Everything it contains is, ultimately, an invitation to have conversations and imagine the future that is necessary, the future that is possible for us. The idea is to begin a conversation that aims to mobilize us towards new destinations, new practices and new policies. And not just now, but as a permanent exercise.

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LETTER FROM THE PRESIDENT

In these pages, the reader will find what may be called a "*travel logbook*"—the notes recorded during the adventure of discovering how to define strategic orientations for an innovation policy.

Although the formal mandate of this Council is to propose a strategy, the first thing we did as we took up this task was to express our dissent. This was not an arbitrary or capricious whim, but a conviction that strategies are impossible in an era of accelerated changes.

The path we embarked upon was one of those where events cause changes in direction, and where different travelers, surprises, opportunities and hazards are continually appearing along the way. A path impossible to predict, where we had to invent something different from the normal planning process. At first, as in all adventures, we were unsure of exactly what we would encounter, but we did understand where we did not want to end up and what motivated us.

Of course, some obstacles began to appear along the way. In the first place, we clashed against a view of innovation based on the traditional formula of "Science + Technology + Creativity = Innovation," which pretty much summarizes what we are accustomed to reading about innovation throughout the world, particularly in Silicon Valley.

We adventurously set out on a different course, which revealed to us that one cannot innovate without "surfing" historical change; that new things may not be discovered without a social sensibility to guide this search in some way; and, above all, that any innovative effort is always an attempt to make history and change the course of our circumstances. When we say "making history," this does not mean pursuing great, heroic

feats, but rather participating in the co-creation of the future, in a permanent dialogue with others, connecting with their interests and concerns. It also means caring about our identity and cultivating our specificity and traditions, because one cannot produce innovation from scratch. What is new also requires a concern for the reception and preservation of our historical legacy.

Imbued with this sense of historicity, we began to establish a preliminary phenomenology of innovation, understanding that this made it possible for us to comprehend how human realities emerge, how they appear, instead of treating them as objects that already exist with specific properties or attributes. Thus, the phenomenon of innovation appeared before us as a game of emergence—meaning both "appearance" and "urgency" (in Spanish, *emergencia* is the word for both emergence and emergency)—revealing a series of concepts heretofore unrelated to innovation, including fulgors, conversations, disruptions and anomalies, among others.

Thus, the phenomena of styles and emotional tones became increasingly relevant to us. We began to realize that entrepreneurship, innovation and design all require fundamental emotional dispositions to open up new worlds: a sensitivity to the era in which we live, trust in others, concern for contexts and spaces, and above all, the strength to face adventures and the mental and emotional capacity to establish relationships, for the fabric of relationships is tremendously important here.

In this dimension, we have seen that pragmatic conversations are undoubtedly important, but that those which allow us to create worlds are even more relevant. In Chile, our companies and leaders generate good pragmatic conversations, but are not good at creating the conditions for opening new horizons. And if we aim to achieve a better quality of life and a growth based on the creation of new wealth, if we wish to move beyond the exploitation of natural resources, combining intellectual work with scientific and technological work, it is necessary—not sufficient, but quite essential—to build a New Economy, and this requires not only a different outlook, but also the ability and commitment to improve our conversations.

Thus, we discovered that one fundamental strategic orientation touches us all: we must make an urgent effort to change our cultural style, characterized today by a short-term perspective that does not know quite how to create trust, that fears risk, and that, perhaps most importantly, does not honor our poetic tradition of engaging in conversations not to win a debate, but rather to listen to each other, to create space for imagination, and to allow this interaction to produce new worlds. For this reason, we invite you to read this book not as an innovation strategy or methodology, but as a conversation about Chile.

Finally, we must acknowledge that although the Council on Innovation has learned about other subjects tackled in recent months—such as professional and technical higher education, engineering and design—these lessons were not included in the present edition. Meanwhile, there are other areas that we consider to be very relevant, but that we have not yet been able to develop, including law, culture (understood as the arts), astronomy, Chilean identity, and the future of food. Nevertheless, we know very well that this document is only a starting point—and this is very reassuring.

Innovation requires tackling more activities, learning more about its practices, and understanding its dimensions much better. Our purpose is to open up new conversations by showing a new style for understanding the innovation phenomenon, but we still have a long way to go.

Fernando Flores Labra
President
National Council on Innovation
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PRESENTATION

The National Council on Innovation for Competitiveness (*Consejo Nacional de Innovación para la Competitividad*, or CNIC) was created in 2005 in response to a growing concern for how the country could develop successfully in a world that is being transformed constantly and ever more rapidly by the pace of globalization and the impacts of science and technology.

At that time, we observed that the market by itself was not enough to successfully face the future and achieve greater development, nor was an economy open to the world with a State that only played a regulatory role. In this context, there was a growing conviction that something different must be done to change the country's productive orientation, and innovation emerged as a promise for greater competitiveness, growth and quality of life for Chileans.

Eight years later, we have made significant progress in this direction: on the one hand, we have new public policies designed to stimulate scientific research, technological development, entrepreneurship, and human capital formation; on the other, we have a greater budgetary commitment by the State and the foundations of a renewed institutional framework to make all these efforts possible.

Nevertheless, a feeling of discomfort still persists, because, in spite of these achievements, transforming a productive system that is overly reliant on the exploitation of natural resources is a very difficult task. And we realize that, as we continue advancing on various policies that have already been defined, it is also necessary to take a new leap forward. Doing so will require not only a consensus on where our attention must be focused, but also a conceptual alignment concerning what type of approach we must use.

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As a starting point for writing this report, we have acknowledged the concerns and frustrations that we share with our predecessors at the Council on Innovation. At the same time, we realize that the context of our task has changed drastically in less than a decade.

From the very beginning, we intuitively sensed that it was impossible to continue using the classic approach to strategic planning, because it presupposes establishing goals, objectives and a coherent linear program to achieve them, while the task of innovating as a country is more like a search or a quest.

This is the conviction that has guided our work during these years, and it is why this document will present Strategic Orientations for Innovation in Chile. With these orientations, we seek to face the future by discovering areas of caution and opportunity that may help create a framework for actions in the present. We do this from the perspective of Chile, thinking about our country, but without ever forgetting that we are living in a globalized world. We also assume a broader horizon, considering not only what concerns us today, but above all thinking about the future generations.

Our perspective takes into account the future trends that are being insinuated throughout the world, because sooner or later these tend to impose themselves everywhere as true avalanches. However, we do not intend to predict the future—no one can reliably do so. Instead, we seek to create an account of how the future is being shaped and how we could take advantage of potential opportunities and avoid the threats that may arise. We have paid special attention to certain dynamics that may radically transform our lives on Earth, , including particularly an expanding globalization, demographic growth and our growing demand for services and greater productivity, as well as global warming and the implications of the new biology for our notions of life, medical practices, and others.

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From the beginning, we also understood that, in spite of all our efforts, innovation continues to be absent from the main debates about our country's future, and that, for many Chileans, it still appears to be the distant discourse of a political and economic elite, and not a response to their most urgent concerns. One of the aspirations of the work summarized in this document is precisely to deal with this indifference.

This is why, in the first place, we have chosen to expand our comprehension of the innovation phenomenon, spanning both the human and social, and, of course, the scientific-technological and economic-entrepreneurial realms. In this perspective, we have discovered innovation as a phenomenon of historical emergence, related to the human concerns of a particular time period and inseparable from a complex, globalized and permanently changing world.

The comprehension we propose in this document does not intend to be a methodology for innovation, because if anything has become clear to us, it is that innovation cannot be reduced to a mere algorithm. What it does provide is a framework, a way to approach this issue that can suggest practical steps for us to take, new rationales for the public policies our country must develop, and new paths for public and private actors to take action.

Finally, we must also stress that this reflection cannot be understood except as a dynamic, open exercise that has been—and must continue to be—developed permanently by various national actors. This document outlines an initial expression of this exercise, with some specific examples for Chile in three essential fields: energy, education and new biology. The goal of each of these is not, as we have already said, to predict the future, but instead to open up conversations about the future that will allow us to make decisions and take actions in the present.

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PART ONE
A COMPREHENSIVE FRAMEWORK FOR INNOVATION

Part One of this book responds to one of the convictions with which we began this adventure: our need to ask ourselves, once again, what innovation is and what it consists of, in order to find some clues that may help us take our next leap forward.

We chose to begin by acknowledging, to a certain extent, our ignorance. We asked ourselves why we are concerned with innovation today, how it occurs, and how it becomes part of our daily lives. What and who must interact for this to happen? Is it just science and technology? What is the role of creativity? Along with these questions, new ones began to appear: what conditions facilitate the emergence of something new? How much depends on the culture, history or attitudes of various individuals, groups and countries? Are there places that are more favorable to the emergence of innovations?

These questions led to conversations and reflections that helped us write the chapters of Part One. They provide us with a certain cartography that helps us move in this world that—as we shall see—is changing at an accelerated pace. They give us a comprehensive framework for orientation that allows us to have conversations and think about innovation and our country, so that we may make decisions and take actions that will help us better shape our future.

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"[In America] events can move from
the impossible to the inevitable
without ever stopping at the probable."

Alexis de Tocqueville

"Because reality is not only what is factual,
nor can it be limited to what is currently possible:
its possibilities and impossibilities,
its uncertainty and its openness
also belong to reality.
The reality of human life and of societies is a
combination of possibilities and impossibilities
that are partly open and partly closed to action"

Daniel Innerarity

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CHAPTER 1
AN ERA OF ACCELERATING CHANGES

"Downside up, upside down
Take my weight from the ground
Falling deep in the sky
Slipping into the unknown.
All the strangers look like family
All the family looks so strange
The only constant I am sure of
Is this accelerating rate of change."

Peter Gabriel ("Downside up")

The world is undergoing an era of unprecedented events. We live in one of those transitional moments in which we are witnessing the birth of new human aspirations, new ways of living, new roles and relationships, new forms of production, new forms of power. It is, undoubtedly, an era where some of our most fundamental beliefs or assumptions are being challenged, and our image of the future is tinged with uncertainty, but it is also a time when new opportunities arise and the horizons of what is possible are expanded.

Various forces crashing against each other—and often strengthening each other—have been generating this tide of accelerating changes that surprise and unsettle us.

Science and the use of new technologies are causing a revolution in human life that never been seen throughout history. In recent decades, changes in transportation, communications, medicine, finance and manufacturing—which have come at an increasingly accelerating pace—have stimulated a reorganization of trade and industry that has not only led to new forms of production, but also to the creation or disappearance of jobs, companies

and even entire industries. The mere emergence of so-called 3D printers promises to bring profound changes to manufacturing, design and the relationship between designers and final customers, to mention just one very current example.

In the last 25 years, one of the fundamental drivers of change has undoubtedly been the digital revolution, which, at the accelerating pace described in Moore's Law,[1] "reduces" distances, "erases" frontiers, "suppresses" time and "promotes" changes in all dimensions of our lives: work, entertainment, cultural production, personal and mass communications, and even political participation. Everything has been transformed in surprising ways.

We need look no further than the new generations to realize that the new digital infrastructure is, more than technology, a platform for a different way of inhabiting the world. Surely, for these generations "the Internet" is not a mere set of information or communication tools, but a network of social environments—of worlds—in which a significant part of life is developed with others. And evidently, the pioneers of the online revolution did not anticipate this happening, much less those involved with this small invention called a "browser," which blazed the path that is now expanding and transforming in "the cloud" and in social networks.

In Chile, we have witnessed huge transformations in this field in the span of just one decade. Just during the brief history of this Council—created in 2005—we have seen profound changes in the publishing industry (where e-books are now a large share of sales), the written and audiovisual mass media (which cannot be understood today outside the Internet), and the personal computer business (which has given way to tablets and smartphones), but also photography, music and many more. Moreover, very few people must remember income tax statements filled out on paper, and even fewer go to the post office to drop off a letter.

But the revolution is much deeper than this, because the future of biotechnology, nanotechnology and medicine, whose boundaries are becoming less and less clear, will begin to alter our lives and the world we inhabit.

Creating synthetic life is an enterprise that is currently generating great ambitions, while also arousing deep fears. Meanwhile, personalized medicine is becoming a reality, as the cost of obtaining a person's complete genetic information falls day by day. And this change will affect not only the relationship between physicians and patients, but also the pharmaceutical industry and even the products and requirements of health insurance or public health services.

Along with technological change, the power of the Internet and globalization are also changing the productive, financial and geopolitical maps of the planet. New powers emerge and traditional ones lose strength. The new Asian powers of China and India—joined by some countries of Latin America—are beginning to rival the traditional Western center more and more seriously.

[1] What is known as "Moore's Law" is an observation made by Gordon Moore regarding the number of transistors that can be installed in an integrated circuit, a determining factor for the capacity of electronic devices that use circuits. Originally, in 1965, Moore showed that the number of components per integrated circuit had doubled annually from the late 1950s until that year, and he claimed that this rate would remain constant until 1975. Later, Moore modified his projection to indicate that the number of components would double every two years. This trend has generally been maintained to the present day.

The financial crisis that began in 2008, strongly impacted the United States and continues to punish Europe, has been a favorable scenario for this, but it has also unleashed a sense of discontent and mistrust towards government institutions and forms of governance, as well as towards politics and large economic powers. In this scenario, of the most recent crisis of modernity, new "micro-powers" are arising: small businesses, local citizens' groups or organizations that—with the expanded connectivity and mobility provided by digital technologies—are now challenging states and large corporations, shunning the technical opinions of experts, and demanding greater participation in political decisions.

This phenomenon of fluidization of power is just beginning, but all it takes is a brief look at the news to confirm that it is accelerating and gaining momentum every day. This is a challenge of governability that certainly requires an innovative perspective. And Chile, as we have seen, is no exception.

Finally, we must recognize that we are currently facing a global phenomenon that is apparently surpassing all our previous limitations, and that appears to be the sum of the unexpected effects of centuries of human history: we are facing an endangered global ecology, and we have an inescapable responsibility to redefine the way we live on our planet.

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Our intention here has not been to provide a complete description of the world we live in today. It would also be a naive pretension to try to do so in such a brief space. What we have wanted to point out, though, is that any attempt at proposing innovation policies cannot remain blind to this historical scenario of accelerated changes and that any strategic view we wish to take cannot help but to begin by comprehending, or at least intuitively sensing, the dynamics that are shaping the future.

We are certain that doing this will require, first of all, defining broad horizons to better observe where these trends are taking us, and to prepare ourselves and respond to their implications in better ways. This is what we shall attempt to do—to a limited extent, of course—in this document.

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CHAPTER 2
THE NATURE OF INNOVATION

"The history of Medicine is replete with examples of cures obtained years, decades and even centuries before the mechanism of action was understood for these cures"

Sidney Farber (*)

It is commonly believed that words such as innovation, quality, excellence and others describe characteristics, realities of the world. However, a more careful analysis reveals that their true origin is in value judgments. Quality refers to something without defects, excellence to something that has been done extraordinarily well, and innovation to the emergence of something new that is recognized by us as valuable.

But if we didn't talk about innovation before, why are we doing so today? Haven't new and valuable things always emerged throughout our history? It is probably because in the era of accelerating change that we live in, our norms, products, conventions and organizations are being displaced or must be renovated at an unprecedented rate. The world we live in today constantly pushes us to seek new things, and therefore innovation has become the way institutions, communities or companies respond to transformations.

In many of the everyday conversations we have, we tend to equate innovation with an ingenious use of science and technology, as if the formula for innovation were Science + Technology + Creativity. This equation, however, soon proves to be insufficient. First of all, because we know that many innovations emerged as practices before science could explain them (beer production and the steam engine, to give just two examples), and not all scientific research leads directly to innovations. Secondly, because we see that it is impossible to limit creativity to a single method or procedure; even more, when we are

(*) Cited in "The War on Cancer," G B. Faguet. (2009)

tempted to place it at the center of the innovation phenomenon, we begin to lose sight of something.

When we think of innovations as products, we naturally assume that there is an exact moment for them—that they must appear "at the right time" so that the "window of opportunity" does not vanish. However, there is an even more important time: historical time, the historical moment and space in which innovations occur. Because new things may only emerge from an already existing world, and only when we have the ability to produce them and the social contexts of demand are appropriate.

1. THE EMERGENCE OF NEW WORLDS

We believe that the emergence of new things, as an eminently historical phenomenon, is crucial for a better comprehension of innovation. The dialogue that we present below—which recreates the conversation between a professor and a student—may help explain this notion better.

– Did you know that one of the fundamental discoveries of modern medicine arose from the problems of a French alcohol producer in the mid-19th century?

– How so?

– An alcohol producer in Lille was facing a serious disgrace: his production was often souring unexplainably, threatening to ruin him. Desperate, he went to a professor at the local university called Louis Pasteur, who visited his facilities and carefully observed the barrels where beet broth was processed. In some of these, Pasteur perceived the normal aroma of fermentation, but in others he noticed a strong scent of sour milk, accompanied by a thin layer of "dirt" covering the surface. The strange thing was that there wasn't a trace of milk throughout the place. Intrigued, he decided to take these samples to his laboratory.

– And what did Pasteur know about producing alcohol?

– Actually, nothing specific. He had studied chemistry at the Normal Superior School of Paris and had access to a laboratory equipped for studying crystals. The fact is, he had the idea of putting the liquid samples under the microscope and, in the sour ones, he found the yeast cells that normally accompany fermentation, but also these lengthy, microscopic little animals that were unknown to him and that surprised him.

– Genius!

– More than genius, what he did was follow the regular working guidelines of his laboratory and his practices as a chemist.

– But if he used his microscope often, he knew he would find micro-organisms.

– In those times, there wasn't even a name for them yet. They had been discovered two hundred years before by the inventor of the microscope, but nobody knew quite what to do with them. So the remarkable thing was that Pasteur

suspected these little organisms might be the ones producing that smell of sour milk. That they were actually chemical agents! It was a real "fulgor" (an unexpected brightness shining forth) that signaled a new horizon of possibilities before his very eyes.

– What strikes me the most is that, for 200 years after the invention of the microscope, nobody had seriously considered micro-organisms.

– Yes, that is certainly surprising, but not so much if we remember that chemistry had just begun to appear at the end of the 18th century with Lavoisier. Until then, nobody had proposed that these microscopic beings might produce chemical effects. This interpretation by Pasteur could only occur in this newly emerging world of sciences—with professors, laboratories equipped with microscopes, a new method for investigating natural phenomena—and amidst the common concerns of the mid-19th century.

– He was changing the world!

– And it was about to change much more. Because as he attempted to verify his hypothesis, Pasteur proved, through still quite elementary experiments, that he was correct: the small germs—that were now being called bacteria—were feeding on some component of the beet broth and had produced lactic acid, which was what had altered the taste of the alcohol. The news spread throughout the European scientific community and the fulgor of new horizons expanded rapidly.

– Is that what you mean when you said this story had to do with medicine?

– Of course. Because after only a few years (and many discussions), those organisms went from being simple curiosities to being recognized as chemical agents. And this gave way to them being considered infectious agents. Remember that, at that time, nobody was even speaking about infections, but about pestilences and plagues that were transmitted in "some way"—nobody knew how. That doesn't mean people were careless or completely unaware. In fact, there were hygienic norms and practices, such as quarantines, that saved lives, but in a limited and contingent manner. And there was a very important movement in those years, the so-called "hygienists," who were recovering old cleaning traditions and promoting new practices… There were even those who, before Pasteur, had thought that perhaps those little germs could have "something to do" with diseases, but the mainstream thinking was that they were simply oddities and that they appeared spontaneously among poor people.

– It must have been hard to believe Pasteur amidst all those dominant certainties.

– No doubt! There were scientists who had harsh criticisms for Pasteur's first tests with beet alcohol. Remember that his laboratory was equipped to work with crystals, not micro-organisms. So he had to invent new laboratory instruments and techniques to "domesticate them" before making further progress.

– So he was pioneering what we now call microbiology.

– Of course. Although that name came much later. What did happen at that moment was that the news of Pasteur's achievements spread among his collaborators and in the scientific world of that time. After years of laboratory work, he managed to decipher the bacterial origin of a silkworm disease that was threatening to destroy that important French industry. Next, he formally announced the germ theory of infectious diseases—the ones formerly called pestilences—and began to study the ones affecting poultry and cattle. He also explored the development of vaccines, which earned him one of his first major victories over those who attacked his ideas. In fact, the triumph that finally sealed his fame was the test done with a French boy and some Russian soldiers of a vaccine against a terrible disease: rabies.

– I remember the story about the many physicians who were opposed, and about the general public that listened to the discussions between the experts of that period and took quite a long time before trusting these new techniques that were apparently so risky. After all, vaccines consist of inoculating yourself with a small infection, with the promise of preparing the organism to reject a larger one.

– That's true. It took quite a while for these new health practices to be adopted generally and for a very basic new understanding of infections to be established. But, eventually, the vaccine became a "necessity" for everyone, as was the case years later with antibiotics. And we must also mention how hygienic habits changed, not just in hospitals, but in everyday life. Washing our hands acquired a completely different meaning, and the same is true for simple actions (from our modern perspective) such as boiling water or covering our mouths when sneezing...

– It's impressive to see how everything was completely transformed by what you described as the "fulgor" that began with Pasteur.

– That's true. The thing is, we generally forget that we haven't always had what we have today.

– One last question. How was the problem of the alcohol producer who requested Pasteur's help ever solved?

– Simply by washing the barrels carefully between each fermentation and then covering them to prevent harmful micro-organisms from forming colonies.

This brief conversation allows us to illustrate that what we have called innovation is, above all, the historical emergence of new practices that modify or displace already existing ones, which are embedded in artifacts or in the ways we relate to each other or organize ourselves. We have also seen that this phenomenon involves individuals who live in a specific historical moment (with ways of understanding that are proper of their time, as well as readily available practices and equipment, such as chemistry and the microscope), who belong to a unique cultural *ethos* (with ways of being, of acting, of relating)[2] and who

[2] In mid-19th century France, the nascent discipline of chemistry coexisted with Jules Verne; technical advances like canals, railroads, steam power coexisted with discussions on the origin of diseases, hospital deaths or Darwin's theory on the origin of species. It was a

intend to tackle a personal or collective concern. For this reason, we say that, more than demonstrating the genius of one individual, what this dialogue reveals about Pasteur is his ability to remain receptive to a history that was being made and to the practices and concerns that were arising in his time.

Although it was impossible for those experiencing it to appreciate this clearly, today we can observe how, starting with something we have called a fulgor, that changed the conversation of its time, new spaces of possibilities began to emerge, along with new explanations and new technologies, as if in a theatrical piece the lighting had suddenly changed, transforming the entire stage and scene.

Of course, this was not an immediate reaction: what is new had to first break through. Thus, Pasteur needed ingenious experiments, as well as new laboratory instruments and techniques, in order to isolate, cultivate and classify these micro-organisms, expand on his observations, and find answers to his conjectures. Only then could he prove, first, that what were previously considered simple "germs" were actually chemical agents; and from there on, open up a pathway for the conclusion that they could also possibly be the cause of many diseases.

And in the task of "dealing with" the micro-organisms—of capturing and channeling a natural phenomenon—new technologies began to appear, which, as we have already mentioned, were necessary for the laboratory work. In the beginning, they were developed by Pasteur himself, but over time this gave way to specialized manufacturers who supplied the laboratories and simultaneously laid the groundwork for the emergence of new, more trustworthy technologies and new industries based on them.

We must also remember that Pasteur was not alone in this new interpretive and experimental space in rapid expansion. The Scottish physician Joseph Lister, for example, studied intra-hospital infections and developed several aseptic practices that reduced the high mortality rates during surgery in that period. The German Robert Koch, meanwhile, discovered the bacillus that causes tuberculosis (one of the most lethal scourges up to that point) and created a vaccine to combat it. And as we speak of vaccines, we slowly begin to depart from laboratory experiments and to approach the manufacturing of products that, although related to the initial fulgor, are not its direct results.

Venturing into this new industrial world of mass-produced goods required, first of all, producing and working with the vaccines: carefully designing them, discovering first how to prepare the deactivated bacteria for each case, and then learning to apply them (measuring the doses, determining periods, and controlling their effects on animal or human health). But it also required dealing with beliefs, prejudices, customs and social norms (mainly tacit) in order to transform the new and marginal into the commonplace and mainstream.

This is why, because of our concern for innovation, we wish to understand not only the emergence of what is new, but the displacement or transformation of what already exists. To ask ourselves once again how technologies or human practices appear or disappear, how science and its applications change the world we live in and our way of

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Europe where the microscope, invented more than 200 years earlier, finally ceased to be a device for observing rarities and became a fundamental laboratory instrument for scientific research.

inhabiting it, how industries and sometimes entire sectors are created or destroyed, or how much the success or failure of a project is affected by aspects such as the culture, social capital, traditions and richness of worlds of those who develop them.

2. INNOVATION IN SIX HORIZONS

By observing the historical nature of these processes of change, we can recognize **six relevant time horizons** that are constantly intertwined with our reality, and that help us improve our comprehension of innovation. Because what is for some the result of years of study and work, for others may be just the beginning of a path leading to completely new fields.

The world of high-tech production tends to be very turbulent, and is a good example that shows how identifying these horizons (which must never be used as linear, explicative models for innovation) may help us with our task. In this world, new goods and services are constantly being created, while products and even entire companies simultaneously disappear. There are more than a few stories of large companies that struggled or disappeared because they were unable to reinvent themselves or because a new technology that they failed to anticipate displaced them from the market.

The horizon of daily life (Horizon 1), of our routine present, is the horizon of mature products that have already established a market position, generating cash flows and profits, and therefore most company executives and employees tend to be concerned only with maximizing economic returns. And they are justified in a sense, because the "bottom line," the *balanced scorecard* and their bonuses are all tied to this horizon. In this context, the tasks of thinking about **new products** (**Horizon 3**) and opening up markets for **new products** (**Horizon 2**) appear to be just a waste of time and money, and are relegated to the bottom of the list of priorities… until it is too late.

We have spoken here of three horizons that are crucial for understanding the phenomenon of the emergence and death of technologies. But before discussing them further, perhaps we must first turn to the **horizon of the fulgor** (**Horizon 6**), since these types of conversations—like the one that began with Pasteur—are where the future is occurring and that the knowledge and practices that shall later produce new technologies begin to accumulate.

Today, when we mention one of the key tools of biotechnology, the polymerase chain reaction (PCR), we are usually ignorant of its history. We must trace back to 1953 to discover the fulgor that created the space for this new technology, when James D. Watson and Francis Crick—inspired by the photographs taken by Rosalynd Franklin—published their famous paper on DNA structure. They had to spend many more years, dedicated to revealing effects and comprehending phenomena, before describing PCR… and still more years before Kary Mullins could transform that laboratory technique into the centerpiece of

a new industry based on the ability to manage and manipulate the genetics of living beings, to the point where we now have the power to begin designing life.[3]

This level of basic science that we shall call **Horizon 5** requires a high level of funding and continuity, both for the institutions that sponsor researchers and for building the necessary instruments. In some disciplines, the cost of instruments is so high that they must be financed by several countries, as in the case of the Paranal telescopes, the Large Hadron Collider (LHC) and the International Space Station.

Advances in basic science provide opportunities for **Horizon 4: the search for more concrete applications** for the principles discovered during research—but with no practical goals defined yet. For example, in 2005 Steve Jobs requested a transparent, highly resistant material for a new product being developed: the iPhone. For this purpose, he contacted Wendel Weeks, CEO of Corning, who told him there was a product invented in the 1960s that satisfied these requirements, but that they no longer manufactured it.[4] Jobs convinced Weeks to destine an entire factory to produce exclusively Gorilla Glass, and the rest is history: there are currently over one billion devices using this material. Another good example is Xerox, whose Development Division in Palo Alto invented the graphic user interfaces and mice that were later popularized by Apple and Microsoft. Adobe and several developments associated to the infrastructure of Internet also arose on this horizon.

On **Horizon 3**, the entrepreneurial interest, markets and customers all spring into action. To satisfy the latter, prototypes and specially designed solutions begin to be developed. These solutions are promoted according to their possibilities for growth and analyzed as relevant options for the organization's results over a period of three to six years. Within companies, whatever is done on this horizon will depend on the resources assigned to research and development. One example of the relevance of acting on this horizon can be seen in the shale gas industry. In 1991, Mitchell Energy performed the first horizontal perforation to extract shale gas, but only in 1998 did they develop the technology needed for it to become economically viable. Today, this energy source represents more than 20% of all natural gas produced in the United States.

Horizon 2 is the critical threshold for new businesses. For the business owner or entrepreneur, this horizon crystallizes the previous advances and develops the products and services that open definitive spaces in non-existent markets. The iPhone or Cirque du Soleil may be good examples.

Occasionally, these products and services produce truly disruptive changes and trigger transitions in entire industries. A well-known story in the world of photography is that Polaroid and Kodak were the undisputed leaders during the 20th century. But a few

[3] The polymerase chain reaction is a technique for rapidly producing multiple copies of a DNA segment, allowing researchers to obtain the inputs for their experiments in the quantities required. In his book "Making PCR: A Story of Biotechnology," Paul Rabinow provides an "ethnographic" account of the invention of this technique, which is essential to the tremendous development of biotechnology.

[4] According to Walter Isaacson, in his book about Steve Jobs, Weeks explained to Jobs that Corning had found no market for this type of material, and had therefore cancelled production, until Jobs, despite Weeks' apprehensions, convinced Corning to create Gorilla Glass® and produce it in the enormous quantities required by Apple, in less than six months.

years ago, chemistry ceased to be the basis of photography, and today the dominant forces are in the digital world.

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This brief journey shows that we can understand the evolution of technologies and the emergence of innovation as an accumulation of horizons and practices that have been advancing throughout human history along with the complexity of our relationships and social organization.

We believe these six proposed horizons allow us to start seeing and understanding innovation from a perspective that is less concerned about creating a product or service, and more aware of both the historical processes of accumulating practices and the horizons that coexist in the present, overlapping and cross-fertilizing each other. It is evident that, in terms of both companies and nations, our concerns must not be limited to today or to what is nearest on the horizon; on the contrary, it is important to open up spaces for new products and services to appear, and for those that prove their value to ultimately create new industries, as happened once before in Chile with the salmon and cellulose industries. And this requires profound changes in the way funds are allocated—which may be applied to company finances or to public management—and in the metrics used to evaluate results for each horizon.

3. ECONOMIC AND TECHNOLOGICAL EMERGENCE

Our concern for innovation has repeatedly raised the question of how technologies and practices appear or disappear, or how science and its applications change the world we live in and our way of inhabiting it. But what do we mean when we speak of technology?

To begin with, we propose three definitions that seem very relevant to us, and that we will describe in the subsections below.

First, we can understand technologies as artifacts or tools that serve a human purpose, and that, as such, give us satisfactions, create or improve our capacities, open up possibilities, help us or replace us in the workplace, and so on. The evolution of artifacts and tools has been essential to hominization—we could not understand human beings without the technologies that have shaped us.

Second, we speak of technological systems when referring, for example, to the transport, energy or telecommunications systems, meaning a series of artifacts—but also specific organizations, regulations and legal systems—that must interact harmoniously, because these systems channel the flow of our lives. From this perspective, we consider technology to be inseparable from the social system.

Finally, we can see technology as the essential complement to capital in the economy. In this sense, we may speak of the era of the oil economy, the automobile economy, etc.

a. Technology as an artifact

If we look to the past, we will find that equipment, artifacts, and ways of doing things go hand-in-hand with the evolution of mankind. Most anthropologists agree that handling stones (as weapons or as tools for working other stones and manufacturing more elaborate pieces) was inherent to the emergence of human beings. Later, we would learn to use fire, and later still hunters forged spears, arrows and other increasingly sophisticated equipment.

We say, then, that tools have been essential to human beings. But what do we have or obtain when we have a tool? The tool serves a function, and this function produces satisfaction through an effect (what happens when we use the tool). Therefore, a tool is recognized as such when it can recurrently cause an effect that produces satisfaction. And this holds true, from the example of the stone that helps us break the nut to eat it, to the telephone that "transports" our voice and allows us to speak to those who are far away.

Having said this, we can formulate three fundamental characteristics of technology as an artifact: purpose, components and recursiveness.

Purpose: Technology is always used to respond to a human concern: a desire to move something, to produce light in the dark, to write, to heal a wound; ultimately, to make possible what is not naturally occurring. The wheel made it possible to move things that were previously difficult or impossible to drag. The nail and the hammer made it possible to assemble wood and manufacture carpentry products that were previously inexistent. Electrical technology and hydraulic power made it possible to produce electricity from rivers and waterfalls, transporting it to faraway places through electrical cables.

Components: This refers to the parts used to build a device, which are historically inherited. For this reason, we could say that all new innovations depend on already existing components. As users, we are somewhat blind to these components—we are simply satisfied that they exist. For example, a hammer seems trivial to us, but it had a very complex evolution: it required tools to affix a stone to a stick. Today we associate it with the nail, but nails almost certainly appeared much later than the first hammer.

We often hear that the components for a new technology do not exist yet: we can imagine it, but cannot produce it yet because we do not possess its components. In astronomy, for example, the instruments that will be used 20 or 30 years from now are being designed today, and a fundamental part of this design is precisely to define their components. And this is also what Jules Verne, Edgard Varèse or Leonardo Da Vinci once did, projecting different worlds with components that did not exist yet, but which they could imagine. But this may also occur backwards: by paying attention to the evolution of components, we can imagine and anticipate future waves of change, as some of the most prominent visionaries of our times are doing today.

Recursiveness: When we speak of components, we apparently refer to simple pieces or parts (such as a piece of metal and the wooden handle of a hammer), but the truth is that today these components are frequently also technologies inherited from previous generations. For example, in the evolution of electronics, which first emerged with vacuum tubes, transistors replaced vacuum tubes and were in turn replaced by microprocessors,

which consist of numerous mini-transistors and other components imprinted on silicon. Each of these is a technology unto itself, but they become mere components when we are looking at a television set, a telephone or a computer.

What we have called recursiveness, in the sense that existing artifacts are used as components for future technologies, ultimately implies understanding that the history of technology is the history of artifacts that are used together, and are thus transformed into components of new applications that were not envisioned by the designer of the first artifact. In other words: a technological chain, which helps us begin to see how wealth is accumulated over time, to the extent that users obtain new satisfactions and new possibilities for which they are willing to pay. One example of this is the laptop, which—understood as the integration of a typewriter, a printing system, a communications machine, and a file storage mechanism—ultimately displaced several previous systems.

b. Technological social systems

Technology as a social system emerges when we observe that the collective life of human beings, particularly in cities, depends on a number of technological ingenuities and domains that must be organized in order to function.

In practice, the phenomenon of packaging components generates many types of industries or industrial domains, because along with an artifact's recurrence, there are domains that are not artifacts but rather pragmatic regions of social knowledge. These are what we call industries, which appear at a given moment. For example, initially electronics emerged as a minor variant of the electrical industry, but suddenly it became clear that it was essential to producing a new value—the control, logging and handling of data—and this ultimately led to control panels, computers and later to the digital world.

In this process, new expertise is developed, roles and specializations arise, jobs are created, and new benefits are produced that have a value on the market. But not everything is "a walk in the park," because this also brings new social and political challenges. For example, as we will discuss in this document, there is no greater geopolitical problem today than energy. The entire energy system is under discussion in terms of land use, pollution problems, and even the use of water, which is becoming another technological asset.

So, everything that was initially simple (at least to a certain extent) is becoming a part of the social fabric, generating new practices, new services and expectations, and new tensions or conflicts of different degrees that require political agreements. Therefore, the discussion on technological systems shows that technology is inseparable from laws, norms and the entire social, political and economic system.

c. Technology as the essential complement of capital in the economy

The path from technology as artifacts to technology as social systems allows us to deal with one last definition that helps answer the question about the nature of technology: the definition related to the economy.

In the previous paragraphs, we have shared some notions of how technology produces wealth and also permanent disruptions. In economic sciences, the iconic figure of these observations is economist Joseph Schumpeter, who in the early 20th century introduced the concept of technological change as one of the key factors for economic development and popularized the term "creative destruction" to demonstrate how the appearance of new products (innovations) may destroy old companies and business models.

But we believe that there is more to this. The economy is constantly generating not only disruptions, but also new worlds, opportunities and possibilities. For example, digital music made available online practically destroyed music stores and markets for the CD, but it opened up new, previously unimaginable possibilities for not-so-famous musicians, such as publishing, selling or promoting their music on their own and generating more live performance opportunities.

In a certain sense, then, we can say that we evolve along with technological systems, although none of this occurs in a linear manner. Linearity is, perhaps, an illusion that we create through our own way of representing the world, which suggests that everything is oriented towards a purpose. But purposes also appear or disappear historically: they emerge from people's needs or discomforts, or, ultimately, from imagination, which allows new realities to materialize. In fact, when the computer appeared as a calculating machine, almost no one imagined that one of its uses would be to play games, much less that it may be used to make movies or that it would replace the classical photographic industry. Similarly, nobody imagined microchips or their transformation into tablets or telephones.

We can view the economy as this permanent appearance (and disappearance) of worlds, and the greatest mistake we seem to make—over and over again—is believing that there are stable concepts that allow us to understand technology forever. The economy depends on technology and culture, and these two human creations are unpredictable and ever-changing, and therefore we must now begin to think about the economy in terms of innovation, and vice-versa, because we live in a society in which innovation and change are becoming fundamental, permanent forces. This is because there is permanent destruction and creation, and there are also changes in our relationships and in our ways of being, roles, emotions and aspirations.

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There is a fourth definition that we initially did not wish to announce: **the Earth as a technological system**. This is perhaps a very poor transitional term, because any notion we have of a system consisting of components is not valid when referring to the Earth, since in this case we must consider not only the elements and all other living beings, but also ourselves: we depend upon and pollute the system.

This is why anthropologists and geologists today have invented a new term: they say we are now living in the Anthropocene era.[5] By this, they mean to emphasize that humans are becoming the main geological force on the planet and, therefore, that it is no longer possible to make distinctions between nature and ourselves.

When we speak of global warming, ocean acidification, the depletion of the ozone layer, etc., we are discussing the negative effects that we are producing. And our challenge consists of learning to live in a way that takes care of the Earth.

This is our great technological challenge and a source of heated debate, because it means that now we must analyze human incidence not only on a limited scale, but at the systemic and planetary level. This is the aim, for example, of geo-engineering, genetics and synthetic biology. For some, each of these actions can represent large solutions to many problems (economic, medical, etc.) and are therefore absolutely necessary. For others, they are humanity's most recent great mistakes and preludes to disaster.

What is clear is that Cartesianism—the set of technological notions that we have applied to this point—is no longer sufficient. We need another way of understanding, and although such a pending task transcends the scope of this report, we believe it is important to acknowledge.

4. A RICHNESS OF WORLDS FOR INNOVATION

As we mentioned at the beginning of this document, we believe that achieving a better comprehension of the innovation phenomenon will help us to better understand which aspects we must concern ourselves with if we wish to strengthen or encourage it. In this search, understanding innovation as the historical emergence of new things, as a historical accumulation of horizons and practices, leads us to observe at least three dimensions:

First, as we have already mentioned, receptiveness and the entrepreneurial capacity of individuals, especially their sensitivity to "listen" to the concerns of their times. Second, the networks of practices and equipment available in the worlds we live in. And, finally, the cultural *ethos*—consisting of traditions, norms, styles and ways of understanding or paradigms of comprehension that were not available—that shapes the relationships and interactions between various actors in society during each historical moment, in different locations, or among different groups.

Although it is tempting to understand this complexity according to the classical notion of a system, we must point out the potential implications of this term: firstly, the illusion that we fully comprehend the components that would constitute this system, with a highly defined and stable structure, functions and relationships; and on the other hand, the assumption that with the correct dose of inputs, the system would be capable of producing the desired outputs. For this reason, we rather coincide with biological metaphors—

[5] The term "Anthropocene" was coined by Paul Crutzen, and is an analogy that references the word "Holocene," which is the scientific name for the current geological epoch (the latest of the Quaternary period).

whether it is a garden, a forest or a seedbed—which are capable of portraying both the complexity and the dynamic nature of the historical and cultural spaces where innovation emerges.

If we return to the example of Pasteur, we can observe not only that he was a scientist in his laboratory or a man sensitive to the concerns of his community. His world, or better yet, his *worlds*, were much richer in relationships and practices, in institutions and culture. On the one hand were the ancestral practices of alcohol production that had no scientific explanation behind them, but had been handed down from generation to generation over several centuries and were consolidated industries that were relevant to the economy of that time (as was the case until then with wine or cheese production). On the other hand were chemistry and science in general, which began to examine the world in a different way and started gaining social acceptance. Their habitats were the universities, where they conversed with other disciplines, new and old, including medicine, which sometimes clashed against and other times took advantage of the new perspectives arising from the laboratories. All this was also occurring at a time when cities were beginning to grow at a much faster pace, compounding the problems of hygiene and disease and witnessing the appearance, among other novelties, of modern hospitals and nursing practices that were very similar to what we are familiar with today.

Transporting this reality (which we have described very superficially) to our times, and using a language borrowed from economics, we can tackle the complexity of these spaces by identifying five fundamental factors: financial capital, knowledge capital (scientific research and technological development), human capital (individual competencies and skills, but also collective knowledge and practices), social capital (trust, networks) and entrepreneurial capital,[6] the latter being defined as the ability to put the first four factors into motion.

This comprehension—which was the result of an attempt to explain the development of the high-technology business sector in Israel—is based on the idea that these five types of capital are already present—mainly in what we have called networks of practices and equipment—and seeks to show how they interact, relegating to the background the historical account of how each of them has accumulated and been strengthened over time. And, in this account, different cultural aspects (such as a more informally organized and less hierarchical Israeli society), historical processes (such as the migration of Russian Jews after the demise of the former Soviet Union), institutional practices (such as those implemented by the Israeli Army among its recruits, promoting improvements in the fields of science and technology) and also strategic decisions or actions by the State (from establishing world-class universities and scientific centers to promoting the creation of businesses in the technological field or intentionally stimulating a risk capital industry linked to its Silicon Valley equivalent) all play fundamental roles.

Ultimately, all this shows the relevance of the richness of worlds that places (cities) or specific societies may possess, as spaces that are more or less favorable to innovation and

[6] We have borrowed the definitions for these five types of capital from the work of Uzi De Haan, a researcher at the Technion – Israel Institute of Technology. In his article "A hotbed for entrepreneurship and innovation," De Haan proposes an economic growth model based on entrepreneurship and innovation.

in which the diversity of practices permits exchanges and cross-pollination (to continue with the biological metaphors).

This historical and cultural dimension also warns us against the danger of believing that it is possible to replicate a formula and reproduce in any particular territory what has occurred in other places simply by using the same types of inputs (the five capitals described previously), without cultivating what we might call the "richness of worlds" that makes innovation possible: being familiarized with, and knowing how to move across, multiple networks of equipment, orthogonal practices and emerging technologies, but also simultaneously having a broad social network—which are now global—and developing an *ethos* to facilitate the emergence of new things.

Taking note of the warning described above, we believe it is possible to learn a lot from Silicon Valley and its history if we want Chile to cultivate the "richness of worlds" and *ethos* required to promote innovation—according to our own history—and if we also wish to connect with the key spaces of innovation throughout the world. But although we have already been taking positive steps in this direction, we are lacking narratives about the future, conversational practices, and states of mind (or emotional dispositions) necessary to strengthen and orient our efforts more effectively. This is precisely what we shall discuss in the following chapter.

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CHAPTER 3

A NEW DISPOSITION FOR FACING THE FUTURE

"When you set sail for Ithaca,
wish for your journey to be long,
full of adventures and full of discovery."

Konstantino Kavafis

In the previous chapters, we have acknowledged that we are living in an era of accelerating historical change and uncertainty. We also know that the future is always placing new demands on us. Day after day, for example, we must make investment decisions, establish public policies and reach agreements on what we want and what path our country will take on horizons that stretch far beyond established political times. This is precisely the realm that concerns the National Council on Innovation.

It is not possible to deal with these concerns if we keep thinking of the future as a specific "condition" in the world that must be grasped or foreseen. Rather, we propose to understand the future as the open horizon of what is possible, as a space that will manifest itself in ways that we cannot fully predict. Yet, we can begin to sketch it out because that future – which depends on our past, our practices, the networks of equipment and the culture we have inherited – is currently being configured, to a large extent, in the laboratories where the new Pasteurs of our time are at work, in places where new marginal practices are being cultivated, and wherever new questions and new interpretations about the world are emerging.

In order to encounter and face this future, we require a special affective disposition, a mood, as we would in any undertaking or enterprise. As we shall see, dispositions are fundamental phenomena that, while resembling attitudes, are still more essential, as ways of being that imprint character. That is why we have chosen to use the term "disposition" in the title of this chapter, in order to consider a particular predisposition of affect or feeling for innovating, that can be cultivated.

The historical times that we are facing – which we have briefly drawn in the first chapter of this document – require a new way of confronting the world. That is, a way of being that leaves behind the fear of newness, recognizes and takes care of our identity, and opens up to whole worlds without reserve. We need a disposition capable of building a sense of solidarity that will translate our concerns for the future generations, in concrete actions and commitments in the present. The politics of innovation must not remain indifferent to all of this.

With these definitions and goals in mind, we want to show in the present chapter how openness towards certain adequate dispositions, and the cultivation of the virtues that go with them, are essential not only for observing and facing the future, but also for participating in its creation, with a sense of historical significance and care for our social concerns.

1. TWO INHERITED CULTURAL STYLES

Our disposition towards the future reveals styles and emotional states that we have received from the past, and that configure our practices. They consist of sensibilities and historical interpretations about our world and how it works, which are expressed –in ways that are not necessarily conscious–—in our actions and feelings, carrying also with them general ways of "observing and anticipating" the future. We say "feelings" to recognize that when we say that we feel at home or not at home in the world as a whole, we are experiencing a feeling, an affect, more than something primarily cognitive, as what predisposes us to understand our world as a whole.

Anchored in our concern for innovation, we will now identify two styles from which we are used to face the future. We will picture them here perhaps with some exaggeration, with the sole purpose of noting some salient and relevant distinctions. One is characterized by certainty and complacency; the other by a joyful and uncontained enthusiasm in the face of change. Let us say that, while these are usually opposites, on certain occasions they articulate themselves in ways that are complementary.

We can try to recognize these styles precisely here, among those who are now reading this text while having heard for many years that Chile needs to innovate more, advancing beyond the simple production and export of natural resources. Since we all know that our country´s future looks very challenging if we do not make this change, we are all surely uncomfortable with the fact that, despite our good macroeconomic results, apparently not enough progress has been made in this direction.

If we belong to the first style, we can feel assured that if we continue growing as we have in recent decades and make the adjustments recommended by our technicians, our country will continuously diversify its productive matrix entering into areas of more complex manufacturing, with greater labor productivity, higher salaries and greater progress. Checking worldwide comparative experience, abundant data, statistics and studies, we may come to believe with certainty that the only thing that could possibly

threaten this future is an exaggerated impatience that may take hold of the public and the political representatives, with the governments being unable to deal with it.[7]

The other style would assume that the world is changing too much and too rapidly, and that we must try to keep up with this pace at all costs, as China and other countries moving at a fast pace have done. Taken by this style, we enthusiastically accept the idea of embracing, decively and without delay, the waves of changes that traverse the world, because they only generate opportunities and progress. We may feel that we are systematically falling behind in the domain of family, in all levels of our education, in our the productive structure, and in our institutions, and that it is important to attack all these flanks, because... we must innovate more and more rapidly![8]

In both cases, we can see that we entertain some sort of certainty regarding Chile´s future. Yet, it's not the case that we have these feeling as a result of a certain tangible future that we can see lying ahead of us. On the contrary, we can recognize that these feelings, by taking hold of ourselves, "present" the future to us in one way or the other. We can see also that – by no means following a voluntary decision – we find ourselves already in a certain predisposed emotional tonality – rooted in our past and the interpretations and practices that have shaped us – that opens the world for us as a whole in a particular interpretation, while preventing us from considering other interpretations.

Certainly these styles do not bring us "naked", so to speak, into the present situation, but their dispositions reflect our assessments of the results we achieved having moved with them in the past. And if they have not provided an adequate understanding for navigating competently in today´s world, we can expect our dispositions to produce more than a few frustrations and dissatisfactions in the future. This is what we recognize is going on, for example, when we observe how difficult it has been for Chile to become more innovative, despite all our conscious efforts.

Complacent certainty, for example, leads us to believe that our diagnoses are completely certain. So if they characterize some situations as permanently negative or unsatisfactory, no matter what efforts we make, we may well conclude that there must be powers that are confronting and opposing what must be done — the implementation of appropriate and certain solutions — because of special interests, ignorance, or whatever. For this reason, this style usually goes hand in hand with victimization. It may assume a resigned tonality, rather conformist and somewhat cynical, or it may display an active tone more resentful. In all likelihood, our different reactions to an unpromising future will depend on how difficult or intolerable the present feels to us. However, in any case,

[7] We feel certainty when we believe there is a truth—whether it is the product of natural, moral, or historical laws, or a combination of all these—that orients and shapes the future. We do not mean a trust limited to certain specific spaces—like a medical diagnosis by our physician or the calculations of the engineer who designed our building—for which we could not operate otherwise; instead, we are referring to a serenity that is projected towards the whole. If the world suddenly began to behave outside of our certainties, it would seem uncontrollable to us, and we would surely be terrified.

[8] We can sense that there are no truths that define the future in the present, but rather that this future is emerging in an arbitrary, shapeless manner, without restrictions or conditions, because it is being created by free individuals whose limitless creative imagination cannot be anticipated or controlled. There are no limits on what the future has in store for human beings! And this is an anxious and joyful enthusiasm that makes us feel its world.

complacent certainty is reinforced as such when we see ourselves as victims: we know that the truth about what is occurring is precisely that we are the victims of bigger powers.

Anxious enthusiasm, meanwhile, which assumes that everything is open to our disposition and that we depend only on our creativity and energy, deals with frustrations by pointing its finger back at us: we are not up to the challenge. The more excited we are by the infinite promise of our creativity, the more anxious we will become with ourselves as we observe the unsatisfactory results we produce.

Clearly, both styles of narratives about the future are out of sync with the dynamic nature of the times and the possibility of making history (which we will discuss later). These two emotional dispositions or moods—whether due to a holistic certainty or an anxious enthusiasm that believes anything is possible—not only represent obstacles to the skillful navigation of today's world, but also bring a peculiar way of not learning from their dissatisfactions and frustrations. People in these moods tend to remain entrenched in their positions.

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After identifying these two dispositions as characteristic styles, we are ready to discuss another disposition that is of particular concern to us in the field of innovation: indifference.

The majority of the population—business owners, politicians or workers in general—are not interested in innovation. This is somewhat similar to what commonly occurs in the field of health care: we all agree that we "have to take care of ourselves," but we continue advertising and consuming junk food, falling into sedentary lifestyles, or drinking and smoking excessively, relegating the care and safety of our bodies to the area of laws and regulations, or simply resigning ourselves to the fact that, when the moment arrives, medicine "may be able to do something for us."

Evidently, in spite of the frustrations produced by the complacent or enthusiastic styles, this indifference has more to do with the fact that accelerating changes may produce a fear so intense that we think it is best not to confront it and to act like we cannot see it. We may let ourselves be immobilized by the inertia of continuing to do what we have been good at doing for years. Or, finally, we may be immobilized by the illusion that this whole "tale" of change—globalization and competitiveness—is something that does not affect us, neither for better nor for worse, or that it is just a game played by the elite or a conversation for technicians and business owners.

2. A NEW DISPOSITION: SURFING HISTORY

In the previous chapters of this document, we have seen that innovation emerges not from the genius of an individual, but from a historical and cultural space that cannot open a path towards something new without a sensitivity to social concerns, and, that any innovative effort is always an attempt to change our world and to make history, whether it

be with a new product, a new form of production, or a cultural change. In this chapter we have suggested that all this also depends on cultural styles or emotional dispositions.

Here we will propose cultivating a new disposition that we call "surfing history."

The "surfing" metaphor is very revealing of the style for acting in the dynamics of the present while orienting ourselves strategically towards the future. First of all, it is immediately apparent that surfing cannot be done from certainty: there is no way to know beforehand how the waves will break. Nor is it possible to surf from an anxious search for chaotic vortices. And surely a sleepy indifference for what lies ahead might well kill us.

On the contrary, in athletes that surf amidst gigantic, indomitable forces that are much larger than they are, we can observe stability surrounded by chaos, balance at high speeds, fluidity, serenity and enjoyment manifesting themselves. And we intuitively sense the persistence it has required for these athletes to achieve such an uncommon mastery. Surfers cannot go where their whims propose to take them—it would be naive to try to control the ocean. They remain in constant harmony with the waves and receptive to whatever may appear, finding a space for stability and a path. We can also imagine them always concerned and receptive to the waves—whether threatening or promising—often in ways that are indiscernible to spectators on the beach.

Another characteristic we would like to point out about surfers is their unconditional commitment. They are always "surfing." When they are not riding the waves, they are studying them, researching them, creating new moves or preparing and refining those they already master, organizing activities or preparing their own bodies. Because surfing is a world that is constantly being built and recreated, and it includes knowing when not to surf. True surfers know when to wait for the exact moment, or when to travel in search of the right place. They are not attached to a single geographical space.

During the times when the world appeared to be mainly solid and stable, human action consisted in exercising power and submitting to it, implementing and obeying rules, using stable skills to handle rather fixed instruments and products. In a general sense, action consisted in manipulating and controlling things. Today, however, in an era when everything is changing as if we were on a stormy sea—power, rules, institutions, technologies, products, needs and desires—we are find ourselves with the permanent backdrop of human beings speaking to each other in different ways, in a long, unending conversation in which we are bringing forth the worlds we inhabit.

"Surfing history" requires the skills to participate in these conversations. Not having the capacity to engage in the conversations may mean, quite simply, that in the era of surfing, we will remain stranded on the beach.

3. THE MISSING CONVERSATION

As we have insinuated, "surfing history" requires certain conversational skills.

To discuss this, we propose to distinguish between **pragmatic conversations**, those that allow us to move in an established world, and others that we shall call **world-opening (or poetic) conversations**. The latter involve different ways of being in the world and open

different possibilities. As a society we are commonly trapped in conversations of the first type, having lost the ability to participate in those that may enable us to make history— and that are crucial for innovation.

Pragmatic conversations are the most commonplace. In them, we operate in an established world of things, institutions and roles, with the aim to satisfy our needs and desires. We participate in them by producing, consuming, undertaking and projecting ourselves as professionals, workers, executives, business owners, scientists or public servants, with our individual and social identities at stake. Essentially, in pragmatic conversations we establish commitments when we talk: by making offers, announcing goals, making campaign promises, accepting requests, agreeing on certain research programs, and the like.

Unlike pragmatic conversations, world opening ones do not happen on an every day basis. The fundamental virtue of conversations that open new worlds is the receptiveness between those who are speaking. We enter into them predisposed to *not* comprehend everything, to participate without the intention of controlling anything, understanding that for a while—perhaps a long while—we will not know where we are headed. We listen in order to "tune in" to the concerns of others, which we may find surprising, and together we hear new insinuations—that perhaps were inconceivable for each of the speakers before they began to talk—regarding what we should be concerned about, or what is worthwhile.

Rigid prejudices of any type—ethnic, social, religious, or of identities—are the main enemy of these conversations: the entrenched belief that our current and common norms and perspectives are the only authentic ones. An insensitive blindness to anything different, whether from arrogance or a simple provincial mentality, is also destructive. So too is a perspective that is only attracted by the common contingencies—market transactions and the defense of political positions are good examples—and which, with a dull homogeneity, ignores essential cultural differences and follows a "common sense" that only represents its own prior experience. In such an immense, globalized world, these are both poor dispositions towards what is different, and may cause us to miss opportunities for radical learning, for including new practices and perspectives, for enriching our lives, and for tuning into what is being suggested about human life elsewhere.

As in poetry, world-opening conversations often tune into feelings of anomalies[9] that abruptly come into the spotlight. Encountering anomalies, we suddenly become receptive to a whole new world that is emerging in what appears at first as only a slight insinuation, a fragile discomfort, something diffuse that, until just minutes ago, we were impervious to.

In 1954, Pablo Neruda began his "Ode to the Air" with these words:

Walking down a path
I met the air,

[9] We often consider anomalies to be mistakes or problems, especially when we are speaking from the perspective of certainty or knowledge. An anomaly, in the sense that we are speaking, is not a problem, but rather a feeling of dissonance, a discomfort that may (or may not) lead us to a new understanding of some phenomenon.

greeted it and said
respectfully:
"It makes me happy
that for once
you've left your transparency,
so we can talk."

The air, our atmosphere, was at that time completely ignored. It was infinite and nothing at the same time. In the poem, it emerges abruptly from its invisibility. As he goes on, the poet anxiously warns that the air is getting scarcer, becoming a manufactured product, packaged and sold in cans and bottles.... Sixty years later, who could deny the almost monstrous possibility of what was at that time only a receptive insinuation?

Since poetic conversation flows freely, without establishing limits, it can harbor concerns or discomforts even when they may not appear to have a viable solution. Thus, pragmatic conversations—focused on fulfilling goals and promises—ignore anomalies (if they are even able to tune into them) or may acknowledge them as unfortunate exceptions. In world-opening conversations anomalies can become weighty and relevant, or move to the center of attention. Obviously, we are not suggesting that we must all become "professional" poets in order to tune into anomalies. It is precisely entrepreneurs that transform this lack of harmony into a creative way to open worlds, because they do not pass them by: they explore and examine them until, eventually, these anomalies give birth to new possibilities, offers, products, services and worlds.

Another possibility that arises in world-opening conversations is detecting and appropriating the fulgors of new practices, new possibilities or simply conjectures that illuminate the world in new ways and, in doing so, create unprecedented possibilities: from bringing new technologies and businesses into the world, to inventing new types of agreements, or renovating cultural styles and projecting them in the world in new ways. All this is what we call *making history*.

4. THREE WAYS TO MAKE HISTORY

When we exit our everyday lives and their pragmatic considerations, we can ask ourselves: where is the world heading? To do so, it is not enough to consider the habitual and commonplace: we must first observe what is happening in laboratories, in business clusters, how political changes are occurring, what cultural leaders are doing, and we must also consider how we may participate in this process. To summarize this way of being in the world, we will discuss some ways to make history.

We can make history in any activity we pursue, because the important thing is our disposition towards the present world and its requests.

When we find ourselves disturbed by ambivalences that we do not know how to reconcile, confused by contradictory values that pull us in opposite directions, causing life to lose its holistic meaning, one way to overcome this stalemate and continue creating the

future (making history) is to bring forth reinterpretations of our essential values, illuminating new possibilities for reorganizing what has been scattered. This is what has been happening over the recent past with our attitudes towards women, sexual minorities, ethnic groups, etc. New, broader interpretations of what it means to be an individual human being are emerging that allow our "human rights" to rearticulate communities that at times seemed to disintegrate and produce a new sense of individual unity in each of us. In this process of "tuning in," we become receptive to the worlds that are emerging based on new possibilities for rearticulation.

We also make history when, seeking to overcome certain human concerns, we appropriate (take as our own) practices that come from other local worlds and that provide us with different ways to make our own path. In politics, for example, the loss of audiences and supporters may move us to consider what other parties are doing, and how they win over audiences whose attention and support we would like to attract. Faint fulgors begin to illuminate our feelings of anomaly in a new way, opening up possibilities that we could not see when we were trapped in our traditional parties and associations. We experiment with new forms of organization and dialogue with the audiences we are interested in, and in these moments, we find mixtures of our historical practices and those of other associations or movements. We normally create new types of organizations to sustain the new conversations with these new customers and audiences (the same thing can happen with business owners operating in a deteriorating market, or who are unable to expand through their industry's usual products and services). In this process of tuning in, we become receptive to the worlds that are emerging from new possibilities for a cross-appropriation of existing things.

Finally, we also participate in the creation of the future when we remain attentive to the appearance of marginal practices that could later become central, shifting and reconfiguring older central practices. This is what happens when we become active participants that are interested in the appearance of new technologies. What will certainly mobilize us will be the fulgor of historically unprecedented possibilities that begins to shine through them. We become receptive to potential changes in various practices and local human worlds. If we bring into the world a new way of handling knowledge, or communications, or cultural production, or the genetic dispositions of the organism, that reduces their cost or increases their range and speed by very large factors, we can imagine that everything around it will change.

Ultimately, we speak of making history to express—in a very simple manner—an active participation in the historical emergence of the world. And we can do so from many fields: as artists, politicians, citizens, business owners, entrepreneurs, professionals, technicians, researchers, or any other activity.

CHAPTER 4

A GENERAL FRAMEWORK FOR STRATEGIC ORIENTATIONS

"Man has always striven to understand
the world around him. To this end he was helped
by stories that made sense of his reality."

Tomas Sedlacek

1. THE STRATEGIC PERSPECTIVE

Strategos was the name given in Ancient Greece to army generals or commanders-in-chief. Their job was to determine how battles and wars would develop over time. To do this, they needed to establish a clear goal, define a horizon, and choose which of the possible paths for achieving this goal they wished to take. This was the *Strategy*, and we have long used this concept to discuss strategic planning.

That world, however, is over, because today's limits and certainties are constantly disappearing and being reshaped. For example, a company like Amazon, which initially positioned itself as an online bookstore, then began competing with retail leaders by selling many other things, and later evolved to provide cloud computing and research services. Today, it is an online store that transformed traditional books into e-books and even sells distribution services for self-publishing. Its whole game changed completely in just a few years; and we can be certain that this entire adventure began with just a few intuitions in a new world that was opening up to trade, without knowing exactly where the path would lead.

IBM, Cisco or even Microsoft itself can testify that the future is not guaranteed for even the most powerful in a world where purposes, limits and identities are constantly

changing. And nobody knows if Chilean production may suffer the same fate as saltpeter at the turn of the 20th century. In fact, that is the recurrent threat hanging over our copper industry. Today, graphene is emerging as the latest of its serious and fearsome competitors.

In this scenario, it is worthwhile to remember that a country's most important asset is that which its inhabitants have to offer. For this reason, our fundamental mission is to establish ourselves in this space with proposals that are attractive to the world. And our goal at the Council on Innovation is precisely to find refreshing ways of creating new spaces for inserting Chile in this globalized world.

Our main concern is the future. The future not as "a thing that lies ahead of us," but as a horizon of possibilities that is being shaped in part by our actions in the present. While the sum of those actions may generate unpredictable effects, our political responsibility towards present and future generations is to look ahead in order to anticipate possibilities—including both, threats and opportunities—and to create orientations that may help shape and open the best paths and actions to deal with our central concerns, such as education, energy, health, or the environment.

Remaining caught up in the short term, in contrast, invites the dangers of haste and imprudence, of forgetting the value of identity and, above all, forgetting that we are concerned with an "us" that includes both present and future generations of Chileans, and also extends to a global "us."

2. TWO HORIZONS FOR OUR PERSPECTIVE

To face this task, we have identified two horizons on which to focus our reflections: the farthest is 2050, a somewhat arbitrary but also pragmatic choice. The other is 2025, which is closer to our present situation, where it is possible to project more immediate actions with greater clarity.

The Council's mandate requires that we deliver our proposals with a 12-year perspective (in our case, until 2025), but we believe it is necessary to extend that horizon to 2050, because there are areas of local and planetary concern—such as education or energy—where the inertias are greater and the time ranges for action or change are longer.

If we focus on 2050, a horizon that appears to be so distant and difficult to sketch out, it is also because it is necessary to challenge our present views and distance ourselves for a moment from short-term concerns in order to concentrate on movements that may appear marginal today, but may powerfully affect our society (or the entire planet) in the long term. We will not paint a picture of what the world will look like or what events will occur towards the middle of the century. Our intention is not to make predictions regarding the future, although looking towards 2050 may imply being able to express certain conjectures, to venture a few hypotheses, or to project trends based on what we know today.

The need to learn how to surf history—discussed in the previous chapter—emerges more clearly in this scenario. And a central element of this ability is the identification and reorganization of conversations, especially the ones we have called world-opening

conversations, which allow us to foresee the impact that some emerging technologies and practices may have on our concerns and ways of inhabiting the world.

This search on the 2050 horizon will in some cases help us begin to sketch out some projects and investments on the 2025 horizon, and even our more immediate future, along with the relationships and institutions that may allow us to make a difference.

3. SOME SIGNS ABOUT THE FUTURE

We previously said that we chose the middle of the century as a more or less arbitrary reference point. However, there are many world-opening conversations already underway that overlap and interweave, and many of these are focused on this same horizon. In all of them, it is possible to identify certain dynamics that, in practice, occur both contingently and concurrently, and help shed light on our strategic orientations and take responsibility for implementing actions in the present or near future.[10]

Let us review some of these dynamics.

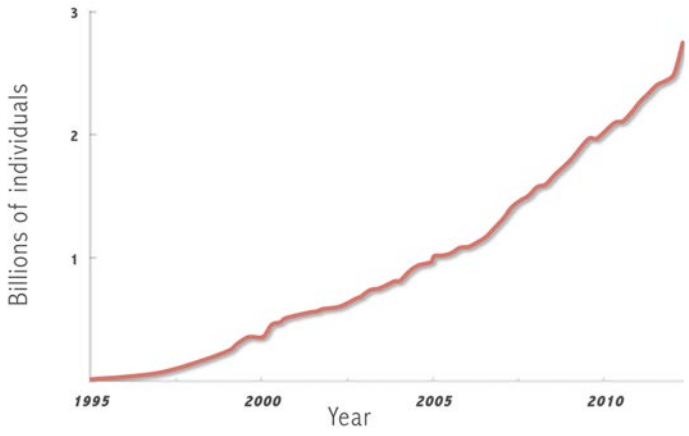
a. Globalization, understood as the economic, social and technological processes that are creating a more interconnected and interdependent world. In our everyday conversations, the term is often associated exclusively with the worldwide integration of markets, especially in trade and finance, and recently also to labor, scientific research and even innovation. However, we know very well that it also has political and cultural dimensions.

While we may believe that, ever since its origin, the human journey has been a race towards increasing degrees of integration, the process we now call globalization appears to have begun several decades prior to the Internet (which is perhaps the most common reference point of this phenomenon today). Although it may seem that a great deal has already been written about the history of globalization, the truth is that, from a broad perspective, the world appears to be in the first phase of a much larger transformation and an even greater integration, strengthened by new communications technologies and new forms of production.

The phases that lie ahead will bring the disappearance and emergence of entire productive sectors and the creation of new markets, new trade partnerships and new alliances. Design, raw materials, components, assembly, and commercialization of any product may come from fifty different countries around the world, to the point where the distinction between the competition and collaboration will start disappearing.

[10] Various sources that we have consulted deal with these dynamics, including: Al Gore, "The Future: Six Drivers of Global Change;" Alex Zhavoronkov, "The Ageless Generation;" The Millennium Project, "State of the Future 2012;" Laurence Smith, "The New North: The World in 2050;" and the chapter written by Charlotte Howard, "The Health of Nations," in the book published by The Economist, "Megachange: The World in 2050."

NUMBER OF INTERNET USERS
1995 - 2012



The number of internet users has exceeded 2.5 billion individuals, just over one-third of the planet's inhabitants. This clearly exponential growth constantly opens up new possibilities for services and spaces of coexistence.

Source: InternetWorldStats.com

b. Demography, understood as the growth, composition and movement of the world population.

Before the invention of agriculture some 12,000 years ago, there were perhaps one million people in the world—equivalent to the current population of the Concepción province—living in small nomadic clans. It took more than 11,000 years (until about 1800 A.D.) for the Earth to reach one billion human beings. After that, a mere 130 years went by before we arrived at two billion in 1930, signaling what has been called the First Demographic Transition.

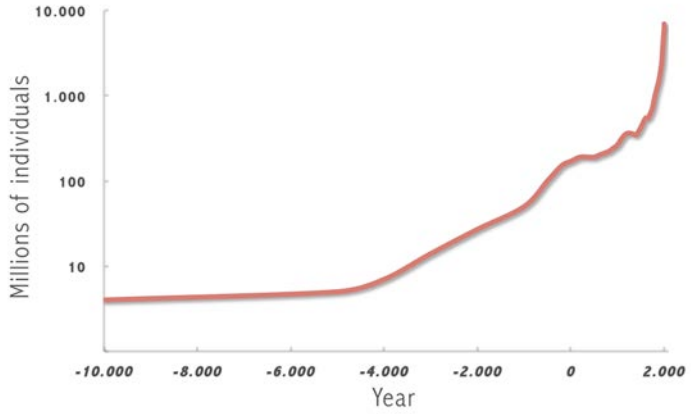
In the Second Demographic Transition, which is still underway, the fastest population growth rates shifted from OECD countries to the developing world, and since the base population levels in that world were so much larger, the resulting surge in world population has been simply phenomenal.

In fact, the acceleration has been so fast that, since the mid-20th century, only 12 years have been needed to add another billion inhabitants to Earth's population, reaching 7 billion people in late 2011. It is estimated that towards the middle of this century the population will be over 9 billion inhabitants, before tending towards stabilization as it reaches 10 billion.

Because of this effect only—without even considering our changing consumption patterns, which we will discuss in the next section—in 2030 the world will need to produce about 50% more food and energy, along with 30% more fresh water. But all this must occur

as we simultaneously respond to the need for mitigation of and adaptation to climate change.

WORLD POPULATION GROWTH
From 10,000 B.C. to the present (until today)



The number of human beings on the planet has grown explosively, mainly over the last two centuries. Mankind took almost 12,000 years to reach its first billion inhabitants. In contrast, the most recent leap forward—from 6 to 7 billion individuals—took only 12 years.

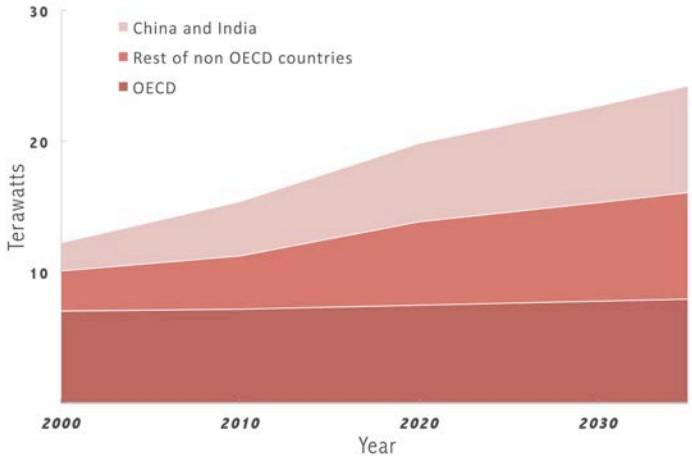
Source: Colin McEvedy and Richard Jones, 1978, *Atlas of World Population History*, Facts on File, New York.

c. The increasing human demand on the Earth's natural resources, natural "services" and gene pool. Although it may seem obvious at first, the truth is that it is difficult to understand how dependent we are on nature, in various dimensions. We generally refer to natural resources as finite assets (hydrocarbons, minerals, and water that move our industries and transport our products) or renewable assets (rivers, arable land, wildlife, and wood). The term natural services, in contrast, is more recent and recognizes other aspects or processes that are essential to life, but less evident in our daily lives, including the photosynthesis that provides us with oxygen, the oceanic absorption of carbon dioxide, and the work done by bees to pollinate our crops. We need all these things, but since we believe it is "natural" for them to occur, we don't worry about them and take them for granted, even though they aren't. The gene pool, meanwhile, is the diversity of genes carried by all living organisms on Earth; these are the building blocks for our food, but recently they have also become raw materials in the biotechnology and pharmaceutical industries.

Population growth, changes in consumption patterns, trade, industry and technology have all increased the demand for all these goods and services. And what began in nations that are now called developed has begun to expand increasingly to China, India and other developing regions.

Some estimates predict that if the level of material consumption in the developing world rose to the current level of North American, Western European, Japanese, and Australian citizens, global consumption would increase eleven fold.[11] It would be as if the world population had grown from 7 billion today to 72 billion. Where would all that meat, fish, water, energy, plastic, metal and wood—required to satisfy their demands—come from?

ENERGY CONSUMPTION BY ECONOMIC REGION
1990-2035 (projection)



International Energy Agency (IEA) projections indicate that, by 2035, China and India will consume almost one- third of the world's energy. Together with all other emerging countries, they account for almost half of the projected growth in the energy demand. In the most industrialized countries, on the other hand, a much lower growth rate is projected.

Source: IEA World Energy Outlook 2012 (excludes ocean and air bunkers).

d. Global climate change. While there are still those in the political world that dispute the degree of human responsibility in this phenomenon, it is a fact that the chemical composition of the atmosphere has been changing to such an extent that the average general temperature of the planet has increased in recent centuries and will continue doing so in the future.

The phenomenon was proposed in the 1820s by the French mathematician Joseph Fourier, who observed that the Earth was much warmer than it ought to be, given its distance from the Sun. He was the first to identify the greenhouse effect, which was later attributed to the atmospheric presence of gases like CO_2.

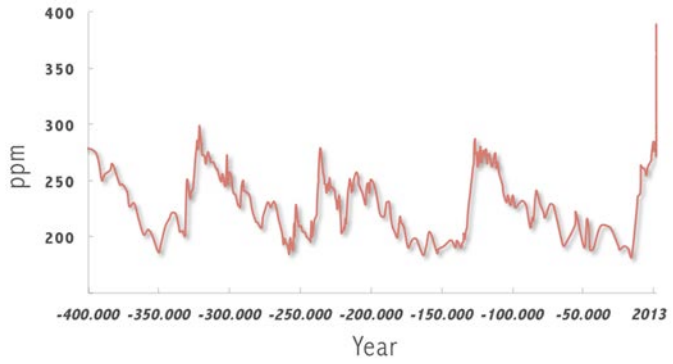
[11] In a New York Times editorial in January 2008, Jared Diamond, of the University of California at Los Angeles, estimated that the "consumption factor" of an average individual living in North America, Western Europe, Japan or Australia, is 32. This means that this person would consume 32 times more resources and produce 32 times more waste that the average inhabitant of Kenya, for example, which has a consumption factor of 1. 85% of the world population has a consumption factor under 32.

Recent research has shown that the atmospheric concentration of CO_2 is almost 40% higher than air in preindustrial times: up from ~280 ppmv (parts per million by volume) to ~400 ppmv. Measurements of the other two powerful greenhouse gases—methane and nitrous oxide—have followed similar growth patterns, as has the average global temperature.

Thus, the projections for the atmospheric concentration of CO_2 towards the end of the century could range anywhere from 450 to 1,550 ppmv, corresponding to a +0.6° to +4.0° C increase in average global temperature, on top of the +0.7° C increase already experienced in the 20th century. In public policy discussions, there is a growing certainty that an average increase of at least +2° C is practically inevitable.

The projected potential impacts of this situation indicate that towards the middle of the century, the planet would be facing an ecological and social crisis that would force us, among other things, to implement severe adjustments to our energy system, changes in our productive and transportation systems, and an unprecedented displacement of human settlements.

ATMOSPHERIC CONCENTRATION OF CO_2
From 400,000 B.C. to the present



The air trapped in ancient glaciers shows that the Earth's atmosphere has registered significant variations in CO_2 concentration over the last 400,000 years. Only in the 20th century did these levels begin to exceed 300 ppm.

Source: U.S. National Oceanic and Atmospheric Administration (NOAA), Scripps Institution of Oceanography (SIO).

e. The biological revolution. Creating bacteria capable of cleaning oil spills in the ocean; developing specific treatments based on each individual's genetic constitution; growing organs and tissues to replace damaged ones or developing bionic prostheses or implants; designing and producing healthier and more nutritious foods; obtaining energy from organic materials to replace fossil fuels. All these possibilities, which seemed very remote or barely surfaced in our imaginations until just a few decades ago, are now realities that are almost within reach. We are experiencing a true revolution in biology.

Years of research have yielded a vast knowledge regarding the components of the complex systems that sustain life, from fundamental molecular events in individual cells to biogeochemical cycles, from the physiology of the most diverse organisms inhabiting the Earth to the complex relationships within ecosystems.

We speak of a biological revolution, but it is probably more appropriate to say this is a revolution *led* by biology, which joins a list of disciplines that, under the general category of life sciences, is growing day by day. This list includes, among others, chemistry and physics (two "old friends" of biologists), engineering, nanotechnology, materials science, environmental science, medicine, zoology, food science, and biotechnology. They are all bolstered by the development of the digital technologies and advanced computing that enable us to manipulate and analyze large volumes of data.

Undoubtedly, all this accumulated knowledge implies new potentials. Faced with multiple human concerns, life sciences may provide answers resulting from a greater understanding of the biological processes that are common to (or very similar in) all living systems. But its cumulative power may also bring new problems, unforeseen effects and changes that may radically challenge our legal, ethical or cultural limits, because we are even facing the possibility of changing human beings in ways that could even blur the boundaries between what is human and what is not human.

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Finally, we may consider **technology as a cross-cutting force** that facilitates or hinders the global dynamics that are driving the future.

Digital communication technologies, for example, facilitate the globalization of financial (and even labor) markets, as well as international trade and culture, thus changing our worlds and forcing us to constantly reshape relationships and practices. Thanks to the Internet, we can quickly and easily find the information, we can be connected "to the world." Beyond that, the Internet is becoming an extension of our brains, the equivalent of a super powerful external memory with an increasingly large capacity to resolve more complex algorithms and process huge amounts of data that were previously unthinkable.

This greater data processing capacity opens up new possibilities involving other important human concerns, such as education and health. For the former, it presents a tremendous challenge to current educational philosophies based on information and knowledge as its main assets. For the latter, the use of genomic and proteomic data taken from each individual implies an unprecedented medical precision that may also drive costs down.

The power of computers also strengthens the progress of many disciplines, such as nanotechnology, biotechnology and materials science. All these, in turn, are affecting the demand for various resources, but also making others more readily available and modifying forms of production and human possibilities in the most diverse fields. Intelligent networks, solar panels, new forms of construction and transportation, and geo-engineering may all help us deal with climate change. New technologies may also help improve crops in order to increase yields and tolerance to stress (caused by lack of water or high temperatures),

improve the intelligent use of water and fertilizers, and/or improve the sustainable use of animal production.

Finally (at least for this brief example), the abundance of data and increasing connectivity are challenging not only the traditional mass media and cultural industries such as music or film, but also our rules of coexistence, our forms of political participation, power structures, and even our security, by permitting the emergence of different kinds of crime that we are only just beginning to imagine.

These traces of the future thus allow us to envision a world of threats and opportunities that will challenge our ways of living, opening up spaces for—or perhaps forcing on us—the emergence of new lifestyles and forms of leadership and governance, both at the local and global levels. We can say without a doubt that by 2050 the world will be very different from the one we live in today, and this will produce a tremendous cultural transformation. Despite all the information we have, nevertheless we cannot make reliable predictions. We cannot act like the *stratego*s of Ancient Greece.

4. TOWARDS STRATEGIC ORIENTATIONS

a. A new way to approach the future

Writing about the future comes in many forms of expression. Science fiction, perhaps the first to come to mind, has been made familiar to us through literature and film. Other expressions are more closely related to our task. Futurology, a discipline that seeks to observe and integrate the future of science, technology, economy and society in the long term, but that constantly struggles with the fact that it is impossible to accurately predict the future. Strategic planning is a discipline we have chosen to challenge in this document for similar reasons.

We would like to propose a different way of writing about the future that we will call Strategic Orientation. Before going any further, however, it is important to discuss historical writing, because we believe that our task of writing about the future has important similarities to the work of historians, who write about the past.

We tend to believe that History is a reconstruction of past events. We must acknowledge, however, that historians write accounts that are created in the present and are addressed to future generations. Historians, like the rest of us, live in the present and move between the conversations of their profession and the concerns of their times. With this perspective, they look towards the past and make an effort to explain what—as far as they can tell—are important anomalies or explanatory gaps regarding events or processes that happened years or centuries ago. Unlike writers of fiction, however, historians have one fundamental restriction: that they must be respectful of the artifacts, documents or other pieces of evidence that have survived from the past. Their job is not to tell us about the past "as it was," but to imagine how historical events were related to one another, to weave together events and consequences until they can produce an explanatory account of the

past—one that is, in a sense, invented, since its protagonists did not necessarily experience it exactly as historians describe it.

Thus, for example, the Industrial Revolution is a concept that encompasses a series of events that, in the eyes of history, are part of one big process. However, for those who participated in them, they were merely everyday—though relevant—events in their lives. And just as neither Leonardo Da Vinci nor Michelangelo saw themselves living in the Renaissance, neither did the inventors of the steam engine or the railroad experience the Industrial Revolution as we understand it today, because this concept is not "the past," but rather a historical interpretation of it.

The greatest value of History (and of the humanities, in general) is the fact that it reveals and makes us aware of how our present (and therefore our future) is conditioned and constituted by the past and by the way social relationships, power relationships, economic relationships, and others were resolved at that time. We could say, then, that the task of historians is to shed light on the historicity of humankind and, therefore, also to illuminate our future possibilities. Their job is to imagine narratives of the past that may help us recognize what we are—bindings and blindnesses, lights and opportunities inherited from the past that we have been—in order to expand the conversation about the future that can be available to us.

At the Council on Innovation, much like historians, we are searching for narratives that may shed light on our present, suggesting potential future threats or opportunities. These narratives regarding the future are what we have called Strategic Orientations.

b. Anticipating (instead of predicting) the future

Approaching our task of generating these narratives, we began by selecting, among the infinite possibilities for imaginable futures, those that seem more plausible to us, considering the historical beings we are and the trends that allow us, first, to envision new technologies, market transitions, and new ways of living in the world, and, second, to interpret goals, suggest investments, and outline actions and projects.

These Strategic Orientations do not intend to provide a description or show any supposed "truth" about the future. We will, however, seek to anticipate some plausible events that may shape certain horizons and regions of possibilities. We will sketch a narrative that makes sense and lets us translate our concerns into actions for the present: relationships, institutions, projects or investments that can make a difference.

To do this, we must be capable of:

- Detecting current avalanches[12] that will trigger disruptions and collections of disruptions that may transform the world, forming new social and productive spaces.[13]

[12] Although we have used it in a slightly different sense, it is important to mention that we have borrowed the term "avalanche" from the report called "An Avalanche is Coming: Higher Education and the Revolution Ahead" by Michael Barber, Katelyne Donnelly and Saad Rizvi for the United Kingdom's Institute for Public Policy Research. March 2013.

[13] If we understand that one of the sources of the economic success of innovations is that they are disruptive, we can then say that an avalanche will be a permanent succession of disruptions that lead to new products and companies that displace the previously established limits of industries, in this case education.

Identifying these avalanches will help us to imagine future possibilities (opportunities or threats) for the planet and for Chile.

- Identifying spaces for policy concerns where new realities may emerge. Global warming is an example of this type of conversation. The aging of our population, on the other hand, is a conversation that is missing in the country and is commonly addressed only as a health problem.

- Paying attention to and monitoring marginalities (studies, practices or technologies) that may trigger new disrupting avalanches. For example, when we talk about energy, we know that there are currently early-stage studies or developments in batteries, carbon sequestration or atomic energy that may be very relevant in the future and must be monitored (observing them closely or even participating in them to some degree). We do not know where all these conversations will take us, but we do know they are emerging as essential for the future.

c. Four areas of concern regarding the future

Keeping in mind the notions presented above, we can identify four main areas of concern that we recommend focusing on:

i. The first one may be called the **Global Viability Challenge**, where several of the dynamics we described in the previous section intersect. The rapid and sustained growth of the world population—with higher levels and patterns of consumption among large groups emerging from poverty—will continue to test the limits of the global ecosystem, creating a growing demand for natural resources and services (primarily food). Unlike previous processes, this demand will have to be satisfied in a scenario of greater restrictions resulting from the impact of climate change and concerns over energy, food and water security.

ii. The second is a **Redefinition of Life and Death** which will emerge both from advances in biology, medicine or biotechnology, and from the development of digital technologies, bioengineering and nanotechnology. These new technologies have the potential to extend human life expectancy to previously unsuspected limits. Molecular and organic medicine, genetic manipulation to the point of making it possible to design synthetic life, and biotechnology as a technological platform that will affect various industries are all possibilities that will configure a world very different from the one we know today.

iii. The third is the **Emergence of a new way of being**. At this juncture, what is at stake is the way we understand ourselves as human beings in a changing, globalized, hyperconnected, and diverse world, faced with the challenge of preserving life on Earth.

iv. Finally, the **Demand for a New Education**. Faced with the challenge of global sustainability and in an era of constant change that defies the foundations of our culture, education seems to require not only new technologies or institutions, but also a different mode of thinking.

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CHAPTER 5

INSINUATIONS FOR A CULTURAL CHANGE

This document is a product of us being Chileans, with our joys and sorrows. In our work, we have discovered the future as an open horizon that resists the illusion of predictability—even more so in these times—and has no other purpose, identity or meaning than those we ourselves may contribute in a complex, globalized world. For this reason, we have kept our children and grandchildren in mind as we wrote, because we understand that, though the future may always be uncertain, their lives will depend to a large extent on the decisions we make today.

As we approach the end of this journey, we can say that, in terms of innovation, Chile's greatest challenge is cultural. If we wish to participate in the invention of the future, we must be capable of developing a new way of looking at and moving within the world, a new way of thinking about the present with other horizons, and of facing life with a different disposition than we have had to this point.

If we had to graphically explain the cultural obstacles that prevent our country from participating fully in the emergence of history, we could begin to insinuate here (as opposed to an exhaustive or final description) four essential cultural features: a) we like to know and act on certainties, without venturing into the almost playful exploration of unknown paths; b) we do not connect—or we do so badly—with the main global conversational nodes where

history is being shaped; c) we do not dedicate ourselves to anomalies, and are suspicious of the "weirdness" of those who do; and d) there are serious weaknesses in the way we engage in conversations among ourselves.

1. ACCEPTING THE CHALLENGE OF ADVENTURE

From the beginning of this text, we have insisted that we live in an era of accelerated and permanent change. Before us lies the open horizon of the future. We can discern trends that illuminate certain areas, but we understand that certainties are limited and it is impossible to apply the traditional rules of planning. The world and history present themselves to us as an ocean of contingencies, with an always unpredictable degree of surprise, in which we must learn to navigate (or surf).

At first glance, these may all seem like handicaps—particularly harsh handicaps for a country with a small population and limited productive capacity like Chile. Nevertheless, these new "playing rules" may also work in our favor if we understand how to find a space, a specific niche. Not everything is a threat, and there may also be new opportunities for us to become active participants in the creation of the future.

In this context, we require, first of all, a new disposition that may allow us to engage in life (personally and collectively) with an adventurous spirit, aware of the risks and open to cultivating networks and exploring new conversational spaces.

A fundamental obstacle to navigating in this new world is how we choose our actions based on the belief that the world is a reality that can be represented and predicted, and that, by obtaining good information on the past, we can discover truths about the future. In the recent past, one could successfully develop plans for the future by controlling the environment—resources, markets, geopolitical regions, cultural and ethical patterns—but this is no longer true. At the same time, we are constantly being pressured to make decisions, to think about the future, to project and to invest.

Faced with this obligation, we are often overcome by a sense of confusion or fear that leads us to lock ourselves up in local spaces or to lower our gaze to the short term, where we still think it is possible to act with higher levels of certainty. Imprisoned in this mood, we become blind to the dynamics of global change that shape and determine the future and are a permanent source of tension for our identities and roles, rules of the game, powers and institutions.

Surrendering to our inclination to feel safe makes us understand everything as problems that must be solved by looking to the past, trying to avoid risk and adventures, as if we were terrified of emptiness.

Whether we like it or not, we are being pushed towards adventure. Being adventurous does not mean running recklessly in the direction of whatever may lie ahead. Responsible engagement in adventures require maps, navigational charts that may be incomplete, but without which it is impossible to accumulate experience or find orientation. This is why we have proposed the need to create strategic orientations (such as those presented in this document) to help us mark our paths and make decisions, always

remembering that something unexpected may be just around the corner. Understanding the future as the combined result of our historical inheritance, our intentions and decisions in the present, and a series of unforeseeable contingencies, is crucial to facing this future with the disposition of the responsible, committed adventurer.

For example, anticipating a world where medicine offers us a life beyond 100 years is not just a science fiction exercise, but a fundamental framework for the actions we must take today, for asking ourselves what type of education we need, what cities we will design, or what new possibilities (opportunities and risks) may emerge for us from an economic and social perspective. We know very well that discussing the retirement age from the perspective of the present is uncomfortable (and practically impossible), but we cannot remain blind to the fact that, looking forward to the horizon of the middle of this century, this issue cannot be avoided.

On the other hand, staying motionless and "doing what we know how to do," — which has worked for us for years (such as the exploitation of our natural resources)— is not enough. Acting in that way is a very risky gamble, and a display of utter insensitivity to future generations. We must confront the fact that it is, above all, a cultural trait that leads us to avoid challenges, dangers or uncertainty; a way of positioning ourselves in history oblivious to global concerns and condemned to the corner of those who suffer the consequences of what others are making emerge.

2. FROM PROBLEM-SOLVING TO DEALING WITH CONCERNS

Our need for certainty also manifests itself in a disposition that is used to dealing with the world as a problem to be solved, whether in business, everyday life or politics. We forget that problems are not "objective" things that exist in the world, but are created by our own assessments. Before any problem emerges there are horizons of possibilities called "human concerns" that affect us all, and are always full of historicity and imagination. It can be said that our concerns are about the future of those who share a common history, concerns that appear clearly before us, unquestioned, providing us with desires, purposes, and threats that must be neutralized or dreams worthy of pursuing.

Reducing atmospheric CO_2 emissions or developing renewable energies might be good examples of very pressing problems today, but the overall concern behind both is global climate change and its inherent challenge of environmental sustainability.

Our concerns, or preoccupations (as the word itself says), have us pre-occupied. They have us aching, hopeful, ashamed, falling in love, impatient, anxious, frightened, eager, challenged, ambitious... and they also move us. Hence the importance of knowing how to "listen to them." Cultures—whether in businesses, localities or nations—tend to enclose us within fixed horizons of concerns that damage our capacity to react to very important changes that we cannot measure or that appear to be out of reach. This can happen to us as individuals or collectively, and the same thing can also happen to businesses and countries.

In Chile, for example, today we are particularly concerned with education, regional development, and/or the availability of energy and water, but we are partially or totally

blind to changes that may be avalanches for the world (and for us insofar as we are immersed in it) such as online higher education, synthetic biology or personalized medicine. This is why we insist that it is crucial to take responsibility for the concerns that transcend the imaginative limits of our past or our cultural space, and actively become involved with the places where the new concerns of global history are emerging.

3. JOINING THE CONVERSATIONS THAT CREATE THE FUTURE

The quality of the conversational networks we engage in alongside other global adventurers can provide a great support system in today's world. If there is something that Chileans have not learned to do well yet, it is precisely to connect with the worldwide conversational nodes where the future is being shaped. We cannot remain blind to the fact that knowing how to monitor future dynamics, detect coming avalanches, and anticipate concerns is becoming a strategic dimension for companies and nations. Moreover, this not only involves being capable of seeing them, but also already being located where they may arise.

This requires a policy of global relationships and investments—not just governmental, but also academic, business and personal—that may allow us to enrich our social capital, replacing the logic of "connecting with the world" with "becoming part of the world." In this sense, we must be able, for example, to rethink our scholarship policy (assigning more value to the creation of lasting networks and even to the placement of Chileans abroad), to define new criteria for our international scientific and technological cooperation agreements, and to take advantage of our "natural laboratories" in order to make Chile a space that is attractive for the development of scientific or technological research in fields where we possess advantages.

We also require the ability to locate new practices and identify new industries and other conversations and worlds that we should be participating in and learning about. Although we have said many times that we want to change our productive matrix, that we aspire to participate in a globalized world, and that we want innovation to be a trademark of our identity, we continue to act mainly within the comfort zones where we have been successful so far.

Participating in conversations that invent the world precisely implies moving beyond these comfort zones and remaining open to the risk of failure; the remains of failed experiences are always metabolized, in one way or another, by the emergence of new practices.

Perhaps the main lesson we have learned is that the great conversations that invent the world do not arise from needs or problems. It is our connections to the worlds we inhabit that allow us to see new ways of dealing with our concerns—always within the technological, cultural and political limitations of a historical moment. We become sensitive to new concerns that initially emerge as poorly articulated emotional anxieties called "anomalies." This then motivates our almost obsessive concern for developing the ability to anticipate avalanches, observe the dynamics that shape the future, and, above all, participate

in the poetic conversation of the world, since this is where we truly reflect on historically unprecedented possibilities.

As Chileans, we have tried to avoid anomalies. We resign ourselves to them, we turn them into well-known problems with difficult or impossible solutions, or into reasons to become antagonistic. We like to know what is known. Those among us who are serious about anomalies arouse skepticism and suspicion due to their strangeness, instead of appreciation and admiration for their commitment to bringing something new into the world.

Committing to anomalies means embarking on a wide-open adventure that seeks to invent a new historical world. In this space, trust is more inescapable than ever, though it may no longer be based on repetitive practices from the past, but rather on the commitment to remain involved with the systematic creation and rebuilding of the future, in spite of the contingencies caused by blind roads, delays, failures, or unexpected difficulties.

4. CULTIVATING TRUST AND COMMITMENT

How will Chileans respond to the challenge of facing a wide-open future, and the mutual trust required to begin the adventure? In a sense, everything else arises from this endeavor. Both our institutions and our public policies must have the fundamental responsibility of nurturing it.

As a society, we have an initial weakness in what we have called pragmatic conversations. Immersed in the market and democracy, we have acquired a certain talent for participating in conversations based on trade and negotiations. It is harder for us to fulfill the promises they generate, sacrificing the possibility of achieving excellence in what we bring into the world, and above all, affecting collective trust. We must acknowledge that, in an environment plagued with mistrust, it is very difficult for us to see possibilities opening up.

Cultivating innovation requires forging social ecologies, creating spaces for exchange where actors from different significant worlds can have conversations, where the exchange of practices between them can take place, and where local actors can help design their new worlds.

Therefore, we must monitor and nurture our emotional dispositions for designing and implementing new classes of public policies. Chile's democratic institutions, our economy dedicated to serving open and competitive global markets, and our good macroeconomic and financial management practices are essential foundations for facilitating the entrepreneurship and leadership that may take advantage of new opportunities emerging in the global world. However, they can only open horizons of possibilities, and we have no reassurance or guarantee that we will effectively assume the challenge and take responsibility for making them our own, because commitment is usually a disposition limited to very few people.

Therefore, there is a large task pending for us: cultivating our historical responsibility as a nation. In this sense, enriching our worlds and expanding the horizons of

possibilities of our country, our businesses, our regions, and our workers arises as a new inspiration for public policies.

As we progress, we must remember that possibilities are not just "objects" in the world, like trees, buildings, or 20 dollar bills. Nor are they freely floating information that is available to all, like the price of bread or a calendar date. Instead, they emerge as whatever we believe is possible at a given moment, under certain circumstances, depending on the universes of practices in which we are immersed, the history we carry with us, and the identities we possess. This is an especially relevant discovery in terms of our concern for development.

So, adopting new technologies, incorporating practices that are a step ahead of our current activities, pioneering the development of new productive sectors, connecting with other places, and knowing how to "move" in different cultures, are all ways to enrich worlds and open up possibilities. We know that in this era of open markets and globalized culture, this is going on every day in the most natural manner. We notice it in the changes to the style of our cities, the services and technologies available, and the aspirations of our citizens. We also believe it is possible to *orient* this type of impact according to the interests of a country or a local community, and public action must play an important role in this sense.

5. RADICAL HOPE AS A NEW EMOTIONAL DISPOSITION TO CULTIVATE

Throughout this reflection, we have discussed the importance of emotional dispositions. Our common sense generally tends to classify people as optimistic, pessimistic or indifferent. Today we face an era of change that has unleashed very large forces, towards which human beings are reacting in unexpected ways.

Like never before, the effects of human actions can produce consequences so massive and unexpected that they can transform our worlds completely—or at least the way we inhabit and understand them. In this situation, it is very easy to fall into emotional dispositions that point either towards utopia or in a completely opposite direction: dystopia. For anyone who aspires to govern, it is also impossible to guarantee that their orientation will be accurate.

Our responsibility is to Chile, and we cannot give in to either of these extremes. If we are optimistic, we might be complacent. If we are pessimistic, we find ourselves immobilized. This is why we believe that, along with cultivating certain virtues, in an era of radically changing worlds it is important to cultivate a new style or mood, which we call radical hope.[14]

This style has been present in the past. In embracing it as part of the future, we are focused upon our responsibility towards newer generations. It represents, first of all, the commitment that, despite the hardships and uncertainties of the future, we will do everything in our power to pass on a better world to our children and grandchildren.

[14] We have borrowed this term and its main implications from U.S. philosopher and psychologist Jonathan Lear. He developed it in his book "Radical Hope," which studied the dramatic changes faced by North American indigenous tribes, particularly the Crow Nation, when the way of life they knew came to an end.

Further, we commit ourselves to granting trust to the generations to come that they will have the talent and capacities necessary to do the same when it is their turn to take responsibility for this world.

We find many examples throughout history that we are convinced have been driven by the essential collective sentiment that we have called radical hope. For example, we think of moments of conquest or in exile when we have been called upon to reinvent aspects of our worlds. The style we are calling radical hope goes hand in hand with taking responsibility, as far as humanly possible, for our present and for whatever we can strategically anticipate in the present, as well as educating and fully training our descendants in a new style of navigating, so that we may both reinvent the meaning of our existence whenever it is necessary.

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PART TWO
STRATEGIC ORIENTATIONS FOR CHILE IN THREE MAIN AREAS OF CONCERN

In Part Two, which emerged from the interpretive framework for orientation described in Part One, we will present three exercises related to Strategic Orientations for Chile.

As we have said already, these exercises do not intend either to predict the future or to be exhaustive, but rather to provide responsible, committed narratives that try to anticipate and help us reflect on the present, opening up new conversations and concerns and preparing us to "surf history."

We assume responsibility for three spaces that—as we have already seen in Chapter 4—are emerging as crucial for the world (and for Chile as part of it): energy, education and the opportunities and threats of new biology.

To examine these territories, we have expanded the horizon of perspectives to 2050. And, as we have proposed previously, we have sought to detect current avalanches, marginal conversations and practices that are emerging and may transform the worlds we inhabit.

The result are three unique interpretive exercises, because each space—though often similar or interrelated—has its own reality, its own implications, its own historicity and its own specific impact on our ways of living in the world.

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I. STRATEGIC ORIENTATIONS FOR ENERGY

It can be said that energy will be the world's main geopolitical and economic issue of the next 40 years. But, to be fair, we must acknowledge that this is only one of the dimensions of an even more fundamental concern of humanity: the **Global Viability Challenge**. This challenge includes the effects of several of the dynamics that are shaping the future of the planet: globalization, climate change, rapid and sustained population growth, and the growing demand for energy, food and natural resources caused by this demographic explosion.

As never before, today we are being forced to see the Earth as a complex system impossible to separate from human activity, a system that is undergoing various changes with often unexpected consequences that are no longer the sole concern of ecological movements or the local communities affected, but that have become the subject of political discussions among states and at international forums, because they also have global implications.

This is why we believe that, on the horizon proposed in this document, the world shall have to make very important and comprehensive decisions to effectively tackle these challenges. While the scant progress at the last international conferences on climate change might suggest otherwise, the expressions of concern and concrete actions that have been implemented recently by the governments of the United States, Europe and China are announcing a new phase of political and economic reconfigurations with global impacts.

In this perspective, we will propose an interpretive—not predictive—scenario, suggesting that by 2020 these changes will come in the form of an international energy agreement. We present this scenario as a highly plausible hypothesis, but we know that its validity depends not on scientific, demonstrable facts, but rather on an interpretive narrative of how states, nations and societies will react to address global changes. We also propose it because we believe that the cost of not engaging in these ongoing conversations could be quite high for Chile.

1.
THE LEGACY OF OUR ENERGY SYSTEMS

The development of mankind has been marked by a constant search for new energy sources, because nothing in the world "moves" without it.

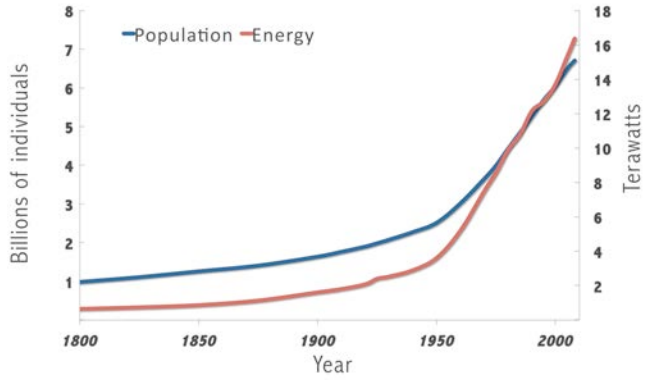
When human beings ceased to be nomadic hunters (about 10,000 years ago), learned how to cultivate the soil and began establishing settlements, our energy needs were generally satisfied with the muscles of humans themselves, and also with the help of working animals and some natural elements or forces. For example, wind and currents were used for navigation, and fire—perhaps one of first technologies used by humans—made it possible to extract energy from wood to heat homes, cook foods, melt metals and produce ceramics. Things went on like this for several thousand years.

During the early phase of industrialization, new technologies were developed—or existing ones were expanded—to transform hydraulic energy into mechanical work. These were followed by the use of coal and steam, which produced a first large impact in terms of production (from craftsmanship and agriculture to industrial manufacturing), transport, urban development (from rural to urban society) and economic organization.

In the late 19th century electricity also arrived, not only greatly simplifying energy distribution and allowing the movement of many machines and industries, but also beginning to change the face of cities and everyday life in the most diverse ways. Electricity is easy to channel and delivers precision, immediacy, and an almost infinite versatility. But it was the innovation brought forth by use of oil that had the greatest impact.

Its abundance, low price and high energy content relative to its volume immediately made oil the best alternative to replace the work done by animals or other forms of energy in all possible activities, from mining and industry to agriculture and transport. A 159-liter barrel of oil produces the same energy as 12 people working for a full year; that is, more than 20,000 hours of manual labor. All these advantages undoubtedly explain why the United States and Europe went from being energetically self-sufficient economies and societies—when they were based on coal—to becoming increasingly dependent on imported oil.

POPULATION AND ENERGY



Energy production and population go hand in hand. The graph shows how the twentieth-century demographic explosion coincides with the drastic increase in energy production.

Source: Grubler, Arnulf, 2008. "Energy transitions." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment).

Note: Energy units have been transformed to power. One Terawatt represents approximately the power of 1,400 hydroelectric plants like Ralco operating at full capacity.

The great availability of energy from more efficient and relatively cheaper sources spurred the growth of industrial societies beginning in the late 19th century, and also brought a strong increase in population, which then increased the demand for energy to produce more. According to data from the United States National Council for Science and the Environment, oil production has increased more than tenfold since 1950, while the population has grown two and a half times and the economy has expanded tenfold.

Although today industrialized nations are much less energy-intensive, developing nations have and will continue to have a high energy demand. In fact, China almost doubled its energy production capacity between 2004 and 2010, and is likely to double it again in just a few years. Meanwhile, the energy consumption of India—another one of the emerging economic giants—is expected to increase by more than two times between 2010 and 2035, and in the same period, the global consumption of energy will grow by 47%.[15]

A very illustrative example of our high energy dependence can be borrowed from Anders Wijkman: a person who works hard can generate 100 watts of power, perhaps producing a kilowatt-hour per day. Based on this fact, we can estimate each person living in Sweden would need the continual support of more than 100 individuals to cover their daily energy needs, while in the United States—a much less energy-efficient country—this ratio would be equal to 200.

[15] The data published by the U.S. Energy Information Administration (EIA) in its annual reports ("IEA Key World Energy Statistics") records historical data, while the OECD's International Energy Agency, based on current trends, makes projections in its "World Energy Outlook 2012."

Our civilization is highly dependent on the energy we obtain from fossil fuels. We know that oil and other fossil fuels, to a large extent, support transport (air, land and sea), heating and industrial activities. Electricity, meanwhile, is essential to lighting, industry, refrigeration, air conditioning, radio and television, and a range of artifacts that we use every day, but we have also added to all this computers, telecommunications and the Internet, which we apparently can no longer live without. What we cannot see, though, is that almost 70% of the electrical energy produced today in the world is based on coal or oil.

As we can see, our current energy architecture was inherited, to a large extent, from decisions made during the 19th century that privileged oil (cheap, available and efficient)[16] and its derivatives over other energy sources. But the conditions have changed because, obviously, the negative effects of fossil fuel use were not part of the available considerations over 100 years ago. The problem is that today, when the concern for the global viability is rising among us, and we are thinking about changes and about different models we would like to advance towards, we cannot ignore that the inertia of a culture built around fossil fuels is not easy to modify, either in everyday life or in the economy.

[16] With oil prices at USD 100 a barrel, a person living in the United States would only have to work 15 minutes to earn 1 gallon of oil.

2.
GLOBAL WARMING

a. The emergence of a new global conversation

Twenty or thirty years ago, a new human concern began to be heard: the conversation about Global Warming. While it had begun long before as a scientific debate, it was around that time that it emerged as a concern involving not only researchers, but also politicians.

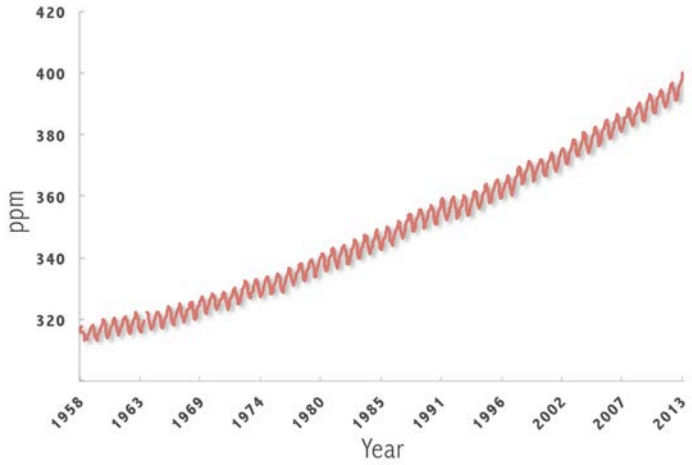
In this conversation, the stakes are high: the atmospheric concentration of CO_2 has soared to levels unseen in human history. When scientists analyzed the air bubbles trapped for the last 400,000 years in Antarctic glaciers, they found CO_2 concentrations that, despite their variations,[17] never surpassed 300 parts per million (ppm). In the last 50 years, meanwhile, these levels have gone from 320 to 400 ppm.

During this same period, scientists have determined that, along with the increase in the level of atmospheric CO_2, average temperatures have also increased, melting ice, causing ocean levels to rise, and flooding large coastal areas all over the planet.

Consider that, under current conditions, an increase of a single meter in the ocean level would be enough for millions of people living in coastal and island areas to see their habitat become extremely vulnerable, and in some cases completely uninhabitable.[18] But this is just one of the impacts associated to global warming. Similar claims can be made about other scenarios, such as: higher or lower amounts of rainfall at different latitudes, more frequent storms and hurricanes, heat waves, the spread of tropical epidemics, a loss of agricultural productivity, glacier melt, ocean acidification, etc. Several of these scenarios could occur in Chile, dramatically changing our landscape and habitability in vast areas of the country.

[17] The concentration found in these studies varies between 180 and 300 parts per million.
[18] According to various scientific estimates, if the Greenland ice cap were to melt completely, the sea level would rise 7 meters.

ATMOSPHERIC CONCENTRATION OF CO_2
(1958 – 2013)



Modern measurements show how the atmospheric concentration of CO_2 has grown steadily since the mid-twentieth century. In 2013 it reached levels of 400 ppm.

The oscillation observed in the graph is due to seasonal patterns of CO_2 capture by vegetation in the Northern Hemisphere.

Source: U.S. National Oceanic and Atmospheric Administration (NOAA).

There are varying estimations regarding the potential magnitude of climate change. James Hansen, a U.S. climate scientist and one of the most respected experts on this subject, believes that a CO_2 concentration of more than 350 ppm is unacceptable. In international political conversations, meanwhile, 450 ppm is considered the limit that would determine a global temperature increase of 2 ° C. England's Stern Report acknowledges that this goal is very difficult to achieve, and has proposed 550 ppm as the target limit.

b. From the scientific conversation to political action

The first international conversational space on this phenomenon was the Intergovernmental Panel on Climate Change (IPCC), created in 1988 by the United Nations and the World Meteorological Organization. IPCC is a scientific panel that updates its recommendations in periods of four to five years. It has already produced four reports (1990, 1995, 2001 and 2007),[19] the latest of which cites more than 6,000 publications and indicates that global warming is unequivocal and very likely (probability greater than 90%) is caused by the observed increase in greenhouse gases.

It has been mainly in this space that the voice of experts has interacted with public policymakers in diverse fields, such as agriculture, economics and energy, and so it has gone

[19] The IPCC received the Nobel Peace Prize in 2007 "for its efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change."

from being an eminently scientific-technical space to being a political space characterized by the pressure it applies for countries to take actions to stop or reverse the impact of global warming. The turning point towards this direction came at the Earth Summit held in Rio de Janeiro (1992), whose achievements include the approval of the United Nations Framework Convention on Climate Change (UNFCCC). This space took the responsibility for initiating policy conversations informed by the scientific conversations summarized in IPCC reports, and strived to reach agreements to address the potential threats of climate change.

Perhaps the most important annual conference in the framework of the Convention was held in 1997 in Japan, where governments agreed on what is known as the "Kyoto Protocol," which established stronger and more legally binding measures to reduce greenhouse gas emissions to a certain level (usually a percentual change compared to their 1990 emissions). This protocol, which was in effect from 2008-2012, strengthened the proposals of the Convention, and had been ratified by 187 countries as of 2009, but the United States and China, two of the countries that emit the most greenhouse gases, still have not fully subscribed it.

Progress since then, however, has been minimal. The agreement has not been fulfilled and the following 16 conferences have been unable to expand the number of countries that fully subscribe to the Kyoto Protocol; its term has not been extended, nor have more stringent and/or binding measures been adopted. While the last conference in Doha (2012) approved an amendment including, among other things, the inclusion of a second period of validity, the countries that ratified it represent only 15% of global emissions.

c. Four interpretations or approximations to the climate change phenomenon

Today, conflicting interpretations coexist in the conversation on global warming. We have identified four main positions.

First are the skeptics, who believe this is a "scientists' discussion" which, therefore, lacks credibility. For this group, the studies conducted have failed to produce certainties or convincing evidence; therefore, there are still no strong arguments for taking action on this issue.

Second are those who not only deny the phenomenon, but claim it is a hoax. According to this group—which includes the prominent U.S. geographer, meteorologist and hurricane expert William Gray—it is an invention by those who oppose economic growth. "Climate-gate"—the disclosure of thousands of e-mails between climate scientists—was an anonymous attempt to denounce this alleged deception and sway public opinion.

Third are those who claim this phenomenon truly exists, and therefore that we must decisively change greenhouse gas emissions. An important number of these actors come from the scientific world that participates in the IPCC.

Finally, there are those who believe that, besides believing that the phenomenon of global warming is real and underway, are alarmed about its possible consequences, because if it is true, we will not have an "undo" button allowing us to go back. Among the adherents of this position are former U.S. Vice-President Al Gore, one of the main international

political leaders committed to this concern, and meteorologist and environmentalist James Lovelock, author of the Gaia Hypothesis.[20] They claim that the consequences of climate change are here to stay and the world we leave our children and grandchildren will be radically different than the one we have known.

And their alarm is so great that they have declared themselves in favor of nuclear power, which—according to them—could more efficiently replace the fossil fuel-based power plants and complement other clean energy sources.[21]

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We must finally add that, despite its international political failures and its various conflicting interpretations, the threat of climate change has already changed the global political landscape.

Therefore, everything suggests that, if climate-related natural disasters continue to get more extreme (as it appears to be ocurring), by 2020 there will be a global agreement that will include measures such as: carbon taxes, fixed emission limits and fines, very strict protection of green areas, and global funds for territorial adaptation, among others. These would cease to be mere recommendations or agreements and become binding decisions. And another, not less likely scenario is that, simply because of the urgency, the most powerful nations may impose their agreement on all others.

Undoubtedly, any of the previous political-economic scenarios would affect our country. Without going any further, our electricity production is becoming increasingly dependent on the fossil fuels that are responsible for over 80% of CO_2 emissions throughout the world. It is therefore recommended that we anticipate those scenarios in which emission-free energy, in its different versions, could play a central role.

[20] The Gaia Hypothesis postulates that the atmosphere and surface of Earth behave as a coherent whole where life, its characteristic component, is responsible for self-regulating its essential conditions, such as temperature, chemical composition, and ocean salinity. Gaia would act as a self-regulating system that tends towards equilibrium.

[21] This position is being actively promoted, to the point where the film "Pandora's Promise" was released in June 2013, explaining the threats of global warming and describing the progress made in terms of security after the Chernobyl and Fukushima disasters. Among the participants were ecologists Stewart Brand and Mark Lynas, and the author of "The Making of the Atomic Bomb," Richard Rhodes.

3.
HORIZONS FOR INNOVATION IN ENERGY

The more our economies grow and the more we overcome poverty, the more energy we require. More people, with more income, will also require more food and water, and these are all very closely related elements: food requires land, water and energy, and producing more energy requires water and land. And all this in a world where climate change appears to be reducing water availability.

For this reason, we repeat that the political tensions derived from this combination of factors must lead to a new international energy agreement around 2020. We can already see the first signs of this. President Obama, who during his first period had promised to reduce CO_2 emissions by 80% by 2050, but failed to make much progress, has once again begun pursing this issue, but with a more modest goal of 17% by 2020.[22] In Europe, Germany is the main country that urges the European Union to set more ambitious goals for reducing CO_2 emissions by 2020. And in early July of this year, China and the United States agreed on five initiatives with the objective of reducing greenhouse gas emissions and atmospheric pollution.

However, in response to the failure of previous agreements, it is quite possible that this new agreement will not follow the current channels (the UNFCCC and the IPCC). Instead, it will depend on a large strategic meeting between the main worldwide consumers and producers, who shall discuss the new environmental requirements that they will impose on themselves. Just as there is now a Security Council, we can expect that there will also be a "Global Viability Council."

Such an agreement will not be easy. The inertias of a system as complex and rooted in our culture and our economy are joined by the interests of different actors (either states or companies): on the one hand, the main energy consumers; and on the other, the emerging economies—whose growth is linked to an increasing consumption of fossil fuels—and finally, the countries and multinational companies that produce fossil fuels, whose wealth depends on that market.

With these considerations in mind, we suggest identifying three time periods: the immediate horizon, from now to 2020, the mid-term horizon between 2020 and 2050, and the horizon beyond 2050.

[22] In fact, a few days after winning the 2008 presidential election, the New York Times reported that Obama had no intention of modifying his campaign promise to reduce them by 80% ("Obama Affirms Climate Change Goals"). However, almost 5 years later, the same source reported that President Obama was promising a more modest reduction—even though the article refers to it as an "ambitious plan." ("Obama Outlines Ambitious Plan to Cut Greenhouse Gases")

i. The period between now and 2020 is the horizon of a more efficient use of energy and, given the inertia in the system, of beginning to implement renewable energies.

Our efforts during this period must focus on producing savings: reducing the energy that is lost due to thermodynamics, transport and inefficiency. And we must take advantage of the spare capacity our system still provides, introducing greater efficiency, particularly in buildings: heating, electricity, air conditioning, insulation.

This horizon also requires introducing clean energies and monitoring some innovations that are aiming in this direction, mainly the development of photovoltaic energy, wind energy and batteries. The role of clean energies will expand, but during this period they will continue to represent a minor component of the energy system.

It is impossible to imagine that the world will be able to reduce its carbon dependence overnight. In the meantime, along with exploring some areas of innovation, it will be necessary to begin a transition from more polluting fossil fuels (oil and coal) to others that have a lesser impact (like natural gas) and to take advantage of hydroelectricity—as long as we choose projects with a small environmental impact.

ii. The second horizon, between 2020 and 2050, is the one of the de-fossilization of the economy and partnerships between clean energies and electrical systems.

On this horizon, it is worthwhile to remain alert to the possibility of obtaining low-cost carbon sequestration,[23] renewable energies and smart grids. It will generally be a time to consolidate mitigation technologies.

On this horizon, we must also pay attention to the development of batteries that may help overcome one of the main problems of some clean energy sources (like solar and wind energy), which is their intermittent production capacity.

Nuclear power, on the other hand, should also be in the sights of the 2020-2050 horizons. Although currently it faces strong opposition, this restriction will not necessarily endure in the future. If the problems of global warming or climate change grow to the political proportions we imagine, nuclear power with modern technology could begin to be considered viable.[24]

On this horizon, we will also be seeking to resolve political problems and consequences apart from the energy issue; for example, floods, migration, etc. We will ask whether it is possible to find some form of planetary government different from today's, for it is clear that the two fundamental institutions—states and markets—cannot solve our

[23] We are referring not only to the capture of carbon through "natural" methods like reforestation, but also to carbon capture and storage technologies in which carbon dioxide is artificially separated from other gases present in industrial emissions, compressed, transported, and finally stored in isolation from the atmosphere.

[24] Through his foundation, Bill Gates is supporting alternative energy projects, particularly the development of safer, cleaner and more efficient nuclear reactors, which need only 10% of the fissionable uranium required by current reactors. These projects are currently in the stage of computer models; there are no prototypes yet, and no plant of this type is expected to be operational before 2030.

problem alone. This will require a major intervention that will have tremendous consequences.

iii. Finally, there is the horizon beyond 2050, where there are a series of opportunities or threats that may arise and that are very difficult to imagine today, although there are people working on research into new forms of nuclear power, on the horizon of atomic fusion, geoengineering, nanomaterials, the use of bacteria (including synthetic ones) as energy sources, among other projects.

The main task on this horizon is to observe and to know that there are laboratories developing these new possibilities, and it is important to monitor them.

4.
ORIENTATIONS FOR CHILE

a. A stroke of realism

Chile is a small country. It is a net energy consumer, but it is far away from the big markets linked to the energy sector. Moreover, it is insignificant in terms of greenhouse gas emissions or the geopolitical layout mentioned earlier, but it will undoubtedly be affected by the decisions made to deal with the problems caused by climate change.

Our country has no fossil fuel resources, no major technological developments, and our electricity is expensive: in 9 years it rose from USD 26 to USD 200 per MW-hour. In other words, it experienced a 670% increase.[25] And, like any developing country, our economy is energy-intensive (the mining sector is the most compelling example). This is why, even with potential improvements in efficiency, we can assume that our energy demand will continue to grow. The question is how we will generate the energy that our own growth and expectations in terms of quality of life will demand in the coming decades. And this becomes more pressing if we consider that changes in energy policy are long-term ventures, since energy matrices carry a great deal of inertia.

In our case, we must also propose such changes in relation to another critical factor: water. We are already witnessing water shortages, and the effects of climate change may aggravate this situation.

Chile must make some decisions on the immediate horizon regarding our energy matrix. This document will not go into this debate, because the current technical discussion has been broad and it is in up to our political authorities to move forward with the necessary changes. However, we hope that these decisions are made with a broader horizon in mind.

b. Some considerations for Chile

Chile has access to large amounts of a non-conventional renewable energy source: the sun. Our country's northern region is a true natural laboratory[26] for the development of

[25] The lack of adequate investment is what explains this surprising increase, according to Jorge Quiroz and Andrea Tokman, in the chapter called "A New Deal for Energy," included in "95 Proposals for a Better Chile" by *Grupo Res Pública Chile*. And this lack of investment is the result of an investment model that ignores the concerns of civil society about what types of energy to use and where to locate the power plants, which, in practice, has delayed and even cancelled investment projects.

[26] We have taken into consideration here the central elements of the proposal made by the President of Conicyt, José Miguel Aguilera, understanding natural laboratories as spaces for possibilities based on a unique comparative advantage that the country

this energy source: it has some of the best solar radiation in the world, with a margin of at least 30% above Spain, 10% above Nevada in the United States, and more than 100% above Germany (one of the leading countries in the use of these technologies). In addition, the constant reduction in the cost of solar panels over the past 30 years[27] is rapidly making the price of this technology more competitive for generating energy[28].

To gauge the magnitude of our future possibilities, consider the following numbers: using our current technology, we would require an area of approximately 600 km² (70% of Lake Llanquihue) to generate the same amount of energy produced by our entire National Energy System (SIC + SING)[29]—and that is a conservative estimate. If we consider the best locations in northern Chile, and take into account the efficiency improvements being developed today, this surface area could be much lower.

These technologies are sure to become competitive sooner or later, but that is not really Chile's current dilemma. Part of our problem today is that we only think about our electricity requirements and we forget that the sun is a primary energy source that can have different uses. This bias prevents us from comprehending the potential relevance of our northern regions for the emergence of a solar energy ecosystem that may take advantage of this natural laboratory through greater investment, research, services, suppliers, etc.

In this scenario, we propose to invest in a marginal solar energy application that would address another problem in northern Chile: the availability of water. With the presence of abundant solar radiation along hundreds of kilometers of coastline, it is feasible to consider desalinating seawater to produce fresh water, an increasingly scarce resource in these regions.

Seizing the opportunity to implement solutions in marginal fields like this would allow us to accumulate technical and human capital, create confidence among investors, and engage with local communities to subsequently advance towards larger-scale applications such as electricity generation.[30] It is also important to mention that water scarcity is a determining factor in the feasibility of large mining and agricultural projects in the northern regions; therefore, the implementation of such a project could also have a large short-term impact.

Choosing to take advantage of the natural conditions (sun, land and sea) and water needs of our north, however, would require overcoming a social, political and economic obstacle: assigning the lands that are appropriate and necessary to carry out such an initiative. In this case, land, water and energy would all be interconnected. They would be at the center of the same socio-political-economic conversation.

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possesses due to natural conditions, traditions that are deeply-rooted in the population, or as a result of past public or private efforts developed.

[27] In fact, writing in Scientific American, Ramez Naam claimed that Moore's Law also applies to solar panels. http://blogs.scientificamerican.com/guest-blog/2011/03/16/smaller-cheaper-faster-does-moores-law-apply-to-solar-cells/

[28] In the document, "Levelized Cost of New Generation Resources in the Annual Energy Outlook 2013," The U.S. Energy Information Agency (EIA) projects a levelized cost of USD 144 per MW/hour for generating electricity with photovoltaic panels in 2018, much less than our marginal cost today with the SIC, which is around USD 200 per MW/hour, as we indicated previously.

[29] As estimated by Professor Roberto Román, an expert in renewable energies, at the request of the CNIC.

[30] In fact, three of the country's most important mining companies (Collahuasi, Codelco, and Antofagasta Minerals) have installed photovoltaic plants that will substitute fossil fuel consumption in several of their facilities.

Another possibility worth exploring is to resume and project the use of hydroelectric power—which represents one third of our current energy matrix—with projects that have a small environmental impact, as well as natural gas, so that, in the short term, these could become the technology that drives the expansion of the electric power grid, promoting our transition towards a matrix with lower greenhouse gas emissions. Recent developments in shale gas, along with its lower CO_2 emissions and local environmental impacts, favor this option from both an economic and political perspective.[31]

As we know, public opinion is strongly opposed to nuclear energy, especially after the recent disaster at Fukushima-Daiichi. However, it is an alternative that does not generate significant greenhouse gas emissions, to the point that some environmental groups that previously opposed it now support this option, as long as the appropriate security protocols are implemented. It is worthwhile to monitor how conversations in this area continue to develop.

Other alternatives, such as biofuels, energy efficiency, wind power, geothermal power, and tidal power must also be on our radar. Given that, as technologies evolve, some of these options may well turn into avalanches, Chile cannot stand by idly. Our international relations (in the political, scientific and technical fields) must ensure a space for us in the conversational circles that are taking the lead on regulatory and technological issues. A country that does not have an abundance of energy resources cannot afford the luxury of missing opportunities.

What we are proposing is a nationwide, unwavering commitment to follow several paths. These paths would require public-private partnerships, legal and political backing, and policies to foster relationships with institutions in other countries through various instruments: cooperation agreements, foreign investment for projects in Chile, scholarships for the education and training of scientists and engineers, venture capital, etc.

[31] While the cost of this gas would be higher than coal, the truth is that "today, creating and approving a coal generation project is a high-risk venture," according to Quiroz and Tokman in "95 Proposals for a Better Chile." This is due to the opposition in civil society, and therefore, despite it being more expensive, it makes sense to project its use when we consider its lower environmental impact.

II. STRATEGIC ORIENTATIONS FOR A NEW BIOLOGY

After years of research on ecosystems, organisms, cells and genes, biology—at the forefront of life science and enhanced by other disciplines or technologies like bioengineering, nanotechnology and computers—is leading a revolution that is defying the limits of life every day. With the speed provided by today's digital technologies, scientists are sharing not only more knowledge about natural processes, but also powerful tools to intervene or modify their most fundamental structures at the molecular level.

As has happened before—we saw one example in the case of Pasteur—although now at a much faster pace, science is challenging our perceptions of the natural world, our awareness of ourselves, and even our social order. The political, legal, ethical, ecological, economic and cultural impacts of these new possibilities are open to debate, criticism, or hope. But it is impossible to tackle these concerns if we do not understand what science and the capacity for disruptive innovation mean for people and societies, both in terms of the new opportunities or benefits they provide, and the adverse effects and unintended consequences they may bring. From this standpoint, we could explore the possibilities that this new biology is opening up in some of humanity's main areas of concern—food, environment, energy and health—and their potential impact on the creation of new industries that may shape the economy of the future.

1.
THE REVOLUTION OF A NEW BIOLOGY

a. The horizon of what is possible

Towards 2050, the estimated world population will be between 9 and 10 billion people (two billion more than today), who will have better life expectancies. Among other challenges, this will lead to a growing demand for food, and new biology could have a lot to offer in this sense. Meanwhile—and as has been happening throughout human history—we will need a better way of managing the growth and productivity of animals and vegetables, but this time in a new, more restrictive framework created by the effects of climate change or the measures taken to deal with it: changes in rainfall patterns, higher temperatures, and desertification would surely be accompanied by new regulations on the use of pesticides or fertilizers, or restrictions to water consumption. Producing foods in this context will require a deep knowledge of the biological processes of our crops and their adaptability to different soils and ecosystems. In this same scenario, the production of genetically modified foods could continue to develop—amidst apprehensions—long before the corresponding norms and laws even come into effect.

The growing pressure to abandon the use of fossil fuels because of their greenhouse gas emissions will continue opening up spaces for biotechnology, which has recently improved or developed new techniques for producing biofuels, which could produce a significant decrease in the cost of energy, but, at the same time, threatening the food supply as it reorients the use of land or crops that had previously been destined to human consumption.

This new biology will also be a stepping stone for a better comprehension of ecosystems, their biodiversity and their sustainability. This will involve combining our knowledge of ecology; organic, comparative and evolutionary biology; climatology; hydrology; soil and environmental sciences; but also engineering. Such an integrated effort, which would require unifying languages such as mathematics and computer sciences, would enhance our ability to monitor the inner workings of ecosystems, but also a renewed hope to produce a more complete knowledge that may allow us to intervene and control these complex systems.

But it is human health that has historically concentrated the major efforts of humanity, and will continue to do so. Living more and overcoming diseases has been a permanent concern that, beyond individual efforts, has regularly led to collaborative work between companies, states or groups of nations to face mankind's most pressing challenges. In the mid-1950s, this collective effort concentrated on the struggle against cancer; in the

1980s the main target was AIDS; and from the 1990s on it was the race to decipher the human genome (with the promise of defeating hereditary diseases). More recently, a new focus—promoted by President Obama—has been Project BRAIN, which seeks to map the interactions of the nearly 100 billion neurons of the human brain, and which has an annual budget of more than USD 300 million over the next ten years with the goal of learning more about our intelligence.

In spite of everything, we still have much to learn. Twelve years after the publication of the human genome, we still do not know what function each piece of genetic material has in the expression of different genes, or how these millions of factors interact amongst themselves. This knowledge, with its enormous complexity, will be necessary in order to fulfill the goal of personalized medicine on the horizon. We still have a long way to go in our comprehension of cancer, and, of course, neuroscience is just beginning to allow us to understand more about how the brain works. In fact, we still have a crass ignorance about something apparently as basic as what self-consciousness actually means.

b. More utopian horizons

Beyond the hopes surrounding the impact of new biology in different dimensions of our lives, and despite everything that must still be learned, there are also those who are looking further down the horizon, towards more utopian frontiers, and predicting that the new possibilities of nanotechnology, robotics, computing and genetic engineering could radically transform human civilization.

Some prominent technologists, for example, argue that progress could amplify our cognitive capabilities to the point where it may be possible to overcome any type of physical and intellectual limitation, bringing about a transhuman race. Other researchers, meanwhile, believe that by 2045, the exponential growth of technology could generate a non-biological intelligence capable of improving itself, reaching a point where its progress would be so fast that unimproved human intelligence would be unable to keep up. This is what has been called "technological singularity," one of whose main proponents is inventor Raymond Kurzweil, who received the United States' National Medal of Technology and Innovation in 1999 and is the current Director of Engineering at Google.

Kurzweil believes that we can overcome death and that we will be capable of reproducing human intelligence in computers. For example, based on his studies of the Internet, he claims that currently at least 99%--if not 99.9%--of the processing power of all computers connected to the Internet is underutilized, pointing out that, if we improve the online operation of this infrastructure, we could multiply our processing power by one hundred or one thousand times, which would be equal to achieving the capacity of the human brain for just USD 1,000 by the year 2020.

There is also the expectation that, over the next few decades, our life expectancy may be extended to unimaginable limits. Aubrey de Grey, a biogerontologist and co-founder of SENS Research, unleashed a huge controversy by claiming that death is "an illness, and as such, it is curable." He claims there are seven types of damage caused by aging, and that they can all be treatable: nuclear mutations that cause cancer, mitochondrial

mutations, intracellular waste, extracellular waste, cell loss, cellular senescence, and excessive extracellular interconnections.

Other researchers, such as Eric Drexler, claim that it may be possible to obtain new structural materials that are one hundred times more resistant than the aluminum alloys used in aircraft, all with just one-tenth or one-hundredth of their density, or compounds more resistant than steel, but with one-fifth of its density. This new promise of nanotechnology is already known as Atomically Precise Manufacturing (APM),[32] and it promises radical changes in various industries: for what we can envision now, products or structures built with less mass and lower costs, and in terms of medicine, the possibility of studying and controlling biological systems with an unprecedented level of detail.

Of course, there are those who will believe that these are all simply utopian mysticism, and therefore highly implausible. For others, these are exactly the types of visions that sparked important technological revolutions.

The truth is, we cannot know if any of the predictions we have mentioned will effectively come true, and exactly how they might change the world as we know it. But this is not the most important thing, because, as we have mentioned many times in this document, we are not motivated by a desire to predict the future. What we can acknowledge is that imagination and utopian ideas play a crucial role in our emotions and influence the goals we set, the projects we undertake, and the resources we assign. This is why our attention is focused on their ability to mobilize our wills, in search of the roadmaps that may help us identify possible avalanches.

c. Our responsibility

At this point, we must remember that, although the modernizing promises of progress are clearly still appealing to us, we must acknowledge that science and technological development may also produce unforeseen effects, unexpected risks and even disasters. Because, in spite of any illusion of control, sometimes things go wrong and can reach catastrophic dimensions: from computer system failures to financial crises, and from industrial or nuclear disasters to global climate change. "Because human beings have in their mortal hands the power to abolish all forms of poverty and all forms of human life."[33]

We must recognize, then, that it is now time to take full responsibility for the consequences of technology, but also to accept that we cannot do without it. We have no room for naïve utopianism, or pessimistic dystopias, or omniscient technocrats, or an impossible "return to nature," or a blind faith in the market, nor an idealist hope in "technicians" or experts. Instead of any of these, what we need today is the active

[32] Eric Drexler is responsible for popularizing the term nanotechnology, when he used it in his book "Engines of Creation" (1986). Drexler has just published "Radical Abundance: How a Revolution in Nanotechnology Will Change Civilization", in which he clarifies his vision for the possibilities of nanotechnology (which he claims has been misunderstood and used to promote "nanosubstances" and not "nanomaterials" as he proposes), and insists on Atomically Precise Manufacturing (APM).

[33] These words are from U.S. President John F. Kenedy's inaugural speech in January 1961.

participation of everyone in the creation of our technology, of our forms of coexistence, and our ways of being and inhabiting the world, assuming that these are all inseparable.

2.
THREE AVALANCHES FROM A NEW BIOLOGY

We do not intend here to give an account of every wave of change that may arise from new biology—that would be impossible and pretentious—but we will consider three that are useful for illustrating the type of transformations we can expect: aging, new forms of medicine, and the use of micro-organisms in many other domains.

a. Aging and new ways of understanding life

Life expectancies have gradually been increasing rapidly over the past century. The current life expectancy is more than twice what it was 150 years ago—and it is expected that in the coming decades it will continue to rise.[34] All this, which undoubtedly may be considered as something very positive, may also generate problems and challenges that are already advancing inexorably.

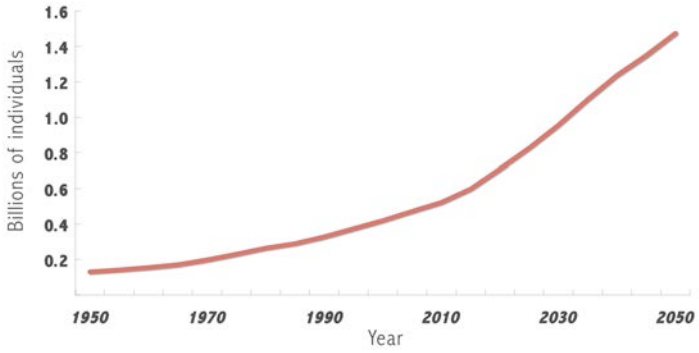
Today, the cost of social security programs and health care for senior citizens represents an important share of our national budgets (especially in developed countries), and is growing at a faster pace than the average inflation rates. This trend is projected to continue increasing in the coming years,[35] while the number of active workers for each senior citizen will steadily decrease. In the most industrialized nations, these problems are already generating pressure and debates surrounding health care and pension systems. And Chile will be no exception.

But financial pressures are only part of the challenges presented by an aging population. The main difficulty is that we still look at our seniors the same way we did 30 years ago: people who no longer need, can or want to work, who deserve a "rest," and who are too old to function in the new worlds we inhabit, anyway. Medicine, new types of health care, and various practices and technologies are proving otherwise.

[34] In a 2011 report, the investment services firm AllianceBernstein referred to "Molecular Medicine", indicating that life expectancy in the United Kingdom increased from 42 years in 1845, to 61 years in 1930, to 89 years in 2011.

[35] Last June, the Organization for Economic Cooperation and Development (OECD) published a number of projections on the cost of health care programs, concluding that "rising spending on health and long-term care will continue to put pressure on public budgets over the next decades." The OECD projects that, by 2060, the 6% of GDP that these costs currently represent for the OECD average, will increase to 9.5% or 14% of GDP, depending on whether or not the public policy implemented is designed to contain costs.

POPULATION OVER 65 YEARS OLD
1950 – 2050 (proyection)



The United Nations projects that the number of individuals over 65 years old will increase by almost one billion by 2050. While the general population will increase by 57%, senior citizens (as they are defined today) will do so by 182%.

Source: United Nations, Department of Economic and Social Affairs, Population Division (2010).

If we look towards the future, our challenge is both cultural and economic, because if those over 65 years of age do not have a place in society that differs from the one we assign them today, it will be difficult for us to meet the challenges of an increasingly older population. To begin with, are we going to continue speaking of senior citizens at age 65 when the life expectancy is over 90, 100 or 120 years?[36] Will it be possible to think about retiring from the workplace when, as we turn 65, we still have a third of our lives ahead of us? Moreover: what will what we currently refer to as "old age" look like if medicine and technologies fulfill at least part of the promises being made today? And if they become a reality, how many of our current norms (regulations, demands or prohibitions) will definitely become obsolete? How will all these changes affect health costs?

From a labor perspective, we can imagine that senior citizens will have some characteristics that qualify them more for certain jobs: for example, they may have a role as guides or mentors for children, youth and adults, giving them the wisdom—as Reinhold Niebuhr insinuated—to build new worlds or learn to live in the ones we have.[37] And in this sense, the new online global training spaces may have a positive impact on employability and labor reinsertion (see chapter on Education).

Since their children will already be independent, it is possible that senior citizens will be more willing to take risks and, for example, start their own businesses, like when Harland Sanders, at age 62 and after having worked for years at a gas station, decided to start a business that would later be known as Kentucky Fried Chicken.

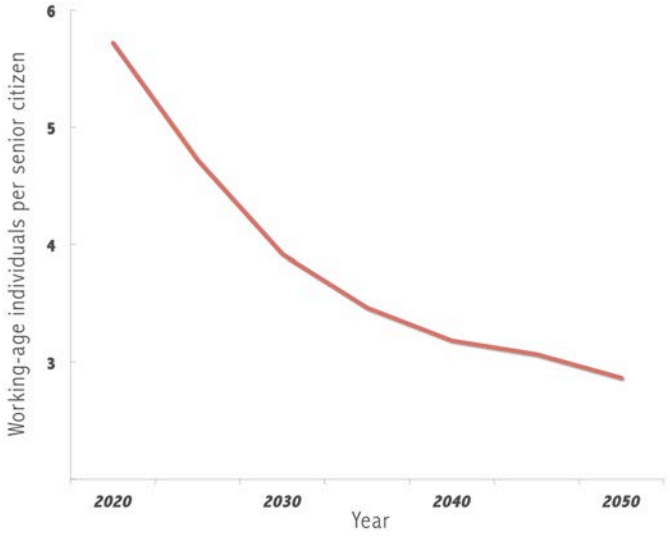
[36] Alex Zhavoronkov, Director of the Biogerontology Research Foundation, in his recent book "The Ageless Generation," explains how genetic therapies have been able to extend the lives of rats, which are genetically very similar to human beings, to the equivalent of 160 human years.

[37] We are referring to the Serenity Prayer, which, although it comes from a long oral tradition, first appeared in its written version as part of a sermon by U.S. theologian Reinhold Niebuhr in 1943: "God, grant me the serenity to accept the things I cannot change, the courage to change the things I can, and wisdom to know the difference."

Finally, the full integration of senior citizens into all social domains will contribute to their welfare, and therefore to everyone's welfare, insofar as it is a fact that psychological aging is exacerbated when individuals have little social contact or remain inactive.

SENIOR CITIZENS VERSUS WORKING AGE POPULATION

Projection of the dependency rate in Chile



While there are currently almost six working-age individuals for each senior citizen in Chile, this ratio is expected to drop to three-to-one by 2050. This projected decrease poses important challenges for our country, both in terms of productivity, employability, and support for senior citizens.

The old-age dependency rate is the ratio between individuals that are 15 to 64 years old and individuals over 65.

Source: Instituto Nacional de Estadísticas (INE). Proyecciones y Estimaciones de Población, Total País 1950-2050.

b. New medicines

In the wide-open world of new biology, one of the most relevant avalanches is **personalized medicine**, which implies a revolution in medical practices and health care in general, that will allow us to live longer and healthier lives.

Everything begins with the power we now have to read the genetic "code" of our DNA, which contains instructions concerning the structure and biological processes that explain life. With these advances, the medical field no longer views diseases as a collection of symptoms or breakdowns in the functions of a particular organ, but rather as a dysfunction in the interactions of biological molecules. Thus, for example, DNA tests allow us to diagnose the propensity to suffer more than 260 genetically inherited diseases. But personalized medicine is more than just faster or more precise diagnostics.

The emergence of this new medicine is a transformation very similar to the advent of the digital era, when new semiconductor technologies lowered the cost of computers, making them available for large numbers of users in their daily activities. This expansion—combined with new developments in the microchip industry and a processor speed that was doubling every two years—fueled falling costs and the production of new applications exploded, attracting even more users.

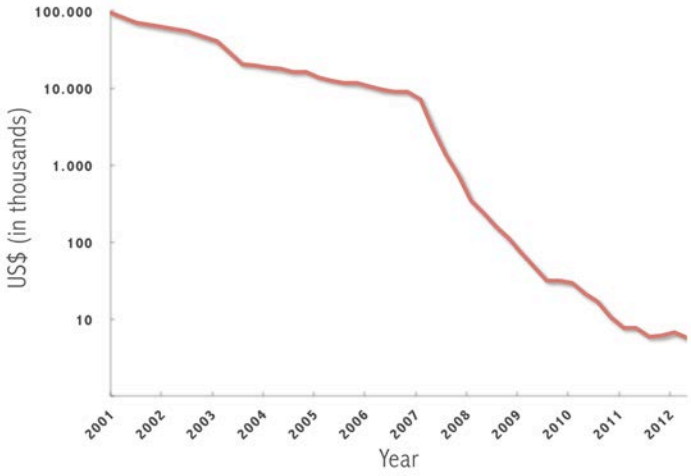
The virtuous circle in medicine looks very similar: the development of new technologies is reducing costs and allowing us to double our capacities for reading DNA every six months. This leads to new data and information about diseases at the molecular level, which is used to produce new medical tools and services for which those who are willing to pay for them, and this, in turn, generates a demand for better DNA deciphering capacities.

It is clear that the growing use of molecular tests will completely transform the diagnostics industry, facilitating not only more precise prognoses regarding the diseases that an individual has a greater risk of developing, but also helping to determine which drugs work best for particular patients, according to their genetic traits. In this scenario, innovative drug companies will use molecular information to constantly reduce development costs and times, and to expand their drug projects.

Meanwhile, this biological revolution, combined with engineering and other disciplines involving materials, should allow physicians to harness the power of **regenerative medicine**, focused on repairing or replacing damaged, diseased or metabolically impaired organs, tissues and cells. This includes the possibility of growing organs outside of the body or repairing damaged tissue from diseased organs by inoculating

stem cells (not necessarily embryonic ones),[38] or even inducing one type of differentiated cell to become another type of cell.[39]

COST OF READING AN INDIVIDUAL'S GENOME



Until just over a decade ago, deciphering the genetic sequence of a human being could cost USD 100 million. Today, it is possible to obtain for around USD 5,000, and this figure continues to fall at an accelerated rate.

The current cost is 0.006% of the corresponding amount in 2001.

Source: Wetterstrand KA, DNA Sequencing Costs: Data from the NHGRI Genome Sequencing Program (GSP).

The projection is that, by 2030, regenerative medicine will account for at least 25% of drug industry revenues. In many cases, regenerative solutions will capture the entire revenues of existing drugs and make organ transplants unnecessary.[40]

The accumulated momentum of this nascent discipline is enormous. But while most progress in this medical field has originated in Europe and the United States (which invested around USD 1 trillion over the last 20 years), it is now expected that the next

[38] In 2007, Shinya Yamanaka was able to induce an adult cell to dedifferentiate towards its pluripotent state and then redifferentiate into another type of adult cell, proving that it is possible to produce a type of non-embryonic stem cell called induced pluripotent stem cells (iPSCs). This discovery earned him the Nobel Prize for Medicine five years later, and has put an end to the long debate on the use and destruction of human embryos in stem cell research. iPSCs also overcame the medical problem of immunological rejection, since cells are taken from the patient him/herself in a surprisingly simple process.

[39] Using the method known as transdifferentiation, skin cells have been converted into heart cells. To accomplish this, it must first be determined which genes need to be activated or silenced and which of the existing cells most closely resemble this genetic pattern. Then, these genes must be programmed to act accordingly and create the desired cell.

[40] The AllianceBernstein report on "Molecular Medicine," which we have already mentioned, claims that clinical research into cell therapies for eye- or kidney-related diseases, central nervous system disorders like Parkinson's, bone diseases like osteoporosis, and various blood disorders, are all currently in different stages of development.

advances will come mainly from China, which will invest over USD 300 billion over the next 5 years to build the great "China Medical City" in Taizhou, northeast of Shanghai. The government wants this facility to become the international center of research on regenerative medicine, housing the main research and development institutions, most of the prestigious hospitals, and the most prominent medical research universities and institutes. It seems natural that this has become a national priority if we consider the accelerating pace at which this country is aging. It is expected that, by 2050, the number of citizens of working age (15 to 64 years old) for each senior citizen will drop from 4 to 2. A similar reduction is expected for Chile.[41]

New diagnostics possibilities and new therapies will redefine the roles of hospitals and physicians: on the one hand, because some diseases that are lethal or disabling today might become chronic and bearable; and on the other, because the effectiveness and lower cost of the treatments now being developed may reduce the need for expensive long-term care for some of today's most widespread illnesses. Along with this, health care—as well as prevention—must also change drastically, contributing to transform the cost structure of a medical model currently based on curing people. In fact, the alternatives being explored to improve health and extend life even include producing foods that have certain molecules with anti-aging properties,[42] or inducing bodily processes to attack aging cells and stimulate their replacement with younger ones.

c. Synthetic biology

Although the possibility of using biological processes for practical purposes is ancient—like the yeast used for beer fermentation—the concept of synthetic biology is recent and refers to designing and building a completely functional biological system or device with a useful purpose, taking advantage of modern biotechnology practices that allow us to work at the molecular level: with DNA, proteins, and other fundamental organic molecules.

The best-known landmarks of this discipline were achieved by the J. Craig Venter Research Institute (JCVI), led by J. Craig Venter. In June 2007, a successful transplant of the complete genetic sequence of one species of bacteria to the cytoplasm of another was reported. In January 2008, scientists from the same institute assembled a modified version of the genome of a bacterium from scratch. And finally, in May 2010, JCVI announced it had developed a synthetic genome for one million pairs of nitrogenous bases (the letters of DNA) and inserted them into the cytoplasm of a bacterium, creating the first functional life form using an artificial genome.

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[41] China's situation will be shared by 20 other countries, according to a 2001 report called "World Population Ageing: 1950-2050" by the United Nations Department of Economic and Social Affairs. It should be noted that Chile expects this ratio to be between 2 and 3 working-age citizens for each senior citizen.

[42] In 2006, scientist Mikhail Shchepinov developed a process that is capable of protecting cells from electron loss caused by free-radical attacks. Since then, this technique has become one of the main contributing factors to dealing with aging and many diseases. Shchepinov used food components fortified with hydrogen isotopes (deuterium).

The promise is to accelerate the development of new, optimized biotechnologies that may be applied in many aspects of industry and life, and therefore efforts are focused on manufacturing cells and micro-organisms that are capable of performing a specific function.[43] For example, these synthetic organisms could be used as factories to transform cheap nutrients into high-value products, such as biofuels with better properties than those achieved through fermentation, or chemicals produced for medical purposes. Another area includes medical applications like drug production or as a direct interface for patient diagnosis, prevention and treatment (biosensors or tissue engineering, for example). It could even lead to improvements in the area of sustainability, where synthetic systems have been proposed for bioremediation, bio-mining, and creation of drought-resistant crops, for example.

From one perspective, synthetic biology is "simply" an extension of molecular biology, accelerated thanks to the tremendous progress of DNA recombination technology. As such, it shares the security concerns that are inherent to this technology; for example, the risk of unforeseen behaviors by synthetic organisms outside the laboratory that may affect the environment or even public health: the discussion is similar to the one surrounding genetically modified organisms. There is also the fear of the development of biological weapons. While some experts argue that the current progress of synthetic biology would make this type of development difficult to achieve, others warn that it is best to consider the worst-case scenarios as early as possible.

Meanwhile, the fact that the main goal of synthetic biology is currently to create a living organism raises many philosophical and ethical concerns, from what the nature of life is to whether we are willing to consider a synthetic organism with properties that do not occur in nature to be "living." The expression "playing God" comes to mind, both in its religious and secular interpretations, when we observe the fact that some individuals may use technological power to cross a line that not everyone wishes to cross.

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3.
SOME OPPORTUNITIES FOR CHILE

We have discussed three of the most relevant waves in the biological revolution, which may radically transform health and many other productive activities over the next decades. In this context, it is always possible for us to stop to look at what is happening, to consider them only as threats, or to remain open to surfing them, anticipating and searching for opportunities.

We can observe, for example, that the appearance of new forms of medicine and related technologies are creating a global scarcity of professionals and technicians in various fields. For now, in large fields like biology and medicine, engineering and materials science, or robotics and clinical services. In all of these, also, markets are becoming more and more globalized thanks to online networking (within the continually expanding capacities of the internet) and, as has already occurred with drug tests and other stages of medical and pharmaceutical research and development, many of these services are provided by different places around the world. India has specialized in capturing these types of opportunities in recent decades.

If we, as a country, are capable of developing quality technical and professional training, in a short period of time and in fields related to those opening up in medicine and biology, Chile could capture a good number of high-level jobs in this global market. Of course, this would require academic and scientific reorientations, but also regulatory and normative spaces in the fields of labor or research.

In this sense, we must join global research networks, beginning with those fields where we have clear advantages or existing relationships, and we must also depart from our traditional institutional and disciplinary fragmentation and slowly advance towards the creation of more integrated and collaborative communities. Interdisciplinary programs, the attraction of international research centers and the participation of Chilean researchers or centers in global networks must play a key role here, including not only universities, but also establishing alliances with government agencies and industries in order to strengthen research results and capabilities. Finally, we must use the comparative advantages provided by the natural spaces and unique characteristics of our territory as natural laboratories (see Appendix) to attract advanced human capital and technologies that will facilitate synergies and progress in these fields.

III. STRATEGIC ORIENTATIONS FOR EDUCATION

Education is always a crucial domain. For the Council on Innovation, it is also extremely relevant, understood as both infrastructure and as a space for producing innovation. However, we see that the conversation has become entangled for various reasons, and that in this area we require not only new technologies or new institutions, but also a different way of thinking.

In this section, we propose to explore possibilities. We are motivated by a sense of commitment and care for our future generations. We know that education has heavy inertias that often obstruct or hold back changes. Therefore, trying to anticipate them in order to act on time is a vital commitment with those who come after us. But we have been losing our ability to make long-term decisions, and also forgetting that our omissions are also ways of affecting the future, for better or for worse.

We will begin by looking towards the 2050 horizon, asking ourselves about education in its most profound sense, so that, on the 2025 horizon, we can begin to discuss more specific aspects of higher and secondary education—those that prepare us for adult social life and work. We will try to be much more concrete and to connect with phenomena that are already occurring and that require attention, monitoring or even of the development of specific initiatives.

Obviously, at this stage we cannot possibly cover all the dimensions that are opening up in this field, so we will address only three that we believe are essential for us to focus on over the next decade.

Finally, and as we have observed before, it is important to remember that these are not horizons of prediction, but of reflection.

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1.
2050: A HORIZON OF FUNDAMENTAL DISRUPTIONS IN EDUCATION

Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?

T.S. Elliot

Education will be very different on our strategic horizon of 2050. As few of the many institutions and practices that are subject to disruptive changes, this field is now being radically transformed and will look quite different when the children, grandchildren or great-grandchildren of those reading this document today assume full responsibility in the world.

By focusing on this horizon, and distancing ourselves for a moment from the contingent problems of the present, we are able to develop a more historical view that is crucial at a time when everything is changing so rapidly.

When we talk about education, we normally carry with us the historical inertia of institutional distinctions, definitions, practices and arrangements without asking questions about the new horizons that this global transformation may be opening and closing. Therefore, the question that guides this section is: What will education be like in a world as different as can be expected around 2050?

As a starting point, we would like to differentiate **education** from **teaching**.

Education does not take place only in classical teaching settings such as schools, institutes or universities. Our early relationship with our mothers, family and friends, work and life in our communities, the mass media and entertainment, are also practices and institutions that shape the field of education. In these spaces, however, we do not learn through the teaching of specific knowledge. Simply by being immersed in these worlds, by observing and following the available examples, we learn the meaning of existing ethical norms, we are moved in one direction or another by what matters, and we begin to assume (without realizing it) a way of being, an identity.

Education, understood in this sense, consists of initiating ourselves into a culture and developing—through the use and cultivation of that culture—our own individual skills

and talents in relation to it; because we are born into cultures[44] that are already "functioning" and we must learn to live in them from day one.

This general interpretation, which represents an existential and constitutive dimension of human beings, is useful to our exercise, because it lets us suppose that, no matter how different the world may be towards the middle of this century, initiation into a culture will continue being one of the foundations of education.

Currently—and this is something we have inherited from the historical past we call modernity—education is not understood as the reception of a culture, but rather as the rational search for certainty regarding the natural and social worlds, and training in a practical use of this knowledge. Our institutions use this rationale, but this was not always the case. The *Paideia*, for example, intended to give the men of Ancient Greece a truly human character, striving not only to teach manual skills or erudition in specific subjects, but civic formation through gymnastics, grammar, rhetoric, poetry, mathematics and philosophy. Centuries later, in the early Middle Ages, the education of the freemen consisted of the seven liberal arts—grammar, logic, rhetoric, arithmetic, geometry, astronomy and music—and clearly sought to produce something far beyond "reason." And a similar meaning can be found even later, in the German tradition of *Bildung*, which was a process of personal and cultural maturity that sought the harmony of the individual mind and heart, as well as the integration between personal identity and society in general.

Today, when everything is changing at such an accelerating pace and in such disruptive ways, the modern assumption that there is a static knowledge that is passed down from generation to generation and increases linearly is increasingly anachronistic. However, we are definitely not suggesting that there is no knowledge—arithmetic, reading and writing, or science—that allows us to function in the world and must be considered part of education. But we share the "suspicion"—one that is becoming more and more recurrent in global conversations—that there is another type of fundamental "knowledge" that has to do with coexistence, with ethics, with the meanings we assign to the world and our way of inhabiting it, which should also be part of education.

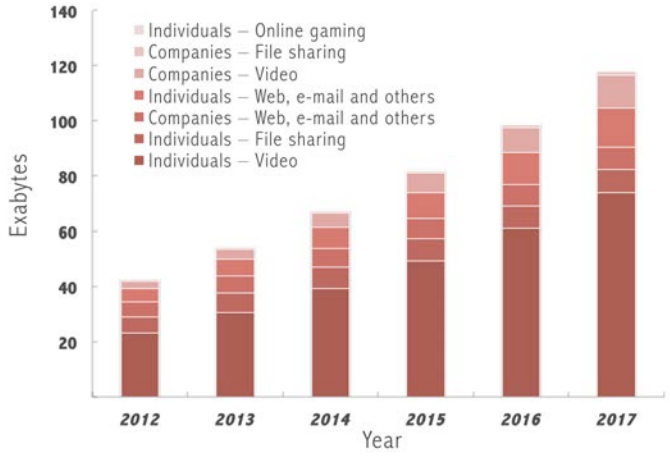
Having said this, and always keeping in mind the key question regarding what education should be like in 2050, we will dare to propose a few conjectures.

a. Some conjectures on the future and education

The entire planet will be strongly interconnected through global digital networks that will be fully developed by the middle of the century. All accumulated knowledge—data, formulas and rules—will be freely available to whoever wishes to use it in any place. Training on how to access and use this knowledge will lose relevance, since machines will get really good at doing exactly that.

[44] We use the word culture for lack of a better term to refer to the space of norms and values, networks of instruments and technologies, sets of practices, skills and specialized roles, identities, as well as beliefs, emotions and ways of thinking, and the corresponding conversations in which we exist and are immersed.

MONTHLY INTERNET TRAFFIC
Projections by application



Internet traffic will practically triple by 2017.

Internet videos represented more than 50% of total traffic during 2012. By 2017, this figure will be around 75% of total traffic.

Source: Cisco VNI Global mobile Data Traffic Forecast, 2012-2017.

Note: One exabyte equals a billion megabytes.

Life on these global digital networks will produce a historically unprecedented articulation between diverse cultures and worlds. In this new space, cognitive skills will be insufficient. They may suffice to participate in commercial transactions or to cultivate formal democratic relationships, but they will not be enough to create new, long-term relationships across the cultural worlds we have become accustomed to.

Ecological issues will become a fundamental concern in the near future. At this point, it is probably not even necessary to justify this conjecture much further. But it is important to realize that to discuss ecology is to speak of local worlds, and that we may not deal with these by using formulas, as if we were simply resolving a technical problem. We will not be able to deal with future ecological problems by studying them as cognitive phenomena that can be fully investigated and understood. We will always encounter diverse opinions and different sensibilities that must be considered, negotiated and articulated. There is no certainty in ecological issues—no true diagnosis—only the emotional opinions of human beings who represent the worlds they live in.

Thus, we can expect that by the middle of the century, education centered on knowledge with no historical context—data, information and formulas or explicit rules—will give way to an education more concerned with the skills and sensibilities that allow us to inhabit worlds that require a permanent reorientation in the face of change and perplexity.

In this perspective, towards the horizon we are observing it is possible to anticipate:

i. That the most valuable characteristic of the new generations will be their ability to take action in the world, and not necessarily an official guarantee—

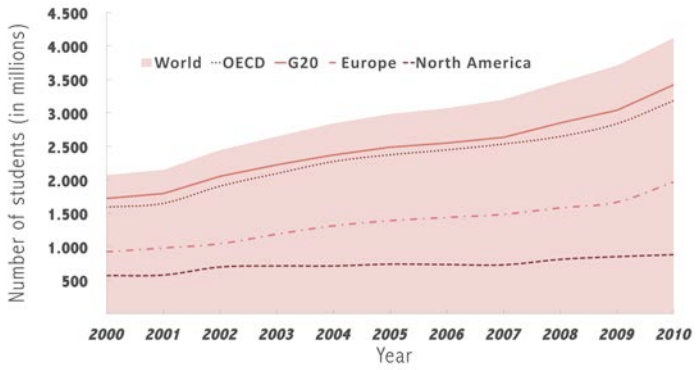
expressed in degrees or titles—that they have been well-trained to handle certain knowledge. This dynamic may have a strong impact on the institutional and regulatory frameworks of global education systems, both in terms of student learning assessment, program certification and institutional validation. In one sense, because the relationship between students and training centers will transcend national borders, limiting the power of states to establish local norms for a market that, in practice, will be global. And in another sense, because in diverse fields of human activity, skills and experience will be the true key factors on the job market, more than the possession of a diploma to certify how much knowledge has been acquired.[45]

ii. That a connectivity exponentially greater than what we have today will allow access to educational spaces that are much richer, more pluralistic, open and flexible, without having to sacrifice depth and roots. This would all have a large cultural impact, permitting the interaction of students from all over the planet (each with their different worlds), an openness to practical worlds and diverse realities, and access to the best professors in the world, available not only through mere class recordings, but also through more complex audiovisual productions that will combine high-quality cinematography and narrative with academic excellence.

iii. That new teaching practices and technologies will become available to radically improve learning, while also reducing the cost of training. Advances in artificial intelligence will allow users to design individual learning paths, including permanent, real-time assessment systems. Also, by taking advantage of some of the inherent characteristics of the Internet—ubiquity, asynchronicity and interactivity—we can expect unforeseen coverage and massive access.

[45] Of course, there are fields (such as medicine or law) in which this is less feasible, but in others, where the key is to possess certain technical skills, change could happen much more quickly: software design, to give just one example.

STUDENTS ENROLLED OUTSIDE THEIR COUNTRY OF ORIGIN
By destination region, 2000-2010



In ten years, the number of students enrolled outside their country has doubled. This phenomenon illustrates the growing internationalization of the demand for education, despite the barriers of tuition, transportation and housing costs. New offers based on digital technologies could radically strengthen this trend.

Source: Education at a Glance. OCDE 2012.

IV. That along with changes as profound as those we can envision, we will also have the opportunity **to recover an old institution that could play a key role if we understand education as the reception of culture and, therefore, as the process of discovering and inventing culture. We are speaking of the figure of the mentor.**

The mentors we refer to are not necessarily great teachers, nor individuals who are completely abreast of the most recent developments in academic literature or laboratories. They are not those who understand emerging products, nor even those who follow every detail of the latest social or political conversations. Mentors, more than individuals capable of transmitting specific knowledge, are guides capable of orienting the emotional dispositions and moods of their disciples, facilitating and accompanying their process of self-discovery, helping them remove the barriers they face in their learning processes, opening up networks and recommending access to others, intervening when harmful moods or dispositions arise, cultivating their enjoyment of the culture received and a personal responsibility towards their own existence. One place where it is possible to find true mentors today are graduate scientific programs, where laboratories often resemble those ancient medieval workshops in which masters and apprentices co-existed.

Unlike professors, who incorporate students into specific discursive domains, a mentor seeks to promote cultural receptivity and places at the center of education—from the earliest age to the highest level—the process of individual appropriation of a history of traditions that we have been relinquishing in favor of knowledge transmission.

b. The danger of trivialization

We are aware that is it uncertain whether the opportunities we have suggested in the previous subsection will materialize exactly as we have presented them.

The same phenomena that are behind these—globalization, the loss of the power to control, and the increasing access to mass media—may also give rise to the banalization of cultural, emotional and ethical meanings, thus trivializing all experiences. The danger is that the desire for fast, easy business opportunities may become the main goal, overshadowing the meaning of living in a culture that matters to us and affects us.

We can see this threat approaching in the lack of motivation among young people faced with the purely cognitive meaning we have assigned to their education. Because if all we teach is how to handle formulas, techniques and instruments that are supposedly valid in any cultural or historical context, we are encouraging our youth to become data-processing systems. And this, obviously, creates feelings of indifference and insensitivity that they instinctively reject, although with consequences, —sometimes serious ones, like violence— both for themselves and the rest of the society.

A fundamental obligation of education must therefore be to create an appreciation of life as the gift of sharing a culture that provides us with meaning, dispositions that move us, a language that allows us to talk and communicate clearly about the world around us, and a horizon of open and challenging opportunities to discover and create ourselves as individuals.

The stakes are very high, and although we have envisioned some historical possibilities to succeed in this task, we might also fail. There is no certainty here.

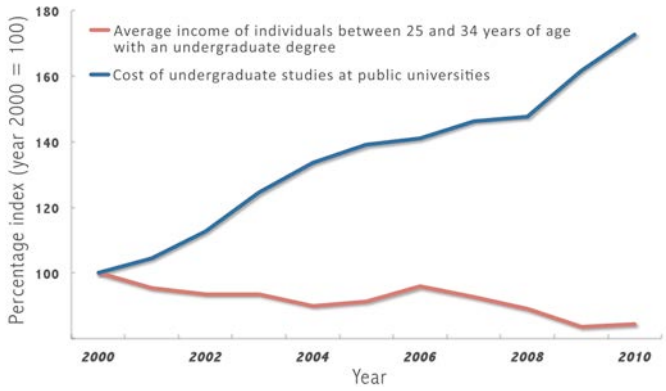
2.
AN AVALANCHE IN HIGHER EDUCATION

For some years, we have perceived that Higher Education is in crisis throughout the world. And regardless of the different realities each country faces, from a medium-term perspective, there are at least two large common denominators: on the one hand, a job market that is changing rapidly, rendering much of the knowledge based on university and technical training obsolete; and on the other, the increasingly present threat of what has been called "the cost disease" that is currently a concern in Europe and the United States.

Normally, when we think about universities in the United States, the elite schools always come to mind (Harvard, Stanford, Princeton or Berkeley, among others) and we forget that the great majority of that country's students attend other institutions that are less known to us. In the case of California, for example, there is a state system divided into three levels, which altogether account for over 2.9 million undergraduate students and a little over 100,000 Master's and PhD students. This is where most of the population studies, and for them the high costs of education and student debt—which have been on the rise for decades—have become the main cause for concern; even more so today, when the U.S. economy faces a large deficit and is cutting state contributions, producing a transfer of costs to families or simply the exclusion of those who cannot afford the higher payments. Europe is suffering from the same disease, further aggravated in this case by the current financial crisis.

It should not surprise us, then, that one of the forces that has begun to generate changes, albeit marginal for now, in the U.S. education system (and also impacting Europe) is motivated to a large extent by cost reduction.

COST AND PROFITABILITY OF UNDERGRADUATE STUDIES IN THE UNITED STATES



Between 2000 and 2010, the cost of undergraduate college education at public institutions in the U.S. increased by 72%. During the same period, the income of individuals with undergraduate degrees fell by 14.7%.

Source: Citi Research, with data from the U.S. College Board, U.S. Census Bureau and U.S. Department of Education.

a. The emergence of a new space of educational possibilities

In this world, there is a rapidly emerging new space for possibilities that is already insinuating new practices and new styles in education. In a certain sense, we could say this is the result of the efforts to "capture" and "domesticate" the technological advances of the digital world, using them to satisfy the demand to reduce the costs and improve the quality of education.

In fact, many of the technologies that are currently gaining strength were available over a decade ago, but with costs that made them less competitive compared against other, more traditional teaching models. But this scenario has changed: internet access is massive (the number of users has increased by 7 times and total traffic has increased by 519 times between 2000 and 2012), the speed and transfer capacities have improved, and data storage costs have dropped drastically (in 2010, these were 100 times less than in 2000). Meanwhile, young people today live their lives "online," and the Internet, besides being a tremendous source of information, has also become a great space for conversations and social relations. Simultaneously, some of the most massive practices—such as online learning—have been attaining a certain degree of maturity and achievements (still through hybrid experiments), which have contributed to generate greater trust and openness towards their development. The appearance and rapid consolidation of the Khan Academy is perhaps one of the most representative examples of this new scenario.

The horizons for the changes that are emerging are very short. This can be explained by several factors, including the high pace of changes in digital technologies, the growing interest of venture capitalists who wish to invest in education-related technologies, the openness of large universities to experiment with new platforms, and the increasing

preoccupation with reducing costs in educational systems manifested by both citizens and governments, as well as international agencies like the Organization for Economic Cooperation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).[46]

In the short term, two technologies could be adopted very extensively in U.S. higher education: tablets and Massive Open Online Courses (MOOCs).

In the United States, the good results obtained with e-learning and part-time attendance teaching modes—which have allowed an increase in training possibilities for those who cannot travel to a classroom every day and also permitted more personalized training processes—have now given way to MOOCs, which began as a branch of a private university, but very quickly became independent companies that turned both public and private universities (including Stanford, MIT, Harvard, UC-Berkeley and Princeton) into their customers and partners.

One of the first milestones of this story was an online course on artificial intelligence at the University of Stanford—free, but high-level—for which, to the surprise of both the university and its professors, over 160,000 individuals registered.

In Atlanta, on the East Coast, Georgia Tech recently announced that it will offer a Master's degree in Computer Science through one of these MOOCs for USD 7,000; that is, 80% less than the price of the in-classroom program. The contents of the program will also be available free of charge, as well as a low-cost certification that, while not equivalent to a degree, might be useful on the job market.

Meanwhile, in California, San José State University turned to one of these companies to deal with State-ordered budget cuts, problems with capacity, and the need to offer multiple leveling courses for incoming students. Although the initial results among students were very positive and costs were lowered, the final assessment revealed a high level of failure (around 50%), which led authorities to suspend the program while they evaluate what is required to increase the passing rate.

The massive nature of these initiatives is greater than the rest by several orders of magnitude. For example, during its first 13 months of operations, Coursera (a company born at Stanford) saw approximately 3 million students enroll in its courses, 10% of whom finished satisfactorily, that is, 300,000. While there is some controversy regarding the dropout rate, it does not have the same meaning in this scheme as in traditional education: students can register for some courses just to explore a specific issue and/or to engage in it completely without completing the required classwork, homework or tests.[47]

[46] The 2010 OCDE report on education ("OECD Inspired by Technology, driven by pedagogy: a systemic approach to technology-based school innovations"), and UNESCO have focused their attention on the convergence between the rising costs of higher education and the emergence of new technologies.

[47] A variation on these initiatives is Semester Online, a consortium that includes ten universities (Boston College, Northwestern, among others). Students can take online courses and receive credit for them, but those who do not belong to this group of universities must apply and pay for them if accepted. Unlike MOOCs, this consortium focuses on small groups with virtual discussions, where students interact with each other and with the instructor in real time.

In the medium term (two to three years), the appearance of two other powerful technologies is predicted: games and their ramification into curriculum ("gamification") and the refinement of learning analytics.

Games seek to involve students in digital scenarios that challenge their comprehension of new concepts in their own fields of study. This has extended to curricular activities, including elements of game design like passing levels, receiving missions, obtaining insignias or badges, etc. For example, ranking or insignia systems may be useful for acknowledging student achievement, and the transparency of student progress may inspire a higher level of competition that may lead all students to a greater interest in the subject matter.

Learning analytics, meanwhile, is a nascent discipline that uses analysis techniques common in the business world to obtain an assessment of student conduct and learning. The information produced may be very useful for real-time instruction, as well as improving the design of course management systems that aim to personalize education. Specific student information may also be used to personalize online course platforms and to suggest resources for students, in the same way that, in business, advertising and offers are tailored to customers. In fact, universities are already using analysis software to make recommendation processes more efficient and precise, while researchers are developing versatile software applications that may train students on how to acquire productive behaviors and habits that will help them be more successful.

In a somewhat longer perspective—which in this case is only five years—we are expected to see the massive adoption of 3D printers and so-called "wearable technology." The former may not only provide cheaper, more accessible desktop alternatives to the faster, more industrial prototype machines, but will probably also open up a space of possibilities for communities of designers, programmers and others who will be able to introduce the "do it yourself" concept to science and engineering. By "wearable technology," on the other hand, we mean the integration of digital devices and references into clothes and other accessories that we use. So far, the most visible product in this line has been *Google Glass*. But there are others, although their educational potential has yet to be specifically displayed. It will probably do so if augmented reality and thin-layer screen technologies begin to establish their market positions.

In short, we can expect that improved connectivity, Internet development, advanced computing, and the implementation of other technologies in the educational space to have a great impact on higher education in a very short time span.

b. A potential avalanche of changes

We cannot accurately predict how deeply new possibilities will impact students, institutions, cost structures, or even the regulatory power of states in the field of education. Nor can we predict what parts of the current higher education system will remain intact. What we will probably see emerging—with greater or lesser success—are different hybrid forms. But it is precisely this combination of opportunities, reduced costs and technology that is announcing a true avalanche of changes.

For example, we can expect:

– That, by taking advantage of these new technologies and educational models, the brightest university professors, who usually dedicate a large portion of their time to research and working with graduate students, may participate more in undergraduate teaching.

– That the time these professors dedicate to bureaucratic or tedious work (including teaching the same class over and over again) will be freed up, increasing their focus on promoting active learning and mentoring students.

– That new "learning machine" technologies will allow students to receive feedback (which will be as individualized as possible) in very short cycles and with individualized training paths.

– That the system will not increase its costs exponentially as it has over the last 50 years, thus contributing to democracy and equity.

Of course, we must also warn that some of these innovations may also have negative effects on culture. It is unclear, for example, how institutions will continue to fulfill their strictly formative role, or what will happen to face-to-face interactions, which are sources of great value in the formation, research and development of our thought. Nor is it certain that our intuitions on the resurgence of mentors will develop at the same pace as the new online teaching models. On the other hand, however, we are convinced that we are witnessing the birth of a space for imagination, initiative and creativity.

We are certain that, during the next five years, we shall see how this wave of changes develops and what its impact will be. The interest that UNESCO, the Inter-American Development Bank, venture capitals and private foundations concerned with education have shown in these new technologies leads us to believe that this impact may be very significant, with its epicenter in the United States, but also impacting Europe, Asia and the rest of the planet.

c. How to face the avalanche from Chile

As we began to suggest in the previous section, we believe this avalanche is an opportunity to once again ask ourselves what the purpose of education is, and especially how we should define quality. And although the danger of trivialization is always present, we see more opportunities than threats in this revolution of technologies and practices. One question keeps coming up: how can we anticipate the future to take advantage of these opportunities? Chile must not remain passive, waiting for this *tsunami* to simply arrive and carry us away. It is impossible to rethink our higher education system in isolation from the rest of the world.

For this reason, over the next years, and especially as we keep an eye on the 2025 horizon, monitoring this wave of changes to understand its depth and scope—particularly the possibility that our national authorities may begin to lose their supervisory and regulatory powers over the issuance of degrees and the practice of different professions—will be a truly key factor in the decisions made by the State.

Meanwhile, it will be impossible to rethink Chilean universities without considering the impact of this wave of changes. Participating in conversations and alliances that are driving them in order to gain experience, to explore this path themselves, and to take advantage (or face the threats) of what is being offered—such as the development of mentoring for their students—are opportunities that are currently arising for their future development. The possibilities of a transformation that may help the figure of the mentor make a comeback, at much lower costs, while also opening a new space for learning in the humanities and for skills that allow individuals to create meaning in their worlds, to build their identities, and to navigate the adventure of life, may be a great revolution in our higher education system.

We know that many Chileans are not going to wait for authorities to establish an action framework, or for local universities to offer their own programs, before they begin exploring the possibilities that are currently emerging. However, we must also recognize that knowledge of the English language and limited connectivity may represent obstacles for a significant percentage of the population. This is also an area that demands action by the State and by universities themselves.

3.
EDUCATING FOR DESIGN AND ENTREPRENEURSHIP

a. The emergence of designers and entrepreneurs

In terms of technology, the era of the nineteenth and twentieth centuries was the era of engineering as the manufacture of tools and as a provider of tools for technological systems. But today we are living in a different era. The autonomy of experts and technicians (always limited to their specific fields of knowledge) are both under discussion, because, in any critical intervention, it is evident that we are affecting life as a whole, the life of societies, and life of the planet.

Today we require the emergence of a new type of engineer, one that we would like to call the "designer-engineer" or the "designer as engineer."

And we use the term "design" because it has emerged today as a fundamental activity. 100 years ago, design was a marginal practice, understood as a decorative and complementary activity, associated with clothing, graphic design, or the construction of automobiles and other artifacts.

The glorification of Apple and Steve Jobs demonstrates the change we are talking about. A company that emerged from bankruptcy to become one of the world's most valuable ones, and that has impacted us with something more than just their products, is an example of the central importance of design. The tragedy of companies that disappeared because they had a fundamentally technological "battle plan," such as Polaroid, or others that failed to realize that the Internet was coming, such as DEC, are examples that in the engineering world, focused on the manufacture of components and tools, design is missing.

Designers and entrepreneurs work together. The former exists in the world as an observer of the evolution of components or life forms. The latter, meanwhile, is interested in producing new offers for satisfaction, using what the designer sees as a cultural mutation. The entrepreneur is into marketing.

When thinking about designers and entrepreneurs, we are not using the term "innovative." In terms of professions, innovation is a quality of new things, of different things, but the practices that are behind it and the disciplines that generate it are part of the craft of designers and entrepreneurs. And we say "craft" because we do not want to call them sciences. However, this is an art that nevertheless requires a solid knowledge of science and other disciplines. A designer who does not know the fundamentals of network technology, of new materials technology, of biotechnology, would be able to do very little today. An entrepreneur who is not up-to-speed on the avalanches that lie ahead or the new

political crises that can change the parameters on which productive and technological systems are built is not going to have much to do either.

b. The designer as an artisan

The designer is a mutation of an older profession: the artisan or craftsman. The craftsman was a worker who was molded with his materials, who experimented, who did not have an industrial production, who reflected on things and spent long periods of time with them, who wanted to observe them. Michelangelo is said to have spent two or three months looking at the piece of marble he was going to use to create his Moses. The craftsman shapes his tool and his body with his materials, dances with them and makes something emerge. Michelangelo did not build a Moses—he made one emerge.

Designers do the same thing. They are individuals who not only observe components, but who are constantly in a back-and-forth synthesis between the world they will affect and the world of the components they use to make meaningful proposals. Now, these proposals do not arise from an infinite catalog of components. All designers have their own style and are very attached to the type of components and materials they use to create a world in which they experiment. And, in that sense, they have a world of components in their design laboratories, and they have aesthetic biases which they express and use to generate proposals. And we say "proposals" because they never have an ultimate solution: the proposal will have to be agreed upon with those who demand it, and this makes them perfectly consistent with the current era. A proposal does not come from the consumer, but is rather what can make sense in an era with its own implicit challenges that are often difficult to express. A good innovative designer is not usually based on focus groups, because those studies are designed to respond to traditional needs. A good designer pursues experiments or proposals that respond to an era.

c. The entrepreneur as a transformer

Entrepreneurship has become fashionable. It is present in many of our conversations and concerns about the future of the economy and the development of the country. But a simple examination of the issue is enough to realize that we still do not fully understand what it is.

It is worth asking ourselves, in the first place, why it has become fashionable now. Because it is at the very least paradoxical that, in the "era of knowledge," entrepreneurship has such a high profile.

If we look back, we see that for 30 years the emphasis was on having a profession, applying knowledge and developing a career. But this idea has lost meaning with the emergence of a new economy—characterized by accelerating technological change—in which the lifespan of traditional professional knowledge is constantly shrinking. Faced with this uncertainty, which leads to job insecurity or the need to permanently reinvent ourselves, entrepreneurship has emerged as an answer, replacing the idea of "pursuing a career" with the concept of creating a business and an identity.

In our opinion, entrepreneurship is, above all, part of human nature, which stems from the condition of being constantly subjected to the possibility of unexpected events that may change our world. And if our world changes, it means that our space of available possibilities, roles and identities will be radically transformed, creating opportunities for some and threats for others, since this process may open or close doors, cycles or lives. Natural disasters (like earthquakes in Chile) or significant political events (like the end of the Soviet Union or the attack on the Twin Towers) are events of this type. But they may also be more commonplace and personal milestones, like meeting new people, finding a partner, or reading a book that changes our life.

We see here that—as mentioned previously in this document—human possibilities will depend on their narratives about the world, and that these, in turn, depend on encounters and interpretations. Therefore, if our challenge is to face a world of permanent changes, we need an entrepreneurial disposition capable of helping us to better navigate this adventure. And, although this includes the ability to invent and develop companies, it also is far more than just the business realm, because it involves renewing our social lives through a product or service, or through a political achievement, an institution, or a cultural event.

The entrepreneur is, ultimately, a maker of history, a transformer of culture.

What we need first, then, is to liberate ourselves from the idea that the world is a fixed thing that we can mentally represent, generating models that allow us to make predictions about reality or control it. This is the idea that led us to place all our bets on knowledge, and it is the great danger of our times, because, sooner or later, we will be surprised by events that change our lives.

Using this new way of facing the world as a starting point, we understand that entrepreneurship requires at least three essential skills or sensibilities:

i. First of all, a special emotional disposition. In other words, a state of mind that remains open to adventure, to taking risks, to not allowing ourselves to be overwhelmed by fear and to understanding that life is a constant "trial and error," a permanent process of adjusting and adapting. This also implies tuning into social spaces and concerns, because those who have better social networks and are more sensitive to the transformations going on around them have a better chance of adjusting their identity or production to changes in the world.

ii. Secondly, a sense of historical events, because the spaces of possibilities depend largely on paths that were outlined or decisions that were made long ago. We can illustrate this with a very current example. In the 19th century, when the civilization of oil and automobiles began to emerge, nobody could have imagined that in the 21st century we would be dealing with the problems that fossil fuel use is causing in the climate or in the quality of life in our cities. But, from another point of view, we realize that all these complications are also opportunities for entrepreneurship in green energies or technologies that would not have emerged (at least not with today's vigor) in a world dominated by an abundance of oil and a lack of knowledge about its harmful effects.

iii. And, finally, creating spaces to cultivate the imagination. We are convinced that a society where imagination does not play a key role will lack the capacity for innovation that we need. Because imagination is the ability to play in search of new ways of seeing and

living in the world, and this is only possible when we are receptive to the past and sensitive to detecting anomalies in the present. In this sense, art, literature, history and the humanities all play essential roles.

The practices of designers and entrepreneurs may be embodied in different individuals—as in the case of the computer mouse, which expressed the relationship between Douglas Engelbart and Steve Jobs—or they may be present in the same person. What is important is that both dimensions are required for innovation to achieve its full potential.

d. Challenges for education

So, if the space of possibilities is determined by historicity, social orientations and imagination, then cultivating all these helps cultivate entrepreneurship. And taking responsibility for this task—as proposed in other sections of this document—requires profound changes to education: transforming schools and universities into closed, vocational-oriented institutions is precisely the opposite of what we need most urgently today.

We cannot deny that many activities require high levels of professional knowledge. But we also know that, in all fields of human activity, we require, above all, the right preparation and attitude for pursuing opportunities that add value to society and mobilize others towards the achievement of this new value—whether as citizens, employees or entrepreneurs.

An education concerned with entrepreneurship, in the sense that we have described, is suitable for everyone and requires implementing a new core of entrepreneurial disciplines, some of which stem from the humanities. This involves changes in three areas:

i. Learning to listen to the concerns of other and identifying with certain historical narratives, because we are living immersed in traditions, and it is not enough for us to better understand the space within this or that narrative—we must be capable of connecting with the narratives of *others*.

ii. Learning to honor our commitments in order to generate and maintain trust.

iii. Learning to "read the world" to see how and where power is exercised, understanding power as the art of continuously building novel material relationships with values that matter to the majority of the members of a community.

From a design perspective, meanwhile, education must assume responsibility for at least five dimensions:

i. Design is attracted to what is tentative and exploratory. Instead of the arrogance of builders, who see their actions as a foundational moment, designers must maintain a dialogue and a concern for what is local or individual. The cell phone is a clear example: designers have been concerned with the idea that, ultimately, each user may configure his or her device and give it a personalized use.

ii. Designers must understand that every design carries symbolism and identity. What we mean is that, beyond its function, design also says something about those who are

using what has been designed. Those who create female attire have worked with this notion for a long time, and they understand that an article of clothing provides identity for those who use it, and it is also sensitive to different contexts: we do not dress the same way on a Monday as we do on a Sunday.

iii. Designing also implies taking responsibility for a world that already exists. And, in this sense, every design is a redesign, or rather, every design is an intervention, and therefore, a successive mutation of practices. Designers must be aware of this.

iv. Every design has ethical consequences. It is not only about solving technical problems, but also implies taking responsibility for a society that has a series of concerns and that has ethics.

v. Finally, every designer must have the capacity to interpret the world, the lifestyles, the components that are part of things and that shape the worlds in which individuals are going to live. This practice cannot be put down on paper or in a graphic design tool, nor is it resolved by "asking people": it is fundamentally a poetic skill that involves living and inhabiting the world.

In short, in the 21st century we require an education for surprise, commitment, innovation, and the creation of identity, an education capable of building a life that is committed to the word we live in. An education that, by doing all this, may become a promise of fulfillment for our children and young people.

4.
EDUCATION FOR A NEW ADOLESCENCE

We do not need to fine-tune our ears much to hear one of the most frequent phrases pronounced by adults: "the world of young people today, let's say those between 14 and 18 years old, is very different from the one we grew up in." There is some truth in this, because students today follow a different path than we did in our world journey: they experience historically unprecedented degrees and types of autonomy; they have new forms of entertainment; and they have access to establishing relationships throughout the world. This has been partially redefining what adolescence means, moving what we call "maturity" in one direction or another, establishing new playing rules on a court that we thought we understood very well.

Today, young people roam through new digital geographies. These new spaces, which have been consolidated in the last seven or eight years, have changed the ecology of relationships between our students. They use these spaces to communicate in a simple, emotional and fast manner, they meet and exhibit themselves, they play, fight, listen and share music, and they watch movies and employ a wide range of group and social interactions. They are constantly connected, even during classes.

Adults are challenged by this new way of living, which we have called hyperconnectivity. From our concern, we understand that it contains significant dangers (just as previous generations experienced in different contexts, but perhaps with other rhythms and other scales). But we must change our emphasis and understand the opportunities that are arising, because just as the Internet creates threats to our privacy or can even represent a space for violence, it is now easier to investigate, to explore a topic down to the tiniest detail, to access valuable texts for free, to watch interesting lectures, and, as we have shown in other sections of this document, even to take formal higher education courses. And all at a very low cost or even free.

We classify our youth into urban tribes, as a more intense reflection of the age-old search for identity, with a constant tension between being unique... but with others. Because if anything has remained unchanged, it is that teenagers put a lot of effort into this search, and that they are dominated by a confrontational disposition. The fronts are many and the borders are confusing: parents, teachers, public officials, the system, etc. They even seem to struggle against themselves, caught between the urge to establish their own identity and the desire for it be recognized as valid by others.

However, there seems to be something more profound, something that unsettles and discourages them, and that they project as anger against the system. Our intuition is that the dislocation experienced by students is not that different from what the rest of us are

going through. Today, we inhabit a world devoid of certainties, we tread on quicksand, and our education insists—as do some adults nostalgic for more solid ground—on trying to convey that the only valuable thing is what is certain. We suspect that many students perceive this contradiction, this "crevice," perhaps without being able to name it, and that their anxiety is only heightened by the absurdity of being limited to a single path towards the future (higher education, particularly the university), one which also possesses significant perceived injustices and large differences in opportunities and expectations that depend mainly on one's origin (family, school, region, etc.).

It is evident that the larger the crevice, the greater the lack of motivation that burdens our students may become.

We can sum all this up by observing that the world our young people are immersed in is heading in one direction, while education is heading in another. Because, while we live in a constantly changing world that requires being prepared for adventure, our teaching is still trapped in the illusion of control and prediction based on knowledge. Because instead of showing them the world where they must build their future, teaching is still based on contents that claim to be eternally valid. Or because instead of acting as a space for receiving traditions and a culture that helps them establish their own identity, school is just a repository of data from the past that must be memorized and recited from time to time.

In this scenario, school bores them with tons of information that seems useless, with codes and norms that are unresponsive to the present, and with the promise of a future that is more and more difficult to fulfill. Young people are sensitive to this lack of honesty, and they punish it.

We want to state very clearly that the main problem or gap between students and the educational system is motivation. And our young people are desperately crying out to be rescued.

This request, sometimes unclear and other times muffled, is a tremendous act of courage, but we have failed to respond to it, thereby increasing their distance and mistrust of the adult world—and especially towards its educational system.

Adults are responsible for this situation, and it is urgent that we take responsibility for this generational "bad mood." But we should warn from the outset that we are speaking of a change that cannot be resolved by teaching a series of "courses" on non-cognitive skills (though this may be a step in the right direction). The way to build a better education system is not to dedicate more class hours to "pass on" new content to our students. Nor is it to add to the already massive amount of knowledge currently being delivered to students (mostly in scientific-technical fields) a new section of "emotional" knowledge.

Emotional dispositions cannot be transformed through cognitive, psychological or moral discourses, but rather through spaces that help young people perceive a richer and more dynamic world than they have known, one which is constantly opening and closing possibilities. Because that is where they will have to build their lives, deal with contingencies, and invent a career[48] and an identity for themselves, which must never

[48] In Chile, the illusion still persists that access to higher education represents the beginning of a professional career. There is also a persistent belief that these careers are stable (regarding employment and the history of the career itself), even though the facts are refuting this every day.

remain isolated from the concerns of others.

In the constantly changing world we live in, a main goal of education should be to prepare students for the adventure that we always embark on with others. And we know it is possible to create this kind of space, which is emerging as an increasingly relevant conversation.

This Council explored such a possibility through an initiative called *Chile Va! A Meeting of Youth, Science and Technology*. The characteristic feature of this program was its generational exchange: conversations with teachers that were not based on cognitive content, but on the experience of creating themselves in the world, and an involvement with science and technology, immersing themselves in their domains. Finally, and no less important, it was a space in which they were effectively made to feel that they are Chile's future, which is being built right now, and that we trust them.

For this reason, we urgently suggest that this type of experiences be replicated and expanded, in order to cultivate a world-opening education, one which teaches skills in diverse fields and not only in scientific-technological ones.

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APPENDIX
NATURAL LABORATORIES FOR A WORLD-CLASS SCIENCE

José Miguel Aguilera,
President of Conicyt

New Zealander rugby players, Filipino boxers and Finnish rally drivers are all examples of athletes from small countries that are world powers in certain sports. The reason? They exploit some advantage or unique characteristic. Maori rugby players weigh over 100 kilos and can run 100 meters in less than 11 seconds, creating unstoppable momentum in their runs; few can beat them at rugby. The Philippines has a public-private program that scouts young boxing talents and trains them until they achieve world-class status; in this case a targeted national policy is exploited. Finally, in Finland people learn to drive at a very early age on unpaved roads that are covered by ice and snow almost year-round; they have established a tradition and acquired a critical mass that creates enthusiasm for car rally racing. Each of these examples is the result of what we shall call "natural laboratories."

We tend to think that the only way to achieve world-class science is by developing **competitive advantages** that we do not possess and that developed countries with long scientific traditions do have: a large amount of scientists, universities and research centers with advanced facilities, modern equipment and abundant funding (though it is never enough for scientists). But a deeper look reveals that there are other drivers of scientific research: collaboration between laboratories and the technology industry, an early and effective protection of the property of discoveries, and insatiable innovators that add value to knowledge by transforming it into products and services. In both cases, there are entry barriers that are almost impossible to overcome for any developing country like ours. They both lead us to a fatalistic conclusion: these countries simply cannot compete with the scientific powers.

But how can this be achieved by small countries that are outstanding in certain sports, even compared to the great athletic powerhouses? Perhaps it is because sometimes **comparative advantages**—those that are unique, whether it is due to natural conditions, public or private targeted policies, or traditions that are deeply rooted in the population—can achieve levels of success in certain fields that are similar, or even superior, to the great powers. This success is possible when comparative advantages are exploited in a space we shall call a natural laboratory.

In Chile, we have a scientific tradition in various fields. We have made attempts to understand the world we live in (and we continue to do so), always in dialogue with other countries. These attempts have not remained detached from the task of creating an identity as a country and as a society, and of discovering opportunities. Today, however, if we wish to strengthen this path and stand out in the scientific field, it seems that we must identify where we have comparative advantages that we can share with world-class scientists as peers. In what fields do we possess these comparative advantages that would allow us to attract high-level scientists to our country?

And remember: the benefits of exploiting our comparative advantages would not only be scientific. The interesting thing about having world-class science is that it also stimulates the development of a local infrastructure of high-level technological support in communications, advanced data processing, engineering tools and services, as well as benefitting math and science teaching and contributing to science tourism. Another advantage would be decentralization. A good number of unique opportunities for producing advanced science are in regions outside Santiago, and their successful implementation would not only provide a boost for science, but would also promote the development of unique regional identities and add value to local resources. By attracting foreign scientists, we could create scientific niches of excellence and critical masses that would otherwise require a long time to establish. Finally, exploiting our comparative advantages might open up an opportunity to conduct transdisciplinary research, since the opening of such a space would require the support and integration of multiple approaches.

Following what we have presented thus far, we could say that a **natural laboratory** is a singularity (or anomaly) that can be useful for scientific research for different reasons:

1. It is a unique location in the world—this may be a territory or a geographical or geophysical feature—and that, as such, presents comparative advantages for scientific research in the broader sense of the term. There are many examples: Antarctica, seismic zones, archeological sites (as in Peru) or paleoanthropological sites (as in Kenya and Tanzania), unique ecosystems (in Galapagos and Costa Rica) and even disaster zones like Bhopal in India or, more recently, Fukushima Daiichi in Japan, useful for studying the effects of environmental, chemical or radioactive pollution on human health.

2. It has achieved a critical mass or tradition in a specific scientific discipline that has made an international impact over time, with significant contributions to science and technology. One emblematic case was the School of Exact and Natural Sciences (FCEN) of the University of Buenos Aires in Argentina, which produced two Nobel Prize winners of that nationality (Bernardo A. Houssay in Physiology in 1947, and Luis Leloir in Chemistry in 1970).[49] This school trained and collaborated not only with Argentinean researchers, but also researchers from the United States, Japan, England, France, Spain and many Latin American countries.

3. It has defined and implemented a public policy that targets a nationally relevant problem or opportunity that transcends this field. For example, the struggle against child malnutrition. Or the development of biofuels in Brazil, a country that was decades ahead in

[49] Another Argentinean, César Milstein, also won the Nobel Prize for Physiology (1984), and although he graduated from FCEN in 1952, most of his career as a researcher was spent at the University of Cambridge.

the generation of energy from renewable resources thanks to a sustained public policy and an availability of cheap, abundant natural resources (sugarcane) for the development of ethanol production technologies.

Natural laboratories seem to have characteristics that are the opposite of innovation clusters.[50] They are based on comparative and not competitive advantages, and in many cases they are location-specific and not easily reproduced or possible to implement. Another important characteristic is that today science does not recognize borders, and funding institutions and agencies from First World countries are willing to collaborate on high-impact scientific initiatives wherever the conditions are well developed. The participation of prestigious international centers—with their contributions in terms of organization, infrastructure and scientists—is key to building a natural laboratory in the Third World.[51] This means that, in many cases, host countries will have to invest in basic local infrastructure and provide benefits for foreign scientists to work there (visas, certain tax exemptions, donation of lands, etc.)

STARTING POINT: ASTRONOMY

There is currently a unique experiment underway in Chile. For the first time in the history of science, an emerging country has access to advanced facilities for world-class scientific research: the world's best, most powerful telescopes (both optical and radiotelescopic) are located in Chile. And this situation will improve, because by 2018, 68% of the world's best capabilities for observing the universe (which will then be worth more than USD 5 billion) will be on Chilean soil. There is a story behind this. For several decades, it has been acknowledged that northern Chile has advantages in the field of astronomy that are unique in the world: it is a natural laboratory. And, thanks to this great comparative advantage, Chilean astronomers may become internationally relevant actors in the development of this science.

If we take into account the international astronomical development that has occurred on Chilean soil, we can see that this natural laboratory functions thanks to the exceptional environmental conditions for astronomical observation, the contribution of international institutions in terms of infrastructure and scientists, and the resolute support of the Chilean State. We are already seeing its impact in the number of good students who are interested in studying astronomy, the growing number of PhD students, and the proliferation of astronomy departments in Chilean universities. National astrophysics is now the discipline that produces the publications with the greatest impact in the field of science.[52] And, in 2012, a document was published describing a roadmap to promote technological development and innovation in the field of astronomy.[53]

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[50] We speak of "clusters" in the sense used by Michael Porter in his article "Clusters and the new economics of competition" (1998); that is, geographic concentrations of companies and institutions that are interconnected within a specific field or industry, and whose relationships help produce competition in this field.

[51] Otherwise, it would only constitute an "international collaboration", of which there are already several examples.

[52] The number of publications and references that other scientists make to them are indicators of scientific activity, known as "bibliometrics," which are currently widely used to evaluate scientific research. In December 2012, Conicyt published a bibliometric study

THE SEARCH FOR NATURAL LABORATORIES

If we wish to produce advanced science on Chilean soil, one alternative would be to "astronomize" other disciplines, describing their particular conditions as natural laboratories and opening them up as spaces for possibilities. Undoubtedly, there are several potential candidates for natural laboratories, but this list obviously does not include every single possibility, and it will be up to national researchers to suggest other opportunities that may fit the description of this concept, as previously explained.

Research on solar power in northern Chile has advantages for reasons that are similar to the case of astronomy: its clear, clean skies provide access to a large amount of solar energy. Santiago, meanwhile, has been chosen by a European institution for an integrated study on issues related to "megacities" in emerging countries, such as rural-urban migration, population segregation, land use, public transport, environmental pollution, and waste management. We also possess a natural laboratory for studying the early development of mankind in the Americas, in the hostile environments of coastal desert areas and Patagonia. We must remember that the Chinchorro culture and its mummies are almost 3,000 years older than their Egytian counterparts, and that the oldest human settlement on the American continent, dating back to approximately 13,000 years ago, is in Monteverde, near Puerto Montt. Our varied geography and geomorphology represent niches where life is present in conditions of extremely high or low temperatures, excessive salinity, high concentration of sulfur compounds, or minimal humidity. The genomics of so-called extremophile micro-organisms may hold important secrets for applications in biomining, the production of sustainable energy sources, and industrial raw materials. From the perspective of seismology and anti-seismic engineering, we are one of the countries with the greatest frequency of tremors and earthquakes on the planet, where over 40% of the world's seismic energy has been released over the last 100 years. The Sub-Antarctic ecosystems harbor a great biodiversity of moss and lichens that is recognized as unique in the world. And then there are the glaciers and ecosystems of the southeastern Pacific Ocean that are useful for monitoring climate change. Chile has one of the few climates that favor the production of foods that belong to the so-called "Mediterranean diet," which is recognized as a significant factor for a healthy diet. Our 4,000 kilometers of coastline make the ocean and its biological and energy resources an unsuspected source of opportunities as we look towards the future.

While the examples presented above correspond mostly to locations or territories (Natural Laboratory type 1, according to the previous classification), in the case of emerging

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of Chilean scientific research during the 2006-2010 period, at the request of the SCImago Research Group. This study identified certain strengths, such as Earth and Planetary Sciences, Astronomy and Astrophysics, but also pointed out that these strengths are highly dependent on international collaboration.

[53] This effort, published as "Astronomy, Technology, Industry, 2012," was led by Conicyt's Astronomy Program and included the participation of the National Council on Innovation for Competitiveness. The route proposed sought not only to strengthen astronomy specifically, but also to take advantage of opportunities in diverse industries provided by the tremendous interest of foreign entities in investing in astronomical infrastructure in Chile because of the quality of our skies.

critical masses we could mention some in the fields of biology and data processing, as well as mathematical modeling (Natural Laboratory type 2). As far as natural laboratories based on public policies that target a nationally relevant problem, there are also some candidates for becoming natural laboratories: preschool education and the search for solutions to child/youth obesity and weight problems, among others.

This list could be expanded, as long as we remain open to adventures, unafraid of revealing our anomalies, and seeking to recognize in them our potential comparative advantages. Chile itself may appear to be one long, rich and diverse natural laboratory.

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FINAL INSINUATIONS

THE CHALLENGE OF A PERMANENT EXERCISE

The end of this document is, by no means, an ending. As we said in the very first paragraphs: this is a starting point, an invitation to open up conversations about Chile's future. In some of these conversations, we have already begun the adventure, and what we learned has been rendered—though perhaps incompletely so—in these pages. In others, however, we have not yet made sufficient progress, either because we thought they were beyond our current capabilities or because we believed they could only be opened up once we generate a new framework and perspective like those we have explored here. In these final pages, we would like to account for what we were only able to insinuate.

The first conversation deals with the institutional framework for innovation. A special committee designated by the President of the Republic[54] worked on this issue for several months, and our basic proposal is that, along with a new organizational map, we must think about institutions from our need to coordinate conversations, and subsequently to support the development of policies capable of cultivating richer worlds for innovation. We are not referring to conversations between individuals, but rather the creation of

[54] The Presidential Advisory Committee on Science, Technology and Innovation operated between January 22 and May 15, 2013, with the goal of creating a proposal for modernizing the institutional framework for science, technology and innovation. This committee included the participation of some members of the National Council on Innovation.

networks and the participation in different spaces that may emerge as we take responsibility for different concerns or dynamics that affect our worlds.

Let us consider one example: aging, understood as the increase in life expectancy, and also the changes in the age composition of the population. Today, this conversation has not emerged as an urgency that must be coordinated, but we can observe the tensions between the different values involved. Undoubtedly, most of us would like to live longer, healthier lives, but a longer life may have repercussions on the economy, job markets, family relationships, or the balance between different generations, that we must bring into the present and deal with. For example, clearly a greater life expectancy would lead to a higher retirement age throughout the world, beyond the present legal age of 65 years. We will have to deal with this impact in Chile, whether we are prepared for it or not.

This case reveals something more than the threats or opportunities it may bring: it shows that an innovation policy and its institutional framework must not be isolated from these types of conversations, since they are precisely what is shaping the future.

The CNIC should strive to make these conversations emerge—while warning, in the first place, about the strong impacts that we will possibly see around 2020 or 2030—and participating in them with a holistic, long-term perspective.

Another pending task is the reflection on how the need to coordinate conversations may affect the way the State is organized. The increasing complexity of our concerns as a planet and as a nation makes it very difficult—maybe impossible—to establish general principles for arranging institutions and relationships. Instead, besides the requisite administrative adjustments, we require a comprehensive capacity to tackle these conversations one by one, flexibly and open to broadening their scope whenever it may be necessary.

Most of the conversations we are referring to occur, to a large extent, outside of Chile. Moreover, they are only partly institutional, and may often require identifying and establishing relationships with specific individuals or groups that are making new spaces for possibilities, explanations and technologies emerge. Every day, we realize more and more that this task cannot be accomplished by governments through "top-down" actions, and that it requires new efforts in public-private coordination.

It is through a coordinated participation in these conversations that it will also be possible—as we have insinuated in this document—to develop innovation policies designed to detect future possibilities that are emerging in the world, catalyze and coordinate relationships between public and private actors (at the local and global levels), strengthen the capacities of individuals and companies, and permanently adjust norms and regulations to facilitate the adoption or development of new practices, products or industries. Because clearly one of the greatest challenges for the success of an innovation is to reshape (or even build) the infrastructure it needs to operate, or the legal frameworks that determine its fields of action. The cell phone industry went through this process some decades ago, and we are certain that something similar will happen with the new possibilities and promises of medicine or biotechnology.

Another dimension that emerged during the reflection, and that we have not developed much in this document, is risk management and funding in the field of innovation. The exercise we proposed in the section on "Strategic Orientations for Energy" demonstrated how the dynamics of technological change and power come into play in these global conversations on the future, along with the time horizons we must use to analyze risk management and funding.

Thus, for example, when a product is in the laboratories, it is not yet capable of guaranteeing results within a specific time horizon (according to the definitions in Chapter 2, this is Horizon 4). What it *must* guarantee, however, is that it makes sense. Meanwhile, in the pilot stage (Horizon 3) the risk changes (because now we know that the idea works), but the complex problem of ensuring a place for it in the market and the culture still remains.

In terms of funding, the concept of time frames can also help us see that different activities move with different rhythms, requirements and projections that must be understood and respected. This is especially true when it is time to evaluate or to design indicators that may tell us whether the funds invested (public or private) are being used appropriately, whether the projects underway have good forecasts, or whether the odds of innovation occurring are improving or deteriorating. Thus, while a project on Horizon 2 is racing against time to establish a market position, an idea on Horizon 3 requires funding—more than time—to prove its validity and possibilities. Meanwhile, research on Horizons 4 and 5 must focus instead on the spaces and relationships in which it occurs, particularly the wealth of interactions established by the actors with their peers (both local and global), with the productive sector, or with education and its different levels.

As shown by the international experience, diverse sources of capital are required to handle these different levels of risk and time horizons: public capital for basic research and laboratories, private or public venture capital for investments on medium-term horizons (depending on each field), long-term funding to develop projects that already have an established development model, and finally, bank capital to constitute and expand capital. In Chile, we have already discussed extensively how to complete this funding chain, and there has been significant progress in this direction in recent years, precisely because of the push generated by innovation policies. However, we still need to take two important leaps forward.

On the one hand, to consolidate a diversified funding chain by different levels of risk, with specific capacities and cultures, but above all fully integrated into global innovation networks. And on the other hand, a substantial change in the budgetary mechanics of the State that may facilitate long-term projects, with funds that truly accomplish this goal—as was the original intention of the Innovation for Competitiveness Fund (FIC)—and are not subject to annual discussions that focus on the short term (like most funds today). Congress and the government must work with the entire community on this issue.

What lies ahead. In this strategic review, we have chosen some specific fields—energy, biology and education—to conduct an initial exercise that brings more depth to our Strategic Orientations for Chile. As we conclude this exercise, we would like to reiterate our

concern for cultural change, integrated conversations, the orchestration of moods, and the development of issues that unite Chileans around a view of the future with broad horizons.

This work must continue, both in terms of implementation and conceptual development. And we hope that the next generation of counselors and authorities responsible for promoting innovation will use this testimony to continue this "relay race". We place our radical hope in them, because we are united in our love for the future generations.

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