Independent Blue Skies Research and Its Chinese Particulars

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Abstract

Science and technology have become the cornerstone of contemporary societies, yet it is still underappreciated that what they are, how they progress, and how did we end up in the current state of affairs. As a result of this intellectual confusions, the role of universities and higher learning is confusing, which results in some distorted and ill-adapted institutes that are expected to serve the kaleidoscopic and ambiguous functions. This unawareness and confusion are a kind of norm throughout history of science or we could say philosophy, and the rare exceptions in history are the golden ages where some fundamental obstacles were cleared away, and an advancing direction had been clarified and supported by social-economical conditions. This essay is an attempt to make sense of the obstacles in our contemporary times, and to discuss a specific problem on the dynamics of doing blue skies research generally, and the particulars in the Mainland Chinese science ecosystem (which includes the native ecosystem and its interaction with the international ecosystem through the Chinese diaspora). Particularly, to do blue skies research under the Chinese context, the situation is not dissimilar to the thinkers in the early Renaissance, which is known as something similar to an independent researcher nowadays.

1 Introduction

Science and technology have become the cornerstone of contemporary societies, and we would rather say civilizations; yet it is still underappreciated, perhaps even among most of the knowledge workers who are known as "scientists" in the general public, that what science and technology are, how they progress, and how did we end up in the current state of affairs. And some myths are being circulated: a great or an authentic scientist is also a philosopher. In some sense, the current public perception has become something resembling a certain kind of mythological god who delivers livelihood, in the sense of consumer products, medical treatments, futuristic gadgets, monetary income, tenured stability, and economic prosperity, or who disrupts "good old way of living", in the sense of job displacement, disruptive "innovation", disappearance of intimacy in previous closely-knit community, and the dramatic speedup of life tempo.

As a result of this intellectual confusions, the role of universities and higher learning is confusing, and this confusion couples with the inseparable role that science and technology play in economic stability and progress, which results in some distorted and ill-adapted institutes that are expected to serve the kaleidoscopic and ambiguous functions. A university is supposed to be a place that should provide universal education access, that should be the innovative engine of economy, that also should be the free play of free intellectuals, or that should be the place where the higher truth is investigated. A university should be self-sufficient if following the idea of free market, or be state-funded if following the idea of public goods for education and basic research; a university should avoid contact with business because the conflict of interests, or should closely interact with business for research transfer. The roles that a university actually performs instead is the outcome of the political, economic, and faculty competition within and beyond the university that are unseen to the outsider (Rothblatt, 2012).

This unawareness and confusion are a kind of norm throughout history of science or we could say philosophy, instead of being an exception. The rare exceptional occasions where societal consensus existed in the history were known as the golden ages, e.g., Periclean Athens, Renaissance Italy, and Elizabethan England. And they existed because some fundamental obstacles were cleared away, and an advancing direction had been clarified and supported by social-economical conditions (Barzun, 2001). Therefore, this essay is an attempt to make sense the obstacles in our contemporary times, and what it takes to be a scholar, or we might even say an intellectual.

Understandably, this would be presumptuous task, and this essay approaches this general theme by discussing a specific problem on the dynamics of doing blue skies research generally, and the particulars in Mainland Chinese ecosystem (which includes the native ecosystem and its interaction with the international ecosystem through the Chinese diaspora). This essay is written to clarify the structural characteristics of contemporary science, to share the experience of the author with other individuals who originated from the Chinese system and are attracted to blue skies research, and lastly to discuss contemporary transdisciplinary blue skies research in general.

We clarify what we mean by blue skies research, and a systematic exposition could be found in Braben (2008). Blue skies research is scientific research in domains where "real-world" applications are not immediately apparent. It is closely related to basic research, but with some subtle difference. Basic research is a type of scientific research with the aim of improving scientific theories for better understanding and prediction of natural or other phenomena, and the impact of basic research has been rather well understood: it leads to major advance in technology in the decades ahead. Therefore, building giant particle colliders to investigate theoretical physics would be basic research, and its utility has been supported by societal progress delivered by the century of theoretical physics beforehand. However, blue skies research are research like theoretical physics at the turn of 20th century, where it is not clear at all that the investigation of the black body emission would lead to quantum physics, and there would be no justification, a rational argument beforehand, or even awareness of the possibility of the undertaking—it could be considered to be too difficult to be possible, or an issue that is not aware by most people (e.g., climate change in 1970s).

In this essay, we shall first discuss the state of science in generally. First, we revisit the science at the Age of Enlightenment in section 2.1: any science at its seed stage is blue skies research, and the difficulties facing today's blue skies research are best understood through the path-breaking efforts of the Enlightenment forerunners who are yet to known as scientists, but known as natural philosophers. This phase of science might be called aristocratic science. Second, we shall proceed in section 2.2 to discuss the institutional phase of science: the success of blue skies research led to the societal awareness of the importance that science and technology could exponentially increase the economical, political (hard) and cultural (soft) power of nations, and drive social progress, and thus institutional support was developed. However, the instrument of disciplines that were born naturally in response to the division of labor in science advance had become institutionalized; that is, it has become social institutions serving their own purposes regardless of real social needs, and stalled the progress in fundamental science. Third, in section 2.3, we discuss the persona that might be known as Transdisciplinary Mind is needed to serve the role of Renaissance Men during Renaissance to synthesizing existing research to understand biotic, nervous, social systems, such that the original vision of Enlightenment could be continued: that is, the ideal of early humanists that reason, will, the observation of nature and active action would lead to scientific understanding of biotic life, mind, societies and civilizations, and their betterment.

Then, we proceed to discuss the state of science ecosystem in Mainland China and its interaction with the international ecosystem through Chinese diaspora. First, in section 3.1, we discus the dominating pragmatic atmosphere in the Chinese research ecosystem: it was built under deep pragmatism for national rejuvenation under severe resource and time pressure; as a consequence, it only takes what has been proved working, and thus inherits the problem of the institutionalized science ecosystem without the structural vestige left by the early Enlightenment thinkers. Although this pragmatism built the modern economy for China, it also made this system particularly unsuitable for blue skies research. Second, we proceed in section 3.2 to understand the root of such pragmatism: the coincidence of the beginning of another civilization cycle of Chinese civilization and the ending of a civilization cycle of Western civilization. China has recently struggled out of a chaotic civilization collapse phase, which is similar to the emergence of Western civilization out of the dark age after the collapse of the Roman civilization; and the Western civilization is in a civilization decadence phase where the spirit of Enlightenment is discredited (i.e., postmodernism, or post-postmodernism) and the cause of Enlightenment failed globally, which severed the guidance of science as an intellectual system for the masses. Consequently, without a critical mass of scientists who understand the Enlightenment ideal to bootstrap the system, the next best thing perhaps is pragmatism, which results in the pragmatic atmosphere of Chinese science ecosystem. Third, in section 3.3, we discuss the individual researcher conditions under this system, which also includes researchers who are educated and work in the Western system later on.

Lastly, the discussion on the macroscopic structure previously is to prepare the stage to discuss in section 4 researcher condition under contemporary science ecosystem to undertake blue skies research. Despite the intrinsic individual unpredictability, there are still regularities in this kind of research, which is discussed in section 4.1, and consists of four phases: a preparation phase where a great amount of prerequisite training are undertaken; a hermit-gestation phase where individuals concentrate a stretch of period to work in isolation, synthesize previous experiences, and work out a proof of concept; a monastery-order phase where a critical group is formed to polish the proof of concept; lastly, a society-engagement phase where the result is disseminated and ultimately leads to societal transform. Despite the institutionalization of the Western science ecosystem, institutional support for independent research during the four phases are tenaciously maintained.

But for researchers get their early education in Mainland China, even if they are educated and work in the Western system later on, institutional support does not exists for the first two phases. This is discussed in section 4.2. Except for isolated lucky cases, structurally and statistically, in the preparation phase, the researchers have to work first as an apprentice to accumulate knowledge and experience, and then as a contracted worker throughout a series of contracts in the preparation stage instead of as an institutionally supported researcher undertaking independent inquiry (e.g., Prize Fellow in Cambridge University, or Harvard Society of Fellows)—this nostalgically resembles the experience of Enlightenment thinkers, who need to move from university to university, and court to court to trade magic, prediction, tutorship for patronage. And the gestation phase that requires high concentration of energy and time is very hard to accommodate in the system, and being independent researcher might be the few structural options to have. This might sound unusual, strange, or scary in the age of institutionalized science, but after all those accumulated experience, this out-of-institution phase would not sound as strange or scary as it might sound.

2 The evolution of science ecosystem

2.1 Enlightenment forerunners and blue skies science

To begin with, we need to discuss what science really is. It is known that it is a way of understanding the world, both nature and the world of humans, through observation, hypotheses, and verification; but less known is the gradation of consequences of such understanding. To give some examples, it is known that the understanding of force led to rockets sent to the outer space; but lesser known is the deterministic characterization of Newton physics revised the concept of linear time from the Christian concept, that there is an end of history when humanity would reunite with God in eternal life (Brunner and Cunneen, 1950), to the humanistic concept that through observation, reason and actions, individual and social progress could be made. It is known that numbers enable national demographic statistics, or monetary economy; but less known is that the concept of counting and geometry transformed poetic, mythological thinking that dominated theological ages to analytic and abstract reasoning that led to modernity. Science started with a way of seeing, developed in a spiral coexistence with technology and commerce, and finally ended up changing the the worldview of humanity.

Understandably, in its early stage, practicing science, which then was known as natural philosophy, was a hard way to earn a living and an easy one for making enemies. Those early seekers continually moved from court to court and university to university, living a vagabond life. Then, Universitas, a Latin word from which University is derived, referred to the group of teachers in the cathedral school who set up with a few students a place for higher education, and self-governed like a guild. And the courts were a federation of feudal lords nominally under the leadership of the Christian papacy. The courts wanted magic, predictions and later weaponry, the universities polemical teaching. These traveling salesmen in ideas were not philosophers in the sense of pale meditators tied to a desk, yet they managed to write an incredible number of books, often not published till after their death but widely circulated in manuscript. This was the case of the most extraordinary character of the first half of the 16th century. The more known character is Giordano Bruno, who was protected by the princes and cities for his skill in magic—which then was to see and utilize patterns unnoticed by average people through natural philosophy—until they could not, and was burned at the stake by Inquisitors. The lesser known Telesio, whose work of 1565, *On Nature*, led Bacon to call him "the first of the moderns". Those pioneers are less known than their youngsters because the first, who struggle out of the establishment and form new and useful conceptions, only appears half right, incomplete, and remote in this history of ideas, but they perhaps more to be cherished than those who come after, who clear off the debris and offer a neater, more fullblown view (Barzun, 2001).

And this is a repeated pattern not only in the history of ideas, but also in the history of science, though in a less dangerous fashion. As a way of seeing, science ultimately became intertwined with the establishment for different regions for a period of centuries, or decades (as the tempo sped up), and the pioneers who saw the new light were oozed from the system, by apathy, vested interests or simply ignorance, because it is a disposition of human's nature to cling to the time-proven way of living and to be repugnant of change. In the early Renaissance, Erasmus was a vagabond hopped among universities and royal patrons, deliberately avoid funds that would curb his independence (though he sometimes regretted it in hard times) while writing the translation of Bible that unified the Greek and the Latin traditions of the New Testament (Froude, 1971). In early Enlightenment, Spinoza was excluded from the Jewish community, had been expelled by Amsterdam municipal authorities, and made a living by giving private philosophy lessons and grinding lenses, while working as an independent scholar writing *Ethics* (which published posthumously) among other works. In early Industrial revolution, Sadi Carnot, the father of thermodynamic, was employed as a General Staff in Paris, on call for military duty, but from then on he dedicated most of his attention to private intellectual pursuits and received only two-thirds pay. He died unfortunately because of cholera epidemic at the age of 36 at 1832, and his work was rediscovered by Kelvin in 1853. As well known, in early Modernity, Einstein could not secure an academic post after graduation, and worked as a patent worker outside the academics before he worked out the theory of relativity (Isaacson, 2007). Bertrand Russell spent his 20s living on his inherited money and in an isolated life for 10 years writing *Principia Mathematica*, which started the analytic philosophy in revolt to the German idealism (Russell and Foot, 1998). And Godel could not find a job after obtaining his doctorate, yet attended the meeting of Vienna Circle regularly and proved the Incomplete Theorem (Sigmund and Hofstadter, 2017). Even during the times between the WWII and 1980s when we might call the golden times of science, complexity science started in a similar way: Brian

Arthur grayed his hair while advocating the concept of positive feedback in economics; Langton had worked hourly jobs, both as a carpenter with a home remodeling company and as an assistant at a stained-glass shop, while developing his prototypical ideas that started the field *Artificial Life* (Waldrop, 1993); and Stephen Wolfram needed to start to a company to publish *A New Kind of Science* (Wolfram, 2002).

To start something fundamentally new, the road is hard and long because the evidence is sparse, the benefits are obscure, and the old systems were good—they had consistency, completeness, and proven access to material abundance; only at a few points did contrary facts or gaps in explanation threaten their validity. None of the pioneers were in "suitable" places where important works were supposed to happen. Out-of-box thinking typically came from the people come from outside the establishment. To understand this phenomena, simplistically, being outsiders allows them to be free of the vested structural interests, manifesting as personal, political, historical and cultural constraints that exponentially slow down the progress, like 10 times—and considering that the time frame of such work is typically minimally 10 years' concentrated effort, such slow down would make the work 100 years-long and thus impossible. Actually, this impossibility manifests as the institutionalized thinking of individuals in the institutionalized systems, making breaking out of the box unthinkable. This is also why there is a myth that the creative energy of an individual exhausts before one's thirties if one has not done anything notable. This is also why Nobel Prizes are so well regarded: they are given to the people who work out the first proof of concept that proves something that previously is unthinkable is possible, and has had a tremendous impact on humanity, even if the work actually done by those people sometimes actually in retrospect very simple—this is perhaps the most difficult task because it takes genius insight to notice the significance of the problems that nobody notices, great courage to think the problem is possible to solve, prolonged efforts to actually solve it, and then the misunderstanding-rife process to communicate the result. And those fundamental progress made by those pioneers determined the rise and fall of a civilization based on reason and science, and perhaps has never been more so nowadays.

Yet this facet of science has been unaware by the general public, and many, if not the most, of the scientists today, and this fact has even to taken a mantle of blue skies research among the world of science being dominated by business, military, national economy, or simply a stable peasant-style life in academics, which we now turn to next.

2.2 Institutional science and institutionalized science

We might call the period of science from the Renaissance to World War II the aristocratic science, not because the people who worked on it were from a more privileged background—many did not—but because it took the spirit of aristocrats to see beyond the mundane and pondering the transcendent. Around WWII, industrialization changed the role of education and the fabric of society, and aristocratic science was subsumed by institutional science, which perhaps roughly started since the German mode of research universities in 1700s, and reached its peak in the American research universities (so far) between the WWII and 1970s. In this subsection, we discuss this transition, and the danger of institutionalization of science in our times—institutionalization means *instruments* of a system that drive progress gradually transforms into *institutions* that exists only to self-perpetuate; that is, transformation of social arrangements functioning to meet real social needs into social institutions serving their own purposes regardless of real social needs.

The new worldview constructed by science and technology discussed in section 2.1 since Renaissance raised societal awareness that science and technology could exponentially increase the economical, political (hard) and cultural (soft) power of nations, and drive social progress. Therefore, the institutional promotion of science and technology education, knowledge transfer for economy development and social welfare, and state-funded research gradually became the goal of national governments. At the beginning, the system was the natural evolution of the Invisible College during the Enlightenment that was a loose federation of the natural philosophers, to a more coherent system that involved the larger society. University of Göttingen was found in 1734 by the George II, King of Great Britain and Elector of Hanover, and was conceived to promote the ideals of the

Enlightenment. Subsequently, research universities were established in the Humboldtian ideal of a unity of research, teaching, and study, which is a system that synthesizes the pre-Enlightenment universities and the scientists societies (Clark and Clark, 1995). And the success of the system had made once German the international academic language. Fast forwarding to the post WWII era, the generous state-funding supported by the economic boom of United States (and the private sectors) had started fields such as Cybernetics, Computer Science, and Information Science. The seed idea of Cybernetics by Norbert Wiener was developed during wartime when he was designing autonomous guns for intercepting warplanes (Conway and Siegelman, 2009). Without state funding, the first computer by John von Neumann was not possible (which then was originally designed to calculate artillery firing tables), and so was Internet (which was designed to be a communication system that could survive nuclear weapons (Isaacson, 2014)) . The hacker spirits (Levy, 1984), and free software movement (Williams, 2009)—which led to open source movement—was originated from technical student clubs in MIT, and was possible because of the spill-over effect of lavish funding that did not stringently constrain the scope of funding usage. Those were the better days, and our contemporary societies were the legacy of this evolution.

When abundant funding and abundant possible ideas to explore exist, the top-down regulation and the requirement of deliverable (to economy, business and military) could be satisfied by the byproduct of science and technology development; however, at economical downturn, and at times when the low-hanging fruits—which was possible because of the centuries of ground works laid by the Enlightenment thinkers—became exhausted, and new paradigm shift as fundamental as the one of Newton paradigm was required, these constraints started to too much to bear, and the system institutionalized.

To appreciate the timeline of science advances, we could look at the example of computer science. In addition to the technological advances, the theoretical foundation of computer science, Turing Machine, was the accumulated result of almost a century's effort. It started with Gottlob Frege, who reworked logic in the middle of 19th century, and was widely considered to be the greatest logician since Aristotle, though he was largely ignored during his lifetime. Giuseppe Peano, Bertrand Russell and Ludwig Wittgenstein continued the effort and tried to rework the foundation of mathematics and even philosophy—which led to analytic philosophy—through logic. The effort ultimately led Kurt Godel of the Vienna Circle to prove that logic formal system is not self-consistent. The result inspired Alan Turing to investigate what is reducible to logic and what is not, and led to the concept what is computable and what is not, which is the Turing Machine. This process roughly took a century. Similar timelines hold for statistical physics, quantum physics, theories of relativity, and perhaps all the branches of science.

One might speculate that such developments could be accelerated in the modern research enterprise, and it is not the case. An example would be the development of Deep Neural Networks. It started with the McCulloch-Pitts model in 1943, which is a computational model of the brain following the logic tradition. As logic could not handle uncertainty, *Perceptron* was invented by Frank Rosenblatt in 1958 to handle uncertainty with probability (among many other similar proposals). Conceptually, the system was inspired from the biotic nervous system, which is an organized complex system and is poorly understood even now. Thus, the progress since then proceeded in a trial-and-error fashion: in 1980s, the concept of internal representation and hidden neurons, and back-propagation algorithm were introduced (Rumelhart et al, 1986) to respond to the criticism that neural networks cannot not handle even simple problems like the XOR problem (Minsky and Papert, 1969), and ideas from statistical physics was imported to design the Boltzmann Machine, after the understanding of spin glasses matured in statistical physics; the development of computational power led to the prosperity of the Bayesian probability, and the porting of the ideas there led to hierarchically stacked Boltzmann machines (i.e., Deep Belief Network) in 2000s; those ideas accumulated through the decades waited for the massive amount of the computational power and digitalized data, and finally unleashed an AI in 2010s. The gap years were under very strong opposition from existing paradigms: the first winter in 1960-1980s was caused by the attack from the symbolic school of Artificial Intelligence, which we might appreciate as the opposition from the logic paradigm; the second winter in 1990-2010s was caused by the competition from the linear-science paradigm (i.e., support vector kernel machines). Each of the ideas that finally composed DNNs took 5-10 years to develop, and one interlocked with another.

The granularity of such developments of research of this significance is decades; even if the current information society could accelerate the information propagation, it could not accelerate the genesis of ideas, which are the concentrated efforts of individuals or small groups that span 5-10 years, interlock with one another, and accumulate into a breakthrough in decades. This is so obvious when one takes the effort to looks into the history of philosophy and science: the apogee of Greek philosophy was reached by the triad of Socrates, Plato, Aristotle, which spanned three generations; the formation of Newton's Law of Gravity resulted from the series of efforts of Tycho, Kepler, Galileo and Newton, which took 140 years; the writing of *Origin of Species* was gestated since Charles Darwin's grandfather who was a naturalist, and had written *Zoonomia, or the Laws of Organic Life*; complexity science gestated since a cluster of people working on self-organization in 1940s, accompanying the development in Nonlinear Science, Condensed Matter Physics, Economics and Evolutionary Biology, and converged around 1980s, best exemplified by the Santa Fe Institute. The appreciation of this dynamics is such problematic now that researchers have to advocate for Slow Science (Lutz, 2012).

Therefore, when a system asks that a specific research spanning five years should deliver a specific result that could be intelligible by the administration and the peer reviewers, it effectively incentizes against fundamental breakthroughs (Braben, 2008). These efforts at early stages could only be understood and appreciated by the peer scientists and administrators (if they are well trained in science) at the timescale of years, and the general public at the timescale of decades. Therefore, despite the increasingly great number of papers published, structurally existing research becomes increasingly incremental, and reinforces existing canons (Chu and Evans, 2021): it is good at transforming fundamental research discovery into applied research and then business, but bad at generating new fundamental breakthroughs (Seno, 2016). As a result, the idealistic scientists are driven out of this system (e.g., Stephen Wolfram, who started a company to study complex systems, or Grigori Perelman, who opted out of academic after proving the Poincare Conjecture (Gessen, 2009)), and the authentic scientists are marginalized (e.g., Geoffrey Hinton, who was once told by conference organizers that the research on neural network should not be incorporated because it would confuse the mind of young researchers). And what is left structurally are the businessmen, the peasant-minded knowledge workers, the bureaucrats who cling to power rather than truth. This institutionalization had happened repeatedly in history, and the stereotypes are known by different names: philosophers versus sophists in Greek civilization; philosophers versus Jesuits in Catholic civilization; scientists who understand the philosophy of science versus scientists who worked as knowledge workers in our times. And when the system sustains itself for a sufficient long period of times, we now have the crisis of the "end of reductionism" (Laughlin and Pines, 2000)—which is a continuation of the crisis of epistemology (Sigmund and Hofstadter, 2017)—and in the general public we have the talk of end of science (Horgan, 2015).

As a consequence, the depletion of fresh input from the source of blue skies research, the previous unity of research, teaching and study that brought societies to the modernity became competing priorities that each of them takes a life of its own and competes for the decreasing attention and resources of the administration and the general public, but none of them could operate adequately in a structural sense: the basic research runs in difficulties because the intellectual confusion in post-modernity (see section 2.3 in Li (2021)), and is being incentized against in the early career stage; the applied research runs in difficulties because the stagnated economy desires concrete and particular deliverables even prior to any research having been done—this results in the practice that researchers submit proposes for research they have already finished, and use that fund to pursue the next iteration of research in the agenda—and because of the lack of sustained input from the basic research; teaching runs in difficulties because in the research universities the priority of professors is not teaching but research—at least in the early stage of career when the junior professors are to survive—and the highly specialized knowledge increasingly becomes irrelevant to undergraduate study, and periodically for scientists as well because many papers published are incremental fiddling that is going to be obsolete when the next breakthrough comes; study runs in difficulties because of absent-minded professors, and further because the academic is shuttered into disciplines and each pursues their own end, and the disciplinary training leaves the character development and worldview forming all to students themselves. These problems do not exist for all fields of science at all institutes at the same time—some fields and institutes are vibrant and exciting—but science as a whole structurally suffers these problems (Rothblatt, 2012).

In other words, institutional science is on the edge of becoming institutionalized.

2.3 Renaissance Men and Transdisciplinary Mind

From the perspective of system evolution, the contemporary ecosystem of science is similar to its state at Renaissance. Structurally, scientists under the capital order function as a social role played by Jesuits trained by the Christian church to maintain the theological order, trading papers with the funding agents for livelihood, and with peers for social network and capital. Although unexpectedly for the contemporary Christian authority, understandably the education base broadened by Jesuit education instead catalyzed the disintegration of the theological order. Similarly yet through conscious reforms, the institutional science is metamorphosing from the current institutionalized state into its next form, under both the space left for blue skies research and catalyzed by the societal complex problems (e.g., climate change, understanding mind and consciousness, managing complex social systems) that disciplinary science is incapable of handling; the system as a whole is brooding for its next major evolution. And the Renaissance Men is a persona that might be referred as the Transdisciplinary Mind that might call for another iteration of universities (Gidley et al, 2000; Frodeman, 2013). In this subsection, we discuss the comparison in more details.

The current public perception of Renaissance is the image of individualists and universalists who "can do all things if he will", however, it is a typical anachronism that mistakes the end result of heroic pioneers with the societal image at the time; before the individuals who could even start to be noticed by the authority (the early natural philosophers discussed in section 2.1), they need to strive out of the previous decaying social order. After the fall of the Roman empire, Europe had been through hundreds of years of chaos, known as the Dark Age: the factions in the disintegrated Roman empire warred with one another, the Danes and Normans caused havoc from the north, and the Arabs invaded from the east. The chaos did not settle until about 1000 A.D., the time when the different ethnic groups became mutually assimilated through these hundreds of years' violent contact, and the Christianity and Islam faced a standstill (Russell, 2004). Despite the gradually emerging social stability, most Italians shared very much the same experience of living in a world that was chaotic, violent, anxiety-ridden, plague-struck, superstitious, depression-wracked, fiercely materialistic, repressively governed, exploited, discriminatory, filthy, and dangerous. It was out of these base materials that those with great nerve—for, as Alberti called it, "will"—made the Renaissance (Mee, 2016).

The Renaissance started with the realization that an earthly life existed in the ancient world, and developed into the humanistic worldview that reason, will, the observation of nature and active action would lead to individual development and improvement of life conditions, and the seeking of good earthly life. This new worldview transformed the strictly functional education, where it trained workers in basic skills and turned out a privileged few for careers in merchant-banking, medicine, law, and the Church, to what is known as the liberal arts education, where the goal is to shape a whole, well-rounded individual (without the irony connotation of our contemporary times) capable of nobility and worldly fame. It catalyzed a new system of school, and universities under very harsh conditions, where the scholars themselves were possessed of a missionary zeal: they believed in education and in the urgent need to popularize and disseminate the fruits of their scholarship; they needed allies, patrons, and printing presses; the goal was to make "everyone lettered and learned" in order to make a new world (Mee, 2016).

It is in this tradition that the currently world-renowned collegiate system of Oxbridge University gradually established, and reformed as times changed (Rothblatt, 2008), which was perhaps the only ones left thanks to the distance of U.K. to the war-torn European continents, and the moderate reforms that preserved previous structure instead of the radical revolutions. It is also this unique history that made the system difficult to replicate in the era of research universities (Rothblatt, 2012): where the focus of universities is not to deliver liberal arts training—even what is the canon of liberal art education now is not clear—but to produce world-class research that contributes to military technology, economy, and social welfare.

The German model of research university was established under the tightly coherent interaction between Enlightenment-spirit education and the research that pushed forward frontier of Enlightenment. The failure of the cause of Enlightenment (cf. section 2.3 in Li (2021)) had made the research university as an instrument for national empowerment—under this conceptualization, it is sensible that the world leading universities of German unfortunately led to world wars and fascism, and the Master Plan of Higher Education of Californian Universities stalled after it has achieved world-class status. Therefore, disciplinary science institutionalizes (i.e., takes a life of it own without being a social instrument), and could keep that way as long as the individual disciplines could deliver the objectives given by the funding agents, and the scientists in it becomes knowledge workers resembling the peasants working under landlords in feudal societies and small businessmen trade with one another, instead of pathbreakers that started the Age of Enlightenment; and the powerful ones get their own land and start their own business.

Consequently, the education in our times become functional, and resembles the functional education in the early Renaissance, where the goal of education is professional careers, in political systems, in tech sectors, in international commerce, in court and hospitals, etc. And the institutional science is cut up into parcels through disciplines, where a thousand professional tracks provide career advances without looking into the development in the other tracks. This dogmatic and rigid education rather resembles the dogmatic following of the theological order, where the livelihood is authorized by high priests of peer review, funding agency, and political priorities (Braben (2008); Baumberg (2018)). These institutes are the residual vestige emerged in a time when the disciplinary science is a timely instrument to divide the labors among scientists in a vast new world. Yet, currently, this new world has been over-exploited, and despite disciplinary science still serves its irreplaceable function, new machinery is needed, which requires blue skies science done at the level, if not the scale, of the Enlightenment thinkers. As a result, disciplinary science became institutionalized, and hinder the development of blue skies research (see section 2.2).

There is general awareness of this problem in the science community, and interdisciplinary science is being promoted for a few decades (Frodeman, 2013; Frodeman et al, 2017), where scholarship, departmental reform, initiatives and interdisciplinary centers are established to promote such research. However, the promotion more reveals the structural problems of the current system, makes clear that the forces of institutionalization is very strong, and it is still precarious and risky to pursue such a path if the intention is simply a career (Lyall, 2019). Furthermore, genuine intellectual pursue is inherently unpredictable, and existing interdisciplinary approach typically takes rather minuscules collaboration among fields, and top-down regulation that aims for specific complex problems, which ask for short term deliverables that look good on paper but in long term have a large chance of being irrelevant. Fundamental research perhaps is intrinsically impossible to plan and regulate, and remains as "free play of free intellectual".

Nonetheless, the situation is not as difficult as the times in the early Renaissance, a large number of scientists in the system are aware of the problem, and structural vestige still exists to promote progress. At the student level, a system of studentship is available to allow independent inquiry without joining without working as a temporal knowledge worker in a research group (e.g., Prize Fellowship in Cambridge University, and National Fellowships). At the faculty level, there are blue skies research funds and tenured professorship that allow for independent inquiry without working for concrete deliverables. Independent think tanks also provides institutional support that protects researchers from the general institutionalized science atmosphere (e.g., the Santa Fe Institute). And there are also venture capital system that could amplify the utilities of the research when it is ready. Despite playing a structural force to promote blue skies research, those systems are still in the peripherals of the whole science ecosystem. And to utilize these systems, one needs to exerts willpower over a long stretch of time, besides possessing talent and knowing how to manage it.

Therefore, the science ecosystem is posing in a state where a fundamental obstacle of science now is the synthesis of the fragmented knowledge scattered all over the disciplines to answer the intellectual challenge to understand biotic, nervous, social systems, such that the original vision of Enlightenment could be continued: that is, the ideal of early humanists that reason, will, the observation of nature and active action would lead to scientific understanding of biotic life, mind, societies and civilizations, and their betterment. In the postmodernity, we might refer such individuals as a Transdisciplinary Mind that revives and transcends the ideals of early humanists known as Renaissance Men.

3 The dilemma of Chinese science

3.1 Mainland China's pragmatic research ecosystem

It is under this state of the art of science discussed up to now that we could start to understand the China' research ecosystem. Chinese research ecosystem was built under deep pragmatism for national rejuvenation under severe resource and time pressure; as a consequence, it only takes what has been proved working, and thus, inherits the problem of the institutionalized science ecosystem without the structural vestige left by the early Enlightenment thinkers—the structural vestige is discussed in the next section 3.2. This made this system particularly unsuitable for blue skies research, which we discuss in this section.

The structural problem, or we might rather say immaturity, of the Chinese higher education system could also be seen in the general international perception that a Chinese is "practical", and by the number of Nobel prizes in science that have been to people trained in the Chinese education system: there is only one, Tu Youyou, who did not even have a postgraduate degree—we have discussed what Nobel prize promotes in section 2.1. And for the people who are attracted to this kind of research, there are enormous obstacles standing in the way. And an exemplar would be Yitang Zhang, who took precarious jobs for 7 years—as an accountant, a delivery worker for a New York City restaurant, also in motel in Kentucky and in a Subway sandwich shop—then a lecturer for 14 years, before he made world-renowned advance in mathematics. The problem needs to be understood in the historical dynamics of China.

The contemporary China started with the echo of the chief architect of China's economic reform and socialist modernization, Xiaoping Deng, "it doesn't matter whether a cat is black or white, as long as it catches mice"; this is the simplistic message to the nation devised by Deng such that the ordinary people could understand, and this echo set the national mentality for the 40 years to come. The fundamental national problem was stated by the leadership as the inadequacy of productivity to satisfy people's aspiration for a better life, which is a congenial way to say that individual development, and social stability and progress both require first building the economy. Therefore, the whole education and research system is built around this central theme.

The education system aims to produce workforce of modern economy, except for some special classes that allow for some flexibility (e.g. Special School for the Gifted Young in University of Science and Technology of China). Though without explicitly formal tiers, the universities and colleges are divided into three tiers: the first tier trains workforce at the national level, the second tier trains workforce at the provincial level, and the last tier trains workforce at the local community level; the admission quotas are allocated according to the need of industrial sectors (and the capacity of the system), and students are not allowed to transfer among majors, unless they retake the national exam. The education system resembles the Master Plan of Clark Kerr designed for the University of California, but without its feature for research excellence, particularly the quest for truth in the sense of blue skies research (we shall discuss this further later), and the transfer of talents (one could not change one's major, let alone change one's university). Thus, it does not aim to be student-centered such that the system is designed to let students find what they are suited for, but to pipeline workers to different organs of the economical system.

The research system aims to train advanced technicians and do applied research to support the economy. Under this context, the goal of publication for the majority of students is not to push the frontier of science, either applied or basic, but to demonstrate that they are familiar with the literature, such that they could be hired as a technician who is capable of being abreast with the international state of the art. Therefore, the prevailing mentality of students do not care how miniature or irrelevant the novelty in the publication is, as long as it is published, and serve as a proof that they understand the literature, and thus this dynamics create a large number of papers most of which are not read by anyone else but the authors themselves. Meanwhile, the applied nature of the research requires that the research should be directly related to the relevant economical sectors, and thus the research areas that align with the national plans would get funded, and that not would struggle to find support (Hao, 2008). Therefore, the researchers are a body of knowledge workers employed by the states to serve an economic function, and thus no independent research is possible.

Research for national empowerment is not a problem on its own, all the nations in the world do so nowadays, and this effort has built China a modern economy and made it the growth engine of the world; the problem is that under this particular junction of science discussed in previous sections, the end result of such an effort led to a science ecosystem that promotes short-sight and nepotism.

First, both as the result of this overwhelming focus on economy, and the lack of a critical mass of world-class scientists, the system did not grow organically by first engendering a seed group of authentic scientists in the sense of the seed of natural philosophers emerging in the Renaissance—which is a rather slow process and difficult process—but by creating a monetary incentive system that measures the domestic staffs against the well established international instruments, i.e., the publication in top journals authorized by SCI index, and citations garnered by the scientists. Those top journals are the result of the better days of disciplinary science, and are milestones of mature scientific fields of proven utilities to societies. It is also a good apprentice experience to publish in such journals. Thus, initially this practice served as a good start point in training scientists. However, as discussed in the previous sections, the disciplinary science has reached its institutionalized phase, and more and more works published in these journals are publications for the sake of publication (i.e. take a life of its own instead of being a social instrument), instead of pushing the frontier of human knowledge. Consequently, the system trained a large body of technicians for the economy but few scientists, and relies on the infrastructure maintained by the international science community (i.e., the birth and decay of fields, sophisticated equipment, the hardware and software stacks, peer review system, and etc.). This system attracts peasant-minded knowledge workers who want stability, businessmen who see opportunities in capital, and power brokers who looks for pathways to power, and marginalizes the authentic scientists, many of whom are simple-minded, purely curious, value honesty and truth above materialistic benefits and thus have difficulties navigating the system—the authentic scientists who could prosper in this system are of exceptional characters, and conventionally, we call them heroes. And structurally, this dynamics ended up with clusters of vested interests where promotion and collaboration are ranked by connections (guanxi) (Shi and Rao, 2010; Shi, 2014).

This pragmatism is sometimes clouded by the mantle of Confucianism, where intellectual freedom is excused in defense of the national interests in the statement that science needs to be centered around societal concern and care, but this excuse is a misunderstanding of how science works, and typically voiced by public policy people who have not done science themselves, and perhaps does not really understand Confucianism. The National Southwestern Associated University during the WWII had educated a number of great scholars; and to give an example, Zhenning Yang has done works of the highest caliber (and won the Nobel Prize). It is not possible to state that the university does not have Confucianism tradition; the great Confucianism scholar, Mu Qian had been the teacher of the university, and later went to found to New Asia College in Chinese University of Hong Kong. The core of Neoconfucianism is to build a just and prosperous world, and "investigating nature and acquiring knowledge" is part of the central doctrine—for a detailed discussion, refer to section 2.2 in Li (2021). The real problem is the lack of a critical mass that understand the dynamics of societal betterment through science, which is a long term process that is not experienced by most of the policy makers and scientists today. The climate change now is a great example: despite the slow societal response, the warning of the climate change from scientists since 1980s might enable humans to avoid catastrophic collapse of human civilization if it is determined to respond. This slow dynamics is impossible to unravel in the current system.

Consequently, the system concentrates opportunists who would only participate in an area when the area has surely shown the great potential (e.g., the recent burgeoning area of artificial intelligence), and very few are doing the hard work of exploration the uncharted territories, which we might say is what scientists are supposed to do, and not only includes blue skies research that are of uncertain but immerse potential, but also many fields that are important for the health of the nation (e.g., theoretical physics, infrastructure research in computer science—compilers, operating systems—sociology, literature, history etc.). That is how the areas and industries, that take a long time, typically decades, to build, became the current bottlenecks that are stuck in the mire of the China U.S. competition: for decades, national government wanted to build an operating system whose intellectual property it could own, and to build a world-class semiconductor industry, but these efforts ended up in scandals and resource waste. And now the nation is in great trouble, urgency, efforts and determination to promote basic research after the rosy relationship with U.S.—which dominates the international scientists community—ended.

3.2 The root of contemporary pragmatism

Nonetheless, despite the analysis, it is hard to imagine how this modernization of science could proceed in a way qualitatively better. This rampant growth meshed with fiercely materialistic interests is the typical phenomenon at early stage of social development. We have briefly discuss the situation of Renaissance and Enlightenment. The glided age of U.S. is also fiercely pragmatism—*The Great Gatsby* by F. Fitzgerald is a persona that embodies the image of the age—and the contemporary philosophers (e.g., John Dewey), who experienced the traumatic civil wars, and found that it was perhaps the only philosophy that worked for a torn apart country. The nation could not depend on and wait for the unpredictable blue skies research. And if it is managed with consciousness and wisdom, it would melt away when the nation is sufficiently rich and developed national-wide. However, why fierce pragmatism seems inevitable? The answer lies in the failure of Enlightenment which dispensed the intellectual guidance of science and caused the Western societies to enter postmodernity. In the international scientist community, a critical mass of scientists who are the children of Enlightenment serve as the structural force to maintain the healthy of the international science community despite the lost of Enlightenment spirit in the general public. But the Chinese science ecosystem lacks such a critical mass of scientists, which results in a pragmatic system. We discuss this in more details in this section.

The direct reason of pragmatism is the lack of a critical mass of scientists to begin with. In a mature science system, breakthroughs happen by first being recognized in the science community, and are unintelligible by the administration and the general public at large. We have discuss the slow dynamics of science breakthroughs in section 2.2. To give a more well publicized example, the theory of relativity by Einstein was taken as suspicious when it first came out, and was not considered a legitimate theory—the word "legitimate" is used, not scientific, or solid because it was so bizarre; the recognition of Einstein came from his other works, particularly the explanation of photoelectric effect, which was recognized by Max Planck who recommended Einstein to be a lecturer at the University of Bern. The experiment confirmation that Sun would bend light and made Einstein world famous did not come until 1919, 14 years after the special theory of relativity was on paper (which itself had a gestation period of about 10 years, and had developed into the general theory of relativity by 1919). This peer recognition has been metamorphosed into the peer review system nowadays. Coming back to the situation of China's science, the society resembles Early Renaissance or Late Greek Civilization, depending on the dynamics in the decades coming. This is a nation of peasants and proletariat workers whose sons and daughters are first or second generation of university graduates, and see education and research as a way to a better life, or simply to survive in the society that is moving so fast. It would ask too much from them for higher ideals, which are typically regarded as bookworms, nerdy, and unrealistic. That's why Chengtong Qiu observes that the Chinese PhDs do not produce good works compared with their developed country counterparts, and John Hopcroft observe that the undergraduates of China after four years became worse than their US counterpart while at the time they start university, they are on the same level: pursuing knowledge is not their priority, and they only want a sufficient level such that they could be employed—this is not even the outcome of a conscious choice at most of the cases, but because of a lack of motivation and confusion of what knowledge is for. In this atmosphere, legitimacy of research comes from the social recognition, which typically means money and social status, and manifests as the phenomenon that the choice of a problem depends on whether it is internationally established, and whether the results could be published in top-ranked journals, which are not where new breakthroughs are coming, but existing venues that discuss relatively mature fields. Without a critical mass of scientists who could demonstrate the importance of blue skies research, and maintain a healthy peer review system, the funding agency could not really appreciate the importance of such research, and could not entrust independent governance to the so called scientists; the "scientists" have the tendency to degenerate into a collage of peasant, businessmen and power brokers; and the new generations of students could only see such individuals leaning to such research being marginalized, and living a decrepit and deficient life. Consequently, the ecosystem resembles the early stage of Renaissance before the Age of Enlightenment, where the masses are deeply pragmatic, and the scientists (natural philosophers) are marginalized group have a structural force to fight over.

However, if we dive further, why China's science ecosystem at the 21st century resembles the times of the Western science 500 years ago? The root problem is that the beginning of another civilization cycle of Chinese civilization coincides with the ending of a civilization cycle of Western civilization: China has recently struggled out of a chaotic civilization collapse phase, which is similar to the emergence of Western civilization out of the dark age after the collapse of the Roman civilization; and the Western civilization is in a civilization decadence phase where the spirit of Enlightenment is discredited (i.e., postmodernism, or post-postmodernism) and the cause of Enlightenment failed globally, which severed the guidance of science as an intellectual system for the masses—for a detailed discussion on civilization cycles of Chinese and Western civilization, and the role of intellectual system on societies, refer to Li (2021)—and the biotic instinctive default state of civilizations in such two phases is to survive. To get a snapshot of this situation, we could look at the society condition depicted by Russell when the Greek civilization fell (Russell, 2004, p. 219):

> The general confusion was bound to bring moral decay, even more than intellectual enfeeblement. Ages of prolonged uncertainty, while they are compatible with the highest degree of saintliness in a few, are inimical to the prosaic every-day virtues of respectable citizens. There seems no use in thrift, when tomorrow all your savings may be dissipated; no advantage in honesty, when the man towards whom you practise it is pretty sure to swindle you; no point in steadfast adherence to a cause, when no cause is important or has a chance of stable victory; no argument in favour of truthfulness, when only supple tergiversation makes the preservation of life and fortune possible. The man whose virtue has no source except a purely terrestrial prudence will, in such a world, become an adventurer if he has the courage, and, if not, will seek obscurity as a timid time-server.

The developed countries are abundant enough to avoid this bleak picture—but not very much, and there is a general pessimism (which is also the mood underlying the backslash of anti-globalization movement) and for further discussion, refer to section 2 in Li (2021). But the developing countries are not that fortunate, and the people scramble simply to survive. It is the Enlightenment ideal that makes the "free play of free intellectual" defensible, and without it, pragmatism in the mantle of national empowerment would prevail. In such a situation, a genuine science ecosystem is very difficult to build without fundamental breakthrough in science that goes beyond the postmodern view of science, where it is reduced to yet another social institutes that serve the ideological goal of the nation, is subjugated to the national interests, and does not gain an independent status. And pragmatism is the next-best thing in absence of a working intellectual system that might prepare the material condition for the real one to come.

Under this generally confusing times, the tradition and ideals of science are only kept in the few high-minded, curious, cultivated or intrepid scientists. Some examples would be E. O. Wilson, the renowned naturalist who wrote *Consilience: the Unity of Knowledge* (Wilson, 1999) to call for the Enlightenment spirit (but in a way that is more a rallying call than a well devised plan), or the missionary of science, Carl Sagan, who directed the documentary *Cosmos*. Despite the applauded as the great science communicators, their messages are still very difficult to understand by laymen, who struggles in the mundane life without the cultivation to appreciate the message. A critical mass of such scientists are the underlying structural force that keeps the international scientist communities healthy. And the Chinese science ecosystem does not have such a critical mass of those authentic scientists. And thus even if many, if not most of the scientists in China are aware that somehow the system is malfunctioning, there is no realistic way to reforming out of this system without first getting a critical mass of such scientists; and without them, a system values intellectual pursue over materialistic benefits would collapse the system without a replacement.

To see how difficult it is to build such a critical mass of scientists, we could look at how the Society of Fellows started in Harvard.

As briefly mentioned in section 2.3, the collegiate university evolved from the tradition of informal universities since Renaissance (which in turn evolved from the university in the theological age); this intellectual tradition has materialized as the *Prize Fellowship* in colleges of Cambridge University, which is an early career/stage fellowship that supports independent intellectual pursuit with no strings attached and purely selects for intellectual potential by the senior fellows in the colleges. To give some examples to demonstrate what the fellowship promotes, Bertrand Russell received such fellowship to work on the logic foundation of mathematics, which eventually started analytic philosophy in an atmosphere dominated by German idealism and inspired the logic positivism movement, and Stephen Hawking worked on the gravitational singularities in the Big Bang situation, and eventually proved that if the universe obeys the general theory of relativity and fits any of the models of physical cosmology developed by Alexander Friedmann, then it must have begun as a singularity.

Around 1920s, frustrated with the conditions of graduate study at the Harvard university, Harvard scholars Henry Osborn Taylor, Alfred North Whitehead believed that in order to produce exceptional research, the most able men required freedom from financial worries, fewer formal requirements, and the liberty to choose whatever object of study attracted them. With then-Harvard-president Abbott Lawrence Lowell, they want to establish a *Society of Fellows* at Harvard, modeled partly on the *Fondation Dosne-Thiers* in Paris and partly on the Prize Fellowship at Trinity College, Cambridge. However, they could not find donors for years—fellowships are typically aligned with particular interests of a social group that funds the fellowship, and for fellowships that promote independent research for the curiosity and general welfare of humanity, this outcome might only be surprising, or not, for many. Lowell funded the Society himself—his last major institutional act before his resignation in November 1932. "There being no visible source of necessary funds," he later wrote,"I gave it myself, in a kind of desperation, although it took nearly all I had." Though it was an open secret that Lowell was the source of the anonymous donation, this was never acknowledged in his presence until his death. The society was officially inaugurated as an alternative to the Ph.D. system with the beginning of the 1933–34 academic year, granting Fellows freedom to pursue lines of inquiry that transcended traditional academic disciplinary boundaries (Brinton, 1959). The scientists that was the Fellows of Society included Noam Chomsky, who studied *transformational grammar* supported by the Fellowship, eventually transformed the whole field of linguistics, and sometimes is called "the father of modern linguistics", and E. O. Wilson studied the social behaviors of ants in overseas expeditions supported by the fellowship, and the work ultimately found the field *sociobiology*, and influenced the formation of evolutionary psychology.

It is such a slow dynamics that builds science communities: it took several generations of presidents until Lowell who could make such an institutional act (Karabel, 2005), and a few more decades, and the critical infusion of world-class scientists from Europe because of the catastrophic WWII, to make Harvard a world-class university. In addition, it needs to be supported by a stable, if not wealthy society. This critical mass of scientists built through hundreds of years after Enlightenment keep the scientist communities healthy amid uncertainty, and the China's ecosystem does not have enough of them.

To clarify at last, this is not because that China lacks such a tradition; as explained previously, it is the peculiar of the timing in the civilization cycle the caused this phenomenon, and Chinese civilization is in a stage that is far away from its golden times. And to demonstrate the message, we only need to look at the attitude of the Royal Society of London to learning in the ancient Chinese civilization, which is quoted in the book *Science and Civilization in China* (Needham and Wang, 1954):

> "To men [he is speaking of the Jesuits in China] so qualified with Mathematical Knowledge, we owe the Discovery, of the before unknown Parts of the World, and from such we are to hope for the Perfection of that Knowledge, and the Discovery of the Rest. I have upon this occasion added some inquiries concerning the Literature of that Country; they are but Conjectures, grounded upon the perusal of some of their Books. A full Discovery is not pretended, however I hope they may serve as hints and incitements to others, who have better ability and other advantages to compleat it. We have hitherto not been admitted but to the Skirts, but this Discovery, when perfected, will lay open to us an Empire of Learning, hitherto only fabulously described; this will admit us to converse with the best and greatest of that Empire, that either are, or ever have been; this will Discover a new Indian Mine and Treasure, and make a new Trade to bring it hither . . .. "
>
> Robert Hooke, F.R.S., (Some Observations and Conjectures concerning the Character and Language of the Chinese's, Philosophical Transactions of the Royal Society (1686), vol. 16, p. 35.

The passage is referring to the Chinese civilization, which reached its peak around 1000s, and was about to enter its decadent stage at the time (cf. section 2.2 in Li (2021) for more details).

The only way out of this reinforcing loop of pragmatism is to create seed groups in different areas that consist of scholars in the Enlightenment thinkers' sense, and probably with some Confucianism-style characteristics. No money, regulation or institutes could solve it without creating a critical mass of such scholars first. It is in such accumulated individual actions under the support of the national effort, a healthy science ecosystem is gradually built. There are encouraging signs, though a mature system perhaps would not exist in 20 years even if the nation is on the right track.

3.3 Chinese researcher conditions

The discussion now has taken a macroscopic view, and we discuss individual researchers' conditions in this subsection. This depiction should be understood as stereotypes, caricatures for the manifold authentic people of kaleidoscopic characteristics that develops under the structural force discussed in the previous subsections.

The newer generations of researchers since 1980s are the outcome of China's state-building process. We have described the state apparatus macroscopically in section 3.1. Microscopically, the process implies a massive number of schools are being created from primary to doctoral level. This massive expanded capacity of education, accompanying the shortage of teachers, resulted in mass education that selects for certain stereotypes that fit for the national purpose, which we have discussed in section 3.1. The system has its good side: it cultivates a good habits of learning and discipline by regimented classes started with daily exercise in the morning, interlaced with short rest period, and the workload gradually increases with the level of education; it promotes honesty, hard work, intelligence, smooths out privilege and promote peer affinity by requiring all students to wear the same uniform (but the quality and privilege of schools and regions varies greatly), and tries to educate people for the general goodness of society; essentially, it gives structure to life in world under rapid change, both in the sense the life of students and the life of parents whose life resolves around their children. However, the downside of the system is that it provides no systematic education in the sense of liberal art education (in China, it should be understood as mixture of Confucianism and liberal art education) in preparing them to be an individual—some how we could use the "well-round individual", but this word has been given a distorted connotation by privilege under the current education system of U.S. It promotes rather rote-learning, heavy concentration on STEM education not without ideological indoctrination education until the university stage, such that the process would turn out quality workers for the state, and evaluates students by a single dimensional scale, i.e., grades. Thus, the mental development of students in the sense of general education is handicapped. As a result, the stereotypical students who survived this system—many are redirected to various vocational schools if they are not good enough for the system—turns out with a deep desire to seek for materialistic betterment, or simply struggle to find a place in the modern China, if they do not fortunately have a family education to let them avoid developing such a mentality.

In such a system, intellectual pursue is largely under-expressed. The students who are creative, curious, extremely smart (such that they see the purpose and limitation of this system early on), courageous, exploratively adventurous are discouraged in the education process, again unless they have family connections and luck to get a special education. Therefore, at the doctoral level, the stereotypical researchers are knowledge workers who are mostly first or second generation bachelor degree holders, and see the benefits of a university career as a place with high job stability and security, instead of a place where intellectual goals are pursued. The predominant results are some mixture of timidity and compromise, where the researchers do some research that are aligned with the national incentive system, and are meshed into the tide of history where a pragmatic machine is running the economic development of China.

That is the state of the national ecosystem; meanwhile, the best are selected by the national elite universities, and they typically seek study overseas; these migrant PhDs are still first or second generation university degree holders who are the sons and daughters of farmers and workers, and study for practical ends, in addition to an idealized perception of academy. But the overseas system is not very kind to them either.

The institutionalized science discussed in section 3.1 has turned the international science ecosystem into a giant knowledge farming machine, and it needs a massive amount of intelligent and cheap labor to cultivate knowledge. As a result, without connections and resources, which mostly comes from family, all existing scholarship, or fellowship are contracts: the national contract requires that after the study has finished, the trainee needs to return back to China to serve the country for some definite years; the foreign contracts requires to work on certain projects under a Principal Investigator as an immigrant knowledge worker for at least four years—the salary of PhD was roughly at the minimum wage. There is no fellowship such as the Prize Fellowship that promotes independent intellectual pursue, both as a result of the lack of funding, and mostly because such fellowship requires a critical mass of scientists who can interact with the students early on for a prolonged period, and understand the capacity of the students even if the students have not done anything significant yet: Bertrand Russell and Issac Newton had nothing scientifically significant when they receive such fellowships to carry on independent study; even at a time when such a critical mass of seniors are missing, which happened frequently in history, the tradition would leave room for independent study—and again, Newton was the example (Westfall, 1983). For the people who have such desires strongly, but could not find a senior competent people to win their admiration and give them guidance, such students would be perceived as an arrogant student "who thinks they are better than their elders", as Einstein was described when he tried to stay in the academic when he graduated, and a naive individual who is unsuitable for research because one does not understand the "rules" of game, and thus is unpredictable and thus best avoided—probably Yitang Zhang had this unfortunate experience. The lucky case would be having a patron who is senior enough to spare quotas and to have resources to let you do what you want, but again, such senior people are rare and mostly are not really a "free intellectual" but are nice enough to give some room to youthful spirits. In addition, they work under great survival pressure: failure means expiration of visa and deportation.

Even if they successfully finish their apprenticeship after four to seven years, the ensuing journey is statistically more an immigrant assimilation process than intellectual pursue of being a scientists. Research is a highly risky and unpredictable enterprise, and as discussed in section 2.1 the early science was supported by aristocratic spirits, and in the contemporary institutional science, it would be immensely lucky to find such a community without first understanding and doing science of the similar caliber. Thus, research career is like migration, one takes one temporal contract after another until one accumulates enough capital to start his own business, implying sufficiently established through a publication record. Although the tenure track system provides institutional support for independent research, and it also functions as a bait, which functionally attracts the peasant-minded who want job security. Therefore, the research career of those immigrants are like backpackers in the mountain: if one goes on a long streak on the mountain to attack important problems, the long time required by such search could starve the researchers, and thus destroy their careers, because the work could not be capitalized in term of paper count, or commercial conversion, and thus the research would be of a high risk being taken as obsessive, impractical, and could not handle the trade-off between research and real world. The people at top-ranked universities could afford to explore in the mountain longer because they are more credited and reputable, but not much longer. As a result, most research done is to explore an incremental extension from an already roughly charted area by others. The situation at lower-ranked universities are more bleak. Instead of making such explorations, they could only afford to work on problems that have already been initially solved, and what is left is incremental perfection where any incremental improvement would lead to a benefit in existing scientific understanding, or technologies.

Therefore, the majority of the successful researchers who pursue overseas study in this system thus are applied researchers, who could crank a great number of publications on the top-ranked journals, and the ones who work for successful business enterprises. As a result, this difficult immigration assimilation process structurally impedes them to develop leadership in science by doing top-class research, because of the economic hardship, diffusive training in the early stage, the pressure to survive in a foreign environment, and cultural and even racial misunderstanding. Correspondingly, they have a difficulty time participating in the elite community, which manifests as some kind of career ceiling circulated in the overseas Chinese. Consequently, instead of being knowledge workers in China, they become knowledge workers in Western countries. A large proportion of them transferred to tech workers, entrepreneurs, small business owners, and other sectors that are unrelated to what their education is meant for.

Nonetheless, a small amount of them could become elite researchers at top institutions or universities, thanks to both their excellence, and perhaps more importantly a great amount of luck. For all the cases that I know, they either follow the default pathway of academically excellent students, which is motivated by the pursue for materially good life, or some idealized image of the academic. They typically go through a confusing period during their PhD days. However, despite this confusions, they manage to meet the right people and deliver the right amount of good enough works to make it to the next career stage, and nothing formidably difficult happens. Despite the confusions, they maintain a stage of naivety, are unaware of the mire of contemporary science, and thus do not get contaminated by this institutional illness discussed in early sections (and also see section 2.3 Li (2021)) until a rather late stage, and thus in this sense, they get very lucky because they are content with working disciplinary incremental works early on until they are established enough to understand the situation. To appreciate this phenomenon, one could look at Phil Agre, who was one of the pioneer working on Embodied Intelligence and later turned a Humanities professor. Phil Agre developed an awareness of real intellectual works during his PhD, roamed the nation after finishing his PhD in Artificial Intelligence at MIT, writing deconstructionism criticism, and ultimately left the public life after working at the capacity of a professor for decades at UCLA. This pattern of luck, diligence and excellence works repeatedly until they are tenured, and each career stage would exponentially reduce the number of researchers left.

The ultimately left isolated individuals work in science at the highest caliber, but they are still rarely capable of writing papers at the level that is indistinguishable between science and philosophy, which is where fundamental breakthroughs are coming from; for some examples, refer to Laughlin and Pines (2000), Longo and Montévil (2011), or Flack (2017). This is also partly because they are not senior enough. Research at this caliber is what Enlightenment science is, and where science starts to have societal influence: some examples would be looking at E. T. Jaynes or E. O. Wilson, and the process would take perhaps a lifelong career and the posthumous influence which combined might take almost a century.

Lastly, we might need to clarify that despite all those difficulties, intrepid souls work in all kinds of ways, and would emerge against all odds, and none of the stereotypes described here apply.

4 Independent blue skies research and its Chinese particulars

We have finally described in a rather succinct style the big picture of blue skies science under Chinese context. Despite the importance to interpret the ecosystem, the point of this interpretation is to seek for meaningful actions. In this last section, we discuss structurally, if such science is to proceed, what constructive actions could be done, or put it more personally, individuals who are attracted to this type of science could do; this is actually the goal of this essay, and the sections up to now are to prepare the stage—to clarify, we are not going to discuss institutional actions, which is beyond the scope of this essay.

To begin with, we again clarify the type of science being discussed in this essay. The greatest scientists typically are those who struggle against ambiguous problems, and signals the first crack in a vast uncharted area; those problems are typically not intelligible by both other scientists and the general public before the solution has been worked out—the solution, when it has been cleaned up in a presentational form, is actually easier to understand than the problem initially. This is what is called the blue skies research, the research whose implications are not immediately clear, and is the seed science that starts basic and applied science. This kind of problem, which typically is not within an established discipline—it starts disciplines—requires polymaths: in Renaissance they are known as the Renaissance Men; in Age of Enlightenment, they are known as Natural Philosophers; in postmodernity, they perhaps are known as Transdisciplinary Mind.

Blue skies research is not the only important problems, and disciplinary research is still important: we need unified theory such as string theory to understand the fabric of universe—but its importance to guide human behaviors is largely gone since we have known that cosmology has little to say about biology in small timescale of millenniums (for a discussion why it occupies a paramount role during Enlightenment, see section 2.3 in Li (2021)); we need condensed matter physics to built superconductors, which has important applications such as building plasma containers for nuclear fusion; we need molecular biology to accumulate empirical data such that theoretical understanding could proceed, and new medical treatment could be developed; we need materials science such that we could have better batteries and permanent magnets, such that sustainable transitions could succeed; we need electronic science for emerging distributed biomimicry chips, information science for high throughput, low latency and responsive communicative links, and computer science to provide secure, containerized, orchestrated, and efficient services that manage the increasingly complex Internet and Internet of Things. It is those incremental advances that accumulate into qualitative breakthrough in science.

However, there is an intellectual wall standing in the way of humanity, which if not solved, civilizations would bound to decadence: we need an intellectual answer on why life makes sense, how mind works, and what leads to the rise and fall of civilizations. Those are the questions humanists are to answer if the world they envisioned since Renaissance, through Enlightenment, thrived in Secularization, and decayed in Postmodernity, is to endure, or more dramatically, contemporary civilizations are to avoid collapse in the coming centuries (and perhaps shorter timescales of decades). We shall not expand this further, and a detailed discussion is given in Li (2021).

This type of science is difficult in any ages, and we have described the structural force, both in the international science ecosystem, and the particularly difficult Chinese ecosystem, that one needs to content with if one wants to pursue such a research. It might be stated that such science is left for established scientists who have the leisure and resources, but this is a typical institutionalized thinking explained in section 2.1: none of the fundamental breakthrough had been made by old people, though the more structural impedance existed, the more likely the works were only published when they are old, or dead. In the following, we discuss the dynamics of such research.

4.1 The dynamics of blue skies research

The world could be changed by individuals not because this particular individual is immensely powerful, but because the world is already on the edge of a bifurcation point, and the structural force of change is leveraged by the individual to push for an end that he or she wants. This is the principle one need to follow to avoid a misdirected life for anyone who want to do blue skies research. On the conditions of the great qualities possessed by Renaissance Men, a humanistic turn at Renaissance was possible because the stability and commercial prosperity accumulated since 1000s in the Middle Age. And our contemporary times is in such a bifurcation point: we are still in great materialistic abundance, immerse possibilities of world-changing science discoveries and technology breakthroughs, but also in a polarized and disoriented world where previous social systems are disintegrating (not necessarily collapsing), both in China and in the Western nations. There are many spiral pathways that could be identified such that the macro direction of transdisciplinary science could be built through a series of intermediate technologies that nudges the social system to the desired state. We shall not discuss particulars in this essay, but only general methodologies, and a particular pathway resolving around Artificial Intelligence is discussed in Li (2021). Therefore, the beginning of blue skies research should start with identifying the a critical problem that is relevant to the bifurcation point, and has technological implication.

However, there is a preparation phase where a great amount of prerequisite training are undertaken prior to that point as well: one needs to learn the history and philosophy of science, understand the dynamics of blue skies research and the history and the development of the local science ecosystem, develop the skills of communication and understand the mentality various sub-communities of science, learn the fundamental concepts of relevant disciplinary science, the skeleton and the state of art of existing branches of science, and accumulate sufficient empirical experience on the emerging technologies. This could be done through all kinds of ways, and it might only make sense only after all those experiences are acquired, and typically this is done without mentoring because no mentors would could have done such a thing, otherwise, it would not be blue skies research. To quote Steve Jobs, “you can’t connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future. You have to trust in something—your gut, destiny, life, karma, whatever.”

But there are still regularities in this kind of life, which had been lived through by intellectuals in history again and again, and it would be stated as a triad of hermit period, monastery order and society engagement, in addition to the preparation phase described previously.

First, after the preparation phase is acquired, the typical ensuing action is a gestation phase where individuals concentrate a stretch of period to work in isolation, synthesize previous experiences, and work out a proof of concept. This action even has acquired a myth both in Chinese civilization and Christian and Greek civilization, where the wise men would live as a hermit sometimes. This kind of isolation is instrumental in working on ideas that are out of the (stalled) intellectual establishment of the times: during the *Great Plague* lasting from 1665 to 1666, Issac Newton’s private studies at his home in Woolsthorpe over the subsequent two years saw the development of his theories on calculus, optics, and the law of gravitation; James Joyce wrote *Ulysses* during the Great War (i.e., the World War One); and as well known Einstein worked out the special theory of relativity while working as a patent officer; before their breakthrough happened, they all had extensive, roughly 10 years of, training, and then worked in an isolated style. To give a more modern example, Ruineihart David worked almost as a hermit while working on the classic work of Neural Networks (the precursor to the major technology, Deep Neural Networks, underlying the current Artificial Intelligence) published in *Parallel distributed processing* (Anderson and Rosenfeld, 2000).

Then, after the gestation period is over, the ensuing action is to form a critical group where the proof of concept could be polished. This resembles the monastery order in the ancient times, where the intellectual feedback is given through communication, debates, and iterative rework of the original proof of concept. Jesus, Buddha, and Confucius all had their disciples, and it is those immediate disciples who collected and complied the messages propagated in the centuries to come. In early Renaissance, they were unpublished manuscripts circulated around the early thinkers. For science, there were invisible colleges, letter communication among scientists, and in contemporary times, academic communities who could understand the problems.

Lastly, after the work has been sufficiently polished, it would be widely disseminated and ultimately lead to societal transform, but we would not go that far here, and only consider the near impact in contemporary times where they are converted into technologies. The technology transformation could happen roughly within one to ten years (depending on the maturity of other branches of science and technologies and the efficient of markets) after the monastery-order period and became publically known. We do not need further example because this phenomenon is well known.

Therefore, blue skies research is to identify the supportive institutions in each stage, and leverage the support there to carry out the research—the institutions in the international science community discussed at the end of section 2.3 roughly maps the three stages here: independent fellowship and blue skies funds for the preparation stage and the gestation phase, university and independent think tanks for the monastery-order phase, and venture capital for the society-engagement phase.

4.2 The particulars of blue skies research under Chinese context

However, under the Chinese context discussed in this essay, none of those institutional support exists. And if we say that the Westerner scientists could play the easy mode of blue skies research, the Chinese scientists have to play the hard mode of Renaissance thinkers that is depicted in section 2.1—the task is literally to enlighten the population with science.

First, if one is lucky, in the sense that is discussed in section 3.3, one could get institutional support through the Western system; however, that requires a chain of luck starting perhaps since the undergraduate days, which in turn requires early conditioning coming from families such that one could seize the opportunities in the undergraduate experience. And in reality, the process is like a random walk, and in each segment of the chain, the chance of institutional support is exponentially diminished. Therefore, structurally and statistically, the researchers have to work first as an apprentice to accumulate knowledge and experience, and then as a series of contracted workers throughout the preparation stage—this nostalgically resembles experience of the Enlightenment thinkers, who need to move from university to university, court to court to seek patronage. And after the preparation phase is finished, it is rarely that a polished publication record could be maintained. This is first because this case is put in the lucky case previously, and second blue skies research and luxuriant publication record is incompatible individually: the slow dynamics of blue skies research has been discussed in section 2.1, and without the proof of concept being developed first, a luxuriant record is either a push in the direction disciplinary science, or the result of a social butterfly; doing the two things at the same time is impossible without institutional and community support early on, and would result in the institutionalized thinking that has been discussed in section 2.1.

Consequently, and the gestation phase that requires high concentration of energy and time is very hard to accommodate in the system, and being independent researcher might be the few structural options to have. This might sound unusual, strange, or scary in the age of institutionalized science, but after all those accumulated experience, this out-of-institution phase might not sound as strange or scary as it sounds.

Although the rest of the phases under Chinese context is still more difficult than the Western counterpart, the similarity is more than the difference, both because at this phase, the international science ecosystem and the Chinese science ecosystem are roughly one system, and in society engagement phase, nobody would reject a breakthrough technology. Thus, we would not spend space discussing them.

In summary, to do blue skies research under the Chinese context, one needs to sometimes be an independent researcher that is not dissimilar to the thinkers in early Renaissance discussed in section 2.1. That is why most Chinese researchers are applied or disciplinary researchers, and did not pose to win Nobel Prize in the past 40 years. The science ecosystem is still immature, and might still need another 20 years to mature, even if things go well. This essay is written to clarify the structural situation, to share the experience of the author to other individuals who originated from the Chinese system and are attracted to blue skies research, and perhaps also to explain to the wider international community this underappreciated difficulties of Chinese scientists, and lastly discuss contemporary transdisciplinary blue skies research in general.

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