GREEN INVOLUTION: Mediating Plant Times and Lifetimes in a Chinese Rice Genetics Laboratory

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"HURRY UP"

In May 2021, more than 100,000 mourners gathered outside a funeral parlor in Changsha, China, to pay their last respects to a rice scientist. Often called the "Father of Hybrid Rice" (*zajiao shuidao zhifu*), Yuan Longping played a leading role in China's socialist Green Revolution: the development of a hybrid rice-production system claimed to have "fed billions" (Wu 2021). Journalists noted with surprise the large number of young students and professionals among the mourners, suggesting that Yuan's death highlighted a moment of generational transition amid China's development from a "land of famine" (Lee 2011) to global prosperity. A university student explained, "The majority of my generation have never experienced hunger or suffered poverty. I read about his contributions in textbooks. After paying my deep respects [*chongjing*], I feel more closely related to him" (Wang 2021).

Inside a laboratory at Meizhou University, the death of Yuan Longping also drew attention to a generational transition taking place *within* the community of

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Chinese rice scientists. In 2019, we conducted more than six months of fieldwork at the Wet Rice Laboratory at Meizhou University.[1] Founded by Professor Huang Jianchi in the 1990s, the Wet Rice Lab studies the genetics of the rice plant using molecular biology techniques. Until recently, the lab was notable for its successful transfer of knowledge and authority across generations: indeed, among the seven professors now leading the Wet Rice Lab, two are former students of the lab. But the junior researchers we met—including master's students, PhD candidates, postdoctoral fellows, and assistant professors—worried that a different fate awaited their generation. For them, Yuan Longping's death not only represented the gift of food security that China inherited from the Green Revolution. It also highlighted how poorly their own struggles in the laboratory compared with the heroic achievements of past scientists.

"It is a competitive field." Yang Zihan, a postdoc in the Wet Rice Lab, carefully chopped pale white rice shoots with a very small razor. Originally from south China, Yang had come to Meizhou for his postdoctoral studies a few years earlier. He was alone in the laboratory this Saturday, dressed casually in a button-down shirt and green rubber gloves, happy to be working without the crowd of students that filled the lab on weekdays. That morning, Yang was preparing a sample to put in the spectrometer to characterize proteins in the rice shoots.

> I am worried that someone else is doing the same thing, so I have to hurry up. I have heard that there are more than 10,000 scientists studying rice in China. Last year, researchers from Huazhong Agricultural University published great papers in *Plant Journal* and *Nature Plants*. Compared to the progress at the same stage of previous students, such as Professors Liang and Song,[2] I am still very far behind. I can only worship [*mobai*] them.

The term *mobai* refers to acts of devotion, traditionally combined with bowing the body or head, that play a ritual role in Chinese religious practices involving ancestors or divinities. Although we should not take Yang's exaggerated language literally, his articulation reflects the hierarchical organization of the "ecology of Chinese academia," in which senior scholars are treated as "big bosses" who demand "loyalty, awe, or even fear from . . . affiliates, admirers, and others" (Tenzin 2017, 15). These days, young rice scientists idolized their superiors and antecedents not only in awe of their scientific accomplishments but also as a more intimate confession that they could not match them.

Looking back at the history of the laboratory, Yang noted a process of inflation. The paper on the gene NAL1 was accepted by *Nature Genetics*, a highly respected journal published by Springer Nature with an impact factor of 23 (a number that indicates a high number of citations to the journal). Ten years later, a paper on a similar gene (NAL5) was only published in *Plant Physiology*, with a much lower impact factor of 5.7. One student had recently completed an experiment, but someone from Wuhan had published on the same topic while he was writing the paper, so he was only able to publish his findings in a low-ranked journal. While competition was increasing in the field of rice science, the impact of published work seemed to be declining.

> These days the research all looks similar, and we just do the same thing with a different gene. If everything goes well," Yang continued, as he poured the chopped rice shoots into a glass vessel, "people can get something in one or two years and that is considered fast. If not, it may take three, five, or even ten years. One PhD student in our lab who studied the gene SUB1 only graduated last year, after working for eleven years in the lab.

"Rice research requires a long time cycle," a PhD student, Zhao Lianhua, later told us. Alongside work at the laboratory bench with spectrometers and thermal cyclers, every experiment also runs through the experimental field where rice plants are grown from seed to observe and characterize the function of genes. Because of the long growing time of the rice plant, "it takes half a year to observe the phenotypes for one generation. If you want to get good results, like a publication, you need at least four years." As increasing competition drove researchers like Yang and Zhao to hurry their experiments, they found themselves obstructed, delayed, and entangled in the tempos of rice growth. "Time is very important to us," Zhao concluded with resignation.

Yang put it clearly: "I have to hurry up."

THE ANTHROPOLOGY OF SCIENTIFIC TIME

Time is a valuable resource in the sciences. In her classic ethnography, Sharon Traweek (1988) showed how scientists in a high-energy physics laboratory negotiated the relationships between their scientific "lifetimes" and "beamtime"—the prized moments of access to laboratory devices. Sociologists of science have examined the complex "timework" required to coordinate career trajectories with machine schedules, experimental systems, and institutional obligations

Figure 1. A rice plant in the laboratory. Photo by Lyle Fearnley.

(Bruyninckx 2017). In particular, the distinctive tempos of the nonhuman objects of scientific research, ranging from the speed of an electron in a particle accelerator to the slow growth of "plant time" (cf. Besky and Padwe 2016), constrain the "temporal emergence" of scientific practice (Pickering 1995).

The importance of time also reflects the changing *times* experienced by a younger generation of rice scientists in China. A generation, in Karl Mannheim's (1952, 290) classic definition, is a group of persons with a "common location" in historical time and an awareness of that historical location. Studies of generational change in the sciences have examined how the "aging" of a discipline can lead to "diminishing returns" (Gusterson 2005), "generational tensions" (Kohler 1994), and questions about "succession" (Özden-Schilling 2021). In China, dramatic economic growth and rapid social change during the Reform-era have also produced stark generational divides, particularly around work, family, and perspectives on the future (Rofel 1999; Pun and Lu 2010; Bartlett 2020). During the Reform, socialist "mass science," which "emphasized the collective efforts of peasants, technicians, and scientists" (Schmalzer 2017, 101), was replaced by lengthy education pathways, high-tech laboratories, and audit regimes that measured the value of individual careers. Amid intense competition over limited academic positions and opportunities, young researchers like Yang now fear they will fall "far behind" if they don't "hurry up."

Concerns about increasing speed in scientific and academic institutions are proliferating in China and beyond. According to the sociologist Ruth Müller (2014, 15), "an increase in experienced tempo of work is characteristic of recent changes to academic research management worldwide." Filip Vostal (2015, 73) has suggested that the "central experiential modality" of scientific time today is "the acceleration of the pace of academic life." In a recent manifesto, the philosopher Isabelle Stengers (2018) decries the dominance of such "fast science" and proposes a range of measures for slowing down. The "idea of 'slowing down' the sciences," Stengers (2018, 74) writes, involves "challenging all those modes of appreciation and judgment through which [scientists] are supposed to take on board their duty 'not to waste their time.'" Alongside Stengers's critique, the term slow science has become a popular discussion point for those who advocate for liberating science from the constraints of funding institutions, industry influence, and audit regimes (Slow Science Academy 2010; Frith 2020; Berg and Seeber 2016).

Yet to envision "another science" that could work at a slower pace, Stengers and others rely on a universalizing account of dominant science that posits a single, linear process of acceleration affecting all disciplines, anywhere in the world. Anthropologists of time have complicated the use of such "singular" or "uniform" temporalities, arguing instead for ethnographic inquiry that elucidates how "social rhythms, conflict, mediation and heterochrony unpredictably emerge in relation" to "dominant representations of time" (Bear 2014, 6). Instead of uniform narratives of global acceleration, anthropological studies are uncovering multiple "time-maps" (Gell 1992) or "timescapes" (Hodges 2012; Bear 2016), including not only human but also nonhuman "pulses of growth" (Tsing 2015). Sociologists of science have begun to challenge the dominant account of acceleration to argue that "science is characterized by layers and levels of diverse temporalities, rather than one type of temporality" (Vostal, Benda, and Virtová 2019).

Laura Bear (2014, 6) suggests that anthropologists can turn the practices that "mediate divergent representation, techniques and rhythms of human and nonhuman time" into an ethnographic object. Such an ethnography examines what she calls the "labour in/of time" (Bear 2014; Bear 2016), that is, how "labour . . . reconcile[s] disparate social rhythms, multiple presentations of time and non-human time" (Bear 2014, 20). For example, in a study of fast fashion in Korea, Seo Young Park (2021, 11) shows that the critique of speed obscures the multiple temporalities at stake in fashion production, and she instead provides an ethnographic account of how workers "embody and stitch together" industrial speed with the lived experiences of multiple "paces, cycles, intensity, and temporal density" (Park 2021, 21). Working in parallel, sociologists of science have arrived at a similar conception by examining the "timework" devoted to the "synchronization" of multiple times and paces. Rather than associating science with either fast or slow speeds, these sociological accounts highlight how scientific success is achieved when diverse and sometimes divergent tempos are "effectively reconciled" (Bruyninckx 2017, 824) by the invisible work of technicians in the management of laboratories or the agility of lead scientists. "Synchronization," conclude Vostal and colleagues, "[is] a central skill of science" (Vostal, Benda, and Virtová 2019).

In this article, we offer an ethnographic account of how young rice scientists worked to mediate divergent tempos in their scientific practice at the Wet Rice Laboratory, ranging from the institutional structures of the scientific career to the nonhuman biological time of the rice plant. Rather than documenting the effective "synchronization" of these paces and temporal cycles, however, we follow their struggles as these rhythms fell increasingly out of sync. Despite working overtime, young rice scientists seemed less and less able to mediate the temporal divergences of their experiments and their careers. Drawing on a concept recently popularized in contemporary China, we describe this increasing difficulty of synchronization as *neijuan*, or "involution."

In 2020, students and young office workers began to blog about overwork, intensive stress, and competition over opportunities that they named *neijuan*, adopting a term that originally entered Chinese discourse as a translation from anthropological discussions of involution in agricultural development (Geertz 1963). On social media, users circulated images of a student studying with a laptop perched precariously on his bicycle's handlebars, and shared news about the death of a woman working overtime at a tech company. Comments described how these viral stories captured a sensibility of increasingly complex gymnastics of effort and futile competition that was widely shared among young students and professionals. The anthropologist Xiang Biao has described *neijuan*/involution as "the experience of being locked in a competition that one ultimately knows is meaningless" (cited in Liu 2021), a definition that the journalist Yi-Ling

Liu (2021) glosses as "acceleration without a destination, progress without a purpose, Sisyphus spinning the wheels of a perpetual-motion Peloton."

As a concept with a long history in anthropology, involution offers an important model for imagining alternatives to modernist models of speed, because it articulates a pattern, rather than a pace, of temporal change. For Clifford Geertz (1963, 81), involution describes "culture patterns which, after having reached what would seem to be a definitive form, nonetheless fail either to stabilize or transform themselves into a new pattern but rather continue to develop by becoming internally more complicated." Neither fast nor slow, *neijuan*/involution highlights how young rice researchers in China are struggling to mediate the increasingly asynchronous tempos of their scientific lives, as if riding on a kind of "perpetual-motion" yet stationary bicycle.

In the next sections, we explore how young scientists experienced conflicting temporal constraints—from the demand for increasing speed of outputs in the post-Mao individualized scientific career, to the slow pace of rice growth and the emerging biological limits of the rice plant. Drawing on ethnographic observations in the Wet Rice Lab, we then show how young scientists struggled to mediate or synchronize these divergent tempos, arguing that the concept of *neijuan*/involution describes a distinct pattern of temporal work that goes beyond linear accounts of fast or slow science.

LABORATORY TIMES: From Mass Science to Individual Career

The institutional organization of science in China, and the associated timemaps that structure rice research, changed dramatically between Yuan Longping's era and today's Wet Rice Lab. The irony of the "heroic individualist narratives" (Schmalzer 2017, 98) surrounding Yuan Longping is that the development of hybrid rice took place during China's Great Proletarian Cultural Revolution, a period where so-called mass science, rather than individual expert achievement, was promoted and recognized. During the Cultural Revolution, government leaders and politicians criticized professional scientists, punished them with imprisonment or forced labor, or sent them to the countryside to work on farms (Dikötter 2017; Jiang 2017). Fields such as genetics were labeled counterrevolutionary (Schneider 2003). As the historian Sigrid Schmalzer (2017, 101) points out, hybrid rice developed within "a research and extension system that downplayed the efforts of individual scientists and instead emphasized the collective labours of peasants, technicians, and scientists organized in a network of numerous, diverse institutions."

Although often attributed to Yuan Longping, the development of hybrid rice was directly built on the institutions and practices of mass science. First, hybrid rice relied on the mass collection of wild and cultivated rice varieties by peasant farmers enrolled as student-assistants, a search that took place across the country—including the discovery of the naturally male-sterile wild rice variety, by student-assistant Li Bihu in 1973. Second, the rapid distribution of hybrid rice technology took place through the mass extension system of provincial agricultural institutes and village communes, which rapidly spread the technology across China and distributed seeds to millions of farmers (Schmalzer 2016).

In the late 1970s, China's Reform and Opening Up policies completely overturned the system of "mass science" and brought professional science to the center of the Communist Party's legitimation efforts (Greenhalgh and Zhang 2020). The reforms placed highly educated, professionally trained scientific "experts" in charge of scientific funding, research institutes, and educational institutions (Andreas 2009). Elite universities established laboratories devoted primarily to research rather than teaching (Orleans 1980; Simon and Goldman 1989). Important changes to the scientific life accompanied these institutional reforms: much like the "individuation" of factory workers (Rofel 1999) and peasant farmers (Yan 2009) during the Reform era, new roles and audit mechanisms tied scientific work to the measurement of individual research outputs. From education and training, to funding for research, and employment or promotion, Reform-era policy reformatted collective scientific work into individual scientific careers.

In the four decades since the beginning of the Reform era, the competition over scientific careers has increased dramatically. Forty years ago, the entire country had only eighteen PhD students. In 2018, 95,502 new students enrolled in PhD programs, bringing the total number of doctoral students to almost 400,000. As a result, students feel tremendous pressure: as a cell biologist interviewed by the scientific journal *Nature* explained, "Graduate students from most institutions are required to have at least one first-authored paper with certain levels of impact factor to get their PhD degree. . . . Therefore, everyone has to be productive, which is impossible" (Woolston and O'Meara 2019, 712).

Competition proves equally intense for junior researchers such as postdocs or assistant professors. Although we do not have precise numbers for the specific field of rice research, Yang Zihan told us that there were more than 10,000 scientists studying rice in China. In the Wet Rice Lab itself, the laboratory employs seven professors and around thirty junior researchers, including postdocs, doctoral candidates, and master's students. Recently, the laboratory increased recruitment of graduate students and other junior researchers in response to the university's efforts to be accredited as a "Double First Class University" by the national government. Since 2017, the number of faculty has doubled and the number of graduate students now exceeds undergraduates in the department. We asked Professor Song Heping, a former student of Professor Huang who successfully built a career for himself as a senior scientist in the lab, about how these new policies would impact generational transition within the laboratory. He acknowledged that career advancement would prove more difficult for the coming generation. "There are a lot of teachers I do not even know," he told us. "Overrecruitment will be a problem in ten or twenty years when they compete for positions and tenure."

In China, academic competition is increasingly structured and intensified by time. Most positions are based on specific durations in which certain levels of research production must be achieved. Graduate scholarships are limited to a specific number of years (typically two or three) during which students must not only complete a dissertation but also publish in a peer-reviewed journal. For faculty, Chinese universities began introducing U.S.-style tenure-track promotion systems in the 1990s. They demand the review of research outputs after three to five years and include an "up or out" policy of promotion or dismissal (Wang and Wang 2024).

China's historical shift from mass science to an increasingly individualized and competitive scientific career has put junior researchers under pressure to "hurry up" their research. At the same time, this experienced demand for speed troubled these scientists because it conflicted with another tempo: what they described as the "long time cycle" of experiments with rice plants. In the next section, we unpack why rice research came to be so "slow."

SLOWING SCIENCE: From Revolution to Improvement

We sat in Professor Huang's office, just across the hall from the laboratory benches, looking over a memorial book that described a pioneering campaign to collect wild rice varieties conducted by his own graduate supervisor in the late 1970s. Professor Huang told us that the tempo of rice research had changed. Rice researchers in China no longer aspired to achieve scientific and agricultural "revolutions," he explained interspersing the English keyword in his speech, like those that followed from the development of hybrid rice (China's

Green Revolution). Instead, scientific inquiry into rice genetics now sought a much slower pace of "improvements":

> Look at our past, the establishment of [the People's Republic of] China is a *revolution*, right? Now today we want to progress [*jinbu*]; how do we want to do it? We want to reform [*gaige*], *reform*. So now we can't do a *revolution*, *revolution* causes society to fall into chaos. In short, we can't overthrow the political authority, right? Today studying sociology, it's the same [as studying rice]: societies change, having reached today's situation, you cannot *revolution*. You can only *reform*, or *improve*, slow, slow slow, slow change, slow, slow advance [*gaijin*], that's what it means. But also today our improvement [*gailiang*] of [rice] varieties, you also cannot say *revolution*, you can only say . . . slow, slow, slow, slow *improvement*. It's like this.[3]

Whereas China achieved a political revolution in the establishment of the People's Republic in 1949, the so-called Reform era (from 1978 onward) sought to achieve progressive change more gradually. Adopting this language metaphorically to describe two generations of rice research, Professor Huang acknowledged continuity in the effort to achieve advances in productivity, but highlighted the different tempo of change.

As we followed researchers in their experiments at the lab bench and in the field, we found this slowing pace of rice research to be the combined effect of two constraints. First, researchers believed there were diminishing opportunities available to improve yields due to constraints in the biology of the rice plant. And yet, second, government-imposed constraints on research—or what the critical agrarian scholar Rajeswari S. Raina (2015) has called "institutional rigidities" that reproduce modernist models of high-technology agriculture—kept rice researchers focused on improving yields. Trapped between the demand for improvement and its diminishing possibility, rice research came to feel slow.

Yang Zihan told us that the potential to get a "good" publication depended on the capacity of the rice "materials" (*cailiao*) that the laboratory provides a researcher to work with, and "whether everything that can be done has already been done." Scientists in the Wet Rice Lab mean something very specific by the term *cailiao*. They use it to describe rice plants or seeds as the embodiment of a single genetic line. Seeds and plants are different moments in a plant's life, but they represent the same genetic line, so a seed and a plant can be the same "material." Scientists also spoke of the two plants that are crossed in a hybridization experiment as representing *different* materials. Initially, we had mistakenly equated the entities the scientists call *cailiao* with "varieties" (*pinzhong*), but a professor explained to us that the term *varieties* refers only to stabilized, commercial lines used by farmers. Materials, by contrast, refer to the seed/plant hereditary lines that remain within the laboratory's experimental system.

The collection of materials is one of the Wet Rice Laboratory's key resources. As a graduate student, Professor Huang took over the collection of wild rice varieties assembled by his graduate supervisor and used novel molecular biology techniques to identify key genes that differentiate domestic from wild rice. Moved between laboratory storage (as seeds) and the experimental field where they are planted, the collection of wild and domestic rice materials constitute the pivotal resources that allow researchers to identify and characterize the functional genes of the rice plant. But why would Yang see this collection of materials as a potential limitation, rather than a resource, for producing "good" publications?

When Professor Song gave us a tour of the experimental fields, we began to understand what Yang meant. Song walked ahead of us and pointed to a patch of rice plants that towered three or four times taller than any others. He told us that the Wet Rice Lab was experimenting with a new approach to increase plant productivity by looking for genes that will increase the strength of the stalk so that plants can grow taller. The high-yielding varieties of the Green Revolution, including Yuan Longping's hybrid rice, were bred to be very short, or "semi-dwarf," varieties. Semi-dwarfism proved key to increasing productivity because it enabled larger panicles of grain without causing the rice plant to fall over. Unfortunately, Professor Song explained, rice researchers had recently hit a roadblock—since there are biological constraints on the ratio of grain to the overall biomass of the plant, the small size of semi-dwarf varieties ultimately posed a limit on further increases in productivity. To increase yield, researchers now believed they needed to increase the biomass of the plant, and that meant abandoning semi-dwarfs and growing tall rice. Yet even as he told this story to us, Song remained skeptical about this research's potential. "Yuan Longping was recently photographed under the shade of a tall rice plant," he told us, laughing.[4] "It's not difficult to make rice grow tall. After all, wild rice is naturally a tall grass. But to make it actually yield more grain" proves much more of a challenge.

Although a sensibility that "the now-familiar tools of the Green Revolution are facing diminishing returns" (Mann 1999) is common in the agricultural sciences today, this concern about scientific practice must be situated within a rigidified agricultural imaginary focused on yield improvement. Critical studies of agricultural science and development have pointed to a tendency for "lock-in" or path dependency in the post–Green Revolution approach to increasing agricultural productivity (see Cowan and Gunby 1996; Stone and Flachs 2017; Puig de la Bellasca 2016). Raina (2015, 7) describes "institutional rigidities" and even "institutional strangleholds" in many developing countries like India or China, in which government and private-sector funds for research remain "euphoric about the technological successes of the green revolution" and unwilling to support alternative research approaches. In China, agricultural science remains framed in the context of its utility for national economic development, continuing "an extensive agricultural history and concerns about feeding an ever-growing population" (Chen 2010, 96).

At the Wet Rice Lab, researchers constantly encountered institutional demands to frame their research in terms of its contributions to agricultural improvement. Any presentation about findings related to a specific rice gene would inevitably be discussed in relation to how this gene (if included in new rice varieties) could increase grain productivity and improve food security. As Yang Zihan told us, "I think the ultimate objective is to benefit the people, [so] we must work in the direction of production." According to Professor Song, even researchers who previously studied model plants such as Arabidopsis "recently . . . redirected to the study of crops [such as rice or maize] because less funding goes to the model plants" that have no immediate agricultural application.

In the next section, we focus on how young scientists at the Wet Rice Lab attempted to "mediate" the fast pace of their scientific careers with the slow time cycle of rice research, examining the techniques that they employed to synchronize divergent tempos in their experiments.

THE LIMITS OF SYNCHRONICITY

Professor Huang acknowledged that rice research was decelerating, but believed that the Wet Rice Lab was still making progress and improving yields—if perhaps only "slow, slow, slow, slow improvement." When we spoke with young researchers such as Yang Zihan, however, they expressed a very different sensibility about the pace of experiments, reflecting a generational concern that it was increasingly difficult to fit experimental "timework" within the timespans of their scientific careers.

Building on Sharon Traweek's (1988) pioneering study of the complex management of "beamtime" and "lifetime" in particle physics experiments, Joeri

Bruyninckx (2017, 825) highlights the “timework” needed to manage “scientific time [that] unfolds across multiple registers at different speeds, intervals, or range that may affect each other.” Bruyninckx (2017) argues that the success of experimental science relies on the (often invisible) work behind the effective reconciliation or “synchronization” of organizational schedules, institutional plans, biographical careers, and the temporalities of research instruments. Steven Jackson and colleagues (2011) add that the multiplicity of temporal frames in scientific practice also includes nonhuman “phenomenal time,” putting the “temporal alignment” of human and nonhuman time at the center of scientific practice.

For scientists at the Wet Rice Lab, the tempo of the rice plant posed the most significant constraint on experimental schedules. Plant growth is one-way and irreversible, and each plant follows the same stages from seed to plant to seed. Moreover, each rice variety or material has a roughly fixed duration of maturation, though these differ among varieties—105–120 days for quick-ripening varieties and up to 180 days for others. Rice plants imply a linear timeline that orients specific material interactions between scientists and rice plants at specific timings. It is not simply that plants are “slow” (Myers 2015; Besky and Padwe 2016), but more accurately that rice plants—indeed, each different rice material—follow their own tempos (Hathaway 2022; Hartigan 2017; Kirksey and Helmreich 2010; Gan 2017b). Indeed, Green Revolution programs that aimed to master rice time through “simplifying logics” struggled to manage an unanticipated “interplay of differential yet coexisting speeds” (Gan 2017a, 77).

At the Wet Rice Lab, scientists strategized how to synchronize the nonhuman tempo of the rice plant with human biographical and social time. For example, scientists grew sprouts under grow lights, enabling them to explore phenotypes in the lab rather than the field, and allowing these grow-out experiments to run at any time of year, independent of seasonal calendars. Researchers also used freezing techniques to slow or stall growth. These classic laboratory mechanisms detach the rice plant from its natural context and, in doing so, also aim to reposition the plant within the social time of the experiment and the career (Knorr-Cetina 1992; Latour 1999).

On a larger time-scale, the annual experimental calendar of the laboratory is closely coordinated with the stages of rice growth. Research activities are patterned on seasonal changes: experiments must factor in the timing of seed-planting; the transplantation of seedlings into the main field; flowering and pollination; and death, each of which occurs at particular times of year from spring to autumn. Although resembling the time-maps of traditional agricultural

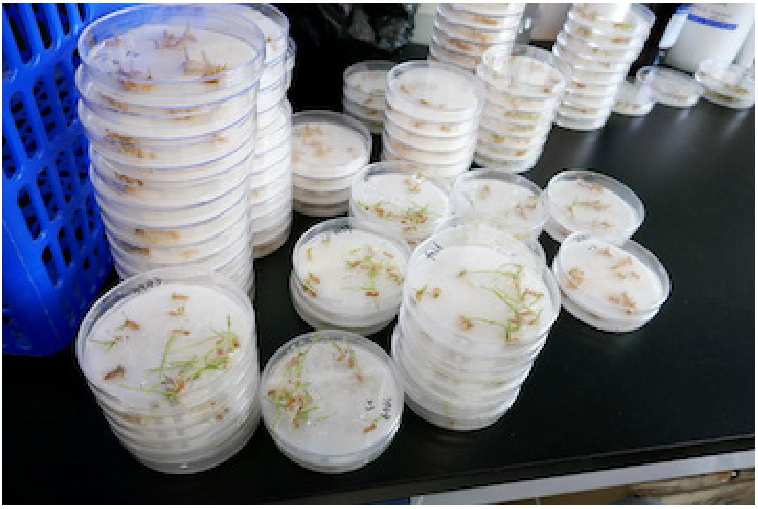

Figure 2. Rice seeds grow in Petri dishes. Photo by Lyle Fearnley

calendars associated with rice societies (Lansing 2007), the Wet Rice Lab introduces a number of mechanisms to mediate or synchronize the growth cycle of the rice plant with experimental schedules. One strategy for adapting rice time to laboratory time is the use of a second experimental research station on Hainan Island, the tropical island south of Guangdong Province. On Hainan, where rice can be grown year-round, the Wet Rice Lab plants at least one experimental crop each winter so that experimental work can continue while the fields around Meizhou University lie fallow.

The flowering stage, during which researchers conduct hybridization experiments, probably constitutes the most significant temporal event on the laboratory calendar. Hybridization experiments involve controlling the sexual reproduction of the rice plant through the manual pollination of two distinct rice materials. Hybridization marks the critical moment when laboratory theories and laboratory objects (such as genetic clones) are brought into the field, so that the phenotypic effects of specific genes can be assessed. Hybridization is also extremely time-sensitive. Rice plants flower for only a few days, meaning the manual labor involved in the hybridization experiments must be done very quickly. Work must be completed before eleven in the morning, when the increasing temperature of midday triggers the plant to release pollen. Finally, because different rice materials (or varieties) have different growth periods (maturing anywhere from 105 to 180 days), they reach the flowering stage at different times. Therefore, researchers typically grow two or three separate batches of rice, separating the planting of different varieties by a week or two. This staggered planting enables researchers to produce a hybridization encounter between different rice materials with different temporalities of flowering.

The difficulty of coordinating rice growth with experimental schedules means that the career of a rice researcher is timed alongside the life cycles of the rice plant. Going beyond the "timework" on the laboratory floor, doctoral students, postdocs, and young professors also engage in a more expansive effort to mediate the divergent time-maps of China's scientific institutions with the tempos and rhythms of the rice plant. As we watched students transplanting seedlings from the sowing bed to the main experimental field, Xu Yongren, a doctoral candidate, highlighted the uncertain tempo of working with nonhuman organisms: "Finding a gene, knowing, and examining its functions is like fishing in the sea. At the early stage, you need to map out the gene and find out the QTLs,[5] which takes two to three years on average. If you have bad luck, the process will take three to four years." Although uncertainty and failure are common in any science, the slow tempos of the rice life cycle means that each failure sets researchers back by a season or even a year. Researchers instinctively calculated their bad luck, uncertainties, mistakes, and worries in rice time. When one student caught a fever during the hybridization, another from her cohort encouraged her to still go to the field: "If you are sick, you can recover soon, but if you miss the hybridization, you need to wait for another year."

As a result, young lab researchers think about the prospects of their own lives in the rhythms of rice time. Anthropologists have recently brought new conceptual tools to examine the mediation of organizational, bureaucratic, and biographical times in labors of repair and recovery. Rather than assuming large-scale "temporal fixes" to the imbalances of modern time, Laura Bear (2014, 85) shows how concrete temporal practices—for her not timework but "labour in/of time"—make possible the reconciliation of divergent tempos and provide a "temporary fix" for the contradictions of global modernity. In her study of shipping pilots on the Hooghly River, for example, she shows that bureaucratic extraction of investment in the upkeep of river infrastructure, driven by temporalities of debt, increases the uncertainty surrounding piloting ships and the likelihood of accidents. Yet through an ethics of "workmanship," river pilots mediate temporalities of historical decline and environmental change: "their labour . . . orchestrate[s] and reconcile[s] incommensurable rhythms" (Bear 2014, 81).

As students transplanted their seedlings into the soil, a recently hired assistant professor named Xie Weihua made clear to us how precarious the coordination of career with the tempos of the rice plant is becoming. As a new member of the lab, he was planting his own rice materials for the first time to begin his research program. However, he missed the sowing season for the first batch, and his second batch did not grow well because of overwhelming weeds. Discussing with the doctoral students, he explained that he needed to publish a "big paper" soon. "At least five years," doctoral student Xu Yongren pointed out to him. "Small papers take about two to three years, but they are meaningless for your level." Xie replied, "My seedlings did not grow well. I can start my research in November next year, after [I grow] one generation in Hainan this year and another generation in Meizhou next year." We were talking in June 2019, and Xie had already estimated a full year of rice growth (two planting cycles) as preparation required to *initiate* the laboratory component of his research study in November 2020. In his plans, he integrated his career objectives with the life cycles of two generations of rice plants.

The problem of time is exacerbated by factors such as age, aging, and gender (cf. Özden-Schilling 2021; Fox-Keller 1984). Xie, the new faculty in the lab, explained that in China scholars are anchored to a linear path because research funds and national prizes have an age limit for application: forty-five is the age limit for Outstanding Youth Funding, one of the most prestigious grants for scientists in China; while fifty-five is the limit to apply for the Creative Team prize. Rice researchers are caught between the growth time of plants and human age-based time limits to receive research funding and awards.

For women, the negotiation of careers proves particularly challenging. Many senior scientists in the lab (all men) believed that women had unique gendered life obligations—such as family and childbearing—that occupied time needed to build a career. Lab scientists have rejected qualified female candidates because, after making calculations for this "lost time," certain metrics of achievement seemed impossible to reach in time. When the department recruited new faculty in 2019, the committee rejected the application of a thirty-four-year-old woman because, as one senior faculty member explained to us, "she is a bit too old. As her background does not match that of our lab, she will need a long time to catch up and it would be hard to apply for funding in the first five years."

The lead professors in the lab also worried about romance among their students. "In our time," Professor Song explained, "students fell in love, but it was more indirect, hidden; but now it is very direct and in the open." To him, it is a big problem if people are dating within the lab—the couple are always together, even doing field experiments together, and they don't get their work done on time. Professor Song told us he has even started asking his female master's students if they have a boyfriend before starting research. If they don't, he discourages them from doing doctoral work. China's contemporary society still looks favorably on older single men, he opined, and they still have a chance to get married. But for women, he believed, their best chance is to find someone when they are an undergraduate. By the time they finish a doctoral degree, Professor Song declared, "it will be too late."

In our fieldwork at the lab, we observed a range of techniques—from the winter migration of the lab to Hainan, to the staggered planting of rice seedlings, to the freezing of plant samples, to the coordination of romance—that aimed to synchronize the tempos of the rice plants with experimental times and lifetimes. But unlike the successful "synchronization" (Bruyninckx 2017) or "reconciliation" (Bear 2014) of divergent tempos observed by sociologists of science and anthropologists of time, we saw that the labor of time was becoming more intricate and convoluted, while the outcome was becoming more uncertain, insignificant, and precarious. "The science we are doing now," Xie lamented, "has become really small and mechanical, and the time pressure to publish and get a position and funding does not allow us to do long-term or slow science . . . . Some of my peers are already excellent, and it is hard to catch up. I try to get some research out in the next few years. If not, I just accept that."

In the laboratory and in the field, social and nonhuman rhythms, careers, and experiments had fallen out of sync. As we observed young researchers at the Wet Rice Lab, we came to see the limitations of critiques of so-called fast science: after all, young researchers did not want to slow down or speed up per se; rather, they wish to mediate and align the divergent tempos they confronted. As this synchronization became more difficult, though, the diminishing returns on their efforts became more and more evident, suggesting a spiraling dynamic that young professionals in China have recently described as *neijuan* (involution).

NEIJUAN **INVOLUTION: Virtuosity within Monotony**

We tend to think about time in the sciences, as Hugh Gusterson (2005) noted, in progressive tempos: the construction of facts, "bursts of creativity," and the advancing rhythms of "scientific evolution and revolution." Yet the experience of young researchers in the Wet Rice Lab seems to reflect another trajectory of scientific time: "the withering, decay or arteriosclerosis of fields of knowledge" that Gusterson (2005, 75) has called "scientific involution." Writing about generational change among nuclear weapons scientists in the United

States, he argued that the scientific revolutions of the pioneer Manhattan Project later gave way to a "pedagogy of diminishing returns" (Gusterson 2005, 76). As atomic scientists retreated to digital simulations after the prohibition of nuclear testing, advances in nuclear weapons design became "incremental" and scientific practice became "increasingly repetitious" (Gusterson 2005, 99). Like Gusterson's nuclear scientists, students and young researchers like Yang Zihan or Xie Weihua described working on ever smaller problems under increasing time pressure, suggesting that rice science in China had "simultaneously matured and withered" (Gusterson 2005, 75).

Yet the drivers of involution in the Wet Rice Lab also derived from institutional changes in China's Reform-era society outside the laboratory, such as the individualization of work that pulled apart the temporalities of scientific careers and wet-rice experiments. In this respect, the involutionary experience of young Wet Rice Lab scientists resembled the experiences of other members of China's 1990s generation (*90hou*, or "born after 1990"), for whom the term *neijuan* has become a key buzzword on social media (Wang and Wang 2021). Young people identified *neijuan* with overwork in the high-tech industry, where managers required workers to perform increasingly laborious tasks, introduced invasive surveillance mechanisms, or set workers in competition against one another (Xu 2022). In the ballooning education industry, young people struggled to outcompete others through additional self-study or tuition programs (Chen and Hong 2024). Others observed a form of "academic involution" (*xueshu neijuan*) among graduate students, characterized by "publication for publication's sake" and stagnant innovation (Wang and Hu 2023). As Wang Qianni and Ge Shifan (2020) explain, "the Chinese word, *neijuan*, is made up of the characters for 'inside' and 'rolling' and is more intuitively understood as something that spirals in on itself, a process that traps participants who know they won't benefit from it." Involution in contemporary China is an "endless, energy-draining loop of competition."

The term *neijuan* was first introduced into China's academic and public discourse through the translation of Phillip C. C. Huang's works on China's agrarian economy (Ling 2006). Huang (1985; 1990) drew on Clifford Geertz's (1963) famous model of "agricultural involution" to explain why China failed to achieve the rapid development associated with Western modernization. Due to population growth, Huang argued, China's farm output expanded per unit of land but declined per unit of labor—a process of "diminishing marginal returns" or "growth without development" that he called involution. Translations published by Zhonghua Books in 2000 introduced the term *neijuan* for "involution" and stimulated wide-ranging discussion around the agrarian constraints on China's modernization (Ling 2006). Today's viral discourse on *neijuan* adopts Huang's pessimistic diagnosis of China's economy but ironically transposes the sense of involuted growth from pre-modern agrarian settings to highly modern offices and classrooms. Rather than an explanation for the failure to achieve modernization or development, young Chinese today articulate a feeling of "despair" (Yu and Yong 2023) about the diminishing returns that have followed in the aftermath of rapid growth.

By shifting how involution is located in time against the trajectory of development, the emerging discourse of *neijuan* draws attention to the temporal features of the original anthropological concept. Geertz's account of "agricultural involution" in Indonesian rice farms does not describe Indonesian rural society in itself as involutionary. Rather, he argues that involution follows from a historically specific interaction—a "mal-integration" as he puts it (Geertz 1963, 48n2)—between the cultural ecology of wet-rice farming and the colonial extractivism of the Dutch sugar industry. Geertz described involution as the progressively complicated technical practices, labor-sharing schemes, and land-tenure arrangements adopted by Javanese farmers to *mediate* between the "dual economy" (Geertz 1963, 48) of colonial sugar and subsistence rice, grown with the same land and labor yet operating in completely different temporal and spatial frames: fast-changing global capital markets against slowly expanding rice ecologies. Because Dutch colonialism led to a "steadily widening disparity" between these two economic tempos, or what he called "runaway dualism" (Geertz 1963, 62), Javanese farmers were forced to increase the complexity of their labor and land-sharing arrangements to maintain subsistence under increasingly fraught conditions—leading to "progressive complication, a variety within uniformity, virtuosity within monotony" (Geertz 1963, 81, quoting Goldenweiser 1936).

Adopting the concept from a short essay by the Boasian anthropologist Alexander Goldenweiser, Geertz (1963, 82) stressed that involution was an "analytic concept" that described a "form" or "pattern." Building on the idea of "culture patterns" popular among Boasian anthropologists (e.g., Benedict 1934), Goldenweiser had explored how a "process of development" takes place within the "frame" set by patterns. His examples of involution included Maori decorative art and Johann Sebastian Bach's fugues, where "the complex design is brought about through a multiplicity of spatial arrangements of one and the same unit," a kind of "pattern plus continued development" (Goldenweiser 1936, 102).

In contrast with dominant theories of modern social time, the concept of involution described the pattern or form of temporal change, rather than its pace or direction.

This concept of involution as *pattern* helps clarify that what troubles young researchers in the Wet Rice Lab is not the increasing speed of the academic career or the slowdown of rice-based experimental systems. Rather, they worry about how to "mediate" and "synchronize" across multiple temporal frames ranging from the time-maps of scientific institutions to the biological growth of the rice plant. Coordination and timing, not simply speeding up or slowing down, are required for the synchronization of diverse and sometimes conflictive tempos. Due to increasing disparities across these tempos—as career demands feel faster and rice research feels slower—the labor of mediating time is complicating research plans, diminishing marginal returns, and producing a sense of despair.

Back inside the lab, we watched Yang Zihan as he chopped rice shoots. Yang worried about whether he could garner a significant publication during his postdoc, particularly given the competition from an expanding cohort of young rice scientists across China. In his own work, he told us, he sought to distinguish himself from his cohort by shifting his research from traditional gene hunting to the characterization of gene *expression*. "These days, the research all looks similar, and we just do the same thing with a different gene," Yang reflected. "So this is why I focus on the mechanism."

Shifting his research from gene identification to gene characterization held out the potential that Yang could achieve a significant, innovative finding that differentiated him from the competition. And yet, we realized that doing so also brought him into more intricate temporal entanglement with the rhythms of rice growth. To study the mechanism of gene expression, Yang's experimental practice involved extracting and analyzing protein RNA from a variety of plant parts (shoots, leaves, panicles, etc.). But protein RNA, unlike genome DNA, only appears at specific moments in plant growth, rendering synchronization between experiment and plant time more difficult. While the genome is a static code that does not change throughout an individual plant's life, the *expression* of these genes into proteins occurs at different moments in time as the plant grows from seed, to sprout, to flower, and to death. Therefore, Yang must take samples repeatedly from roots, leaves, or flowers to extract RNA at every important stage of growth.

Protein RNA also degrades more quickly than DNA, meaning that Yang needed to work faster in each experimental procedure. Yang cut samples from shoots, tillers, chaff, flower, or other plant parts, then froze them on tin-foil boats that floated on a liquid nitrogen bath inside a Styrofoam box. Back in the lab, he would transfer these samples to the freezer, or else immediately unwrap them, continuously pouring liquid nitrogen as he crushed the sample on a mortar before submerging them in a prepared chemical solution. Studies of "cryopolitics" have pointed out that techniques of freezing aim to defer death: "temperature work[s] as a temporal prothesis" to "create a form of life without death" (Kowal and Radin 2015). But temperature can also freeze a *moment* of life (e.g., a rice plant's development of green chaff) and extract it from the temporal process of growth. Yang could then, to the best extent possible, coordinate the life cycle of the rice plants with the rhythms of his experimental study and the duration of his postdoctoral position.

As his shift in research objectives toward genetic mechanism made timing more important, the laboratory choreography that aimed to synchronize rice time, lab time, and career time became more intricate. Science, for Yang, was neither too fast nor too slow. Rather, his effort to achieve "virtuosity within monotony" (cf. Geertz 1963; Goldenweiser 1936) merely intensified a process of *neijuan*/involution that followed from the desynchronization of rice time and his own lifetime.

CONCLUSION: Beyond Slow Science

When young scientists at the Wet Rice Lab speak about the need to "hurry up" or worry that rice research is "too slow," the critique of fast science seems ready to hand as an explanatory and moral frame. In the "Slow Science Manifesto," a group of Berlin-based scientists write that "science needs time." "Science," they write, "creeps about on a very slow time scale, for which there must be room and to which justice must be done" (Slow Science Academy 2010, 1). The philosopher Isabelle Stengers (2018) compares slow science to the more well-known slow food movement, arguing that slowing down enables scientists to consider public matters of concern alongside the production of facts, reconnecting scientific producers with the broader public.

Yet this critique of speed tends to ignore the specific, multiple, and divergent time-maps mediated in the everyday practice of science, and it therefore obscures "the attempts by people to bring incommensurable rhythms and representations into synchronicity" (Bear 2014, 18). Staggering the planting of rice materials, freezing and thawing samples of rice plants, working overtime in the laboratory or in the field, young scientists in the Wet Rice Lab design increasingly complex experiments to make plants, experiments, and careers align in time. But whereas sociologists of science heroize the work of repair that mediates divergent tempos, these young scientists struggled as lifetimes and rice time diverged. Instead of "effective reconciliation" or successful "synchronization," the mediation of divergent tempos led to increasingly complicated, repetitious, and intensive forms of work. Neither fast nor slow, the labor of the young scientists in the Wet Rice Lab is better described by the imaginary of *neijuan*: pedaling faster and faster but stuck in place, as if riding a "perpetual-motion Peloton" (Liu 2021).

As an analytic concept, *neijuan*/involution points to a pattern, rather than pace, of temporal change. In doing so, it allows us to think critically about the sciences beyond the critique of speed. Stengers (2018, 68), in the end, clarifies that "'slowing down' the sciences is not itself the answer"; for her, it is a necessary first step toward identifying underlying problems such as the "capture" of scientific practice by "technical-industrial innovation" (Stengers 2018, 74). At the Wet Rice Lab, though, the individualization of the scientific career and production-focused agricultural policy pushes young scientists in *divergent* temporal directions, not along a linear path of acceleration. For them, the legacy of the Green Revolution is not only the heroic discovery of hybrid rice, but also a persistent "stranglehold" (Raina 2020) on their own research, as agricultural science policy drives them to seek new ways of increasing rice productivity at the very biological limits of the rice plant. Facing "diminishing returns" despite virtuosic experimental labor, the imaginary of linear advance associated with the Green Revolution is now left in tangled spirals: green involution.

Although aspects of *neijuan*/involution may be specific to contemporary Chinese science, a concern with the patterns of temporal mediation is also apparent in other scientific settings. In the field of protein modeling, Natasha Myers (2015, 128) describes how "faster computers and better equipment helped to speed things up," enabling an "exponential" growth in contributions. Yet speed itself was not the critical problem, she later notes; rather, the move from a physical to a virtual medium transformed the relationship between models and proteins, creating new challenges for "adjudicating truth claims." In a very different context, Tom Özden-Schilling (2023, 13) points out that the slow growth of temperate forests requires forestry scientists "willing to cultivate deep, long-term attachments to the locations of their work." Once again, it is not the pace of forest growth that is the problem on its own. Rather, forestry scientists struggle to maintain continuity and "succession" (Özden-Schilling 2021) of research experiments across shifting political demands, budget cutbacks, tenuous alliances with Indigenous communities, changing research technologies, and their own biological lifetimes.

The critical interrogation of scientific labor requires more than a blanket call for science and scientists to slow down. Instead, anthropologists can contribute to remediating the labors of scientific time by revealing multiple and site-specific time-maps, understanding their unique historical and cultural patterns, and explaining the causes and consequences of their divergence. The temporal challenges involved in the allocation of beamtimes, a scarce machinic resource in particle physics (Traweek 1988), differ from the challenges faced by rice researchers who time the growth of rice plants to match the growth of their careers. And both differ, in turn, from the struggles of anthropologists to redefine the classical form of long-term fieldwork to be more responsive to contemporary events and audit cultures (Strathern 2000; Fischer 2003; Rabinow et al. 2008). It is not so much that we need manifestos for "slow" science against a universal increase in pace. Instead, anthropological inquiry can untangle the conflicting temporal demands inside and outside the laboratory that are pulling the sciences—and *scientists*—out of sync.

ABSTRACT

The Mao-era development of hybrid rice—known as China's Green Revolution—is one of China's best-known scientific achievements. For young rice scientists in contemporary China, however, this heroic past contrasts sharply with their struggles to keep pace in increasingly competitive scientific professions. Engaging with the anthropology of time, we argue against treating their experience as an inevitable response to the global acceleration of academic work. Instead, young rice scientists struggle to synchronize the divergent tempos of the contemporary scientific career with experiments set to the rhythms of the rice plant. Drawing on a current Chinese buzzword, we argue that young scientists are experiencing neijuan *(involution), a pattern of growing intensity and complexity of work that yields diminishing returns. Philosophers have issued manifestos for "slow science," but anthropological inquiry illuminates the locally specific patterns of temporal mediation that are pulling scientists out of sync.* [laboratory ethnography; anthropology of science; China; multispecies; slow science; anthropology of time; involution]

NOTES

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Özden-Schilling, and from suggestions by the editorial collective of *Cultural Anthropology* and three anonymous reviewers.

1. We conducted fieldwork over a year-long period, either singly or together, to capture key moments in the laboratory schedule and rice life cycle. The research was reviewed by SUTD's Institutional Review Board for Social, Behavioral and Educational Research. Meizhou University is a pseudonym, as are the names of all Wet Rice Lab researchers.
2. Professors Liang Yonglin and Song Heping are the two former students in the Wet Rice Lab who are now lead professors
3. All English words italicized here indicate times Professor Huang used English vocabulary in his speech.
4. This was several years before Yuan Longping's death.
5. A quantitative trait locus (or QTL) is a region of DNA that is associated in a statistical rather than discrete manner with a specific trait.

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