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An unassuming genius

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Abstract An ability to think independently, instead of being swayed by scientific trends, was key to the genius of Yoichiro Nambu. So was his sheer delight in exploring the mysteries of nature.

From an early age, Yoichiro Nambu learned to think for himself—a quality that was, I believe, integral to his genius.

Born in Tokyo, Japan, in 1921, he was 2 years old when the city burnt down after an earthquake. The family had to return to Fukui, his father's hometown, where Nambu spent his childhood. At the time, Japan had a highly militaristic culture and Fukui had an especially militaristic school. At 4 a.m. in midwinter, the little boy had to walk a mile to school to learn Samurai sword fighting on bare floors with bare feet. Older students were encouraged to bully the younger ones. The entire culture was caught up in the grip of this militarism. Nambu remembered being told a story of heroism in which a schoolteacher died trying to save the portrait of the Japanese emperor from a fire. The message being, of course, that the portrait was more valuable than the teacher's life [1].

Thankfully, Nambu was insulated from this conditioning because of his father, Kichiro Nambu, who hated the regime. Kichiro had run away from home to attend Tokyo university, and he brought an eclectic library back to Fukui. His diatribes ensured that his son did not succumb to the pervasive propaganda. Instead, Yoichiro learned to go through life observing everything, being aware of everything, and yet being able to think things through for himself. I believe that early training was key to his genius as a theoretical physicist. He was aware of trends, but always followed his own passions and trains of thought.

In 1932, Nambu himself started studying at Tokyo University. At an autobiographical talk he gave in Chicago, he said he was interested in mathematics, philosophy and physics, but abstract thinking was not satisfying enough for him. He wanted to do something that related to nature. "I do not have a good memory," he said in his talk. "I hate to cram a lot of facts into my head. In physics, a fundamental law can be written on one page. If I can master the laws of physics, I should be able to solve every problem in principle, given sufficient time. Although that time may be my whole life. Physics also presents puzzles all the time, and it is more satisfying when I succeed in solving a puzzle."

For Nambu, the enterprise of physics was infused with play and joy. He did it for the pure pleasure of solving puzzles. If you met Nambu, or heard him talk, you would not have the impression that he was the smartest person in the room because he was often very rambling in his speech. He did not seem to make logical connections, but associations—halfway through a talk, a string would become a vortex and then a flux tube. He was very confusing as a teacher. I met many other physicists who seemed quicker, apparently more brilliant. But Nambu had some other quality that was almost mystical: profound intuition, informed by decades of immersion in physics.

Nambu's early college years in Tokyo were difficult. He was a youth from a small country town, and the other students he met were very smart. He could not understand entropy and failed thermodynamics. But he learned quite a bit about the outside world from underground communist students who told him about the massacres that Japanese forces were perpetrating in China. This was not news you could get through normal channels, but it was also news he had to keep to himself.

So all the time, he was observing and very aware of his surroundings. But he guarded his inner world, because sharing what he knew could get him into real trouble. He started a master's degree but was soon drafted into the army. The work was physically hard: digging trenches, building bridges, carrying boats. But inside, he said, he was free: "As long as you said, Yes, sir, yes, sir, they left you alone."

Nambu was a small man, very unassuming. He kept to himself, but his inner life was unimaginably rich. He got used to physical hardship, and later he managed to transfer to a technical department where he

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was assigned to design a shortwave radar system. Eventually, his team finally managed to build a radar. But when he got someone to take a metal rod out into the ocean, Nambu chuckled, it could be seen with bare eyes, but not with the instrument they had built.

Nambu did succeed in "stealing" a paper from the navy. It was a paper on field theory from Werner Heisenberg, which had arrived in Japan after a year-long journey by submarine. Tomonaga was using it to develop a theory of waveguides. Nambu studied it too, learning field theory even as he was in the army.

Life was not all bad. He fell in love with an assistant, Keiko, who would become his lifelong partner. But one day he watched an American B59 bomber fly overhead towards Osaka. They overflew the city and instead bombed Fukui: his grandparents were killed. Fortunately, his parents, who had built their home on the outskirts of the town, were spared.

After the war, Nambu returned to Tokyo university, where he lived in a laboratory for 3 years. Most of his time was taken up trying to find food. During his speech in Chicago, he said: "I felt too hungry and weak to be able to commute by riding jam-pack trains. So I lived in a room in the Physics Department with large tables for doing experiments. I could use electricity, gas, and water freely. Nobody cared, and I lived there for 3 years." Sometimes his roommate, Ziro Koba, would come in and surprise him sleeping across both of their desks.

But these were also Nambu's richest formative years. Many students were there, mostly trying to survive. But they were also thinking, living and talking physics, and Tomonaga's offices were just next door. Koba was a student of Tomonaga, and he would share what he was learning with Nambu. One time, Koba shaved his head after getting a calculation wrong. Nambu asked him why. Koba replied that in an earlier era, he would have had to commit hara-kiri; shaving his head was mild in comparison. Such was the level of indoctrination.

In later years, Nambu and science historian Laurie Brown wrote an article for *Scientific American* on the amazing advances that Japanese physics made during the war years, when Yukawa and others developed field theory, independently of the West. Nambu eventually moved to Osaka, where he was the first to write down what is nowadays known as the Bethe–Salpeter equation. He never followed it up, he wrote, because he never found it particularly useful. He predicted that strange particles should be created in pairs, an insight normally attributed to Abraham Pais [2].

This would be a pattern throughout his life, not only in Japan but also in the US. Because he was a quiet and reticent man, and because he often did not publish a finding right away, he routinely failed to get credit for his discoveries. While I was his student, I remember him pulling out some papers on symmetry-breaking in Helium III. He had never bothered to publish them. These were papers that could have made the careers of some physicists, but they were just sitting there in his files.

Laurie Brown spoke of his exuberant sense of play. For Nambu, physics was pure joy. I would meet him for an hour every Monday, and he would talk to me about the project we were doing and explain his ideas. I would take notes, and I often did not understand what he was talking about. But I would emerge from his office all fired up, because his excitement was so contagious.

In 1952, thanks to a recommendation from Tomonaga, Nambu got an offer to move to Princeton. Coming from a ravaged country, the plenty in America was stunning. In Japan, he had periods of acute hunger, and had to spend the entire weekend going to the countryside, begging farmers for food. But it was a difficult move in other ways. Post-World War II, there was a lot of racism against Japanese people. Nambu said that he had a hard time finding a place to stay; prospective landlords would see him and shut the door in his face.

And although Princeton was where a lot of brilliant people were gathered, it was not a place where the shy young man could thrive. He had a long conversation with Einstein, who was at war with quantum physics, which upset his belief in the predictability of nature. Nambu was steeped in quantum field theory from his time in Japan, and just listened without saying anything. He met some brilliant and aggressive young men, like Feynman. Oppenheimer was in charge of the group at Princeton. He was also, I think, personally very intimidating.

Years later, Nambu wrote to me that he could not accomplish what he wanted to and had a nervous breakdown. He was saved from this dark period by an offer to go to Chicago by Goldberger. Chicago had a much more pleasant and welcoming atmosphere. And when I was in Chicago, Nambu was the informal head of the theoretical physics group, and he maintained that atmosphere. People collaborated, more than competed.

While at Chicago, Nambu proposed the existence of the Omega particle. Laurie Brown told me that when Nambu talked about it at a conference, Feynman shouted derisively: "In a pig's eye!" The Omega particle was subsequently found in an accelerator. Listening to a talk by Bob Schrieffer, one of the discoverers of the BCS theory of superconductivity, he was puzzled that the wave function did not conserve electron number. His studies of fermion pairing would eventually lead him to the discovery of spontaneous symmetry-breaking, and the existence of what is now called the Nambu-Goldstone boson [3].

Nambu suggested that gluons are held together by something called color quantum number, a discovery that Murray Gell-Mann is often credited with. But Nambu made a mistake. He thought that the quarks have integer charges, and Gell-Mann was the one who gave them the correct fractional charges. Nambu saw that particles act as if held together by strings and was the first to write down the "string action", foundational to string theory. He proposed an evolutionary theory of the universe, an idea Lee Smolin has built on. After retirement, he moved back to Japan, and continued to work on physics till close to the end. For him, of course, physics was never work, but pleasure.

There is no question that Nambu had a rare genius. But I also want to give you a sense of what he was like as a human being. I once found him working hard for days, trying to understand a handwritten paper on relativity some stranger and non-physicist had sent him. Any prominent physicist gets just all kinds of junk from strangers–why was he even bothering to look at this, let alone spending so much time on it? I asked him that. He said that when Einstein got a paper out of the blue from India, he had read it and deciphered it and realized that it was a work of genius. It was a paper from Satyendra Nath Bose and it led to the discovery of bosons. If Einstein had not bothered to read that paper, that discovery might have been lost. So Nambu would read through everything that he got, because he wanted to be sure that he did not toss out a work of genius hidden under a lot of obscure math. I was amazed at the quality of this human being, that he spent days working through those calculations to see if there was any value to this paper or not.

The other thing I want to leave you with which is personal. After my postdoc at Caltech, I could not find another job, and I was desperate. I wrote to Nambu asking him if I had any future in physics, and he shared with me some insights on what it takes to be a physicist. I will read a section from this letter, because, I think, it speaks to many young physicists. He wrote:

"I understand your question. To be a physicist is not easy, although it is not as hard as becoming a concert pianist, as a friend of mine who had given up music for physics discovered. In the case of music, you have innate talent, or you do not, and that's that. The pursuit of physics is also an art. So it is still primarily a matter of talent. But talent can have many shapes, and there is room for different styles. Furthermore, talent does not equal accomplishment. The latter is a more dynamic thing. It helps if you have self-confidence, but usually, self-confidence and accomplishment bootstrap themselves. When you are young, you tend to be more idealistic, ambitious, and impatient, just as I was myself. You would be satisfied with nothing short of solving the significant problems of physics. But at the same time, you have nagging self-doubt, constantly gauging yourself against others.

"I experienced this acutely when I spent two years at the Institute for Advanced Studies in Princeton. I could not accomplish what I had wanted to. Everybody looked brighter than I was, and I had a nervous breakdown. I thought I was the only poor guy who had the problem. Much later, I found out from my old rivals that they had all gone through the same experience.

"The current trends of the physics community worry me. Some areas of physics are in a state of stagnation. Some others, if not stagnant, have become a mission-oriented collective enterprise. But let me also tell you another aspect of the pursuit of physics or any discipline for that matter. It is that you enjoy it just for the fun of it. You should not be deadly serious all the time. All work and no play is no good. When you are stuck, you relax and try other things that you can handle without specific purpose or ambition. Learn to be flexible in your pursuits on a short-term scale and patient in the long term. It sometimes happens that the paper you wrote in a playful moment gets more attention than the paper you think is more serious and vital.

"I was fortunately saved from my depression by Goldberger, who brought me to Chicago; it was the only job offer I received, just the last moment. You need luck. But luck does not happen in a vacuum. It has to be cultivated."

I will leave you with that piece of wisdom from a gentle genius.

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