

Institute of Advanced Studies

Supplementary Newsletter

July 2013

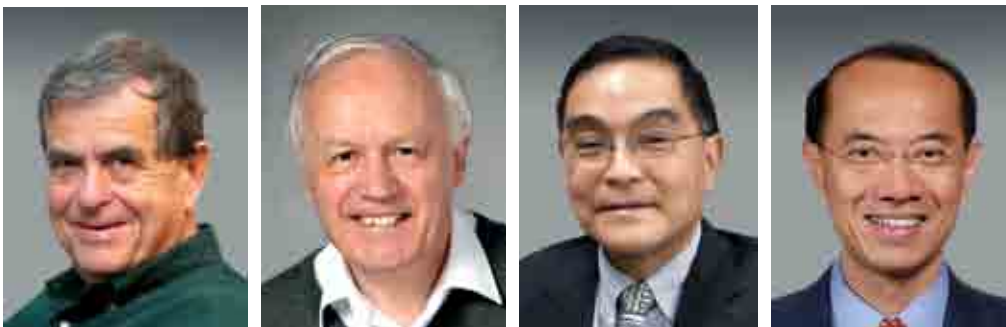
Editor-in-Chief: Prof Phua Kok Khoo, *Director, Institute of Advanced Studies, NTU, Singapore*



Different Universities Providing Different Pathways to the Future

Exclusive Interview with
DPM Tharman Shanmugaratnam

Also Featuring



From left: Prof Aaron Ciechanover (Nobel Laureate in Chemistry, 2004), Prof Anthony Leggett (Nobel Laureate in Physics, 2003), Prof Feng Da Hsuan (Senior Vice President for Global Strategy, Planning and Evaluation, National Tsing Hua University), Mr George Yeo (IAS Patron and Former Minister for Foreign Affairs), Prof Bertil Andersson (President of NTU) and Prof Chen Ning Yang (Nobel Laureate in Physics, 1957)



Greetings from the Institute of Advanced Studies (IAS) at the Nanyang Technological University (NTU), Singapore!

This issue of the IAS Supplementary Newsletter features exclusive interviews and scientific articles from some of the greatest personalities in their respective fields. In an in-depth interview with the Deputy Prime Minister of Singapore, Mr Tharman Shanmugaratnam, he spoke about Singapore in an age of a changing global environment and technologies, and the range of university models that will be needed to meet the challenges of such a shifting landscape.

Echoing the same concerns, the President of NTU, Professor Bertil Andersson shared with us the transformation of NTU's campus and curriculum in an effort to produce a different type of graduate to meet the challenges of the 21st century. Also, the Senior Vice President of National Tsing Hua University, Professor Feng Da Hsuan gave us an insight into the US\$2 billion new campus of the University of Macau.

Separately, in the interview with Professor Aaron Ciechanover, one of Israel's first Nobel Laureates in Science, he shared with us his personal views on science and life. Included in this issue is also a speech by our IAS Patron Mr George Yeo on his conferment of an Honorary Doctorate at the Hong Kong Polytechnic University, as well as an article by Nobel Laureate Professor Anthony Leggett on the writing of scientific English for Japanese physicists.

Last but not least, in "*Father and I*", Nobel Laureate Professor Chen Ning Yang gave a heartwarming reminiscence of his close relationship with his father, Professor K.C. Yang.

I wish you well, and happy reading!



Phua Kok Khoo
Director
Institute of Advanced Studies
Nanyang Technological University

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Different Universities Providing Different Pathways to the Future

Exclusive Interview with
DPM Tharman Shanmugaratnam

Poon Sing Wah
Translated by: Lee Xiao Wen



Students have different outlooks and abilities, and society has different needs. Furthermore, no one knows what's going to happen beyond the next ten years. As a responsible nation, Singapore therefore needs to offer new and different types of university education in order to prepare its next generation for such a future.

Singapore's Deputy Prime Minister cum Minister for Finance Mr Tharman Shanmugaratnam is Chairman of the International Academic Advisory Panel (IAAP). In an interview with *EduNation* magazine, he spoke about Singapore in an age of a changing global environment and technologies, and the range of university models that will be needed to meet the challenges of such a shifting landscape. In doing so, he talked both about the special characteristics of the country's new universities as well as the expanded role of its existing ones. As Mr Tharman described it, the goal is not to "change the direction of the whole university sector" but to provide new pathways including those for applied education. He also talked about the educational objectives both for our universities and for the education system as a whole.

Different Skills and Mindsets Needed

As Singapore develops into a knowledge-based economy and more emphasis is placed on innovation, it will require different kinds of talent to handle different kinds of needs. If too many undergraduates receive a general academic education, there is risk of them being unemployed upon graduation, and the understandable social dissatisfaction that this brings. This can already be seen happening not only in the West but in some Asian countries as well.

As a responsible nation, Singapore therefore needs to offer new and different types of university education in order to prepare its next generation for such a future.

This is one reason why we have stepped in as a government to shape the type of education that is being provided at university level.

We want to meet young Singaporeans' aspirations not just in university but when they eventually enter the world of work. We have to tailor the education they get so that it meets the economic and social needs of the future.

"Whether you look at the US or Europe or any other advanced society, you will find that there's a limit to the demand in the employment market for people with a general academic degree. Some of the Northern European systems, on the other hand, have been more focused historically on a technical and applied professional education and have therefore produced large numbers of graduates with these professional degrees. Unfortunately, the more prevalent Western and Asian systems are still too academically-biased. Employers know this very well but education systems have been generally slow to adjust," said Mr Tharman.

The Singapore government has always restricted the number of graduates majoring in general academic education, and that is why the employment rate of fresh graduates has generally been very high. However as the society becomes more affluent, more families are able to afford to send their children overseas for university education, and a degree in general academic education is a common choice. But whether the skills of these graduates are a good match for the needs of the future is something that is an increasing source of worry.

"This is one reason why we have stepped in as a government to shape the type of education that is



Fortunately the government has done **major upgrading of both the hardware and the software of our polytechnics in the past 20 years**, at the same time that we were improving the school system.

Mr Tharman speaking at the Ministerial Forum at Nanyang Technological University (NTU) in 2012.

being provided at university level. We want to meet young Singaporeans' aspirations not just in university but when they eventually enter the world of work. We have to tailor the education they get so that it meets the economic and social needs of the future.

"It is risky to put all your eggs in one basket as you may end up producing too many people of the same ilk, of the same mindset and skills. It is a more robust education strategy, for both individuals and society, if we nurture diverse skills and diverse mindsets and outlooks as well," explained Mr Tharman.

The New Applied Pathway for Universities

Singapore's new pathway of applied education at the university level has some unique characteristics.

"The idea of an applied pathway at the university level is not new. Among the top universities globally, MIT has distinguished itself from others in this respect.

Several Northern European universities have been pursuing the applied approach for some time now. But the idea of a curriculum where design is infused across disciplines is something MIT and Singapore felt we could do in a more holistic way in a new university, in a green-fields setting. It's easier to make this innovation when you are starting a new school. The Singapore University of Technology and Design (SUTD) is an exciting development for that reason.

"Likewise the Singapore Institute of Technology (SIT) — the basic idea is not new, but what is unique is that SIT builds on the well-reputed local polytechnic model, which means its entrants have been receiving an applied education since they were 16 — which is quite unusual internationally, because the polytechnic model in most countries is only available after the age of 18. This makes SIT unique in melding what you do post-secondary school, post-16, with a university education. It is not necessarily superior to what is being

done internationally but it offers different possibilities, and I think it will be a valuable complement to our existing system.”

Our Polytechnics Have Won People Over to Applied Education

Singapore was a British colony, and has had a predominantly Chinese population. Our society has therefore been influenced by the education systems of both Britain and the East, with a traditionally heavy academic bias.

“The legacy of the two systems was a strong one. The first was a British educational system which was heavily academically-biased, and hierarchically-layered — the best students in the UK went to Oxbridge and the next tier went to a second layer of academic institutions and so on. Secondly, we inherited a predominantly Chinese educational tradition which was also geared to nurturing an academic elite, for reasons that go far back in history. Both were powerful influences on social attitudes in Singapore, and the combination of the two made for an intensely academic system.

“Fortunately the government has done major upgrading of both the hardware and the software of our polytechnics in the past 20 years, at the same time that we were improving the school system. As a result polytechnic graduates are popular with employers, and this has in turn changed the bias some parents had against polytechnics. The fact that we have very academically capable students choosing polytechnic courses over those offered by the junior colleges (JCs) is also an illustration of this. With SIT now upgraded to a university, parents will have further confidence in the applied pathway to educational advancement.

“The Singapore polytechnic system was inherited from the British, but we made a strategic decision not to convert our polytechnics into universities. We decided on a different route from that taken in Hong Kong and Australia, who converted their polytechnics to universities just like the British did. Employers and many educationists in Britain now lament the loss of the polytechnics.

“For a long time our polytechnics were essentially focused solely on providing a good diploma-level education, even as they were expanded and strengthened. Then, in 2005, the government encouraged the polytechnics to collaborate with overseas universities to offer specialised, applied degree programmes. We expanded this ‘Polytechnic-Foreign Specialised Institutions (Poly-FSI) initiative’ further from 2007 onwards. The idea was to expand opportunities for polytechnic students to advance themselves locally while staying within their specialised, industry-relevant fields, instead of having to go abroad or switching to more academically-oriented degrees. It was only after these partnerships had been successfully up and running for a time that SIT, which was formerly responsible for managing these new programmes, was itself made into a university in its own right in 2012.”

However, with the addition of this new pathway of applied education at the university level, Mr Tharman does not believe that students will now flock to the polytechnics in significantly larger numbers.

“What is important is not the exact numbers to JC or poly, but in not having a thick black line dividing the two in terms of the differences in curriculum and learning methods. They should be part of a continuum, with a few JCs having features that are borrowed from the polytechnic model, and some polytechnic courses providing strong academic foundations. So as that continuum evolves you don’t need to force the numbers too much in one direction or another to achieve a planning target. Over time I think we will get a welcome fluidity between the JC and the polytechnic systems. And the basic idea must be to provide routes for advancement, whichever path a student takes.

“We aim to produce graduates of the highest quality: scientists, inventors, social workers and health professionals, financial engineers and so on. But to develop mental abilities, we need different approaches. In fact it starts in the schooling years. That is why the government set up the School of Science and Technology for example — to give students a chance to do something real, to manipulate, to develop their craft. There’s a very close connection between the mind and the body. The best craftsmen are usually

brilliant in their own way, be they the best designers and carpenters or the best technologists.”

A Carefully Planned Expansion of the University Sector

SUTD opened its doors in April last year, 12 years after the setting up of the Singapore Management University (SMU). But the setting up of the fifth and sixth universities was announced by the Prime Minister, Mr Lee Hsien Loong, in his National Day Rally speech a mere four months after SUTD had started teaching. As a consequence, the university cohort participation rate which had stood at 30 per cent from 2015 onwards was upped to 40 per cent from 2020.

Is there any significance behind the accelerated expansion of Singapore’s higher education?

“Yes, there was a long interval of 12 years between the setting up of the third and fourth universities. Why? The basic approach then was to expand the National University of Singapore (NUS) and the Nanyang Technological University (NTU), our first two universities, and to ensure they developed strong reputations at the same time. They still had room for expansion then. However, we have since reached the limits of their expansion — NUS has an enrolment of 37,000 students while NTU has 35,000. They are in fact very large national universities by international standards. So any further expansion of the university sector has had to come about through new institutions.

“Setting up a new university is a very careful decision, and cannot be taken rashly. It gives everyone great confidence when we have developed a few good universities by international reckoning. Once you’ve achieved that, you feel you’re able to expand the space and develop new institutions with confidence, and without high risk to the university system as a whole.

“There’s another reason why we’re expanding university enrolment, and this has to do with the fact that our school and technical and polytechnic system has done well to train Singaporeans to a high level where a larger percentage of them are now able to go on and get a university degree. If you don’t provide such

an opportunity locally, more people will go abroad, at a greater cost to their families, and they may not necessarily study in disciplines that will enable them to get good jobs in the future. These are the considerations that led the government to decide to increase the local, publicly-funded university participation rate to 40 per cent by 2020.”

There has been a lot of experimentation with our higher education models, but although they may be unique, Mr Tharman does not feel that we are in a position to export them to the rest of the world.

“I think some humility is required. We don’t have some unique answer that meets the needs of all societies. We have made innovations, and that’s a reflection of the fact that we’ve succeeded in providing a good education system and we’re no longer able to borrow and import lessons in a simple way. When we learn from schools or universities abroad we always adapt the lessons before we implement them in Singapore. I feel that as a small nation, if we are able to groom our young people into individuals who can create a gracious, inclusive society and an innovative economy, we have fulfilled our goal.”

More Research in the Social Sciences

Singapore’s universities have made great strides in scientific research with the help of A*STAR and the National Research Foundation, and have gained a worldwide reputation. However, Mr Tharman feels that greater effort needs to be put into expanding research in social science from here on out.

“It is not that the social sciences are doing badly. I mean, economics, business and law graduates in Singapore are very highly regarded. But I think when it comes to research and to developing peaks of excellence, we can achieve more with the social sciences. In some areas we already have those peaks, for instance in some areas of international law, but these are very specific niches. We want to take social science research to a much higher level, and that means providing an attractive career in social science teaching and research, and also developing an ecosystem around the universities that includes more transitioning between academic and government



Mr Tharman interacts with students during the NTU Students' Union Ministerial Forum (5 Sep 2012).

circles. We really have to develop the whole ecosystem for this to succeed.

“Research funding is one way to incentivise talent development. It’s also useful in its own right because I think there’s a lot of untapped potential in social science research in Singapore and Asia generally.”

Mr Tharman feels that this new direction will help on the one hand in the universities exploring new fields of excellence outside of science and technology,

and on the other with spearheading the necessary understanding and solutions in social science fields that are crucial for so many countries, including Singapore. One example of this is in the universal challenge of keeping medical costs under control while expanding care with an ageing population, and providing a sense of equity and fairness. “This is a very important issue that requires thinking not just in medicine but in the social sciences, economics, business and even in the logistics of care networks.

“While everyone understands that prevention is better than cure, preventive care is a matter of public psychology, education and changing social norms. Preventive care is the most efficient form of healthcare and it costs the state, society and the individual far less over time. How we reach this goal will be aided by research and collaboration among different fields of expertise. And this is just one example. Other areas like housing, or the environment and new water technologies will also need in-depth solutions that research in the social sciences can help advance.”

In addition, many problems have arisen because of the rapid development in Asia, and research in these areas has been lacking. Work done here will help fill a gap.

“Asia is going through an immense transformation, particularly through urbanisation. The need to develop liveable cities and to avoid social dislocations is really critical. There is also the challenge of ensuring a sense of cohesion in the midst of racial and religious diversity in several of our societies. I think there will be a greater premium on economists and sociologists, as well as people who are involved in thinking through the social dimensions of urban planning. There will be a greater premium on proactive thinking that filters into government policies as well as into community initiatives.

“Singapore has a distinct vantage point for research. Everything to do with education, making a city liveable, and achieving harmony in a multiracial and multi-religious community is central to how Singapore governs itself. Singapore’s universities can perform research on other societies too, and develop reference points for both Singapore and other Asian nations.

“With this in mind, the Ministry of Education is carefully considering the possibility of setting up a council for social science research. Developing research in the social sciences is not just about the research itself, but includes developing talent and providing them with the relevant access to data and policy thinking.”

Developing the Ability for Independent and Imaginative Thinking

Talking about higher education in Singapore, Mr Tharman also places much emphasis on grooming students to think critically and innovatively.

He proceeded to talk about what he felt were the three main objectives of education: firstly to develop strength of character; secondly to nurture the skills and knowledge that every citizen needs to participate with confidence in a modern economy; and thirdly to develop in individuals the ability to think for themselves and think in original ways. All three objectives are important with regard to each level of the education system, but the ability to think for yourself is something that needs particular emphasis at the tertiary stage. All three objectives serve to groom individuals who can contribute and make a difference to society.

“Singapore does quite well with regard to the second dimension — skills and knowledge. We do very well by international standards. But even in this area, we always need to update the curriculum, the way we train teachers and lecturers, and the way in which the whole process of learning takes place so it prepares students well for the realities of a modern economy and society. Although we are doing well in this respect, it is a matter of constant improvement, and the refreshing and rejuvenating of our systems.”

The setting up of universities for applied education is one of the ways the government is refreshing the system for this second goal.

The ability to think for yourself is something that needs particular emphasis at the tertiary stage.

“With regard to the first and third objectives, I think greater emphasis is required as we evolve our education system. Not because we are lagging behind other countries, but we want to do much better for ourselves; to do better in developing strength of character when people are young, and also increasingly, to develop the ability to think for oneself. And the last dimension, thinking in original and imaginative ways, becomes more important as Singapore becomes a society that is driven by innovation in every field of life. It need not be in high science or developing entirely new technologies. It is often about constant improvement — using imagination on the job will increasingly be an advantage for both the individual and society as a whole.”

Mr Tharman feels that all three objectives are important at each stage in a young person’s education, but there’s a different emphasis at each stage. He said, “The foundations for developing the first dimension, strength of character, are most importantly laid down during the school years, and cannot wait till the

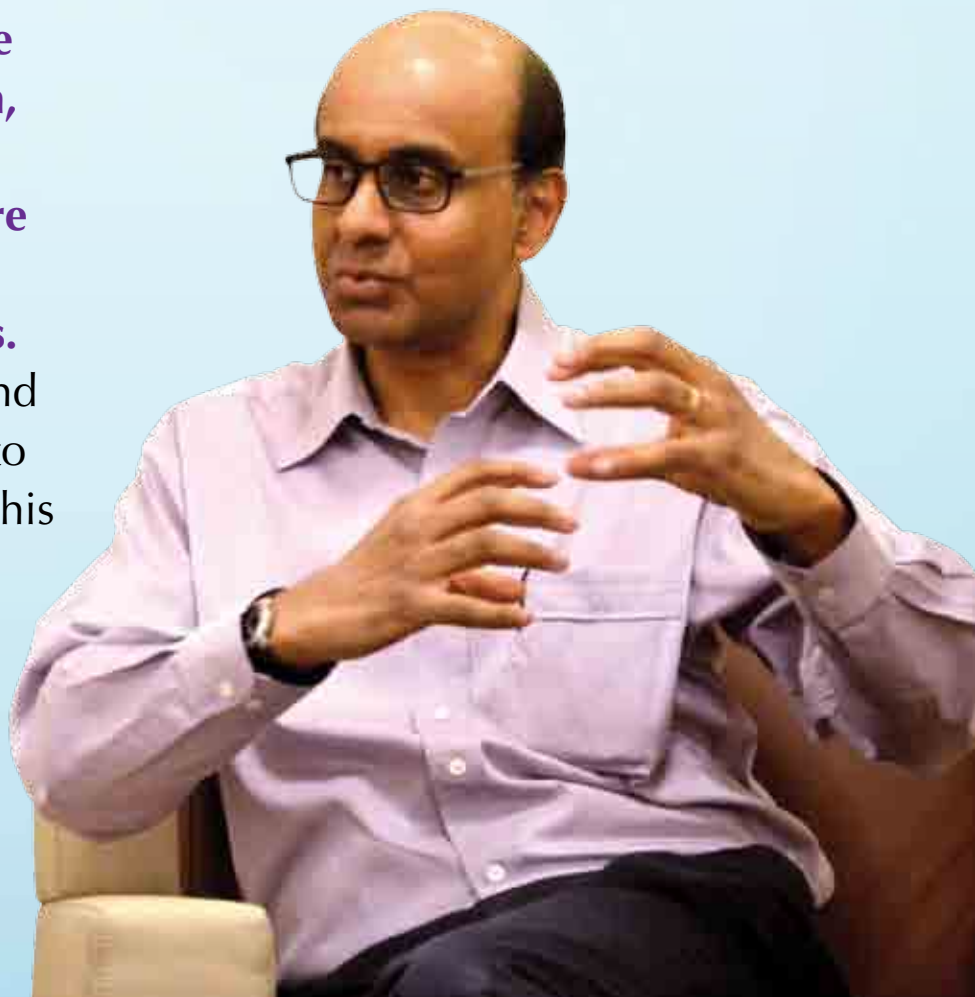
university stage. Conversely the ability of students to think for themselves is something that needs especial emphasis at the tertiary stage, regardless of whether the degree programme is theoretical or applied.

“This third dimension cuts across all disciplines and all methods. It’s a habit of mind: the willingness to question, to imagine something different, and the desire to constantly improve what we see around us. Both our established and new universities need to focus on encouraging this habit of mind. I get the impression that too much of university learning is a carry-over from our school and junior college system, in terms of the method of teaching and learning, the reliance on lecture notes, and the type of and focus on examinations for example. This does not help us develop thinking and imaginative individuals.

“We are diversifying our system of meritocracy. We are broadening it to recognise different types of talent and merit. But the standardised exams are still at the core

It’s a habit of mind: the willingness to question, to imagine something different, and the desire to constantly improve what we see around us.

Both our established and new universities need to focus on encouraging this habit of mind.





Mr Tharman at the NTU Students' Union Ministerial Forum (5 Sep 2012).

of the school system, to preserve transparency and a sense of fairness as students progress from one stage of education to the next. However, our universities have an important advantage in this respect. They do not need to worry so much about the transition to another level of education, because university is the final stage of the pre-employment education system. After that you enter work life, and your exact scores in university

do not matter. At most, the class of your degree will matter at the start of your working career, and continual learning takes over from there. Universities therefore do not require the same degree of standardisation that we need in a meritocratic school system.

“This is a very important distinction. The universities are sending students not to the next level of education,



but into real life. This means they have much greater freedom to break away from standardised learning and testing, greater freedom to encourage students to explore and innovate."

Pride in the Past, Looking to the Future

Mr Tharman was full of praise for our national universities who take in a large number of students

each year yet manage to achieve strong international reputations. This is "a little remarkable", but he stressed that our universities still need to evolve and meet the requirements of a new era.

"Singapore's ability to set up new universities has been built on many years of developing a strong and rigorous foundation. That foundation gave employers confidence, and it would not have been possible without it to experiment with new pathways. As we advance, and recognising the realities of global competition, we know that to sustain living standards in Singapore and to raise them even further, we have to enter the space of creative activity in every sector of our society, and I mean creativity in the very broad sense of the term.

"It is not just about the MNCs (multinational corporations). Many of our small and medium enterprises (SMEs) are doing quite well, here and abroad. They study the market, what the gaps are, look for things that existing players are not doing, and they find a niche for themselves. It may not be path-breaking technology, but it's a value that they can bring to the market. They take advantage of the Singapore brand, and at the same time add to the Singapore brand. We need more of our young people to help Singapore companies to venture and do well, so that local SMEs remain at the core of our economy.

"No matter what area of innovation we are talking about, the innovator's state of mind is never satisfied — never satisfied with the state of things and always wanting to make things better.

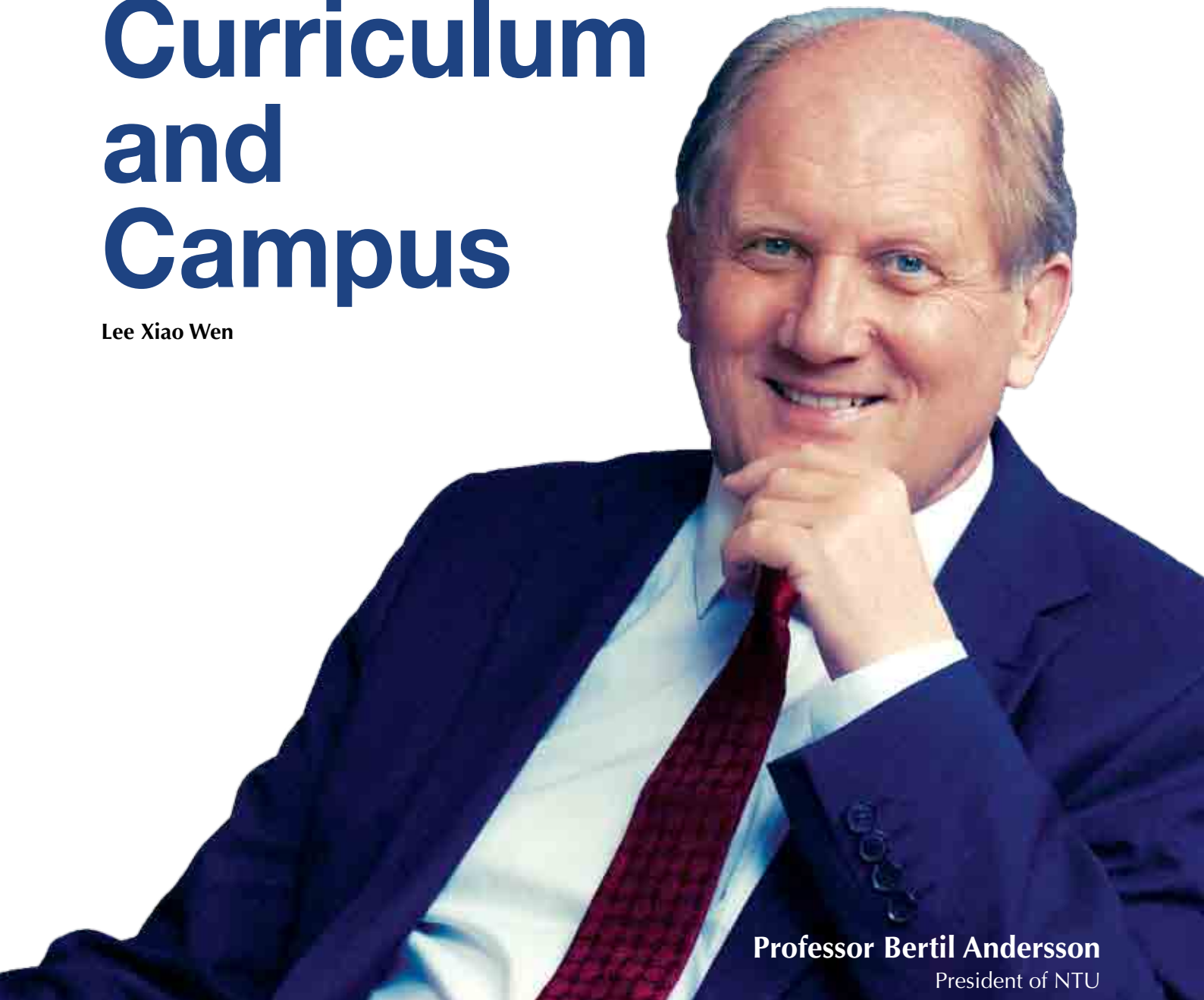
"That's a state of mind that each new generation must have, and it is not just about material progress. Societies advance in leaps when enough individuals want to take a less conventional path, and create something new. Our universities need to make the most of their autonomy, and do all they can to groom a generation of young people who enjoy thinking critically and imaginatively, who care and who want to keep making things better for their fellow citizens."

This article first appeared in *EduNation* magazine
Issue 2. Mar-Apr 2013

Nanyang Technological University

A Transformed Curriculum and Campus

Lee Xiao Wen



Professor Bertil Andersson
President of NTU

The Nanyang Technological University (NTU) wants to produce a different type of graduate to meet the challenges of the 21st century. Its President, Professor Bertil Andersson, tells us how this is translating into new courses and learning methods, as well as major infrastructural upgrades for the school.



Profile

Established in 1991
(Its predecessor institution, Nanyang University, was established in 1955)

Student Profile

Undergraduate students: 23,500
Postgraduate students: 9,500

Faculty Profile

Full-time faculty: 1,700

Colleges and Schools

College of Humanities, Arts, and Social Sciences

School of Art, Design and Media
School of Humanities and Social Sciences
Wee Kim Wee School of Communication & Information

College of Engineering

School of Chemical and Biomedical Engineering
School of Civil and Environmental Engineering
School of Computer Engineering
School of Electrical and Electronic Engineering
School of Materials Science and Engineering
School of Mechanical and Aerospace Engineering

College of Science

School of Biological Sciences
School of Physical and Mathematical Sciences

Nanyang Business School

Lee Kong Chian School of Medicine

Official website

<http://www.ntu.edu.sg>



Students in NTU perform research in state-of-the-art research facilities.

These are some of the things that the Nanyang Technological University (NTU) undergraduate of the future can look forward to: graduate from a brand-new medical school established in collaboration with the world-renowned Imperial College London; leverage online learning platforms and high-tech classrooms that foster group discussion and interaction; attend courses that go beyond their core disciplines; and stay in new hostels with trendy spaces for students of different backgrounds to meet, exchange ideas and get to know each other better.

The whole idea is to nurture graduates who will have an even sharper competitive edge once they enter the workforce.

The ideal NTU graduate will be: an upright person and a smart leader who also possesses a strong social conscience, expert knowledge and skills, and an enquiring and creative mind. It is NTU's hope that the new undergraduate experience that it is moulding will give its students a distinct competitive advantage in the new global talent marketplace.

A New Paradigm for Undergraduate Learning

The most apparent and immediate change is to the undergraduate curriculum. This is being done to allow students to take courses outside of their core disciplines.

Following the recommendations made in 2011 by its own review commission, NTU cut the total course

The increasingly interdisciplinary nature of the NTU experience is designed to produce **T-shaped individuals who have a depth of specialised knowledge in one discipline and good, working knowledge in a number of other areas.**

content of its degree programmes by up to 14 per cent. It also introduced a number of new minors in areas ranging from environmental to sports sciences; implemented a new set of broad-based prescribed electives; and made its course in Environment Sustainability a compulsory cornerstone of the first-year curriculum. The increasingly interdisciplinary nature of the NTU experience is designed to produce T-shaped individuals who have a depth of specialised knowledge in one discipline and good, working knowledge in a number of other areas. Professor Bertil Andersson, President of NTU, hopes that the reduction in the overall course requirements will free up time for group-based learning and self-reflection.

“Reflect — that is a good word. Students should take time to understand what and how they are learning, and to review, plan and take responsibility for their own learning. Students should also be engaged in student activities, leadership activities, entrepreneurship, and running their own coffee shops and so on. In today’s world, more employers are looking for broader skills. It is not just the major discipline — the softer skills

are becoming more important. If you are an employer and you have five top-scoring candidates, you would select the applicant with the better soft skills. And if one candidate has been a student leader, then that’s the most attractive one, because he has already proven that he can lead.

“Of course, there are students who are not so used to this kind of thinking. They say, ‘Oh, if I don’t amass and learn more knowledge, I will be less competitive.’ But you see, more is not always better. When it comes to learning, you have quantity and quality. I cannot only push the quantitative.

“Also, scientific knowledge and information is doubling every five years. I came here in 2007, that’s five years ago, and in that short time the world has generated as much information as it did in the whole of the period from the birth of Christ up until 2007. That is fantastic, but it is also a scary thought. This also shows why we cannot continue to deliver all our information via lectures, because then a university education would probably take ten years. The fact is that one has to prioritise knowledge in the modern world because we have an absolute tsunami of information these days — and this makes the job of a university president very difficult.

“One has to realise there is a lot of false information and obscure information online. Therefore, you have to teach students how to evaluate information, because not all of what you see on the Internet is true, so you have to foster a critical mind, or you could say, a quality-assurance mind.”

For Professor Andersson, the curriculum also has to encourage entrepreneurship. “When I was President of a Swedish university, we had 300 start-ups around the campus. 150 of these were started by students. Here, I don’t see that. It’s not that Singaporean students aren’t smart. They are super smart. But they don’t see their role as creating things. A few have, but much less than the Swedes.

“That is another reason why we have revamped the undergraduate curriculum. As a university we should give them the freedom to be entrepreneurs and start companies without being punished.”

Ironically, the ease of finding a job dampens the entrepreneurial spark. “Almost all our students get a job within months of their graduation,” said Professor Andersson. “If it is so easy to get a job, why go through



The Cool Campus in NTU offers students various spaces that support and enhance group learning and collaboration.

the hassle of starting your own company? Sometimes the difficulty of finding work is also an incentive, which explains why there are so many more start-ups in, say, Middle Eastern countries, where unemployment is high.

“That is why we are reforming the undergraduate curriculum. We hope it will pave the way for a change in behaviour. Having so many international students will also slowly change the culture. We have to be open to change and not stick to the old ways of doing things. So much has changed since the 1960s, and we cannot educate students in the same way as we did back then.”

Transforming the Campus

The revamp of the curriculum means changes not only to the academic experience and student life, but to the infrastructure as well.

At a new Learning Hub, which will be ready by early 2014, tutorial rooms will be stacked into iconic towers that cluster around a shared circulation space and atrium. The seven-storey hub will house 55 new-generation classrooms designed to promote interactive, small-group teaching and active learning.

“A student should not be a consumer of lectures. In the past, we had 300 students come to a lecture hall for a two-hour lecture. The students sit, take notes, and some play on their mobile phones. That is old-fashioned. Today, it must be much more active. Lectures can be recorded and put on the Internet. Today’s professor does not have to stand in front of a lot of students and give facts. Facts can be gathered very easily. You can even get facts from studying at Harvard while you are sitting here in Singapore. Therefore we need more self-studying, tutorials, project work and other interactive assignments.”

Eight new residential halls will also be built, adding 5,000 new hostel places to NTU by 2015. Construction of the first



Mr Heng Swee Keat (3rd from left), Minister for Education, admiring a model of the new learning hub at NTU. With Mr Heng are (from left): Prof Bertil Andersson (President of NTU), Mr Edmund Cheng (Board Member of NTU), and Prof Kam Chan Hin (Associate Provost, Undergraduate Education).



An artist’s impression of the new halls of residence located at the corner of Lien Ying Chow Drive and Nanyang Crescent.

two began in August 2012 and will be ready by July 2014, in time for the new academic year. These eight blocks, resembling Y-shaped tree branches, will be built around a centrally-linked common space that will feature cultural and sports plazas flanked by a recreation pond. Three gazebos will serve as look-out spots around the pond, providing meeting or party spaces by the water. As these will be open spaces, they can also be enjoyed by members of the public.

“An additional 5,000 new students will be living here in future, so there’s going to be enormous building activity in the meantime. But we have to build in a way that retains the character of this campus, which is uniquely lush and green. There will be a lot more student activities and student clubs. We are going to have more cafés, restaurants and meeting places. Many of these are going to be run by students. I want NTU to be livelier, with a strong culture. I also wish to encourage closer integration between our students who come from different countries.

“We will strongly encourage all freshmen to stay on campus in their first year. During their first weeks here, we will tell them what the university is about in order to facilitate such integration. I think, philosophically, this is very important.”

Lee Kong Chian School of Medicine

NTU is accepting its first batch of 50 medical students in August this year.

The Lee Kong Chian School of Medicine (LKCMedicine), a tie-up between NTU and Imperial College London, has in its faculty some of Britain’s most respected clinical scientists. Among them is Professor Stephen Smith who joined the University as Vice President for Research, in addition to being the founding Dean of LKCMedicine. Professor Smith has published over 200 papers and is responsible for developing and implementing a new healthcare model between universities and hospitals in the United Kingdom.

In August 2012 Professor Smith was succeeded as Dean by Professor Dermot Kelleher, who was previously head of the medical school at Trinity College Dublin before becoming the Principal of Imperial’s medical faculty, and therefore Dean of LKCMedicine as well. He now divides his time between NTU and Imperial College.

“It is beneficial that the LKCMedicine and Imperial medical faculties share the same Dean, at least during this initial phase,” explained Professor Andersson.

This is partly because the new course and its curriculum have been adapted from Imperial, and students will graduate with a joint Imperial-NTU degree.

“To get a joint degree from NTU and Imperial is extremely attractive,” said Professor Andersson. “You don’t have to go to London to get an Imperial degree, so that’s fantastic. With new schools there are always uncertainties, but I’m confident that LKCMedicine is going to be very good. This is also why we are only taking in 50 in the first year. We want to firmly lay the groundwork before we raise the intake to 150 in the next few years.”

About ten professors from Imperial College will be teaching at the new medical school, and Professor Andersson is looking at recruiting other faculty members from all over the world.

“The new medical school gives us an opportunity to enhance Singapore’s manpower capacity. If we only recruit internally, it’s not a capacity increase — it’s just a shuffling around of existing resources. That is why we have to recruit global talent for these positions.”

LKCMedicine aims to train the kind of doctors we want to be treated by. To that end, it holds a series of eight mini interviews for short-listed applicants with outstanding pre-tertiary and BioMedical Admissions Test (BMAT) results, in order to look out for soft skills like empathy and the ability to communicate.

Dr Laura Coates (2nd from right) demonstrates to prospective students the way to perform surgery.



In addition to cultivating these soft skills, Professor Andersson wishes to broaden the education of the medical undergraduates without compromising on their core competencies.

“We need to widen the scope of doctors. You see, a doctor must not only know how a liver works, or how an infection works, or when to treat an infection. We also need to have doctors who understand engineering. Increasingly, healthcare is based on engineering — hip replacements, bio materials, artificial eyes, artificial hearts, heart stents, pumps under the skin for delivering insulin and so on.”

The new medical school will focus its research on three areas — metabolic diseases, neuroscience, and infectious diseases.

Diabetes, for example, is a chronic disease that affects many people worldwide and is one of today’s leading causes of death. The World Health Organisation predicts that diabetic deaths will have doubled between 2005 and 2030, and Professor Andersson feels that more research can be done in this area to manage the problem.

“I feel that a lot of studies have been done on Caucasians in the Western setting,” he said. “But studies also have to be done on the Asian population. Many diseases have different symptoms. Diabetes is quite different in the West and the East.”

We need to widen the scope of doctors. You see, a doctor must not only know how a liver works, or how an infection works, or when to treat an infection. **We also need to have doctors who understand engineering.** Increasingly, healthcare is based on engineering — hip replacements, bio materials, artificial eyes, artificial hearts, heart stents, pumps under the skin for delivering insulin and so on.



The cupping therapy is available at NTU’s traditional Chinese Medicine clinic.

Being at Novena, the School’s campus will be able to leverage on several nearby healthcare facilities upon its expected completion in 2015. And given that its primary clinical partner is the National Healthcare Group the nearness of Tan Tock Seng Hospital, in particular, will greatly help the students’ integration into clinical settings. In addition, there will be an Experimental Medicine Building at NTU’s main campus that will be shared with the School of Biological Sciences and the School of Chemical and Biomedical Engineering.

“We want to create an interdisciplinary complex between the basic research doctors, the biologists and the engineers,” said Professor Andersson.

NTU’s Success Factors

The medical school, the general undergraduate curriculum revamp and the infrastructural improvements can only add to the sparkle of what has been a trophy year of achievement for NTU: in October last year, the university shot into the top 100 universities in the world, after being placed 86th in the rankings published by Times Higher Education — an astonishing jump of 83 places from the previous year.

In another ranking exercise of global universities conducted by Quacquarelli Symonds (QS), which employs different performance indicators, NTU broke into the top 50 after a rise of 27 places to 47th position in just two years. These results place NTU in the top one per cent of universities worldwide.

How has it been so successful on the world stage?

Professor Andersson suggests that, firstly, the Singapore government has steadfastly supported NTU’s research.



Above: NTU's iconic School of Art, Design and Media building which won the Green Mark Platinum Award in 2011.

Right: ADM student Daniel Ng filming a school video at the hangar at the School of Mechanical & Aerospace Engineering.



With the National Research Foundation (NRF) being set up by Dr Tony Tan under the purview of the Prime Minister's Office, a department was created to oversee the research of different agencies within the larger national framework in order to provide a coherent strategic overview and direction. The NRF has given generously in support of many of NTU's research programmes, and in so doing it has contributed to NTU's improved scores for research in the world university rankings.

Secondly, the university places great emphasis on recruiting and retaining top talent. "The fantastic thing in Singapore is that it is becoming a very attractive place for academics to come to. Singapore is very highly respected in other countries," said Professor Andersson. "Our pay package is competitive, but more important for many researchers is the support they get for doing research, which is very generous here in Singapore."

Thirdly, the university recruits from around the world, and was placed fifth in the world for faculty diversity, with about 70 countries being represented in its 3,800 faculty and research staff. Singapore is, according to Professor Andersson, one of the easiest countries to adapt to in Asia. This also is a great help to the recruitment and retention of exceptional faculty members.

"I can tell you that of the six countries in the world I have lived in besides Sweden, of course — Singapore, Ireland, the Ukraine, France, Australia, and Israel — Singapore was the easiest one to come to. On paper, moving to Singapore — a country with a predominantly Chinese culture — sounds much more difficult than the other countries. But it was the easiest because Singapore is so friendly, so welcoming. It's so easy for a foreigner to feel

at home here. And I think it has a lot to do with this East-meets-West concept. When we induct the participants of our Mayors' Programme, coming to Singapore from China to study is akin to going to the West for them. But we also have people from Ireland, for example, who definitely feel they are going to the East when they study here. So I think Singapore has been very smart in being able to be so cosmopolitan," said Professor Andersson.

And lastly, besides applying many of the best practices from top universities worldwide, NTU has been especially successful at working with top industry players. Professor Andersson himself has been instrumental in getting major international companies such as Rolls-Royce, Bosch, and Siemens to set up research facilities at NTU.

"This gives us a very good reputation in the business world, and it is also part of our success. Here we've done considerably more than other universities. I don't want to compare, but here we have really been able to utilise our strengths as an engineering university."

These, then, are the four factors that Professor Andersson identifies as being the key drivers of NTU's impressive rise in the world university rankings. Understandably, he is extremely pleased about this achievement but cautions against unreasonable expectations as a result. "I cannot say that we're going to continue at this rate because if we did we'd be number one in the world in three years — and that's not possible."

However, he remains very confident about NTU and its future, and even if the university can't top the world it won't be for the want of trying.

A US\$2 Billion New Campus:

University of Macau is Undergoing the
Unthinkable Transformation in
the 21st Century!

9 MARCH 2013

Professor Feng Da Hsuan

Senior Vice President for Global Strategy,
Planning and Evaluation
National Tsing Hua University



“...No one in the 20th century would think that this sleepy town known as Macau would one day “hail Mary” to the front line of higher education. Who would have thought in the 20th century that by the early part of the 21st century, Macau would “rent” land from the Mainland in order to build a world class university? The fact that this is now a reality within grasp tells us how far Asia Pacific has come along, **POLITICALLY, CULTURALLY AND ECONOMICALLY!**”

For me, the University of Macau should be viewed as Asia Pacific’s higher education window for the world. If successful, its impact will be global! The World must focus on this development of Macau!”

On March 6-8, 2013, Vice Rector of University of Macau, Professor Haydn Chen (程海东,) graciously invited me to visit the university, and to deliver one of the “Liberal Arts Lectures,” a series he initiated several months ago since assuming the position.

In land mass, Macau is tiny. It has roughly 30 square kilometres. This “minuteness” is only matched by its small population of about half a million. Politically, Macau was a Portuguese colony since the 16th century. In 1999, it became a Special Administrative Region (SAR) of the People’s Republic of China. It is the second region (the first is Hong Kong) to take on this special feature under the now world famous auspices of the so called “one nation two systems” (一国两制). Since becoming an SAR, Macau has made enormous stride in economic development. Its “gaming” industry, an euphemism for “gambling” industry, has grown exponentially. Indeed, today, Macau’s gaming revenue is many times larger than its closest competitor, Las Vegas in the United States.

The higher education history of Macau is a short one. Prior to 1981, there was for all practical purposes, no tertiary educational institutions. Secondary schools’ graduates of Macau either would go to Hong Kong, Taiwan, the Mainland or overseas for advanced education. This situation was altered somewhat when University of Macau (UM 澳门大学) was founded in 1981 as a private institution. Later, in 1991, some eight years before the “political hand-over,” UM’s ownership was transferred to Macau’s government, thus becoming a public university.

I suspect that with the looming hand-over in the horizon, the Portuguese colonial government probably did not have the time or the resources, and maybe even more important, the need to seriously considering building UM into a modern university. For these reasons, UM’s campus, just as Macau, is minute. It is roughly 1/20th of a square kilometre. It must be one of the smallest, if not the smallest, land area universities in the world. Indeed, there would be no area to expand even if the desire was there, and I suspect there was not!

Hence, just as 20th century ended for Macau rather quietly, so was the University of Macau!

There are a number of regions in the world who made gaming industry its primary or sole economy. The one I mentioned earlier, Las Vegas, is one. Atlantic City in New Jersey is another. On a much smaller scale, Monte Carlo in Europe is another. Then there is Macau. All the others are situated in North America or Europe. Macau is the only one in Asia and it is the only one that in the 20th century had undergone monumental political transformation.

That transformation would be nothing extraordinary if Macau merely leveraged the opportunity to render it from a small gaming center in the 20th century to become a mega size gaming center in the 21st century. If that were the case, Macau could be considered as merely a larger Las Vegas.

But something in the middle of the first decade of the 21st century made Macau absolutely and stunningly

different from all its counterparts in North America and Europe. The leadership of Macau, having now acquired a very deep financial pocket, began to think of how to leverage this “new found wealth” to transform Macau into something that it was not before.

They realised that what was sorely missing in Macau was a world class university. The leadership of Macau inherently understood that for Macau to reach the next level of being a world class city, it must become a city of “knowledge!” Not having a world class university could be and was the major stumbling block in having that eventuality to occur!

So their attention turned to the only public university in Macau, UM!

Building a world class university needs at least four major components:

- (1) **Financial resources;**
- (2) **Strategically minded and sustainable leadership team with courage and vision;**
- (3) **Land mass to expand.**
- (4) **Hire world class faculty and attract world class students!**

Macau has already possessed the first one. For the second component, it has launched a worldwide search for a new Rector (a Portuguese terminology for a President) of the university.

The third component became a major challenge. As I mentioned, Macau, with only 30 square kilometres, had absolutely no land to spare. If UM could not expand landwise, then there was no hope that it could one day become a world class university.

There is a Sung Dynasty poem by the famous poet Lu You, in which two lines read as: 山重水复疑无路，柳暗花明又一村. Essentially, it means that however hopeless the situation may appear to be, there is always a way out. This philosophy, it appears to me, is the underlying reason why Asia Pacific today is one of the most robust regions in the world. People always seem to find a way to mitigate difficulties.

The solution to the problem of land sounded almost like a **miracle**.

The following is a map of Macau and the surrounding area, which is entirely within the jurisdiction of the People’s Republic of China. There are two parts of



University of Macau’s new campus on the Hengqin Island, Guangdong Province.

Macau, a northern part which is a peninsula linking with the Mainland and a southern island known as Tum-Zai (Cantonese pronunciation 氹仔.) Sitting on the western side of Tum-Zai, just across a narrow water of about 250 metres wide is a large and totally underdeveloped island of the Mainland known as Hengqin Island (横琴岛.)

Apparently someone in Macau's leadership in the fledgling era of the 21st century figured out that perhaps the university could acquire land there for expansion. There were two problems which needed to be solved.

First, the land is not in Macau.

Second, even if UM could build a campus on Mainland's land, the legal jurisdiction would be Mainland's and not Macau's. That means in that scenario, the university would be a Mainland university and not Macau's.

Facing these two challenges, the Macau's leadership decided to "kill two birds with one stone." That is to negotiate with the Central Government of the People's Republic of China of "renting" 1 square kilometre of land in Hengqin Island to Macau. The land would then be utilised by the Macau Government to build a new campus of University of Macau. This was a very complex issue because by doing so, Macau and the Mainland *de facto* would have to redraw their border. The laws in this 1 square kilometre will be that of Macau's. For example, the currency would be Macau's dollars and not Renminbis!

Another interesting feature about Macau as an SAR: it has no water rights. So the surface of the water between Tum-Zai and Hengqin is under the Mainland's jurisdiction. This means that if one were to utilise a boat to cross from Tum-Zai to Hengqin, then the passenger

would have to cross the "Mainland," and presumably obtain whatever travel document that is needed to do so. One can easily imagine the bureaucratic nightmare associated with that scenario!

Remarkably, after several years of negotiation, the government of People's Republic of China accepted these conditions. To ensure that one could overcome the issue that China owns the surface of the water, it was negotiated that building a tunnel under the water would be in the jurisdiction of Macau!

Hence, in 2009, pumping into close to US\$2 billion, with a "b", into the construction project, a new campus of more than 80 very large and ultra-modern buildings on the "newly acquired land of Macau" on Hengqin Island broke ground! In the following photos which I took a few days ago standing on the side of Tum-Zai, you could see that breathtaking view of the new campus is near completion!

It is worth pointing out that all the mountains in the background behind the buildings belong to the People's Republic of China!

In the Q&A session of my speech, I made the comment that going suddenly from a 1/20 square kilometre campus to a 1 square kilometre campus is analogous to what we learn in thermodynamics, and that is the "non-adiabatic expansion of a gaseous system." When expansion of a gaseous system is very fast, faster than the system has no time to readjust to the new conditions, chaos is inevitable! But, this is certainly preferred over the alternative in this case, which is no expansion at all. Facing such an immediate and somewhat uncertain future, it is no wonder that everyone I talked to in my two days at UM, from leadership to students, was full of enthusiastic anticipation!





A breathtaking view of the new campus

Will UM eventually become a world class university? I think only time will tell. The fourth challenge I outlined earlier should not be underestimated. In discussing with the leadership and many faculty and staff members, I sensed that all recognised the fundamental challenges UM faces. But I do sense there was palpable and ubiquitous sense of optimism. With that, I think the battle is already half won!

I have often said lately that it is really incredible, and perhaps purely because of serendipity, that there were many things that were simply “unthinkable” in the 20th century are now “thinkable” in the 21st century. For example, building international high-speed rail in Asia Pacific was unthinkable in the 20th century, be it economically or politically. Yet in the 21st century, it is now thinkable.

No one in the 20th century would think that this sleepy town known as Macau would one day “hail Mary” to the front line of higher education. Who would have thought in the 20th century that by the early part of the 21st century, Macau would “rent” land from the Mainland in order to build a world class university? The fact that this is now a reality within grasp tells us how far Asia Pacific has come along, **POLITICALLY, CULTURALLY AND ECONOMICALLY!**

For me, the University of Macau should be viewed as Asia Pacific’s higher education window for the world. If successful, its impact will be global! The World must focus on this development of Macau!

How exciting indeed!



Speech by **Mr George Yeo** at the **Conferment of an Honorary Doctorate** at **The Hong Kong Polytechnic University**

27 OCTOBER 2012



Mr George Yeo
IAS Patron

Chairman Yang, President Tong, Guests and Friends,

I am deeply honoured by this award from The Hong Kong Polytechnic University and would like to dedicate it to the young people of Hong Kong and Singapore.

I dedicate it to the young because they have to rebuild a world that is corroding.

Technology and globalisation have altered the power relationship among human beings, enabling old lines of authority to be bypassed. With the ease of travel and communication, individuals enjoy choices and freedoms which never existed before.

Everywhere old hierarchies are breaking down. The relationships between parents and children, teachers and students, doctors and patients, priests and flock, government leaders and citizens, are changing dramatically. The social media has become unstoppable.

However, what all this will lead to is not chaos but the emergence of new patterns in the organisation of human society.

Human communities will increasingly be defined not by geography but by networks. Each of us has multiple loyalties and we do not want to have to choose from among them.

Human society will have to be rebuilt from the bottom up, strand by strand, network by network, on the basis of trust and respect for diversity.

In times of great transition, it is natural that the burden of leadership should shift to younger members of society. Communities and organisations trying to prevent this will be left behind.

Hong Kong and Singapore are two cities most alive to the changes taking place in the world. Because we are so connected, our citizens are among the first to feel the stresses of change. But we can also be among the first to adapt to them, helping to create new patterns for the future. In this exciting journey, the spirit of the young will be decisive.

(From left):

Prof Timothy W. Tong (President of the Hong Kong Polytechnic University), Prof Xie Heping (President of Sichuan University), Prof Harry Lee (Chairman of Textile Alliance Limited Group), Prof Chung K. Law (Robert H. Goddard Professor of Mechanical and Aerospace Engineering at Princeton University), Mr George Yeo (IAS Patron, Vice Chairman of Kerry Group) and Ms Marjorie Yang (Council Chairman).



Nobel-Winning Chemist **Professor** *Aaron Ciechanover* **on Science Education and Life**

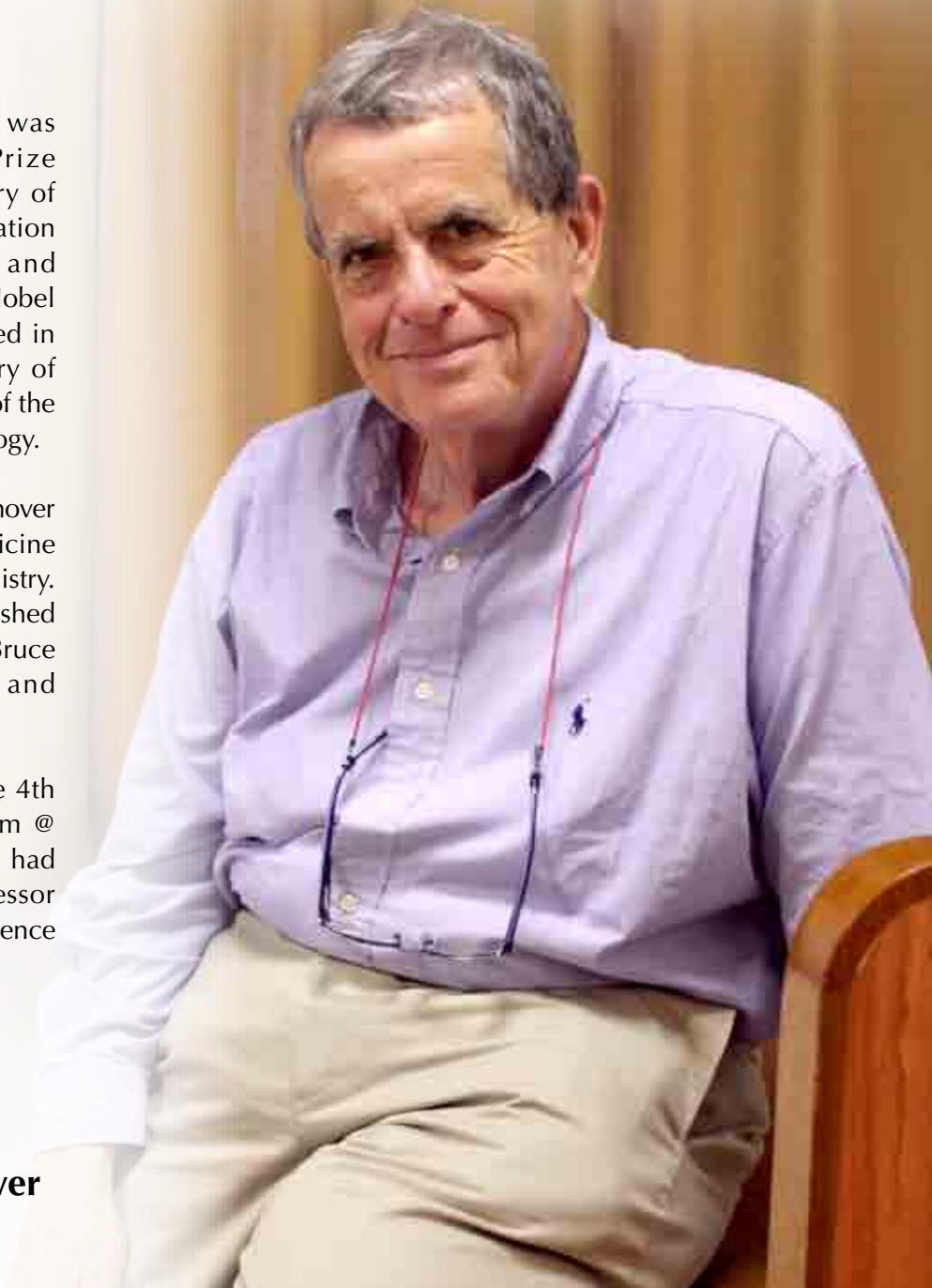
Priscilla Kham

Professor Aaron Ciechanover was awarded the 2004 Nobel Prize in Chemistry for his discovery of ubiquitin-mediated protein degradation with Professors Avram Hershko and Irwin Rose. As one of Israel's first Nobel Laureates in Science, he is honoured in playing a central role in the history of the state of Israel and in the history of the Technion - Israel Institute of Technology.

Born in Haifa, Israel, Professor Ciechanover left his initial course of study in Medicine to pursue his true passion in Biochemistry. He is currently a Technion Distinguished Research Professor in the Ruth and Bruce Rappaport Faculty of Medicine and Research Institute at the Technion.

Professor Ciechanover attended the 4th International Science Youth Forum @ Singapore in January 2012. The IAS had the opportunity to hear from Professor Ciechanover his personal views on science and life.

Professor Aaron Ciechanover
Nobel Laureate in Chemistry, 2004



I've read in your biography that you've met very inspiring teachers when you were still a student. How did they influence your interest and passion in the sciences?

It started in high school where my teachers in biology and chemistry were taking me hand-in-hand. They were very personal, and they noted that I was interested so they nurtured my interest by challenging me, by giving me work, asking me questions, and most of all by encouraging me. They inspired me to think out of the box and to challenge them as well.

I also had very good teachers in medical school in University and later in biochemistry, for example my mentor Professor Hershko who worked with me and thus shared in winning the Nobel prize. At MIT I had a very good mentor, Harvey Lodish, with whom I did a post-doctoral fellowship. I think that mentorship is critical mostly through encouraging you and I had very good mentors along the way. I felt that they were very much interested in what I was doing on a personal level.

Having been a faculty member yourself, did you try to instil any particular qualities in your students?

I do encourage them and I take them very seriously. I teach them how to tackle failure; I try to tell them that failure is a part of life. I talk to them a lot about their careers, advising them on where to go. I hope I inspire them. I have one student that became a professor. Several others are on the way so I hope that I will grow a generation of my own.

Could you tell me a bit about any challenges that you met in your study of ubiquitins and how you managed to overcome them?

Well, you learn to tackle failure, and you understand that failure is a part of success. If you only succeed and not fail then you never learn. So you fail, then you analyse why you fail. There are many reasons to failure: maybe the idea was wrong, maybe the idea was right but the performance was bad. So you analyse it and then you go back and repeat the experiment, with a little variation and in the end, you succeed.

Do you find the process of analysing frustrating and tedious?

Well it's not a matter of time, it's a necessary process. Without analysing your failure, you'll repeat the same mistakes again and again, and you don't want to do that.

Your discovery of ubiquitins helped in the process of developing anti-cancer drugs. Can you tell us a little about that and what you hope your discovery will ultimately achieve?

Well let's be honest, we didn't know the discovery was going to take us that far. We were doing things out of curiosity. Then a point comes where you realise, "Wow, it's new", but you don't know whether it is important. New is not necessarily important and important is not necessarily new. Then other people started to work on it and all of a sudden, you start to swim along and you see that you are swimming in the middle of a crowd and you say, "Wow it's important, other swimmers jumped into the pool also." It's a gradual process and not something that comes about overnight. It takes years until you realise it's important.

Congratulations on receiving the Humboldt research award. Can you tell me more about the projects you will be undertaking and how you feel about receiving this award?

We are now studying some mechanisms of cancer, maybe one day there will be another drug... I don't know. I'm going based on my gut feeling, I don't focus on developing drugs, I don't think of big things. I'm just driven by my curiosity. I have a big laboratory with very good students and I try to stay excited about science. I'm not dreaming to rescue the world.

Who do you think bears the most responsibility in breaking down the walls of knowledge that prevent us from discovering new things?

I think good, curious people should do it. Yes, governments should fund it, it's their responsibility. But, you know, human beings are very smart and if you are passionate about what you do and you're good at it, you will break the walls of knowledge.

Do you feel that these walls of knowledge are the biggest barrier preventing us from getting even further?

Well, there are financial barriers too but you cannot jump over knowledge. Let's say I give you a billion dollars, ten billion dollars, a hundred billion dollars and I tell you: "In one year, break cancer, bring me the drug". You cannot do it, because you need to overcome certain steps of unknowns in knowledge and that takes time. Money helps but it's not the only limitation. We need to move step by step, we need



Prof Ciechanover in his laboratory at Technion-Israel Institute of Technology in Haifa, Israel.

to move sequentially. You cannot jump over steps of knowledge unless you are very lucky but that doesn't happen too often.

What ingredients do you think will create the best environment to nurture budding scientists?

You need a critical mass of good people, scientists don't work alone. You also need infrastructure and very good students. You need enthusiasm and passion around you to stimulate others and to stimulate yourself. You cannot tell what the most important ingredient is. It's like asking what the most important organ in the body is: the mouth, the eye, the brain or the kidney. The brain cannot live without the kidney and the kidney cannot live without the brain. Science is the same, it consists of many parameters. But mostly, it's about nurturing in an encouraging environment, and having an appreciation of the value of knowledge and science.

What do you feel are some of the factors in achieving success in one's field of work?

I think that in time, the borders between disciplines

will break. Biology will link to chemistry, and the usage of mathematical tools. We are now moving toward greater merging of disciplines. Let's say you are interested in something very peculiar, but developing a career in it requires elements from other disciplines, so you will need to work with other people. You don't need to know it all, we are not Renaissance people. What I am saying is that people will start to work together. For example, now I'm working with chemists, because I'm not a chemist and I do not have the knowledge in chemistry. Also, it's more fun to work with other people, they teach you things and you can have discussions, so working across disciplines is very exciting.

From all your years of research and study, what are some of the most important lessons that you can share with aspiring readers?

Only one: passion. Love what you do. Don't do it because you have to bring home money at the end of the month. If your hobby is your profession, then you're okay. Don't go to work everyday, go to your hobby everyday. And then the rest will work itself out.

Notes on the Writing of Scientific English for Japanese Physicists

Professor Anthony J. Leggett

Nobel Laureate in Physics, 2003

Reprinted with permission from the Physical Society of Japan



Introduction

These notes are emphatically not intended as a comprehensive guide to the writing of scientific English; I am sure there already exist many good books devoted to this purpose. However, during my work over the past year correcting the English of papers submitted to “Progress”, I noticed that certain patterns of mistake turned up over and over again; many of these, it seemed, could be avoided by the use of a fairly simple rule. These notes, therefore, are simply an attempt to eliminate some of the more common errors and sources of obscurity which sometimes make “Japanese English” difficult to read.

The main guiding principles I have used are the following. First, it is much more important that the English written by Japanese authors be clear and easily readable than that it be elegant. Therefore, in a situation where there is a choice between an elegant form of expression which, however, may easily lead to confusion if misused and a less elegant but practically “foolproof” one, I have never hesitated to recommend the latter. Secondly, the importance of avoiding a mistake is roughly proportional to the amount of misunderstanding it may entail and/or the amount of psychological “wear and tear” it may cause on the reader’s nerves. Accordingly, I have spent a good deal of space on “macroscopic” points like sentence construction, and proportionately less on “microscopic” ones like the correct use of “a” and “the”; prepositions, which most Japanese writers seem to consider a major point of difficulty in writing English, I have scarcely mentioned, not only because this is the sort of point for which one can easily refer to dictionaries but because I believe the reader can usually correct any mistakes for himself with very little mental effort. Thirdly, the usefulness of a set of notes such as this is much reduced if the rules given become too complicated. Therefore, rather than give a complicated set of rules which would ensure correctness 100% of the time, I have often preferred to give a simple rule which will be right 95% of the time,

provided that in the other 5% of cases, it is unlikely to lead to confusion. I do not claim that anyone who tries to follow the advice given here will write beautiful or even invariably correct English; but I hope that what he writes will be clear and readable and that any mistakes he does make will be minor ones.

The order in which the subject-matter is arranged is, roughly speaking, from “macroscopic” to “microscopic”; consequently, the points covered in the earlier sections are of more fundamental importance but the advice given is necessarily somewhat general and vague, while the latter sections cover more detailed points where fairly precise rules can usually be given. I hope any notation used will be self-explanatory (“A → B” means A is incorrect and B is the correct replacement). Most of the sentences quoted as examples of typical errors are either entirely my own invention or are substantially changed from their original forms; it is not claimed that they necessarily make sense as physics.

I should like to express my gratitude to Dr. K. Nishikawa, who generously devoted a good deal of time to constructive criticism of these notes. The responsibility for the opinions expressed remains of course entirely my own.



Professor Anthony J. Leggett
Nobel Laureate in Physics, 2003

§1 General

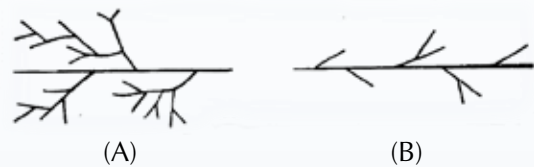
At first sight, it is tempting to think that the problem of writing good English is solved if one can write good Japanese and then give a perfect translation. I believe this is not necessarily true. “Japanese English” [1] has the peculiar property that it can be grammatically perfect and yet, if not completely unintelligible, at least “opaque” and baffling to the average English reader. This property is often shared by English translations (even by expert translators) of articles written originally in Japanese; it is clearly, therefore, not due to bad translation.

I believe, therefore, it is necessary to recognise that some *patterns of thought* which are acceptable in Japanese may be unintelligible or puzzling in English (and, no doubt, vice versa). Moreover, ways of saying things which make sense against a Japanese background may either be nonsense or give quite the wrong impression when interpreted against a Western European one. (For instance, if you state a conclusion tentatively or indefinitely, a Japanese reader will understand that this is because you do not wish to be too blunt or assertive, but a European reader will often conclude simply that you are not really sure about it). Since, presumably, the vast majority of your readers will share the Western European background, it is necessary to make allowance for this fact. Of course, this problem is less important in scientific writing than in some other kinds, and the vast majority of Japanese physicists obviously recognise and make allowances for it; however, when it is not recognised the resulting confusion is so deep-seated that it is worth emphasising in some detail.

Here are some ways in which I believe acceptable modes of expression may differ in English and in Japanese.

1) In Japanese it seems that it is often legitimate to state a number of thoughts in such a way that the connection between them, or the meaning of any given one, only becomes clear when one has read the whole paragraph or even the whole paper. This is not so in English; each sentence should be completely

intelligible in the light only of what has *already* been written. Moreover, the connection between one thought and the next should be completely clear when it is read; for instance, if you deviate from the “main line” of the thought to explore a side-track, this should be made clear at the point where the side-track *starts*, not where it finishes. Perhaps this is the best illustrated by the following diagram, where the “direction of reading” is from left to right:



To an English reader, the Japanese pattern often seems to be like (A), whereas only (B) is usually allowable in English. Notice also that the tree in (B) has only a few branches; in English it is usually not a good thing to wander too far off the “main track”. [2]

2) In English the sequence of thought should always be made quite explicit, even when, in Japanese, it would be legitimate to leave the reader to fill in the connection for himself. A common vice of J.E. is the writing of sentences like “It is uncertain whether this resonance should be assigned to the (56) or (82) representation, though Jones has suggested that its spin is $1/2$ ” (where the reader is left to fill in “which, if true, would force us to assign it to the (56) representation”). Of course, to some extent what you may safely leave out depends on the degree of background knowledge you are presuming in the reader, but it is much better to be over-explicit than not explicit enough. Western readers sometimes compare J.E. to a classical Japanese painting; the reader has to fill in most of the picture for himself. If he is used to doing this, of course, it presents no great difficulty, but most English readers are not and the effect is merely bewilderment.

3) In English it is essential to be precise and unambiguous. You may sometimes feel that it is advantageous to leave a certain amount of ambiguity in a statement, — a certain amount of “room for manoeuvre” as it were; but this is never allowable in English. Ask yourself continually “what *exactly* does this

[1] Hereafter abbreviated J. E.

[2] If you want to make a lengthy excursion, it is often better to do so in a footnote.

sentence mean?" If you can't answer this question, it is usually best to leave the sentence out altogether.

Similarly, when you write an "it" (or "which," or "this," etc.) always ask yourself "what?" An "it" in English should always refer to something definite,[3] and moreover something which has already been mentioned in the text (it may of course be something quite complicated, like "the fact that..." — in this case the word "fact" itself of course need not have occurred). Too many Japanese writers appear to use "it" to refer to something which they have in their minds and they expect the reader to have in his!

4) Japanese seems to have a strong tendency to avoid too definite or assertive a statement, possibly because it is thought presumptuous to impose one's own views on the reader without conceding that there are possible alternatives. This notion is completely foreign to most Western readers, and they will usually be unable to make the "mental jump" necessary to appreciate it; if you state your opinion vaguely because you want to leave room for various possible interpretations besides your own, they will often simply take this as a sign of vague and muddled thinking.

Therefore, try to be as definite and assertive as possible, even it feels a little unnatural. If you have definite, concrete reservations about your views, or conclusions, then state them explicitly (in a footnote if necessary); if not, then don't try to soften the force of your assertion at all.

In particular, it is almost hopeless to try to translate phrases like "であろう", "と行ってよいのではないかと思われる", "と見てもよい" etc. into English (see also section 6); if you find you have to think out your sentence in Japanese and then translate it (a process which is of course not to be recommended but may be unavoidable for many people) then before translating change the first to *である* and leave out the second and third altogether.

5) To an English reader, Japanese (and J.E.) often seems vague and diffuse — there seem to be many

clauses or sentences which add nothing substantial to the meaning. In English, on the contrary, every clause should "pull its weight". In particular, it is a very bad habit to imply vaguely that there is something more to be said unless you intend to say it explicitly. Thus, sentences like the following should usually be avoided:[4]

"This may give a very definite picture."

"This may be viewed from the standpoint of various considerations."

"It will be essential to study the problem from this point of view."

"This is useful not only for... but also for examination of the effect from various sides."

Such sentences are quite legitimate if they introduce an explicit discussion; for instance, the first is all right if you go on to describe the "definite picture" or the second if you go on to enumerate the "various considerations". However, it is definitely a sign of bad writing in English to use them in isolation as a *substitute* for an explicit discussion. If this were merely a matter of good style one might afford to neglect it without serious confusion; however, I believe it is just such sentences which make a major contribution to the peculiar "opaqueness" of some J.E..

The point is that the English reader is not usually expecting such sentences in isolation, and therefore if you make "microscopic" (grammatical and other) mistakes in it he will often be unable to guess the intended meaning from the context. Therefore, if you don't want to state an idea or set of ideas explicitly, don't refer to them at all.

To summarise: make sure that your argument runs as a logical *sequence* and that no essential steps are left unwritten, be as precise, unambiguous and explicit as you can, and don't hesitate to state your conclusions boldly and definitely. Once this is done, the problem of writing good English is indeed largely reduced to the problem of good translation.

[3] Except of course in certain special grammatical constructions, such as "it is clear that..."

[4] The isolated examples given here are in fact unlikely to lead to very serious confusion. To give an example of a sentence of this type which could completely baffle the reader would require writing out the whole context.

§2 Sentence Construction

Write short sentences.

This may seem unnecessary advice since random sampling shows that the average sentence in “Progress” is already a good deal shorter than that in “Phys. Rev.”; you may in fact sometimes hear Westerners criticise J.E. on the grounds that the sentences are too short and it reads jerkily. To some extent this is true, but this is a small defect and it is very much less wearing on the nerves to read a succession of short sentences, with the connection between each properly indicated, than to have to try to sort out a long and ill-constructed one.[5] The shorter the sentence, the less the chances of serious ambiguity. So, if your sentence is more than 40 words long, you should think seriously whether you cannot break it up with at least a semi-colon (see below); as to the *average* length of a sentence,[6] 20 words is a good average to aim at and even 15 is probably not too short.

Remember in any case that the English sentence is a system of strictly limited *capacity*; it can tolerate only a few subsidiary clauses and these must all be fitted tightly into the sentence structure. *There is no analogue of the Japanese “suspensive” construction in English.* The following points should be given special attention:

a) If you have an important idea to express, don’t put it in a subsidiary clause. Instead, start a new sentence. For example, consider the following sentence:

“Compared with the Nagoya model, these newer models seem to be rather more plausible in explaining the mechanism binding the baryons and leptons, by introducing a third quantum number besides the usual isotopic spin and hypercharge and by considering the existing baryons and bosons to represent a neutral state of this quantum number, although they must generally produce many particles so far undiscovered, as a result of the increased number of elements and the reduced symmetry.”

This sentence (76 words) is much too long on general grounds. In addition there are presumably three different important ideas in it:

- 1) The newer models are better than the Nagoya model in explaining the binding mechanism.
- 2) The origin of this superiority is the introduction of a third quantum number, etc..
- 3) Nevertheless they predict many particles so far undiscovered. Each of these ideas deserves a sentence, or at least a main verb, to itself. Thus,

“Compared....leptons. This is because they introduce....number. However, they must.... symmetry.”

This point applies particularly to sentences containing a long relative clause as the final part. For instance, consider:

“From eq. (3.10) we get the final result that the inelastic shadow scattering must dominate the cross-section above a few tens of BeV, if we assume $SU(6)$ symmetry and take the parameter λ to have a reasonably small value, which is in strong disagreement with the experimental results unless we assume a very peculiar form for the function $f(S)$, as was shown by Brown from considerations of crossing symmetry.”

Again this sentence is too long, and in addition the fact that the result is in disagreement with experiment is an important new point. Thus,

“From....value. This result is....symmetry.”

(Another good reason for breaking up the sentence in this way is that as it stands it is not clear what the “which” refers to — see also below (section 3)).

b) Don’t suspend a subordinate clause or phrase at the end of a sentence when it is not perfectly clear what it refers to. Be especially careful with clauses beginning

[5] To some extent jerkiness can be avoided by replacing some of the full stops with semi-colons (see below).

[6] That is, (number of words) / (number of periods *plus* semi-colons).

with “as” “similarly to” or “by (in)ing.” A very common and misleading type of case is the following:

“We find that the function $F(x)$ has an infinite range but the magnetisation below T_c does not tend to a finite value, as was suggested by Brown.”

From this sentence as it stands the reader who is unfamiliar with Brown’s work may draw any one of three conclusions about his suggestion:

- 1) The function F has a finite range and the magnetisation does not tend to a finite value.
- 2) The magnetisation does not tend to a finite value (no conclusion about F).
- 3) The magnetisation tends to a finite value.

It is easy to remove the ambiguity by breaking the sentence up into two, either by a full stop or by a semi-colon (see below). According as the meaning is 1), 2) or 3) we should write:

- 1) “We find.... value. These results agree with the suggestion of Brown.”
- 2) “We find.... value. This second result agrees with....”
- 3) “We find.... value. This second result conflicts with....”

This is not necessarily always the most natural way of removing the ambiguity but it is by far the safest. Compare also the sentence:

“This feature seems to be disadvantageous to the collective nature of the excitation.... especially in bringing about a large transition probability.”

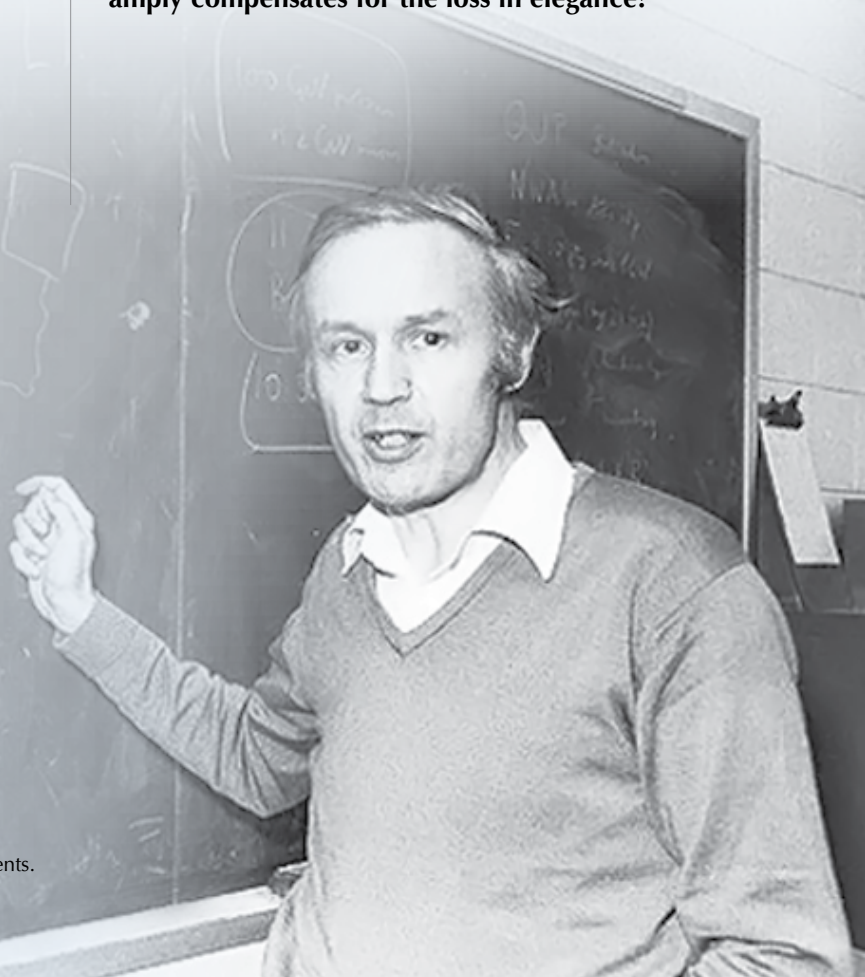
As it stands it is not clear whether this means that the feature in question does or does not bring about a large transition probability (though I think most readers would assume that it *does*). Again a straightforward way of removing the ambiguity is to start a new sentence:

“In particular, it brings about....”

or

“In particular, it cannot bring about....”

In short, whenever you are tempted to write a subsidiary clause after the main one, ask yourself whether it wouldn’t be better to start a new sentence. This may sometimes be the less elegant alternative but, provided it is grammatically possible, it is rarely wrong and the gain in intelligibility usually amply compensates for the loss in elegance!



Use of the semi-colon.

Too many Japanese authors (like many English ones, unfortunately) seem unaware of the existence of this punctuation mark (;). Roughly speaking, it is used to break up a long sentence when the ideas are too closely connected to be put in separate sentences; it indicates a break in the thought considerably stronger than that implied by a comma but weaker than that implied by a full stop (period). For grammatical purposes it is equivalent to a full stop. Thus, consider the sentence.

“High energy scattering above a few GeV is investigated as the shadow scattering of multiple production, for which phenomenological, peripheral and uncorrelated jet models are used.”

In this sentence the clause beginning “for which” is important enough to stand by itself, but since it is so short and so closely connected with the rest of the sentence a full stop would give an unnecessarily jerky effect. Thus, use a semi-colon:

“High energy.... production; phenomenological.... used.”

In many other cases, when you are tempted to start the second part of a sentence with “...., which....” or “...., and it....” it is much better to put a semi-colon: “....; this (result)....” etc.. In most cases it is largely a matter of taste whether to use a semi-colon or a full stop. (But remember that it is unusual for a sentence to contain more than one semi-colon.) However, ample use of the semi-colon will help to avoid over-clumsy sentences while giving a less jerky effect than a sequence of completely detached sentences.

Keep qualifying phrases and clauses to what they qualify.

Consider the sentence:

“We investigate the scattering of pions by protons at a few MeV, paying special attention to the problem of the imaginary part of the phase shifts, which was previously discussed by Jones, who assumed a hard-sphere potential, in the SU_3 model.”

As it stands it is not clear whether “in the SU_3 model” refers to “discussed by Jones” or to “we investigate.” In

either case it should follow the verb directly “discussed in the SU_3 model” or “we investigate, in the SU_3 model,....” (Actually this sentence would in any case better be broken up, with a semi-colon after “shifts”.)

Similarly consider:

“The theory can explain the magnetic moments of the baryons, the approximate $SU(6)$ symmetry scheme satisfied by all lowlying resonances and the fact that the scattering amplitudes appear to be well predicted by the Smith formula in a unified way.”

Here it looks as if “in a unified way” qualifies “predicted” whereas it presumably is actually meant to refer to “explain.” Thus we should write

“The theory can explain in a unified way the magnetic moments.... Smith formula.”

Try to avoid qualifying a word by more than one phrase or clause; if this is unavoidable it is generally better to put the shorter and less important one first. Thus, e.g.

“We can carry out the integration in a straightforward way by making the substitution $x = y^2$ and transforming to polar coordinates” (not “we can... integration by making.... coordinates in a straightforward way”).

Above all, make sure that qualifying clauses and phrases qualify something which is actually *in the sentence*, not something in your mind.

Typical of a common fault in J.E. is the sentence

“The proton and neutron masses are different by considering the effect of the pion cloud.”

“By considering” here is obviously meant to qualify some unwritten verb like “understand” or “explain”, but this is not allowable in English, so we must write, e.g.

“We can understand (explain) the fact that the proton and neutron masses are different by considering....” (or, of course, “the proton.... are different *because of the effect*....”)

This particular example is fairly easy to disentangle, but I have read many similar ones where this mistake could make the sentence quite unintelligible.

In short: remember that in English every subsidiary clause and phrase must have a definite place in the sentence structure, and that as far as possible this place should be clearly indicated by the sentence order. Don't hang subsidiary clauses on to the end of a sentence if you are not sure just where they fit in — start a new sentence instead.

§3 Relative Clauses (..“which...”, “who...”, etc.)

English distinguishes quite sharply between two types of relative clauses (as far as I know, Japanese does not make this distinction explicitly): those which *identify*

and those which *describe* or state a further fact about the subject of the clause. In the second type a comma is put before the “which”, in the first it is omitted. Thus, distinguish the two sentences:

- a) “We find the solution of eqs. (8–10) which remains finite as $x \rightarrow 0$.”
- b) “We find the solution of eqs. (8–10), which remains finite as $x \rightarrow 0$.”

Sentence (a) implies that there are (or at least may be) other solutions which do not remain finite; it *identifies* the solution which we find. Sentence (b) on the other hand implies that the solution is unique (otherwise the “the” would be replaced by “a” (see section 9)) and, further, states that it remains finite. In this case and in many similar ones we could rewrite (b) as:

Prof Leggett having a light moment with students.



"We find the solution of eqs. (8–10); this remains finite as $x \rightarrow 0$."

In fact it is probably better to rewrite it this way whenever it is grammatically possible. But, in any case, remember that the insertion or omission of a comma can change the meaning entirely.

Generally speaking, a relative pronoun (in either of the senses a) or b)) should immediately follow the noun to which it refers. (This is always true for type-b sentences) "Some solutions were obtained by Jones which satisfy (3.9.)" is best avoided;^[7] and "the pion parity which is emitted in the reaction" is *never* allowable (it is the pion which is emitted, not the parity).

A common case in which this rule does not apply is when the noun is qualified by some other phrase as well as by the relative clause: e.g.

"the solution of eqs. (8–10) which remains finite"
[type (a)],

"the solution found by Smith, which remains finite"
[type (b)].

Be very careful to avoid ambiguity, however, in this kind of sentence; in the above examples both grammar and sense tells us that "which" must refer to "solution" and not to "eqs. (8–10)" or to "Smith", but in other cases it may not be obvious. Consider for instance:

"Let us consider the solutions of the equations which were found by Jones" [type (a)]

"One then gets periodic solutions to the dynamical equations, which agree with those found by Jones"
[type (b)].

Did Jones find the equations or the solutions? A reader with a detailed background knowledge of the subject may know, but you should never take such background knowledge for granted if you can possibly avoid it by rewriting the sentence in an unambiguous form. In a type-b sentence this is very easily done by starting a

new sentence after "equations": "...equations; these equations agree.." or "...equations; these solutions agree..." as the case may be. Case (a) is rather more difficult; a somewhat inelegant but foolproof way of removing the ambiguity is to replace the "the" in front of the noun to which the "which" refers by "those":

"Let us consider those solutions of the equations which were found by Jones"

or

"Let us consider the solutions of those equations which were found by Jones."

Again, the sentence

"We consider the irreducible subspaces of the space to which P and Q belong"

may be ambiguous under certain circumstances; it can be made unambiguous by rewriting it, according to the meaning, either as

"We consider those irreducible subspaces of the spaces to which P and Q belong"

or as

"We consider the irreducible subspaces of that space to which P and Q belong."

If you do not do this, then generally speaking an English reader will tend to take the "which" as referring to the last noun to which grammar and sense permits it to refer (that is, to "equations" and "space" in the examples given above). Remember that the use of "that" and "those" in conjunction with "which" is confined to type-a relative clauses.

Make sure "which" actually refers to something.

A type-b relative clause occasionally appears not to refer to any noun which actually appears in the sentence, as in:

"This argument predicts that the spin of U is 3/2, which is in contradiction with experiment."

Here the "which" actually refers to "[the prediction] that the spin is 3/2". However, this kind of usage is full of pitfalls and I would therefore advise Japanese writers

[7] This construction is sometimes legitimate but it is difficult to give a general rule.

not to use it if they can possibly avoid it; one of the most widespread vices of J.E. is the writing of relative clauses which apparently do not refer to anything. It is almost always possible to avoid this by beginning a new sentence and referring to the noun explicitly: e.g.

“This argument predicts that the spin of U is 3/2;
this *prediction* is in contradiction with experiment.”

(The same warning, incidentally, applies equally to “this” and “it” — see section 1)

§4 “Any and “All” especially in Negative Sentences

Consider the following two cases:

(a) $\alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 \neq 0, \alpha_4 \neq 0$

(b) $\alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 = 0, \alpha_4 = 0$

We can describe each of these cases in a number of ways: ((3)–(5) would of course be correct only in an appropriate context)

(a)

- 1) “All of the α ’s are different from zero.”
- 2) “None of the α ’s are equal to zero.”
- 3) “We have set all of the α ’s different from zero.”
- 4) “We have set none of the α ’s equal to zero.”
- 5) “We have not set any of the α ’s equal to zero.”

(b)

- 1) “Some of the α ’s are different from zero.”
- 2) “Not all of the α ’s are equal to zero.”
- 3) “We have set some of the α ’s different from zero.”
- 4) “We have not set all of the α ’s equal to zero.”

However, we can *never* say[8]

“Any of the α ’s are not equal to zero”
or
“All of the α ’s are not equal to zero”

It is best to use the rule that “any” can never directly precede a negative, though it can follow it (as in (5a)). If you are tempted to write, e.g., “Any mesons are not

stable,” think carefully whether you mean “No mesons are stable” (= “all mesons are unstable”) or “Not all mesons are stable” (= “some mesons are unstable”). In my experience, Japanese writers who write “any....are not” usually mean “none.... are”; on this assumption the following replacements should be made:

“Any problems.... do not occur”
→ “no problems....occur”

“Anything.... cannot be done”
→ “nothing.... can be done”

(or { “We can do nothing”
“We cannot do anything” })

“Anyone.... has not proved”
→ “no-one has proved.”

“This series does not ever converge” is not actually wrong, since the “ever” (which is analogous to “any”) follows the negative, but “This series never converges” is much more natural. On the whole it is better to replace “not.... any” by “none” or “no” whenever you can;[9] thus 4a) is preferable to 5a) under most circumstances.

“Any” and “all” in positive sentences.

The sentences

- a) “All higher-order terms may be neglected”
and
- b) “Any higher-order terms may be neglected”

have a similar but not identical meaning. a) Implies that higher-order terms certainly exist; b) makes no such implication, but simply says that if they do exist, they may be neglected. “Any” is especially common before a relative clause, e.g.:

“Any interaction which breaks the symmetry will change the results”

The rule about “any” not preceding a negative does not apply, of course, if the negative is in the relative clause; thus the above example could be rewritten.

[8] “All.... are not” occurs occasionally in spoken English in sense (b). However, it is practically unknown in written English.

[9] In this respect usage is different in spoken and written English.



Prof Leggett giving a class lecture at Nanyang Technological University (NTU) in 2008.

“Any interaction which does not conserve the symmetry will change the results.”

§5 “Only”, “Mainly”, “Not Only”

The positioning of “only” is very important.[10] Contrast the three sentences:

- 1) “Only the spin-orbit interactions renormalise the lifetime” (i.e. other interactions do not renormalise it).
- 2) “The spin-orbit interactions only renormalise the lifetime” (i.e. they have no other effect).
- 3) “The spin-orbit interactions renormalise only the lifetime” (i.e. they do not renormalise anything else).

It is best to try always to put “only” immediately before the word which it qualifies.

Thus, if $f(x,y) = x^2 + y^2$, $g(x,y) = y^2$, write “only f is a function of x ” while if $f(x,y) = x^2$, write “ f is a function only of x ”. Avoid “ f is only a function of x ” or “ f only

is a function of x ” which are often ambiguous. If in doubt, it is often possible to rewrite the sentence to make the point quite clear: e.g. we could rewrite 1), 2) and 3) above respectively as

- 1) “It is only the spin-orbit interactions which renormalise the lifetime.”
- 2) “The only effect of the spin-orbit interactions is to renormalise the lifetime.”
- 3) “The only thing renormalised by the spin-orbit interactions is the lifetime.”

Very similar remarks apply to “mainly” (or “chiefly” “principally” etc.) In sentences 2) and 3) “only” could be replaced by “mainly” with the analogous meaning in each case. In sentence 1) this is also grammatically possible but for some reason it sounds rather odd and 1) would usually be rewritten “It is mainly the spin-orbit interactions which....”

“Not only”: Like “only”, this refers to the word which it directly precedes. Thus, e.g.

[10] Here I discuss only the adverbial use of “only”. The adjectival use does not usually give trouble.

“Not only x but [also] y is divergent.”

“ x is not only divergent but [also] meaningless.”

“ x not only diverges but [also] contains a factor T^{-1} .”

If the “not only” refers to the whole clause it is usually necessary to invert the order, e.g..

“Not only *does* x diverge but x contains a factor T^{-1} .”

(However, “not only x diverges”, though incorrect, is unlikely in practice to lead to serious misunderstanding.)

Finally (a somewhat disconnected point): “We have introduced only one free parameter” but “ x is introduced as *the only* free parameter” (not “only one”). Also note “The only free parameters are x and y ” (not “The free parameters are only x and y ”).

§6 “May be” / “Can be” / “Is”

“*May be*” is *not* the equivalent of “であろう”, which indeed is practically untranslatable into English (cf. section 1). The sentence “ y may be a function of x ” implies that you (the writer) *don't know* whether y is a function of x or not; if you use “may be” merely because you think “ y is a function of x ” sounds too blunt, the average English reader will be completely baffled. “May” in English has two main uses:

1) to indicate uncertainty, e.g. “this series may not converge” “the experimental data may be erroneous”

2) to indicate permissibility (in this sense it is often replaceable by “can”), e.g. “We may approximate this term by....” “this term may not be neglected”.

“May” is *never* used in English just to make a sentence sound more polite (the connection between politeness and vagueness is completely unknown in English); so, if your sentence does not fit either of the above cases, don't use it.

If you feel you must find an equivalent for であろう at all costs, probably the best is “we may say that....” (sense (2) of “may”); but it is much better to be blunt and have done with it (cf. section 1) (“we may say that y is a function of x ” sounds odd since this is presumably not a matter of opinion!). Note also that although “it may be interesting/plausible/possible that....” is not wrong, it is more usual to replace the “may be” by “is”.

“*It is shown (proved, demonstrated)*” almost always refers to a definite occasion, very rarely to the fact that something can be proved, has been proved at some indefinite time in the past, or has been proved by the author but not published. Thus, “*It is* (was, has been) shown in ref. (6) that Z_3 is finite” or “*It is shown* in the Appendix that....”, but “*It can be shown* that Z_3 is finite [but we shall not bother to do so here]”. If this remark precedes a proof, then use “can be”: e.g. “*It can be shown* as follows that Z_3 is finite:....” Similarly “*The cross-section can be* calculated as follows:....” Also note “*f(x) can be* rewritten in the form....” (“is rewritten” is sometimes allowable but “can be” is hardly ever wrong.[11])

“*It is thought (believed) that....*” almost always means “it is thought by people (physicists) in general that....” not “I believe that....”. Thus “it is believed that the nucleus consists of protons and neutrons” but “*The present author believes* that this result is incorrect”. Similarly “*V is regarded* as an effective field” means it is so regarded by physicists in general; if, on the contrary, this is a view which you are proposing, say “*V may be regarded* as an effective field” (sense (2) of “may”).

Other common errors of this type:

“is noted”

→ “is to be noted” or “may be noted” or “should be noted”

“is desired (that)....”

→ “is to be desired” or “is desirable”[12]

“is emphasised”

→ “is to be emphasised” or “should be emphasised”

[11] “We rewrite $f(x)$ in the form....” is of course equally good.

[12] However, note “it is desired to express y in terms of x ” (= we wish to express....)



Prof Leggett engaging in discussion with his students.

“is hoped”

→ “may be hoped” or “is to be hoped”

With regard to the last, however, distinguish “it is to be hoped that this question will be investigated” (= I hope someone else will investigate it) from “it is hoped to investigate this question” (= I intend to investigate it myself).

§7 Qualified Adjectives etc.

If an adjective or participle is qualified by a phrase, it *must* immediately precede it.

Examples:

“inverse relation of eq. (7)”

→ “relation inverse to eq. (7)”

“exchanged particles between them”

→ “particles exchanged between them”

“isobaric state of the initial one”

→ “state isobaric to the initial one”

“identical equations with (3.7)”

→ “equations identical with (to) (3.7)”

“relative order of magnitude to”

→ “order of magnitude relative to”

“an intermediate stage of the first two”

→ “a stage intermediate between the first two”

Be specially careful not to write, e.g. “their intermediate stage” instead of “the stage intermediate between them.” or “its identical equation” for “an equation identical with it”. Always think twice before translating ζ の by “its” or “their”. “Its”, “their” etc. can replace only “of it (them)” and even then the replacement is not always correct.

In particular, if the “of” is directly connected to an adjective or adverb, as in “independent of” the replacement is never correct; thus, “the independent solutions of the wave equation” can be replaced by “its independent solutions”, (or, though less naturally, “the independent solutions of it”), but “the solutions which are independent of x , cannot be replaced by “its (i.e. x ’s) independent solutions” — we must write “the solutions independent of it”. When in doubt it is probably safer on average to write “of it (them)”.

An even more misleading type of error is one like the following:

“this is a gauge-transformation invariant of the electron operators.”

Here “of the electron operators” qualifies “gauge-transformation”; we must therefore rewrite the clause

“this is an invariant with respect to gauge-transformation of the electron operators.”

§8 “A” vs “The” vs Nothing

Probably this is one of the most difficult points in the whole of the English language for most foreigners (not only for Japanese!). Luckily it does not usually cause serious confusion if you get it wrong, so I only mention a few points.

“The” usually implies in some sense the uniqueness of the object you are talking about, while “a” (or in the case of the plural, the absence of an article) implies its non-uniqueness. Thus,

“The solution of (3.9) is given by (3.10)” implies that this solution is unique, while “A solution of (3.9) is given by (3.10)” implies at least that there may be other solutions. Compare the following pairs of sentences:

{ “ $f(x)$ is an analytic function of x .”
“ $f(x)$ is the function of x defined by (3.11.)”

{ “ $f(x)$ is a Bessel function” (there are many Bessel functions but only one Airy function.)
“ $f(x)$ is the Airy function.”

{ “Two components of the momentum commute with H ” (assuming the system is three-dimensional).
“The three components of the momentum commute with H .”

{ “Very small values of t are unphysical”
“The very small values of t given by eq. (6) are unphysical.”

{ “We regard x and y as quantities independent of R .”
“We regard x and y as the only unknown quantities in this equation.”

The fact that the noun in question is qualified by a type-a relative clause (section 3) does not necessarily imply that it must take “the”: e.g.

{ “We must look for the metal which has the highest transition temperature.”
“We must look for a metal which has a high transition temperature.”

“ X theory” vs “The X theory”. This is not an important point but a fairly definite rule can be given. If X is the *subject-matter* of the theory, then “ X theory”: e.g. “solid-state theory” “electromagnetic theory” “superconductivity theory”. When X describes the postulates or methods of the theory, or names its author (s), then “the X theory”: e.g. “the quark theory” “the BCS theory” “the quantum theory of radiation”.

Thus, Professor Yukawa formulated “the meson theory [of nuclear forces]” but Schweber *et al.*’s book deals with “meson theory”. Possibly in 1976 there will be “quark theory” but at present there is only “the quark theory”!

In general, however, I would advise authors not to worry overmuch about “a” and “the”; there are many other points which deserve more attention.

§9 Singular vs Plural

The following nouns are never or very rarely used in the plural.[13]

Nature, character, behaviour, notation, knowledge, information, (experimental) support, agreement,[14] emission, scattering, advice, encouragement.

In general abstract nouns describing a process or action are used in the singular unless you are referring to a number of different occasions on which the action took place. A very common example is “*discussion*”: thus,

[13] On the rare occasions when they can be used in the plural, the singular is equally correct.

[14] In physics contexts, at least!



Prof Leggett with NTU's CN Yang Scholars at the dialogue discussion in 2010.

"We give a discussion of this point in section 5"
(not "some discussions"),
but

"The discussions of this point given in refs. (7)
and (8) are inadequate."

(However, "the discussion of this point given in ref. (7)
is inadequate".) It is also conventional to thank one's
colleagues for "helpful discussions".

"*Situation*" is used in the plural only when it refers
to two or more distinct cases. Thus, "This situation
is to be expected" (not "these situations") but "There
is a superficial resemblance between our case and
that studied by Smith, but the two situations are really
entirely different."

"*Experiment*": one usually uses the singular if the
sense is general, e.g. "in agreement with experiment"
"according to experiment" "conflicts with experiment"
"take the values of α from experiment". However,
"the experiments of Jones" "high-energy p - p
scattering experiments". (Distinguish, incidentally,
"experiments" from "experimental data": One usually

says, for instance, "the experimental *data* are subject
to a large error".)

The following nouns are normally used in the plural
when the sense is general; they are used in the singular
only when you are referring to *one particular* property,
etc:

Features, properties, aspects, characteristics,
circumstances. Thus, e.g.: "let us examine (the properties/
some features/ various aspects/ the characteristics) of
this problem." "In these circumstances....", but, e.g.:
"The solution (2.8) has the peculiar property/feature/
characteristic of being invariant under the interchange
of x and y ." "A disturbing aspect of this situation is
that...." "The unfortunate circumstance that f diverges
makes it impossible to...."

Notice in particular that one always says "transformation
properties" "symmetry properties" but (usually),
"Hermitian property" (this is the property of being
Hermitian, whereas "transformation properties" does
not simply mean the property of being transformed).

§10 Words to Avoid or Use with Care

"Image" is practically never used in scientific literature. [15] "Concrete" is much less common in English than 具体的 in Japanese; it is best to confine it to phrases like "a concrete example" or "we chose a concrete form for the potential". "This may give some very concrete images" is typical J.E.: [16] if you must say it at all (cf. section 1) say "This may give a very definite (clear) picture". "Standpoint" is also much less common in English than 立場 in Japanese; "from the standpoint of ..." is often best replaced by "in connection with [the fact that....]" or "in the light of (the fact that)...." Much the same applies to "viewpoint". The words *aspect*, *character*, *nature*, *characteristics*, *features*, *circumstances*, *situation* seem to be particularly troublesome for Japanese authors; I can only recommend you to study their use when you read English papers, or use a dictionary which gives a large number of examples. Here is an example of the correct use of each:

"This equation has a Markoffian character."

"The true nature of
 { the forces binding the baryons }
 { the random-phase approximation }
 is still not well understood."

"The solution (4.3) has a number of interesting features."

"The principal characteristics of the solution are as follows."

"Various aspects of this problem remain insufficiently explored."

"In view of the circumstances mentioned above, experimental detection may prove difficult."

"The situation here is entirely analogous to that encountered in p - p scattering."

In certain cases two or three of these words may be interchangeable (cf. the example in section 9), but it is rash to assume that this is always so.

§11 Miscellaneous

Note the following pairs, which are often confused:

{ "Ferromagnetism is usually *attributed to* the electron spins."
 "The electron spins are usually *invoked to explain* ferromagnetism."

{ "The nucleus *consists of* protons and neutrons."
 "Protons and neutrons *constitute* the nucleus."

If $f(x,y) = f(x)$, then

{ " f is *independent of* y ."
 "[The value of] y is *irrelevant to* f ."
 (unusual)

If $f(x,y) = x^2 \exp - y^4$, then

{ " f is *sensitive to* the value of y ."
 "The value of y is *critical for* f ."
 (unusual)

"Necessarily does not..." vs "does not necessarily": "CPT invariance does not necessarily imply T invariance" but "If the mass of the fission fragments is greater than that of the parent nucleus, then fission necessarily does not occur" (= cannot occur). The second use is however rare and best avoided.

"Both" vs "the two": "Both" in English has the sense of 両方とも; thus "both the renormalisation constants are equal to unity" but "the two renormalisation constants cancel one another." "Both renormalisation constants are equal" (i.e. to one another) \rightarrow "the two r. cs. are equal".

"Quite" vs "considerably": The meaning of these two words is often very similar but "considerably" is usually used only when a comparison is stated or implied. Thus " x is considerably larger than y " " x is considerably reduced" but " x is quite large". Actually "quite" is a rather ambiguous [17] word and it is often safer to replace it by "rather".

Note the following expressions which are listed roughly in order of increasing strength:

[15] Except of course in a technical sense, as in 'the image of the Fermi surface'.

[16] "Concrete image" = コンクリートで造った仏像. In this kind of case there is really no good translation of 具体的.

[17] "The effect is quite strongly suppressed" = "suppressed to a large extent but not completely." "The effect is quite suppressed" = "completely suppressed."

“X is a little larger/somewhat larger/rather larger/considerably larger/a good deal larger/very much larger than Y.”

“X is fairly large/ quite large/rather large/very large.”

(Actually in the second row “fairly” “quite” and “rather” are almost indistinguishable.)

“*Namely*” vs “*that is*”: “*Namely*” is used when you are about to *name* or *identify* something you have already described: e.g. “Using the best available data, namely these of Brown...” or “There is one difficulty. Namely, the integral in (3.1) does not converge.” “*That is*” is used to introduce an explanation of something you have said, e.g. “Region II, that is, the region in which the heavy mesons play a dominant role....” or “The validity of this procedure is doubtful. That is, it is not clear that we can replace....” In my experience “*that is*” is right 90% of the time, especially at the beginning of a sentence.

“will be able to be replaced” → “can be replaced”

“may have a possibility to” → “may be able to” or “can”

“suggests us that” → “suggests that”

“formulae (expressions) *for* f ” (not “of f ”)

“conditions (restrictions) imposed *on* M *by* rotational invariance” (not “to M”)

“effect of the Coulomb terms *on* S” (not “to S”)

“X can be expressed (rewritten) *in terms of* Y” (not “by Y”)

“construct the wave function *from* Bloch waves” (not “with”)

“X is insensitive *in comparison with* Y” but “X is less sensitive *than* Y”

“associate A with B” (not “to”)

“The concerned baryon” → “The baryon concerned”

Σ_p is “a summation *over* p ” (not “of p ”)

“our interesting amplitude” → “the amplitude of interest to us”

“We pick up the ring graphs” → “pick out” or “isolate” or “select for special treatment”

“operating $\partial/\partial X_\mu$ on ψ ” → “operating with $\partial/\partial X_\mu$ on ψ ”

§12 Minor Stylistic Points

Try not to start sentences with “and”, “but”, “so”. [18] Instead of “and” use “moreover” or “further”, instead of “but” use “however” or “nevertheless”; instead of “so” use “therefore” or “hence”. Don’t end sentences with “too” or “however” (or indeed any conjunction), though “however” is sometimes allowable at the end of a very short sentence.

Be careful about starting sentences with “Then”. It is *not* legitimate to use this in the sense of “therefore”. Japanese authors are probably confused by sequences like: “Let us suppose the series converges. Then we can replace....” The “then” here does *not* mean “therefore”; the sense is “when (or if) we have supposed the series to converge, then we can....” Although the use of “then” for “therefore” is not a serious mistake, it is very widespread and worth watching out for.

“*Especially*” usually qualifies an adjective or adverb (“It is especially important to....”) not a whole clause. At the beginning of a sentence it should usually be replaced by “In particular”.

“*Somewhat*” vs “*more or less*”: “This is more or less established experimentally” means roughly “The experimental evidence is not completely conclusive but it is very good.” “More or less” is *not* the equivalent of 多少. “Somewhat” is roughly equivalent to “rather” or “quite” (see section 11) (e.g. “this is a somewhat doubtful procedure.”)

“*A few*” vs “*several*”: “A few” tends to emphasise the smallness of the number involved, while “several”

[18] This is another point in which spoken and (scientific) written English differ.

tends to emphasise its largeness. Thus, e.g. “The strength of this interaction cannot be more than a few keV” but “Detection of this effect requires a field of several million oersteds”. When neither emphasis is needed “a few” is usually used, e.g.: “*pp* scattering at a few BeV is investigated.”

“*Based on*”. This is an adjectival phrase and as such *must qualify a noun*. Sentences like “Based on the Landau theory, the magnetic susceptibility is investigated” are very bad English; [19] we should write “On the basis of the Landau theory, the m.s. is investigated”. However, “we give a treatment based on the Landau theory” is correct, since “based on” qualifies “treatment”.

“*We had better*” sounds very colloquial: it is best replaced by “it is best to....”

In the sentence “X and Y are equal to each other” the “to each other” can usually be left out without any danger of ambiguity.

Events “take place” (or “occur”) but poles (of propagators etc.) “occur” or “appear” (not take place).

“The functions F_i 's” → “the F_i 's” or, better, “the functions F_i ”.

“The Okubo-Marshak formula” but “Okubo and Marshak have shown....” (never “Okubo-Marshak have shown”.)

Of course a few Western names are actually hyphenated (Gell-Mann, Lennard-Jones, etc.)

あとがき



今回、京都大学の小林稔教授より、Leggett 教授著、「Notes on the Writing of Scientific English for Japanese Physicists」が送られてきました。これは筆者が京都大学理学部に一年間在籍し、英語誌である「Progress of Theoretical Physics」の英語コンサルタントとして、投稿された論文の閲読、英文添削をされた経験を基に、日本の物理学者に向けて書かれたものです。本会誌編集委員会にて出版について協議したところ、この論文は、日本の物理学者の英語論文の執筆、そして悦読者の英文添削に非常に役立つと考え、掲載に至りました。

Anthony James Leggett 教授について簡単に紹介させていただきます。オックスフォード大学にて1959年に古典学の学位、1961年に物理学の学位を取得後、Drik ter Haar 教授指導のもとで同大学にて博士課程を終え、1964年から1965年までイリノイ大学で博士研究員として勤め、Pine 教授のもとで、超流動の研究、1965年9月からは、京都大学理学部物理学の松原研究室にて客員研究員として在籍し、英語誌「Progress of Theoretical Physics」の英語コンサルタントをされる。Leggett 教授は日本語に非常に長けている。その後オックスフォード大学モードリン校にて助手、サセックス大学物理学科にて講師、東京大学理学部にて外国人研究員、サセックス大学物理学科にて教授、1983年から現在に至るまでイリノイ大学アーバナシャンペン校、物理学科で教授をされている。

(編集委員)

[19] Despite the fact that they occasionally appear in Phys. Rev.!

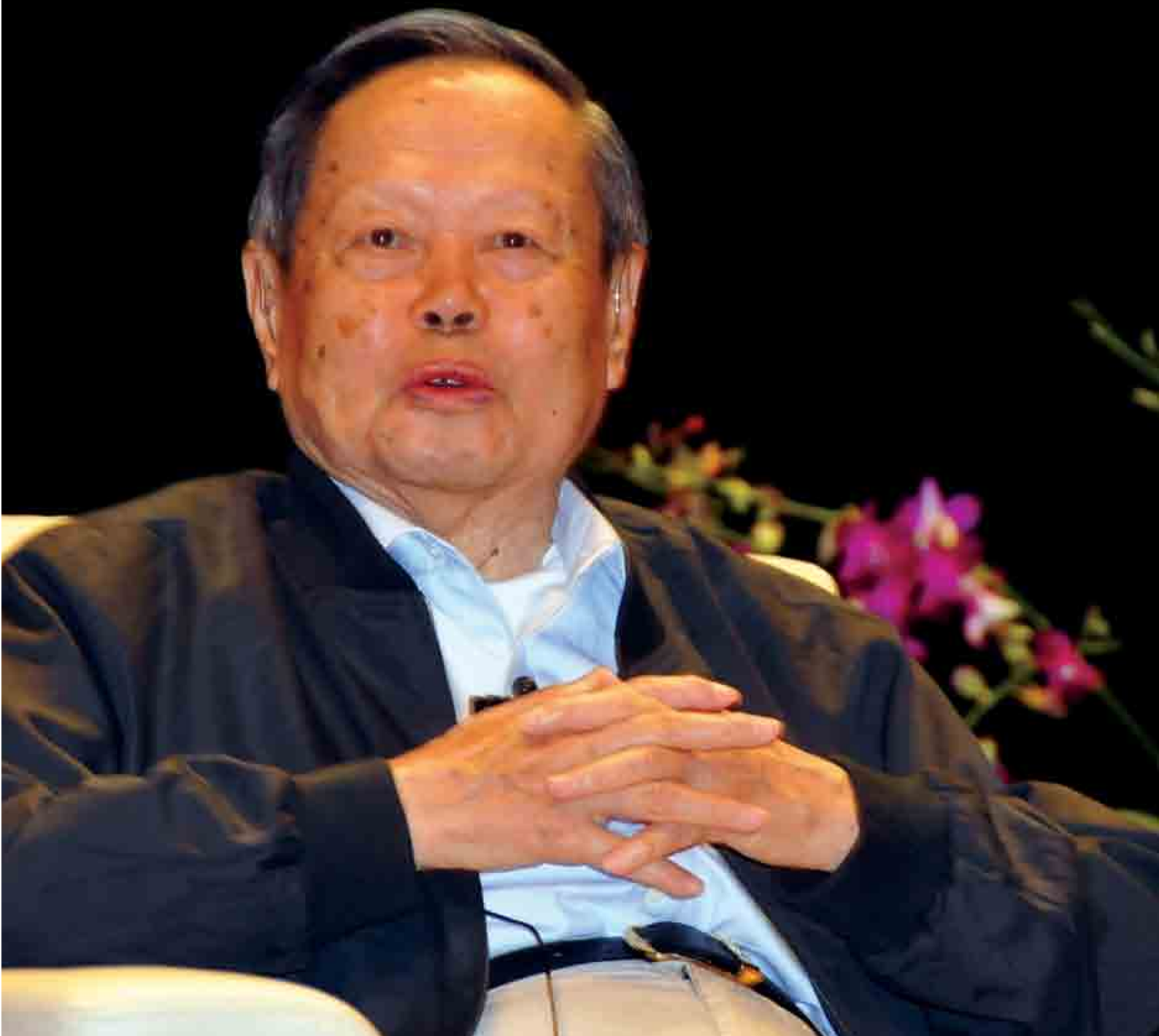
Father and I

Professor Chen Ning Yang

Nobel Laureate in Physics, 1957

The Chinese University of Hong Kong, Hong Kong

Translated by the author from *Twenty-First Century* (December 1997)



1

Father (K. C. Yang (楊克純), 1896-1973) was a high school teacher in Anqing (安慶) in 1922 when I was born in Hefei (合肥). Anqing was then also called Huaining (懷寧). Father gave me the name Chen Ning, of which Chen was the name of my generation in our family, and Ning was derived from Huaining. Before I was one year old Father won an Anhui (安徽) Provincial Fellowship for studying in the USA. We had a family picture (Figure 1) taken in the courtyard outside our bedroom a few days before he left home. Father had on the traditional robe and coat, standing stiff and erect. He had probably up to that point never worn a western suit. Two years later he sent a picture (Figure 2) to Mother from the University of Chicago, in which his attire and bearing had both entered the twentieth century. Father was a handsome man. The exuberance and optimism of his youth were clearly captured in this photograph.



Fig. 1 My parents and I, 1923, in Hefei.



Fig. 2 Father at the University of Chicago, 1925.

Father enrolled in Stanford University in 1923, receiving a B.Sc. degree in 1924, whereupon he transferred to the Graduate School of the University of Chicago. Forty some years later when visiting Stanford University I attended a party at the Chinese Students' Club held in their Club House (Figure 3). That House, which was later razed in the late 1960's, had been built by the Chinese community of San Francisco in the early years of this century for the Chinese students of Stanford who had suffered racial discrimination on and off campus. The rooms upstairs in the Club House were used to house Chinese students, and the rooms downstairs were used for parties and as an eating club. That day when I was visiting, I was shown some old photographs of the Chinese Club and the minutes of the meetings of the Club in earlier years. One of them, dating back to



Back row: HOW, TSI, CHEU, HUANG, TSUI, WU, H. WONG
 Third row: SAH, BAIN, TSAO, T'AN, HAO, CHENG, K. SHEN, WANG
 Second row: T'AAM, E. SHEN, FANG, YEE, CHI, K. YANG, TENG, L. YANG
 First row: CHUCK, PING, HAHN, CHANG, CHUAN

CHINESE CLUB

Founded at Stanford University, 1910

MEMBERS

Nineteen Hundred and Twenty-One

YAO-TUNG HAO

SONG-PING TSAO
SHU KAI WANG

LIANG-KUNG YANG

Nineteen Hundred and Twenty-Two

DAVID KIONG CHANG
KUO-LIANG CHI

FAW-YAP CHUCK
YOUNG D. HAHN
HUA-PIAS HUANG

SHULIN LINCOLN T'AN
NELSON Y. YEE

Nineteen Hundred and Twenty-Three

PEN-TUNG SAH

EUGENE SHEN

Nineteen Hundred and Twenty-Four

TUNG HO CHENG
CHING-SZE HUANG

TSONG-HSUN TSUI
CHIU-HUNG LEE
ER-CHANG PING

KWAN-CHUN SHEN
CHUN-KAO TENG

KO-CHUEN YANG

Nineteen Hundred and Twenty-Five

LI HWEI BAIN
HENRY DOO FOO CHEU
CHIH-HO CHI

HUNG-CHAU WONG
TSENG KU CHUAN
ROLAND CHUNG FANG
JOHN HOCK HOW

WEN PING HSIEH
WU T'AAM
YU FANG TSI

CHIN-CHUAN WU



Fig. 3 A page from the Year Book of Stanford University, 1924. Father's name at that time was K. C. Yang. He was number three from the right in the second row from the bottom. The small picture was the Chinese Club House.



Fig. 4 The signature page of the Chinese Club in the autumn of 1923. Father was number 11.

1923–1924, bore Father's signature: K. C. Yang, (Figure 4), which was the name he used at that time.

Father received his Ph.D. degree in mathematics in 1928, and went back to China in the summer. Mother and I went to Shanghai to meet him at the pier. To me he was of course a total stranger. After a few days in Shanghai the three of us, together with a maid servant, Sister Wang from Hefei, embarked on a short voyage to Xiamen (廈門) in the south, where Father became a professor of mathematics at the University of Xiamen.

My memory of the year 1928–1929 in Xiamen was a very happy one. That was also the year in which I

learned many many things from Father. Before that year I had learned approximately three thousand Chinese characters from Mother, and had learned to recite the classical primer "Longwen, the Horse, and the Shadow of a Whip" (龍文鞭影) from a tutor. But I had had no contact at all with modern education. In Xiamen, Father explained to me the structure of the solar system, using big and small balls. He taught me the alphabets "abcde...", and arithmetic problems like the puzzle of chickens and rabbits (雞兔同籠). He did not neglect knowledge about Chinese history and culture either: he taught me scores of Tang poems, the order of the dynasties in Chinese history "唐虞夏商周, ..."; the order of Gan-Zhi "甲乙丙



Fig. 5 In Xiamen in 1929.



Fig. 6 In Xiamen in 1929, on Sun Light Rock, Gulang Islet.

丁...”, “子鼠丑牛寅虎 ...”; of the eight symbols in Yijing “乾三聯, 坤六段, 震仰盂, 艮覆碗, 離中虛, 坎中滿, 兌上缺, 巽下斷”, etc., etc.

Father had liked to sing Chinese opera when he was a teenager. That year in Xiamen he would still occasionally sing “我好比籠中鳥, 有翅難展...”. But he did not teach me to sing Chinese opera. He only taught me a few modern songs popular in the 1910’s, such as “上下數千年, 一脈延,....”, “中國男兒, 中國男兒 ...”, etc. Father played Weiqi (圍棋) well and he taught me the game in Xiamen. We started by his giving me a handicap of sixteen stones. Later on it was gradually reduced to nine, but I never really got the feelings of this deep game. Many years later, in Geneva in 1962, when we played the game again, he still had to give me seven stones.

Figure 5 was taken in Xiamen in 1929. Father and Mother were both so young. Figure 6 was also taken that year on the Sun Light Rock (日光岩) on top of Gulang Islet (鼓浪嶼) in Xiamen. Thirty some years later, in 1960, when my parents were preparing to fly from Shanghai to Geneva to have a family reunion with me, Third Brother had looked through old albums and produced this picture for my parents to bring with them to show to me. Father said, “No, no, not this one. I had scolded Chen Ning that day and he was so very unhappy.”

This is a story that cannot be completely understood by a person who had never been a parent.

After teaching in Xiamen for one year, Father accepted an offer from Tsing Hua University (清華大學) in

Beijing. The three of us travelled to Beijing and moved in the fall of 1929 to West Compound No. 19 in the Tsing Hua campus. Our court-yard-styled house was at the northeastern corner of the West Compound at A in Figure 7. Later on in the 1930's when the West Compound was enlarged southward, our house was renumbered No. 11.

We lived inside the Tsing Hua campus for a total of eight years, from 1929 to the beginning of the War of Resistance Against Japan. These eight years in Tsing Hua campus were very beautiful and very happy in my memory. While multitudes of crises, internal and external, constantly beset Chinese society in those years, we lived within the walls of the peaceful university campus and had little contact with the outside world. I thus spent my childhood in this academically oriented and protected environment. In my memory, the campus was very beautiful: my elementary school classmates and I roamed all over the campus, climbing almost every tree and examining almost every blade of grass.

The above was translated from p. 112 of a small book *“Studying and Teaching for Forty Years”* in Chinese that I published in 1985. The places that we “roamed all over” were mostly in the squarish region east of the West Compound up to Jingzhai (靜齋, number 14 in Figure 7). In those years many of the buildings in this large area were not yet built, and most of the land were wooded hillocks, lily ponds and a few farming families and their paddy fields. The region constituted an ideal place for us to roam over and explore.

Figure 7 was taken from the *Tsing Hua University Year Book 1948*. Building 32 was my elementary school: Cheng Zhi School (成志學校), which is now the Union building. I had studied in this school for four years 1929–1933. Every morning I would start from point A in the figure and walk first southward, turning then toward the southeast along a footpath, to climb a small mound and to then descent to point B, which was just inside the wall of the campus at that time. I

would then walk along the campus wall eastward to my school at building 32. The trip would take some twenty minutes, if no important events like butterflies congregating or ants moving to new nests should claim my attention.

Another path that I often took started from point A and went northeastwards along a well paved road, reaching point D which was the University Dispensary at the time [now the Meng Minwei Building (蒙民偉樓).] Every time there was an athletic meet on campus I would ride my bicycle along this road to go to the gymnasium to form a cheering squad with my schoolmates for the Tsing Hua athletes.

Father and I often took a third path, starting from our house heading eastward, to go to Guyue Tang (古月堂) or to his office in the Science Building (科學館). This little footpath was quiet and rarely travelled. After going through some wooded area we would be walking for a long while near point C, with lily ponds to our left and low mounds to our right, rarely encountering other people. The sceneries during the four seasons were dramatically different, of course, but the atmosphere of quiet solitude remained always the same. I was not able to realise then that along this path Father and I had spent more quiet moments together alone than at any other time or any other place.

When I was nine or ten years old, Father had already observed that I was gifted in mathematics. When I reached the junior high school at age eleven, my ability in this direction was quite obvious. Looking back at those days, had he taught me analytic geometry or calculus at that time, I would certainly have made rapid headway which would probably have greatly pleased him. But he did nothing of this sort. During the summer vacation between grades seven and eight, I was instead coached by a Mr. Ding Zeliang (丁則良), who was a student in the History Department of Tsing Hua University. Father asked him to teach me Mencius. Mr. Ding turned out to be an excellent teacher, and I learned much from him, not only about Mencius' teachings, but also about many things concerning

國立清華大學平面全圖

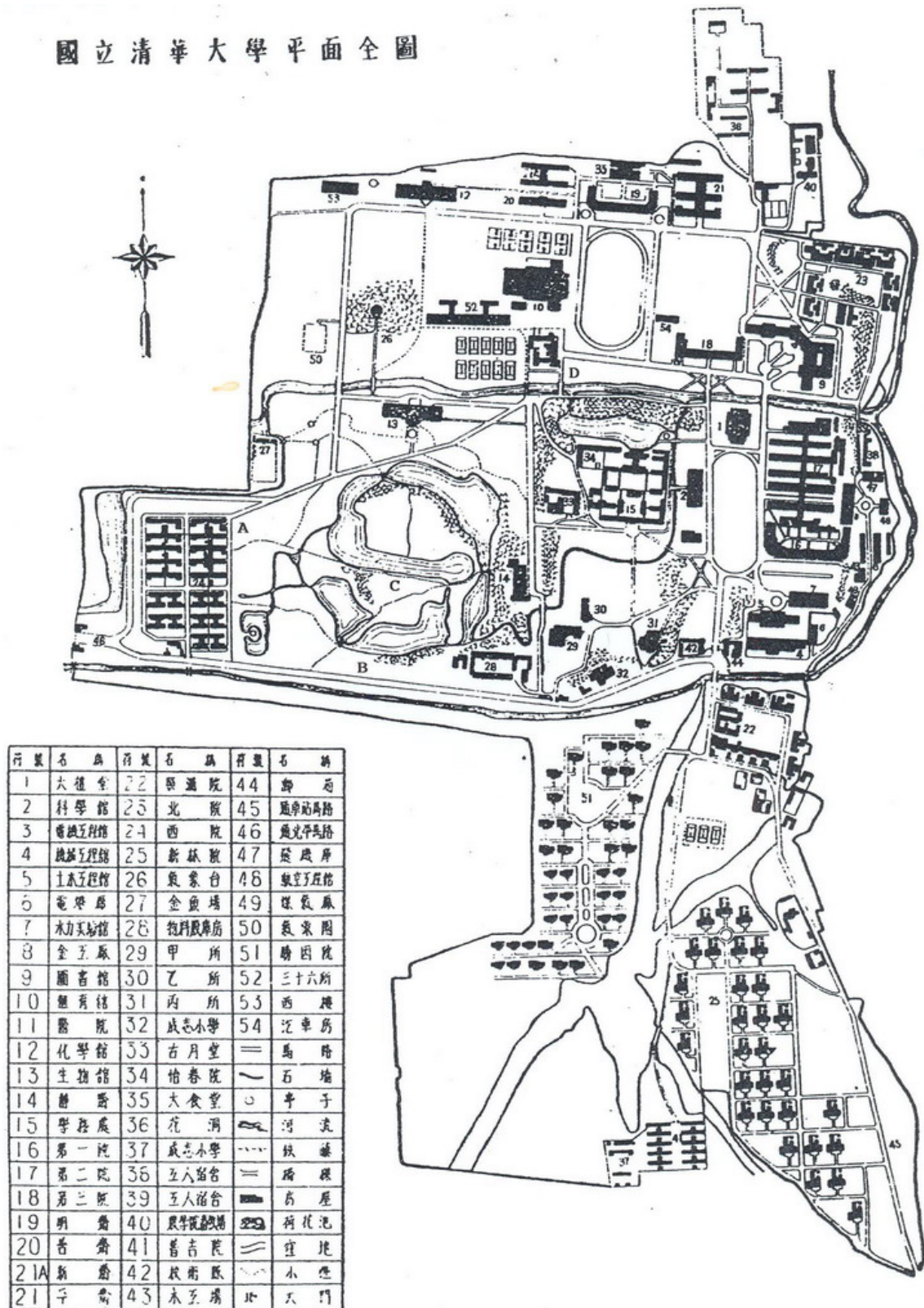


Fig. 7 Map of the campus of Tsing Hua in the Year Book of 1948. The group of houses in the western part of the map is the West Compound where we lived 1929–1937. Our house is the northeastern-most one in the Compound, with entrance at A. Points B, C and D are described in the text. Small building 32 was my elementary school.

ancient China which one could not learn from textbooks. During the following summer vacation, Mr. Ding taught me again, and finished the latter half of Mencius, so that throughout my high school years I could recite Mencius from the beginning to the end.

On Father's bookshelves there were many books on mathematics in English and in German. I liked to browse through these books. Of particular interest to me were the theorems in "*Number Theory*" by G. H. Hardy and E. M. Wright and the illustrations of space groups in "*Finite Groups*" by A. Speiser. It was not possible for me to understand the details since I did not know enough foreign languages. I tried many times to ask Father to explain things to me. He always said I should not hurry, and only occasionally introduced to me a few basic concepts.

The War of Resistance Against Japan started in July 1937. We first moved back to Hefei, and then after the Japanese reached Nanjing (南京), took a long journey through Hankou (漢口), Hong Kong (香港), Haiphong (海防) and Hanoi (河內), reaching finally Kunming (昆明) in March 1938. I enrolled in the eleventh grade in the Kunhua Middle School (昆華中學) for a few months, and skipping one year, entered the Southwest Associated University (西南聯合大學), Lianda, in the fall of that year.

During the year 1938–1939 Father introduced me to some of the spirits of modern mathematics. He borrowed for me from the university libraries G. H. Hardy's "*Pure Mathematics*" and E. T. Bell's "*Men of Mathematics*". He discussed with me set theory, the transfinite numbers and the continuum hypothesis. All of these left indelible impressions on me. Forty years later, in "*Selected Papers, 1945–1980, with Commentary*", (Freeman and Co. 1983), I wrote[1]:

Most of my physicist colleagues take a utilitarian view about mathematics. Perhaps because of my father's influence, I appreciate mathematics more. I appreciate the value judgment of the mathematicians, and I admire the beauty and power of

mathematics: there are ingenuity and intricacy in tactical manoeuvres, and breathtaking sweeps in strategic campaigns. And, of course, miracle of miracles, some concepts in mathematics turn out to provide the fundamental structures that govern the physical universe!

Although Father had introduced me to some of the spirits of modern mathematics, he did not want me to major in the field because he thought mathematics was not practical enough. In the summer of 1938 when I registered for the entrance examination to the universities, I entered in the registration form Chemistry, which I had studied in the eleventh grade



Young Prof Chen Ning Yang

[1] Chen Ning Yang, "*Selected Papers, 1945–1980, with Commentary*", p. 74 (Freeman & Co. 1983).

and had liked. Then in preparation for the entrance examinations I spent several weeks to read up on twelfth grade physics, and found that physics was better to my taste. So I ended up in the physics department.

In my senior year 1941–1942, to write a B.Sc. thesis, I went to Professor Ta-you Wu (吳大猷). Wu[2]

gave me a copy of an article by J. E. Rosenthal and G. M. Murphy in the 1936 volume of *Reviews of Modern Physics*. It was a review paper on group theory in physics. In retrospect I am deeply grateful to Wu for this introduction, since it had a profound effect on my subsequent development as a physicist.

I had actually already been exposed to the rudiments of group theory by my father when I was a high school student, and I had always been fascinated by the beautiful diagrams in the book by A. Speiser on finite groups that he had on his bookshelf. When I showed him the Rosenthal and Murphy article, he suggested that I should learn about group representations from a small book called *Modern Algebraic Theories*, by L. E. Dickson, who was his thesis advisor in the mathematics department at the University of Chicago in the 1920's. Dickson presented in a short chapter of twenty pages the essentials of the theory of characters. The elegance and potency of the chapter introduced me to the incredible beauty and power of group theory.

This year, 1997, to celebrate Professor Wu's ninetieth birthday, T. T. Chou (鄒祖德) and I coauthored an article[3] using group theory to calculate the vibrational frequencies of C_{60} . C_{60} has a very high degree of symmetry and is most suitable for analysis with group theory. [Neither Professor Wu nor I had anticipated in 1941–1942 that there existed molecules

with such large symmetries. Even in 1983 when I wrote the paragraphs quoted above, nobody had anticipated the existence of such molecules.]

The eight wartime years, 1937–1945, were difficult years. They were also the years during which I absorbed new knowledge at an incredible rate. Recently Third Brother Zhen Han (楊振漢, 1932–) wrote about the situation in the Yang family at the end of the war[4]:

In the summer of 1945, Big Brother won a Fellowship to go to study for his Ph.D. in America. Father told us happily that the long and difficult years of War of Resistance Against Japan were apparently also drawing to an end together with the end of the war against Nazi Germany. Although our family had suffered great spiritual and material losses during the war, all seven of us had been together and had remained healthy. The children had been making progress in their studies, and what was even more important, there permeated within the family the spirit of harmony and cohesion which every one of us treasured.

It has been fifty-two years since the end of the war. Father, Mother and Zhen Fu (楊振復) [comment by CNY: Zhen Fu, 1937–1985, was our Fifth Brother] are now permanently lying in a cemetery at Suzhou (蘇州). Recalling the eight difficult wartime years, I am proud to say that our family was fortunately filled with beautiful harmony and lasting love.

I still remember some details of the morning of August 28, 1945, the day that I left Kunming to fly to Calcutta, India, on my way to America. Early that morning Father accompanied me on two rickshaws, diagonally cutting across the city of Kunming from our house in the northwest to Tuodong Road (拓東路) in the southeast, to board the bus that was to

[2] Chen Ning Yang, "Selected Papers, 1945–1980, with Commentary", p. 5 (Freeman & Co. 1983).

[3] T. T. Chou and Chen Ning Yang, *Phys. Lett.* **A235** (1997) 97.

[4] Translated from Yang Zhenhan's article in "Biography of Chen Ning Yang", p. 261 by Xu Shenglan and Meng Dongming (Fudan University Press, 1997).

take me to the airport at Wujiaba (巫家壩). When we left the house, my four brothers and sisters, all much younger than I, were very emotional. But Mother was composed and did not have tears in her eyes. After Father and I arrived at the bus station, he said some encouraging words and I climbed into the bus, both of us remaining calm. I could see through the window after a few minutes that Father was being pushed away by the big crowd around the bus. Inside there were many familiar faces, all travelling to the USA, and my attention was quickly diverted to conversations about the weather and the route our airplane was to take. After a long time, more than an hour, the bus had still not started. Suddenly the American sitting next to me beckoned to me to look outside through the window. Father was still there waiting! Seeing his lean body robed in a traditional changshan, his hair already touched with streaks of grey, realising how anxious he must have been all this time, I was unable to prevent the eruption of hot tears that had been held back all morning.

From 1928 to 1945 were the seventeen years that Father and I had lived in the same house, the years when I grew from a small boy to a teenager to an adult. In ancient China one used to say that a person owes his birth and nurturance to his parents. One does not say that in the modern era any more, but its truthfulness I believe remains undiminished.

2

I enrolled as a graduate student at the University of Chicago in January 1946. I chose Chicago not because it was Father's alma mater, but rather because[5] Professor Enrico Fermi, whom I had greatly admired, had moved there. The University of Chicago was absolutely first rate in those years in physics, chemistry and mathematics. I spent altogether three and a half years there, the first two and a half as a graduate student and the last as an instructor, moving to the Institute for Advanced Study in Princeton in 1949. Father was naturally very pleased

that I had distinguished myself as a graduate student at Chicago and was even more pleased by my going to the famous Institute for Advanced Study. But his main worry at that time was my marriage. In the fall of 1949 Professor Ta-you Wu told me Mr. Hu Shi (胡適) wanted me to go to see him. I had met Mr. Hu a couple of times in Beijing as a child. What had prompted him to think of me in New York after so many years? When I did see him, he started by praising me in my academic career, then said that before leaving China he had seen Father who had asked him to introduce me to some young ladies. I still remember what he then added humorously, "Your generation are much more capable than mine. You hardly will need any help from me!"

Chih Li (致禮) and I were married in Princeton on August 26, 1950. We were not introduced to each other by Mr. Hu or any other friends of Father's. She had been in fact one of my students in the year 1944–1945 when I taught an eleventh grade class in a High School in Kunming. We did not know each other very well then. Four years later we had accidentally run into each other at the only Chinese restaurant in Princeton. The Buddhists would say ours was a marriage arranged in our previous incarnations. In the 1950's Mr. Hu frequently visited the Gest Oriental Library in Princeton and had been often our guest for dinner (Figure 8). The first time he came he said, "Just as I have expected, you have found such a beautiful and capable wife by yourself."

Father was very much interested in the first paper I published in the USA and in my Ph.D. thesis of 1948, since both were related to group theory. Later in January 1957 when C. S. Wu and her collaborator's work proved the theory of parity nonconservation, I called him in Shanghai. He was greatly excited, especially since parity was related to symmetry and to group theory. He was in bad health at that time, and the news provided great satisfaction to him. (In 1955, because of his diabetes and an infection, he was not able to absorb insulin and his case had been considered hopeless. Fortunately the infection miraculously disappeared and he gradually recovered, but was still very weak in 1957.)

[5] Chen Ning Yang, "Studying and Teaching for Forty Years", p. 115 (Joint Publishing Co., Hong Kong 1985).

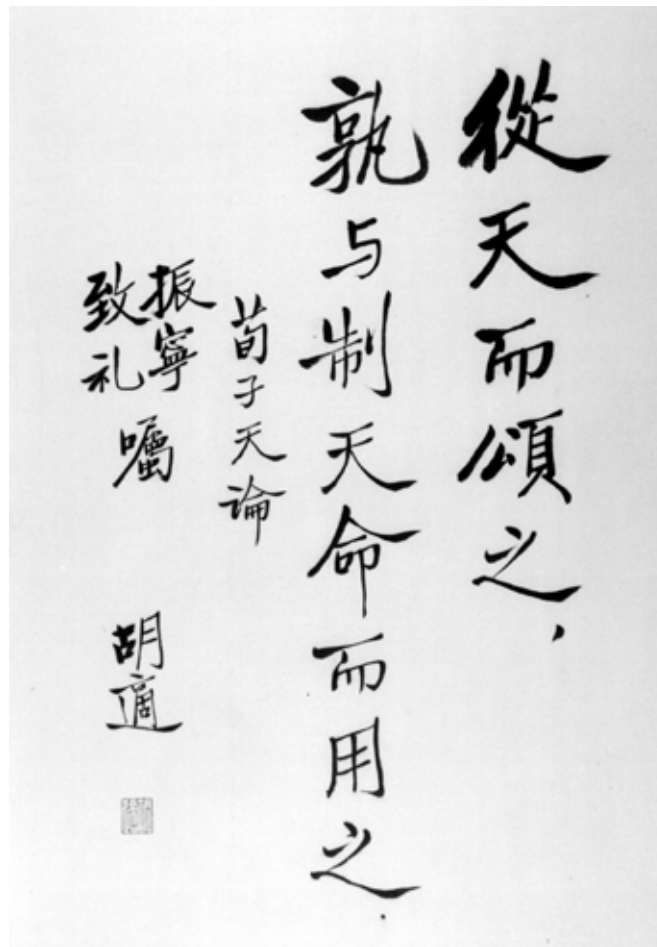


Fig. 8 Calligraphy presented to my wife and me by Hu Shi in the 1950's.

In the summer of 1957, Chih Li, Franklin (who was six), our only child at that time, and I planned to go to Geneva, Switzerland, where I was to work at CERN for a few months. I wrote to Father asking him to join us in Geneva. He got the permission of the Chinese Government to come, and flew to Geneva via Beijing, Moscow and Prague, stopping over in hospitals for checkups all along the way. Arriving in Geneva in early July, he was checked into a hospital immediately. After a few days he was released, but had to examine his glucose level and to inject insulin himself everyday. That summer we rented an apartment on Rue de Vermont. Every morning Franklin, who always got up early, would watch Grandfather making urine analysis over an alcohol lamp with great interest. After I woke up he would come to me saying, "It is not good

today, it is brown," or "It is very good today, it is blue." After a couple of weeks, Father's health greatly improved and Franklin could explore with Grandfather the neighbourhood parks. They were especially pleased to have found a "secret path" in the woods in one of the parks. Every time when the two of them were preparing for one of their walks, with Father combing his hair in front of the mirror in the hallway, and Franklin jumping up and down to open the door of the apartment, I was suffused with a sense of fulfilment.

Father introduced to Chih Li and me many aspects of the New China. He greatly admired Chairman Mao, especially Mao's poems, such as

指點江山，	Pointing to our mountains and rivers,
激揚文字，	Setting people afire with our words,
糞土當年萬戶侯。	We counted the mighty no more than muck.

(Translation from *Mao Tsetung Poems*, Peking: Foreign Languages Press, 1976.)

and

惜秦皇漢武，	But alas! Chin Shih-huang and Han Wu-ti
略輸文采；	Were lacking in literary grace;
唐宗宋祖，	And Tang Tai-tsung and Sung Tai-tsu
稍遜風騷。	Had little poetry in their souls.
一代天驕，	And Genghis Khan,
成吉思汗，	Proud Son of Heaven for a day,
只識彎弓射大鵬。	Knew only shooting eagles, bow outstretched.
俱往矣，	All are past and gone!
數風流人物，	For truly great men
還看今朝。	Look to this age alone.

(Translation from *Mao Tsetung Poems*, Peking: Foreign Languages Press, 1976.)

One morning he wrote down two lines for Chih Li and me (Figure 9). Young people today probably would find these lines old-fashioned. I think while a number of old-fashioned things should be rejected, others do have permanent sterling values.

In the summers of 1960 and 1962, Father and Mother and I had reunions again in Geneva. Chih Li, Gilbert (our second child) and Second Brother Chen Ping (楊振平) joined us also. Each time in these reunions everyone was very emotional at the beginning (Figure 10), immersed in the happenings and experiences of ourselves and of friends and relatives. Only after a few days could we quiet down and enjoy what Switzerland had to offer.

Father had, during his three trips to Geneva, especially during the last two, a sense of responsibility to convince me to go back to China. This was of course partly due to the somewhat implicit suggestions of the Chinese Government. But it was also due to a desire in the great depths of his own soul. He was of two minds: on the one hand there was this strong desire, on the other, he felt I should remain in the USA to strive for higher levels of research achievements.

The three trips to Geneva to meet my parents were of decisive influence on me. In those years it was very difficult in America to learn of the realities of things in China. The trips taught me how my parents

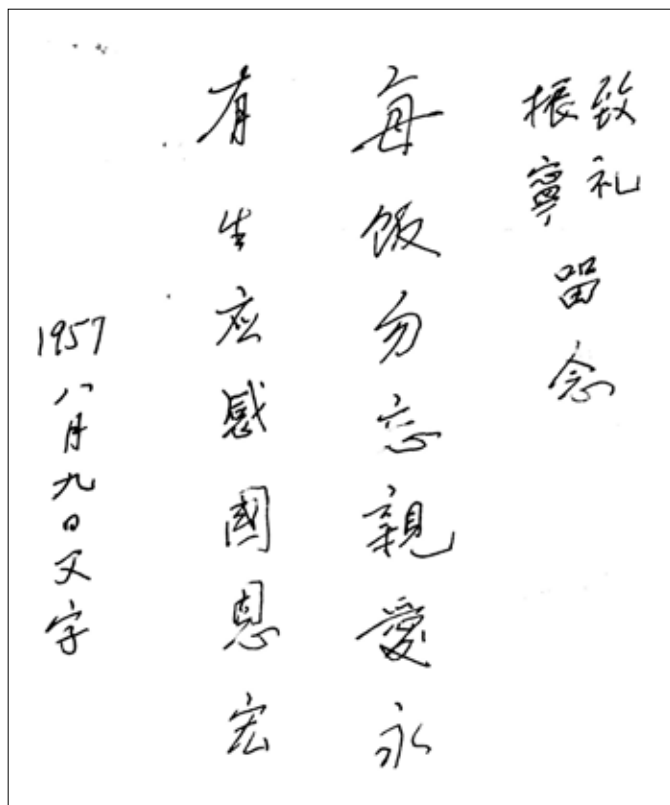


Fig. 9 Calligraphy given to my wife and me by Father in 1957 in Geneva. It read,

Remember your parents' enduring love
At every meal,
Be grateful to your Motherland
All your life.

viewed the developments in China. I remember one evening in 1962 when we were living in an apartment on Route de Florissant, Father described to me the great progress China has made. He said the Chinese people have now really stood up. Whereas in the old days China could not make even a needle, today China could make cars and airplanes. (He did not know that China was already in the process of making atomic weapons.) Whereas in the old days there were oftentimes disastrous floods and droughts, killing millions of people, today these disasters disappeared. Whereas in the old days illiteracy was rampant, today every child was able to go to school, at least in the cities. Whereas in the old days..., today.... As he was getting more expansive, Mother interjected, "Don't just talk about these. I have to get up before dawn and have to stand in line for three hours to buy two lousy pieces of tofu, what is good about that!" Father was furious, saying that she



Fig. 10 Picture at the airport on May 21, 1962 when Father and Mother arrived in Geneva. Father was deeply emotional. (Taken by Dr. T. F. Hoang.)

specialised in contradicting him; that she was creating wrong impressions for her son. He walked into his bedroom and slammed the door.

I recognised that what Father and Mother had said were both realities of China, and there was in fact no contradiction: The birth of a nation is like the birth of a baby, but with more difficulty and greater pain.

3

In the summer of 1971, after twenty-six years, I had the opportunity to visit China. When the Air France plane that took me from Burma eastwards entered Chinese air space, and the pilot announced “We are now in China”, my heart almost jumped through my throat.

We arrived in Shanghai in the early evening. Mother, Third Brother and Sister met me at the airport. We then drove to Huashan Hospital to see Father. He had been there for almost seven months. The last time we had met was in late 1964 in Hong Kong when he was sixty-eight years old and was still quite healthy. In the six and a half intervening years, he had suffered some mild form of political criticism during the “Great Cultural Revolution”. Older and leaner, he was incapable of standing and walking. He was beside himself upon seeing me.

I visited China again in the summer of 1972. Father was still in Huashan Hospital and was much weaker. He passed away a year later, in the early morning of May 12, 1973, at the age of seventy-seven. At the funeral service which took place on May 15 I gave a short speech which included the following paragraphs[6]:

In the last two years Father’s health was failing. Realising this, he thought long and hard about us, about our lives and our future. In 1971 and 1972 when I came to Shanghai to see him, he said many things to me. He wanted me to look far ahead, to clearly discern the sweep of history. His words produced great influence in the last two years on me.

Father passed away on May 12. In his seventy-seven years, there have been profound changes in the history of mankind. Yesterday there came a letter from one who had been his old schoolmate and colleague, saying, “In our youth, we had looked forward to a prosperous new China. In the twenty some years after Liberation, under the heroic leadership of

Chairman Mao and the Chinese Communist Party, the new China that we had dreamed of in our youth has materialised.” I believe the great historical fact of the emergence of the new China and its meaning to the future of the world is precisely what Father had wanted us to fully appreciate.

Before six years of age, I had lived in our old household in Hefei. Every lunar-calendar New Year’s Day, besides the door of the main hall, there would be pasted new scrolls. The right scroll read “Loyalty and Generosity in the Family” (忠厚傳家) and the left scroll “Poems and Classics through the Generations” (詩書繼世). In his lifetime Father did personally exemplify loyalty (忠) and generosity (厚). He also especially treasured the character Purity (純) in his name Ke Chun (克純) for personal behaviour, and the characters Trustworthiness (信) and Responsibility (義) for relationship between friends. After his death, my childhood schoolmate and close friend Ping Ming Hsiung (熊秉明) wrote to console me, saying although Father had passed away, his blood still circulates in my body. Yes, circulating in my body is Father’s blood, the blood of Chinese culture.

In 1964 I became a US citizen. About twenty years later I wrote[7]:

I had been living in the States for 19 years, 1945–1964, a period that covered most of my adult life. Yet, the decision to apply for citizenship was not an easy one. I suppose this is true of many immigrants from most countries, but it is particularly true of a person of Chinese ethnic origin. The concept of leaving China permanently to emigrate to another country simply did not exist in traditional Chinese culture. In fact, to emigrate was once regarded as downright treachery. Furthermore, deeply ingrained in the psyche of every Chinese is the mark of the humiliation and exploitation suffered for over a century by a once-glorious culture. It was a century that no Chinese could easily forget. My father was a professor of mathematics

[6] Chen Ning Yang, “*Studying and Teaching for Forty Years*”, p. 71 (Joint Publishing Co., Hong Kong 1985). Father’s old schoolmate and colleague referred to here was Prof. Zhou Peiyuan.

[7] Chen Ning Yang, “*Selected Papers, 1945-1980, with Commentary*”, p. 56 (Freeman & Co. 1983).

in Peking and Shanghai until his death in 1973. He had earned a Ph.D. degree at the University of Chicago in 1928. He was well travelled. Yet I know, in one corner of his heart, he did not forgive me to his dying day for having renounced my country of birth.

4

On July the first, 1997, at 00:00 hours, I had the honour to participate in the historical handover ceremony at the Hong Kong Convention and Exhibition Centre. Watching the flag of the People's Republic being slowly raised while the band played "Arise, you who would not be enslaved..." my foremost thoughts were: had Father observed this historical ceremony marking the renaissance of the Chinese people, he would have been even more moved than I. He was born in 1896 — one hundred and one years ago, during the era of the Sino-Japanese War and the Boxer Indemnity, in the poverty-stricken Motherland that was in the process of being carved up by the Powers. The intellectuals of his generation had to personally experience the humiliating

exploitations in the Foreign Concessions, the Twenty-one Treaties, the May Thirtieth Massacre, the September Eighteenth Incident, the Rape of Nanjing and countless other rampant foreign oppressions. They had to personally experience pervasive racial discriminations when they went abroad. How they had looked forward to the day when a prosperous China could stand up, when the British Empire had to lower the Union Jack and withdraw troops, when they can see for themselves the Chinese flag proudly announce to the world: This is Chinese territory! That day, July the first, 1997, is the day their generation had dreamed of throughout their lives.

Father had always been optimistic that such a day would eventually arrive. But up until when he passed away in 1973, he had never thought his son would be able to personally participate in that day's historical ceremony. Otherwise, he probably would have rewritten the famous lines of Lu You (1125–1209) into:

The day you celebrate
That all national shames are gone,
You should not forget to
Inform me, your late father.

Commentary In 1929 when I was seven years old, my father became a professor of mathematics at Tsinghua University in Beiping (now Beijing), and we lived in a house on the campus for eight years. Many years later in the mid-1990's, President Wang Da-Zhong (王大中) of that University asked me to come back to the campus to build up an Institute for Advanced Studies. China was rapidly modernising and I willingly accepted the invitation. But I was still not retired from Stony Brook, so the beginning of the Institute was slow. The first few years were devoted to fund-raising in the US and in Hong Kong.

Early in the morning of November 15, 1997 I felt some discomfort in the chest. It seemed to go away after a while. Fortunately Chih Li insisted that she should drive me to the Stony Brook University Hospital. In the Emergency Room I was told I had just suffered a mild heart attack. On November 18, I had a quadruple bypass operation. It was very successful: Thirteen years later in the summer of 2010, I had an MRI of the heart in the Peking Union Medical College in Beijing, and I could see all four bridges around my heart, all clear of obstructions. Amazing!

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