A Univ Conversation with Rudy Marcus

Michael Collins: I'm taking this opportunity while I'm visiting the California Institute of Technology in Pasadena for about a month to talk to Professor Rudy Marcus, slightly ahead of his 100th birthday. Rudy of course is an Honorary Fellow of the College and has been for something like 30 years now. He was first at Univ in 1975/76 when he was a Visiting Professor of Theoretical Chemistry at the University, attached to Univ, and shortly after that he moved to Caltech where he's been ever since. Rudy is a Nobel Prize Winner, has an honorary degree from Oxford and is an extremely distinguished theoretical chemist.

Perhaps Rudy I could start by asking you something about that early visit to Oxford. What was it that brought you to Oxford?

Rudy Marcus: I knew two of the Fellows at Univ, both chemists, one was Mark Child[i], working in the field of semi-classical theory, and the other was John Albery[ii], working in a very different field, that of electrochemistry, and I was working in both at the time, so I got to know them and the College invited me to come out. It was a truly wonderful experience. What I liked so much about it, was getting together with many other people at lunch, other Fellows at lunch, from all sorts of fields. For me that was quite unique. One was a Vice-Admiral in the Second World War, but there was just a great range of Fellows. It sounded like an ideal way of living and I enjoyed those six months very much.

MC: Do you have any observations about having met people like George Cawkwell?

RM: George Cawkwell was just a splendid person, with a sense of humour and a sense of dignity. I don't think he took himself seriously, but he just generated so much that was erudition and friendliness. That was a unique experience – meeting George and talking to him. He spent some time with Laura trying to see if he could persuade her to persuade me to come here so yes, of course I remember George Cawkwell. That was academia's best, and he cared so much, if I remember rightly, about students.

MC: Indeed. I wonder if we could talk a bit about you yourself as a chemist, how did you come into chemistry as a young man, perhaps even as a boy?

RM: Well of course, like every other young future chemist I had a chemistry set – it wasn't a very good set! They weren't very interesting experiments. I always enjoyed constructing things – I had construction sets of all kinds, whether it was Meccano or some stick and ball type of construction set, or an erector set, I had a number of them. I always like building things, and in retrospect science really is something like that. You put bits and pieces together and you get sometimes a beautiful structure coming out, almost miraculously. I always enjoyed that construction part and I think that more than any chemistry set was a factor in making me go into science, and going into chemistry in particular. As far as why did I go into chemistry rather than, say, physics – I'm not quite sure but an adviser at McGill gave that advice. I think it ended up being a very good decision.

MC: Did this give you a particular opportunity to make a mark in chemistry?

RM: I never thought of "making a mark" at any time, maybe strangely enough, I just enjoyed trying to solve problems – and I still enjoy trying to solve problems. Of course, one always likes to really make a mark, but that wasn't the motivation at all.

When I lived in Canada there were no theoretical chemists, none – there were some in the United States, there were some in the United Kingdom, but there were none in Canada – so those of us who were in chemistry never even thought about where even theories come from. They could have been handed down from on high for all we knew. So, like every other chemist in Canada, I did experiments.

After getting my doctorate in 1946, I went to the National Research Council doing quite different types of experiments, working with E. W. R. Steacie[iii] and then I became very dissatisfied – truly I know what it's like to be unhappy, because I wasn't using any of the math that I had learnt at McGill. As a student in chemistry and in my PhD, I took more math courses than probably any other chemist at that time had taken. There weren't many, but I just loved it, I love the manipulation of things and so on. I wasn't able to use any of that in the experimental work that I was doing, so I was extremely unhappy.

After a couple of years on the post-doctoral program at the National Research Council of Canada in Ottawa on gas phase reactions, I decided that enough's enough and why don't I apply to some theoretical chemists to see if I can get a postdoc in theoretical chemistry, even though I knew no theoretical chemistry. O. K. Rice[iv] who was at the University of North Carolina, and a wonderful scientist, was the only one of the six who offered me a postdoc if he could get the grant from the Office of Naval Research. He applied, he got the grant, and I went down and from the very beginning I was just in heaven, it was everything I wanted. I know what it's like to have an almost overnight change in feeling about life, because I was now learning so much. That's what I've always enjoyed doing.

MC: Were you, you might say, working as a pencil and paper theoretical chemist?

RM: Yes, this was pre-computing pretty much, as far as chemistry was concerned, although we had a Marchant calculator! All of the work I was doing – and in fact – what I do personally is still pencil and paper work. I have co-workers who make computations and so on, but it's still – the question of can you capture the essence of some set of experiments in simple terms, even though it's not 100% accurate, even though precision is not one of its goals – understanding is one of its goals. That was the evolution, but for me it was a qualitative overnight change in feeling about the world.

MC: How did your career progress after that?

RM: Well after that – Oscar Rice was a wonderful person to work with, since I knew so little about theoretical chemistry we would meet once a week where I would describe some theoretical papers that I'd read and he would point out various things that I'd missed and so on, so that was an example of his generosity.

Later on, after a couple of years, postdoc-ing there, I got married to Laura, whom you knew, in the meanwhile and was looking for an academic position. Laura and I wrote 35 letters and, as I've often said, I didn't get 35 nos because not everybody replied! That was the situation. Then, by a combination of circumstances, including going off for some meetings, meeting some people, just an unusual, highly improbable set of circumstances I met the Dean of the graduate school of Brooklyn Poly at the meeting and he was looking for people to hire. We connected and I went up and gave a seminar then got my first academic job. That was great – and it turned out that Brooklyn Poly was a great place to be and there were a lot of people actually who were refugees from Europe who were part of the faculty, and there was just so much enthusiasm and friendliness, so it was a wonderful transition. But what strikes me so much is how much these

various sets of circumstances, whether it's getting the position with Oscar Rice, or getting the position at Brooklyn Poly, they were in a sense accidental. It's true there's a certain force – you had a to apply for something – but nevertheless, the combination of accidents and that a person's career can depend so much on accidents it's unfortunate, because one's life can go one way or the other – in my case it turned out for the better.

MC: And it turned out extremely well of course. Did you go straight from there to Urbana (University of Illinois)?

RM: After thirteen years at Brooklyn Poly, the University of Illinois Urbana-Champaign offered me a position and it was one of the best chemistry departments of the country. Scientists are naturally attracted towards excellence so – even though we enjoyed so much the people and the spirit of Brooklyn Poly – it was clear that I was interested in moving to more challenging work. The University of Illinois was a good place to go, and so we went there and enjoyed the years from 1964 to 1978 there.

MC: Did you find therefore when you were in Urbana, having more people around, that new challenges appeared in things you wanted to think about?

RM: Well I'm not sure, I had some wonderful interactions at Brooklyn Poly, including one chap who was tremendously taken with rigour, and so I had a variety of ideas in our discussions and float them out and he would try and pin me to the wall 'how do you know this?' And I think that was wonderful experience. He taught group theory.

MC: My subject of course, Rudy! As an aside, I will remind you that when I was here at Caltech in its centennial year 1991, you and I processed together at the commencement ceremony and we talked about matrices. I was writing a book on representation theory and finite dimensional matrices, you said, "no, let's take infinite dimensional matrices" and we processed that way.

RM: By the way, I've learnt about a new set of matrices that are relevant in the operation of cyclic motors in biology. I'll tell you about it, I've got a book on it.

MC: So how did you find it when you came to Oxford?

RM: Oxford was again a dramatic step forward for me. I liked the closeness of the town. There were all sorts of things together to go to, you didn't have to travel long distances as often you did in New York City. Of course I loved the interactions of the College. I loved that – was it at 11 and 4 – teas that one had in one's department. I liked the historic background of everything. There's such a continuity with the past that's there, whereas in the US – it's a wonderful place to live – but it's all relatively new. I loved the majesty of the colleges, the beauty and variety of the architecture, the homogeneity within each college of the architecture. I think that's changed a bit now, looking at some of the modern buildings.

MC: Well certainly I think Oxford has very recently gone through a far bigger phase of building than at any time since the beginning of the last century. The first ten years of the twentieth century saw massive building, the same now. How did you find Oxford scientifically after Urbana?

RM: I guess with Mark Child there and John Albery, and then some others from other colleges, I may have had more people to interact with – that's possible – because it's not just one department it's a whole bunch effectively of colleges! There may have been, possibly, a wider spread, but sometimes just being different is its own stimulus. Especially with Mark and John.

MC: What took you to Caltech after you'd been at Oxford?

RM: I'm not sure where to begin. When I was at Illinois at one point, I was chairman of the staffing committee in chemistry, and we were interviewing people for a particular position in experimental work, and one of the people we interviewed was Ahmed Zewail[v] who later became a very famous chemist and Nobel laureate. Ahmed and I hit it off immediately – we had the same kind of enthusiasm. The trouble is he was doing work in advanced techniques involving dephasing, but he wasn't doing chemistry, so neither I nor the other members of the committee made him an offer at that time. Later he was made an offer at Caltech and came here, so that's one factor. I know Ahmed Zewail through the set of circumstances where we didn't make him an offer but we're good friends!

Later on Laura, my late spouse, who enjoyed Oxford tremendously, Laura and I were having breakfast at the time when you could have sit down breakfasts at the National Academy of Sciences, at one of their annual meetings, and at the same table were Harry Gray[vi] and a good friend of his, distinguished chemist George Hammond[vii], and Harry was at Caltech. Laura happened to mention that I'd been to Oxford and enjoyed it, and I think that was enough to awaken Harry's eyes. Harry is an active pioneer in many respects in electron transfer reactions in biochemistry, so I think that put a bug in his thoughts so Oxford indirectly played a role. So anyways, with the combination of Harry and Ahmed, who was on the faculty, the two of them together, they persuaded the other members of the faculty to make me an offer. So, Oxford played a role in my going to Caltech!

MC: I'd heard the name Harry Gray a long time ago, I actually met him at Caltech, probably at a dinner party, about 10 or 15 years ago when he told me about how he'd persuaded Caltech to hire you. Of course, you're quite remarkable because you're now approaching 100 and you're still an actual member of the faculty!

RM: Well, I haven't learnt to do anything else Michael! I just enjoy so much, thinking of problems, being stuck on the problem, and not seeing where to go, and then sometimes, finally, finding a way to go and connect things. I enjoy so much connecting different dots and learning new things. I'm enjoying so much doing research with a close friend, Professor Emerita Maria-Elisabeth Michel-Beyerle of the Technical University of Munich.

MC: All I would say is it's a pity you're not a mathematician because if you set yourself a goal, you say here is something I want to achieve, if I believe it I should be able to get there. Is that a good philosophy in chemistry as well?

RM: I remember at McGill taking a course in complex variables, and in that class was Louis Nirenberg[viii], the well-known mathematician – the rest of the people were mathematical physicists – that was one of the options, and I was the only chemist. In that class, Louis came in first and I came in second, but it was there that I saw what true genius was and I thought, "what a gap there is between us." He would come in with his own original proofs of various things, and debated with the math instructor. I always liked math, but more as a vehicle towards enabling things.

MC: Of course, Caltech is a quite remarkable institution, tremendous standing, some people say relatively few students, but a tremendous research output. You mention Ahmed Zewail; of course I knew him as well, Nobel Prize winner, and now there's a third chemist, Frances Arnold[ix], who won a Nobel Prize four years ago and she is getting an honorary degree at Oxford this summer. What is it about Caltech that produces such tremendous scientists?

RM: That's a good question. It may be in how it got started because once you get started with good people it's easier to hire more good people. If the department starts rolling downhill and eventually for quite a while, then it's difficult to attract top people. Caltech used to be more of a technical kind of school called Throop University, then Throop Polytechnic Institute, and then around 1921 I think it became Caltech and they hired three people to try to get things started. There was an existing faculty but it was mostly very applied, and they hired three people to try to make it a truly outstanding institution. One of them was Robert Millikan[x], who later won the Nobel Prize, the other was George Hale[xi], who was an astronomer, foreign secretary of the National Academy of Sciences, and the third was Arthur Amos Noyes[xii], who was Provost or Acting Provost at MIT.

So they brought three people together who complemented each other, and Millikan formed a nucleus of a new university using the buildings through the polytechnic, but making it a new institution. I think it was Millikan who was just so good at hiring people. He hired in a very short space of time at Caltech, truly outstanding people. From there they just continued in that sense of excellence. It's because those three individuals worked so closely together in three quite separate areas. Hale was a very well known astronomer, for example. They chose good people and those good people then chose good people. It took an effort. Many institutions can't make that jump – they don't have that triad of people. Probably Millikan deserves a lot of the praise because he had so many contacts.

MC: You talk about Caltech and its early development, but it's more than 40 years ago now just after you came that I spent a full year here, and it felt quite a small institution then. It's now perhaps almost doubled in size since then. Do you think this is a good feature of an institution?

RM: The research groups I believe have become larger, and especially with laboratories – that requires expansion. I'm not sure that the student body is increased particularly, but probably the number of postdocs has. Whether that's a good thing or not I don't know, but probably it's necessary with the competition. If you're competing against some other group, and it's pretty large or growing for whatever reason, then you're forced to become large in order to compete, in many cases.

I think it's as a result of somehow, for whatever reason, groups expanding in their size. At one time it was mainly organic chemists who had large research groups, but now some physical chemists and some theoretical chemists have large research groups too. I think there's been a change, but I've not sat down to actually look at the figures.

MC: Historically one would probably go into a teaching position quite early, whereas now a career usually consists of a number of postdoctoral posts.

RM: Especially for a biologist I believe. I think there the amount of postdoc-ing is quite large.

MC: Just looking at your career, what advice would you offer to a budding scientist, whether an undergraduate or someone who's a research student in terms of thinking about the goals for their career, to encourage people into science, to stay in science?

RM: It depends so much on one's nature. I know how much pleasure it can be to think about problems – even going to sleep at night thinking about problems, whether one's successful at the moment or not. I think it's unparalleled. Of course, not everybody's interested in doing that, maybe not everybody can do that. I have enjoyed so much, as I said earlier I know what it's like to be doing something you're not enjoying doing – and it's a tremendous contrast. If possible,

one shouldn't make any compromises there. If one knows, what one really likes to do – and if it's a positive thing – once you go for it. It's gambling sometimes, it's taking a chance. It's easy to keep on doing something and more difficult to make a jump to another area. But if one can, if one is willing to gamble, it can work out very well.

MC: If we perhaps move back to Oxford – you've visited on several occasions, since you were here for those six months and, of course, you came to Oxford in 1995 to receive an honorary degree from the University. Would you like to tell us a little bit about that occasion?

RM: I remember what a glorious occasion it was. Walking through the streets with the other honorands and the other faculty members from Oxford, to receive the honorary degree. I remember the dignity. Of course the whole family was with me, our three sons, wives, granddaughter, my late spouse Laura. For them it was a very special occasion, as it was for me. So there was that atmosphere of having all of that family support in addition to the support of the people at Oxford on that occasion. I have received and continue to receive a number of honorary degrees. The one at Oxford was a very special one.

MC: That's one, of course. I'm very pleased that you chose to remember, because when I was here for the inauguration of the current President of Caltech, we have a photograph – I was wearing doctor's robes and you chose to wear your Oxford robes on that occasion. That photograph, which we'll put on the website to remind people, was on the website at that time, in 2014. People see you there, as an Oxford DSc.

RM: You mention the unusual hood that I had, one doesn't normally wear hoods with that gown, and that's fine, it's just that I'd been so used to wearing hoods that I just picked one off the wall and put it on!

MC: I was in full sub fusc because I was asked by the Oxford Vice Chancellor to represent him at that inauguration. Would you like to share some recollections of those subsequent visits?

RM: One of course I remember, in a sense there was such a contrast, was one where there was a meeting and celebration of John Albery's 75th birthday. John was in a wheelchair at that time. He still had his wit, but it was sad to see him – from a physical point of view – compared with what he was like not so many years before. I remember the very positive attitude that other people had towards John, because he had many students, many successful students. He was very good at somehow bringing out qualities in students in electrochemistry. It was great to be back in Oxford, and all the surroundings and wandering around various buildings and streets. It brought back many happy memories. I thought it was a very friendly college, in my experience anyway, and such a variety of people to meet that one doesn't normally from all sorts of different fields. I thought, "well, I'll never see this again."

Sometime later I came to Caltech, and while we didn't have those long tables – we had round tables where faculty from all sorts of different areas came together to have lunch. Of course, Oxford has continued that way, and at Caltech it's decreased. When I came to Caltech in 1978, there were four round tables the faculty randomly sat down and met at lunch – well, not quite randomly because one was known as the engineering table, another was known as the chemists' and maybe the geochemists' table! There were four distinct tables and now there's only one. Most of the people have passed away, and the younger people at Caltech are maybe so busy with managing large research groups and preparing grant proposals that they spend their lunchtimes perhaps with their groups, rather than in this wonderful, relaxing and regenerative way of spending a lunchtime – it was present at Oxford, in the colleges, and it was present at Caltech.

MC: I have you to thank for introducing me to a round table; that certainly has enhanced my visits here over many years.

RM: Well, that was to the benefit of the round table.

MC: Well, thank you!

---

[i] Mark Sheard Child FRS, British chemist and Emeritus Fellow of St Edmund Hall, Oxford. Mark Child was Professor of Theoretical Chemistry and a Fellow of Univ from 1994 to 2004.
[ii] Wyndham John Albery FRS (1936–2013), former Master of Univ (1989–1997) and sometime Weir Junior Research Fellow, Fellow in Physical Chemistry, Senior Tutor of Amalgamated Clubs, Tutor for Admissions, and Dean.
[iii] Edgar William Richard Steacie OBE FRS FRSC (1900–1962), Canadian physical chemist and president of the National Research Council of Canada from 1952 to 1962.
[iv] Oscar Kneffler Rice (1903–1978), Kenan Professor Emeritus of Chemistry at University of North Carolina, Chapel Hill from 1975 to 1978.
[v] Ahmed Hassan Zewail (1946–2016), Egyptian-American chemist. He was awarded the 1999 Nobel Prize in Chemistry for his work on femtochemistry and became the first Egyptian to win a Nobel Prize in a scientific field.
[vi] Harry Barkus Gray, Arnold O. Beckman Professor of Chemistry at Caltech.
[vii] George Simms Hammond (1921–2005), American scientist and theoretical chemist who developed "Hammond's postulate", and fathered organic photochemistry.
[viii] Louis Nirenberg, (1925–2020), Canadian-born American mathematician who was noted for his work in analysis, with an emphasis on partial differential equations.
[ix] Frances Hamilton Arnold, American chemical engineer and Nobel Laureate. She is the Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry at Caltech.
[x] Robert Andrews Millikan (1868–1953) won the Nobel Prize in Physics in 1923 "for his work on the elementary charge of electricity and on the photoelectric effect."
[xi] George Ellery Hale (1868–1938), American astrophysicist, best known for his discovery of magnetic fields in sunspots.
[xii] Arthur Amos Noyes (1866–1936), American chemist, inventor and educator, who served as the acting president of MIT between 1907 and 1909 and as Professor of Chemistry at the California Institute of Technology from 1919 to 1936.