This is the second interview of Dr. Julius Axelrod
Friday, January 26, 1996
Grosvenor Apartments in Bethesda, Maryland
Interviewer: Dr. Martin Flavin

Flavin: So, I feel that Julie Axelrod's early life is probably never going to be known except from what we're able to talk about, and I know he thinks it's uninteresting and I can understand why. If he thinks it's not fun to think about, then it's really not good and we shouldn't go beyond this session probably.

We were just talking beforehand about getting into various graduate schools right after the end of the war and how different it was from what it became later on. I guess maybe I'll-- I'm interested in how you started reading. Now normally I shouldn't talk about myself, but I'll say one thing. I started reading, becoming an intellectual, very suddenly at 14. And it wasn't because of teachers, schools, or parents. My father was a writer and had thousands of books. None of them had any influence at all. It was because of the one boy who had always been within walking distance of where I lived and was my age, and I came back from boarding school in Europe and before that we'd been firing our .22 rifles around and playing with toy soldiers and things like that, and bang, he was transformed. He was interested in Marxism and in Hinduism and classical music. And we set up all these things in an abandoned tool shed and got our little study together and the first two books, the key books, were called *Erewhon* and *South Wind*, the first adult books I read,

and from then on I became a reader.

Axelrod: It was just pure chance that the library, Hamilton Fish Park Library, was a half block from my house, and I just may have stumbled into it, or I don't know why, but I liked to read. At that time, I remember, when I was 7, I used to read books like *Pinocchio* and *Robinson Crusoe*, and things like that. The adventures. But, it took me away from the kind of life I was living and I was very easily fantasized by, what kind of a life that could be and my real life wasn't very interesting. We were very poor. My mother had to go out to work, you know, as a maid, as a domestic. My father, he made some money, but he gambled a lot of it away. Our diet was mainly chicken soup and spaghetti, something like that. And I just loved to read, and reading just took me away from my life, my real life. I really was very much just transformed by these books. I loved reading, though it wasn't a very systematic type of reading. I just looked at the pages and if I got interested in it, I took it out of the library.

Flavin: So it wasn't under anybody's influence?

Axelrod: No. Nobody's influence at all.

Flavin: You just started on your own?

Axelrod: I suppose because of the life I really lived and I started on my own because I was very good at comprehension. It was no problem reading. In fact, I think most of my education and intellectual inspiration was

through reading. It wasn't directed in anyway; just whatever book I picked up I read.

Flavin: And did you have a group of friends with similar--

Axelrod: Yes, there were. There were a group of friends. At the time I was Bar Mitzvah I knew these street gangs. After I was Bar Mitzvahed, at 13, I just didn't believe in religion. I had to learn, the prayers, from a very old-fashioned rabbi, who had his little shtibl --his study--in a cellar someplace and he used to smack you. He was very unpleasant and I just didn't understand a thing I was reading. It was just rote. And I really became an atheist just after I was Bar Mitzvahed. I played hooky from cheder (Hebrew school). I just stopped going. My mother gave me a half a dollar to give to the rabbi, but I played hooky. I didn't know what to do with the money. I bought skates and I did a lot of things. I felt guilty. I used to leave half dollars around in my house. I just didn't know what to do with the money. And I was found out and my father gave me a real beating. And I was relieved and eventually, after the formalities of a Bar Mitzvah, I never went into a synagogue again.

And at that time there were a group of kids that went to a Yeshiva--that's a Jewish Hebrew School--right close by, and kids who were very interested in intellectual things, who I knew. There was an older man, Henry Schoenberg, who lived in my street, and he also had a great influence in my life. He took me to concerts. He used to give me issues of *The Mercury*. I don't know whether you remember--what's his name--

H.L. Mencken. And I became very much intellectually inclined in that period.

Flavin: You mentioned that one of the things you read now is *The New York Review of Books*, so I gather that you had developed early some interest in literature, serious literature?

Axelrod: Oh, yes.. Again, I read Sinclair Lewis, Upton Sinclair--I was very fond of him--and the Jack London stories. *The Mercury* had an influence on me, the type of literature that they had, and I became very much interested in Marxism during that period.

Flavin: A lot of people did.

Axelrod: I used to read *The New Masses,* and occasionally *The Daily Worker*, and that was just before I went to college I became very much interested in politics. The times were really dreadful. The Depression began, and I went to college just at the beginning of the Depression.

At first I went to New York University for a year downtown and thought I had a better chance of getting into medical school. My dream was to become a doctor.

Flavin: When did you begin to see medicine as--

Axelrod: Well, I think my parents wanted me to become a doctor, every Jewish family would like to have a son as a doctor. My parents and my mother, particularly, and she was indoctrinating me from a very early age to become a doctor. All successful Jewish boys became doctors. She had no idea about science at all. And I became interested in science, reading

books on science. I told you *Arrowsmith* and *The Microbe Hunters*, and again I was interested in politics--Marxism, socialism. After a year at NYU I just didn't have any money and fortunately I got into City College. I had the grades. It was not easy to get in. You had to have an 80 average. And the kids were very bright. And there was all kinds of political ferment there, at that time. We used to have all kinds of splinter Marxist groups--the *Lovestonites*, the *Trotskyites*, the *Schachtmanites* -- they didn't call them *Stalinites* then. And I was fascinated with that. We used to have what was known as the "Alcoves" at City College, where we had these little groups--particularly the *Trotskyites*--hung out together with the *Lovestonites*. I sort of wandered among them all. And then we had socialists and communists who were just very antagonistic towards each other.

Flavin: Now, in reading, in one way it's possible I was a little bit more like your father, because I have never been able to read as long as it's daylight. I feel I have to be doing something and I only read after dark. And I see you're quite comfortable reading.

Axelrod: Yes. I just used to be reading all the time. I had my nose in a book all the time. Of course, I can remember when I was in high school I built myself a crystal set--just in shop they taught you how to do that, and I used to listen to music. It was very terrible reception, but I'd try to read and eat and talk to my mother. I remember I was very much interested in that little crystal set that I made.

Flavin: You mentioned that you used to enjoy Saturdays when your father rented a horse and buggy and--

Axelrod: Oh yes. And we drove to--

Flavin: --you took the baskets uptown to sell them.

Axelrod: We went uptown.

Flavin: Did you have much contact with your father, except for those rides?

Axelrod: No. Not really. Not very much. My father, he was a nice, sweet man but, you know, a weak sort. My father was much more literate than my mother. He read newspapers. My mother could barely read.

Flavin: In Yiddish too?

Axelrod: In Yiddish or English. She learned how to later.

Flavin: You said, I think, that you felt you were close to your father.

Axelrod: Closest to my mother because my father was sort of a distant person. He was hardly home and my contact with family was my mother. She had a very strong personality. She was a nice woman but she had, her way of doing things which was very hard to argue against. If she'd tell me to wear rubbers, I had to wear rubbers, and gloves. She was a very nice, gentle woman most of the time.

Flavin: So with mostly your mother and two sisters you were in sort of a woman's world.

Axelrod: Yes. A woman's world. But I really read a great deal. I used to have my nose in a book all the time. And my mother, I thought, was very pleased that I could read. She never discouraged me from doing it.

Flavin: Did you ever-- You know, it was your mother that wanted you especially to go to medical school. Did you--

Axelrod: Oh, to become a doctor. Yes.

Flavin: Did you ever, you know, have any rebellion, or any--

Axelrod: No. I really was very interested in it.

Flavin: You wanted it?

Axelrod: Yes. Biology and medicine. I used to get the catalogs from various medical schools. I fantasized about the courses I would take. Yes, it was my dream to become a doctor.

Flavin: Did you have a particular best friend, a special one?

Axelrod: I had a couple of friends--they weren't best--but we used to hang out. We used to do a lot of hanging out, in candy stores. Most of them were fairly radical and some were some cynical at times, but I used to enjoy their company. We used to talk a lot.

I didn't go out with girls. Of course, I thought a lot about them. I was very shy. And it was much later that I really went out with girls but not many.

Flavin: When? At what age did you?

Axelrod: Oh, when I was about 20 I started to go out. I was very shy. Recently, *The Daily News* had a section called "The Ultimate Yearbook," high school yearbook, and they had pictures of all the famous New Yorkers who graduated from New York high schools. They had one of all the Nobel Prize winners, including myself. And what they said about me in

my yearbook, it says, "Don't forget me. I'm here." I was very shy.

Flavin: Right. I guess they had cause to change their minds.

Axelrod: Well, later on. But, you had these kids who talked very well--and were sort of aggressive, always raising their hands in class, and they participated and had all kinds of social activities. I didn't even have a girl when I went to my high school prom. I went with a bunch of guys to see "The Blackbirds of 1929."

Flavin: Well, what should we talk about?

Axelrod: It's hard for me to recall, my life then. I know I went to high school, Seward Park High School. That was on the lower East Side next to the *Forward* (a Yiddish newspaper) building on Hester Street, almost all the students were Jewish. The kids were bright. I don't remember whether I was particularly an outstanding student, but I was a good student. Most of my grades were A's and B's.

Flavin: You know, I didn't decide to go to medical school until after I finished college and, even then, it was really the Army was looking for students--

Axelrod: Oh, they had that special three year course.

Flavin: I had the three year course, and it was not hard to get in. I took the entire Pre-Med Course in the Army, the whole 3 or 4 years, in 9 months. But in that 9 months I got fascinated by chemistry and I already decided I'm not going to do medicine, but I went all the way through medical school-

Axelrod: Oh, really?

Flavin: --knowing I was going to do chemistry.

Axelrod: Did you get your M.D.?

Flavin: Yes. I got the degree, and I interned, but all the way through I--

Axelrod: But you were interested in--

Flavin: But this easy-- But then after the war there was a bottleneck to get residency training, which didn't bother me because I didn't want it, but that's where the tight spot was.

Axelrod: Oh, really?

Flavin: But, during the war, getting into medical school was not such a big deal, and my classmates were not awfully bright, and I have the feeling, though I may be wrong, that they didn't realize--they weren't looking to this great gold mine that medicine turned out to be--they didn't-- Now, in your time was medical school regarded as a kind of gold mine?

Axelrod: No. It's not for money so much as the prestige amongst Jews being a doctor. "My son the doctor." You know they had a great deal of respect. Money didn't bother me. I didn't even think about it then. It was just the study of medicine to treat people, and I had that romantic notion of curing diseases and a sort of a faint idea of research. I didn't know what it really was. I had all kinds of fantasies, of doing research, treating people.

Flavin: But there was still an intense competition, even though the money wasn't in the picture?

Axelrod: Oh, I couldn't get into medical school, because I tried, because there were quotas for Jewish students. You had to be exceptionally good.

When I got out of college my average was a B, a little over a B, and if you were Jewish you had to be a straight A student or a son of a doctor to get into medical school. Very few--Arthur Kornberg from City College, who was a bright guy, got into medical school.

Flavin: Right. So, it wasn't just academic distinction, but there was this quota problem?

Axelrod: Oh, there was this quota problem. It was very marked, you know, in that period. There was some anti-Semitism. There was, even after the war, for a while. And also socially. You know, you couldn't get into clubs, you couldn't get into a law firm, a gentile law firm.

Flavin: But for the goyim that did get into medical school there wasn't this tremendous competition for pre-med grades?

Axelrod: Yes. There was competition.

Flavin: For them too?

Axelrod: Yes. City College was highly competitive. These were aggressive, striving, Jewish kids. We all competed.

Flavin: But the business of getting straight A's is kind of a special knack. I mean, it's--

Axelrod: Yes. Very good at taking exams. I was not a very good exam taker. I read the biographies of the Members of the Royal Society--I'm a foreign member--and I read the autobiography of Mitchell, Peter Mitchell, and he had a terrible time. He couldn't take examinations. He didn't get very good grades. But, he was really a very original thinker.

Flavin: A most interesting lab in that time.

Axelrod: He got his own private lab. But anyway, yes, there's a knack at getting good grades. I didn't have that knack. I studied. I didn't have much a chance to study. I worked. I had to study on the subways.

Flavin: You continued working with your father through--

Axelrod: Well, not my father; for other basket makers, all through school. Although we were very poor, here I was going to college and my mother made great sacrifices. There was no question that I would go to college. And when I did get out of college I couldn't get into medical school. I almost took a job at the Post Office and then I heard of a position at NYU to assist a biochemist. It was almost what they call a "volunteer." I got $25 dollars a month. And it was a good fateful choice. I was interviewed by William H. Park, who was a very famous bacteriologist. He was a professor of bacteriology at NYU and also Head of the Public Health Department of New York City. He interviewed me and he sent me to a man, W.H.G. Falk, who was a fairly wealthy man. He was in one of these old German-Jewish families that did well. And he got a grant from the Harriman's to do research on cancer, and I assisted him in doing esterases activity in tumors. He was a good biochemist but he was not of the stature of Schoenheimer or someone like that. Dr. Falk wrote a textbook on enzymology which he never mentioned that it was a protein. At that time Willstätter, he was a German biochemist, didn't believe that enzymes were proteins, even after Sumner isolated and crystallized

urease. It's an interesting book that Dr. Falk wrote. *The Mechanism of Enzyme Action*. But anyway, I was very much interested in what I was doing. The vitamins were being introduced at that time, in the '30s, and they were added to foods as supplements. The City of New York was very concerned about whether these supplements stated, truly stated, what was present in the milk and vitamin pills, and they set up a laboratory with Dr. Falk, a biochemist, as president, I was asked to join the lab and it was the first time I really made a decent salary. It was not bad. And it wasn't a bad experience. I learned how to adapt methods for measuring vitamins--most of them which adapted were published in *JVC*. I used all kinds of assays, biological, chemical. I used microbiological assays for the B vitamins and chemical assays, say, for vitamin A, which I adapted. It was a good experience.

Flavin: Let me ask you what that laboratory looked like? What sort of-- You said something about a pH meter that was as big as a small closet?

Axelrod: I had to set up a pH meter with Wheatstone bridges and glass electrodes. It was a very complicated business, then, to set up a pH meter. And I was given the task to do it. And it was a good experience on how to use instruments. And I had to crystalize the salts to make sure they were very pure before I made the buffers. And I had to read papers by Mansfield Clark. I don't know if you've heard of him. He was a great authority on pH. He was in the Public Health Service, I think, and became Professor at Hopkins. W. Mansfield Clark. The lab subscribed

to the *The Journal of Biological Chemistry* and I read it very religiously and I became interested mostly in the isolation of vitamins, and enzymology, TPN, DPN and those.

Flavin: What sort of equipment did the lab have?

Axelrod: Well, we had colorimeters, DuBosque colorimeters. We had no radioactivity then. You measured the intensity of color by using this colorimeter. And I remember one reaction of stannous chloride, to measure vitamin A. We had a lot of rat cages. Diets. We had to make up special diets for various vitamins. They were vitamin-free and then we added supplements to try to test them. And we used to do silver staining of the bones, to test for vitamin D. And weight gain and weight loss. And the big school then, the place that did most of the work on vitamins was the University of Wisconsin. They did a lot of the vitamin work with Steenbock and Wooley. I don't know whether you know these names. They did the best vitamin work, and I always dreamt of going to Wisconsin because it was a great school. This fellow Wooley, who was blind, who discovered nicotinic acid.

Flavin: Oh yes. Yes, I do. I did meet him.

Axelrod: And I used to go to hear him lecture. A great friend of Dr. Falk, was a Professor Nelson, from Columbia, who worked on sugars. Did you know a man by the name of Nelson in organic chemistry?

Flavin: I don't remember that name, but I did meet Wooley actually on the way to the 1961 Moscow--

Axelrod: Oh yes, the famous one, where Marshall gave his talk?

Flavin: Yes. And we both got stuck in Kiev for a while.

Axelrod: Yes. I think Nelson was dead by then. But Nelson was very famous, a sugar chemist, and the kinetics of sugar reactions and all that. I became interested in biochemistry and biology.

Flavin: Now, during all those long years you were married?

Axelrod: I was married in 1938.

Flavin: You'd already--

Axelrod: I met my wife in 1936. She was pretty young. She was still going to high school. And she had the same background I did. She was born in Elizabeth, New Jersey, but her parents were very poor. They moved to the lower East Side. Sally (my wife) was a very intelligent woman. She was a girl then and she had similar interests that I did, very intellectual interests.

Flavin: So you were married and then you moved out of your parents' house?

Axelrod: Moved out of my parents' house in 1938. I lived on East 15th Street. I don't know whether you know New York.

Flavin: I'm not fond of New York. I try to--

Axelrod: No, but I am. East 15th Street. And then we moved to Brooklyn at just about the beginning of the war. I lost an eye--I think I told you--when I started working at NYU.

Flavin: But I don't think you told me what the accident was.

Axelrod: I had to open a bottle of concentrated ammonia which had these glass

stoppers, and you had to bang it, and suddenly it just spattered into my face, and I was blind in both my eyes. One cleared up and one didn't. I was only 22 or 23 and I was hospitalized at Bellevue. I thought I'd be blind. Having one eye never handicapped me in any way. I had one eye for most of my life. I never felt handicapped by it. I didn't even try to get any money from NYU. I didn't even think of it, to sue them.

Flavin: Was it something from the autoclave that was really hot?

Axelrod: Yes. I don't know what it was. It was in a very hot day. I tried to open it. There must have been enormous pressure built up and as soon as I released that pressure by banging on the glass stopper the ammonia vapor splashed in my face. I was very lucky to save one eye.

Flavin: Anyway, so now you're married and your children began to come along.

Axelrod: My children came on much later. I was married in '38 and our first child was born in 1945. Sally, went to college, Hunter College. It's the equivalent of City College but for women.

Flavin: Yes. Hunter College?

Axelrod: Hunter. Again, it was interesting. The two women Nobel Prize winners, Gertrude Elion and Rosalyn Yalow, were Hunter College graduates.

Flavin: Who was the--

Axelrod: Rosalyn Yalow.

Flavin: I--

Axelrod: Yes, she won the Nobel Prize for the development of radioimmunoassay, and Gertrude Elion, who worked on the synthesis of nucleic acid

blockers. Well, Sally, I persuaded her to major in chemistry, but that was a mistake. She didn't do very well. She switched her major to psychology. And I was working and she went to college, got her degree, in '42, and so then she worked for an insurance company until we decided to have a child.

Flavin: So, all this happened while you were at that Industrial Hygiene Lab?

Axelrod: Right.

Flavin: But the children came along just towards--

Axelrod: Well, I became very despondent actually. I thought I was at a dead end job in 1945, and I just wasn't seeming to get anyplace. And then the rest I told in that book. I don't know what you read. But I had the opportunity to work on analgesics with Brodie at Goldwater, and that changed my life.

Flavin: From there on its history.

Axelrod: What's that?

Flavin: It's history. From there on it's already history that everybody--

Axelrod: Yes. But, it was just pure luck that I got a job at Industrial Hygiene, considering the times, and pure luck that I had this opportunity to go to Goldwater. I don't know what would have happened. In fact, I just didn't know what I could do with my degree. I took it when I-- Yes. When I was at the Industrial Hygiene I took a Master's degree in chemistry. I did it at night. And my thesis was "Ester Hydrolyzing Action in Tumors and Tumor Tissues." It was a very pedestrian sort of a

problem. And I enjoyed going to night school to get a Ph.D. My grades were pretty good. But somehow I was reluctant to go to graduate school. I heard all these stories that you had to pass these tough exams and all of that.

And while I was working in Dr. Brodie's lab--I think I told that all in that book. Then I wanted to ask for a raise when I discovered an important group of enzymes which are now the P450 enzymes. I thought I deserved a raise, but they said I didn't have a Ph.D. I think I was a GS-12. I then decided to get a Ph.D. And it wasn't hard at all; I got it in a year.

Flavin: But the last years at this Industrial Hygiene Lab, you weren't really happy there. You--

Axelrod: Well, I wasn't really happy. I was glad to work, in a lab, during that period (the Great Depression). I was happy to get a job in chemistry but the work became almost routinized, so boring, but I just didn't have any desire to go for a Ph.D. I once tried--I told you I wanted to go to Columbia, but this lady professor, she was very, very disparaging of my background. I didn't have the right courses. So I just didn't bother any further. And when I first came here to the NIH I thought of going [for the] Ph.D. I went to evening classes--sort of late afternoon classes--at Georgetown and I had terrible teachers there that didn't interest me at all. I thought if I took a Ph.D. degree early after City College I didn't think I would have done very well. I had to have this research experience, at

Goldwater which wasn't really experience--I just did it. I must have had some kind of feel for research, but within 4 months I solved the problem I intended to solve.

Flavin: The Tylenol?

Axelrod: When I went to Goldwater, Brodie was a very stimulating man. I don't know whether you knew him. He was in Building 3.

Flavin: He was around, but I didn't really know him.

Axelrod: Yes. He was in Building 3. During the war Shannon was the head of the Anti-Malarial Program, the clinical testing for anti-malarials at Goldwater. He was a very dynamic man.

Flavin: The main thing about Brodie, a lot of people say Nobel Laureates need two things: they need talent and they need aggression. And you seem to be a person who has no aggression at all.

Axelrod: Very little, and I was and still am shy.

Flavin: Never having known Brodie, I just have a guess that he was a person who had a lot of aggression but maybe a little short on the talent side?

Axelrod: Yes. Well, he had a big ego. He was very imaginative. He said, "You try this--". You know, he inspired you to try all kinds of things.

Flavin: Were they really his ideas, or--

Axelrod: Well, at the beginning they were.

Flavin: --or did he walk in the hall--

Axelrod: Let me tell you what I had. I had no experience. I had an interview with him. The Institute of the Study of Analgesic Drugs, they were

manufacturers of analgesic drugs, they came to the head of the lab and at that time there was a nominal head who was a retired professor of Pharmacology, George B. Wallace, and was a very distinguished pharmacologist, and they came to him and said, "People who take non-aspirin analgesics like Phenacetin, or Acetanilide came down with methemoglobinemia. If they take large amounts and became habituated they came down with methemoglobinemia," and the analgesic institute wanted some help to find out what was going on. Wallace asked me, "Would you like to work on this problem?" And I said, "Well, I have no experience." And he says, "Well, I have an associate down at NYU who is now with Goldwater," NYU--had a branch at Goldwater. This was during the war and they had this Anti-Malarial Program. The Japanese cut off the supply of quinine and new antimalerial drugs were being developed. And what Brodie did was to develop methods to measure plasma levels of drugs, and that was a big revolutionary thing. It was influenced by the introduction of sulfonamides to show that plasma level would give you an idea of how long they acted. There was a pharmacologist called A.K. Marshall, Jr., at Hopkins, who was a great proponent of this. I don't know whether you've heard of him. He was Chairman of Pharmacology at Hopkins and a great influence on Brodie and on Shannon about blood levels. And Brodie systematically set out to measure blood levels of Atabrine and quinine. He was very good at that. I remember he had a series in *JBC*, five papers, a very systematic

analysis of these anti-malarials. And he had working with him Sid Udenfriend was his-- I don't know whether you know Sid.

Flavin: Oh, yes, I know Sid.

Axelrod: Well, Sid was working just before I came. He worked there during the war. I came soon after. I went to see Brodie. I had no idea about doing research. And we talked and he told me that when you take any drug or foreign compound it is changed in the body, sort of detoxified in most cases. Brodie asked me to put the structure of acetanilide on the blackboard. It is a benzene ring with amino acetyl group on it. And he says, "Now one of the possible metabolic changes would be the removal of the acetyl group to form aniline." And I looked through the literature and saw aniline will cause methhemoglobinemia. One thing I learned was to ask the right questions. That's the most important thing.

Flavin: This is another tape. We're still talking on February 12, 1946, just for the record, so someone can find out what it is.

Axelrod: This is about my beginnings in research. I had a Master's degree. I had this experience developing methods.

Axelrod: --microbiological, chemical and animal, and I spoke to Brodie about this problem of why people who take a lot of these non-aspirin analgesics get methemoglobinemia. So we decided to see if aniline was formed after one takes acetanilide. The problem was to develop a method, an accurate method, to measure aniline in plasma to see if it's sensitive and specific, and what I did, was to modify the Bratton-Marshall reaction for

measuring sulfonamides. With Brodie's help I developed a color reaction for aniline. Optical aniline gave color and the most intense at alkanine temperature of 60 degrees C. And then to concentrate it we extracted in a small volume of organic solvent. The color reaction we used was diazidization coupling with--I forget what the reagents were--we got a color and then we extracted it. We developed a sensitive assay for aniline. I took some acetanilide and I found it--.

Flavin: So there was quite a few challenges?

Axelrod: Well, it was sensitive enough. There was only a few percent of the acetanilide that was present in the urine. And we showed-- And fortunately I was good at methods. This is sort of what I was doing, fooling around with the conditions, and the extraction procedure was Brodie's forte. He knew a lot about the solubility and polarity of solvents to extract it. He also used a counter current apparatus-- I don't know whether you know Lyman Craig.

Flavin: Lyman Craig I knew quite well because his wife's sister was a girlfriend of mine in San Francisco, and I talked to him about the sulfonamide days. They got this little sample from North Africa from German troops and they gave the Rockefeller the job of finding out what it was, and he was involved in doing the structure.

Axelrod: Well, he modified the counter-current. Do you know the principle?

Flavin: Oh yes, I've used it.

Axelrod: Well, he knew so much about solvents and pH, and Brodie learned those

lessons, and I exploited that to get the color into the solvent and then to measure specificity what we did, there was so little, you know, we couldn't crystallize it out, and what we did is take advantage of the optimal partition coefficients in different solvents at different pHs. This is the Lyman Craig thing. And it was a very ingenious way of just getting compounds out of biologic material.

So we developed a method for aniline, and we found aniline in blood and urine and there was a direct relationship between the amount of aniline and methemoglobinemia in plasma after acetanilide. And I loved doing it. I was good at it. And without a Ph.D.

And then we decided to see what happened to the rest of the acetanilide molecule in the body. Acetanilide, was completely metabolized. There was only about 4 percent aniline and maybe 1 percent acetanilide in the urine. And just over a period of 6 months--mainly myself-- I identified the major metabolite. It was N-acetyl-para-aminophenol, which is now called Tylenol. And I knew I had a flair for research.

Flavin: Some years ago I heard your talk to the Washington History of Medicine Society about the Tylenol discovery, and someone has got to look up and find out exactly who has made how much money from that work.

Axelrod: N-acetylpamino buenol--had been synthesized way back in 1888 and used as [an] antipyretic but they didn't check it for analgesic activity. We did. At least Brodie gave it to an expert. It had analgesic activity. It didn't form methemoglobinemia. In our first paper--we reported--that

acetanilide forms a toxic metabolite (aniline) and another metabolite, a main metabolite, which is nontoxic and had the same analgesic activity of acetanilide, and we stated that acetanilide is probably producing its analgesic effect through the conversion to N-acetyl-para-aminophenol. Well, see, fortunately, I happened to do a research problem which I was comfortable with to develop methods.

Flavin: Looking back, my impression is that the ability to develop new methods has gotten more and more rare among young scientists.

Axelrod: If you have a problem and you have an idea, unless you can test it out by a method that's specific and sensitive, you just can't do it.

Flavin: At the very beginning at NIH, in Building 3, I remember developing some new method. I developed a method for assaying threonine, I think. And for a few years postdocs were developing new methods to measure something, and then, for the last 30 years, if it's not in the literature it's, "Well, that's too bad, it can't be done."

Axelrod: Well, one of the qualities you have to have to be successful in research is learning how to develop methods and either apply them--you don't have to develop them originally--but modify published methods that you can apply to your own particular problem.

Flavin: A rare ability.

Axelrod: Well, I was good at methods. I developed lots of methods to measure drugs in biological materials using UV or color reactions or enzymatic reactions. I developed a lot of methods. And that's a big secret, you

know, if you have an idea and you can't develop a method to test it, it's just an idea. So that's one of the big secrets I learned from Brodie not to be phased by this tackling the problem. And I knew I was good at it. I never had very much self-confidence, but one thing I learned, when I knew I can develop methods, I really took off.

Flavin: A very rare and unique ability.

Axelrod: Well, considering the background I had. You read those books and that chapter and I had a lot of interviews and it covers the same ground. I don't know whether you can get anything new out of that just by talking. I think I've done it very well. In fact, the Society of Neuroscience are--they're having a series of volumes called "The History of Neuroscience: In Autobiography," and so they asked me to write one. I published an autobiographical sketch called An *Unexpected Life in Science*, as a prefatory chapter in these annual reviews of pharmacology. The Society of Neuroscience were happy to publish this chapter with an epilogue.

Flavin: And your wife was a schoolteacher?

Axelrod: Yes, she taught for 20 years, 2nd Grade. She was very conscientious.

Flavin: So that was a late start too?

Axelrod: Oh yes. Well, there were a lot of late starters who lived during that period during the Depression and the war years. It disrupted a lot of careers. I happened to go to the right place, going to Brodie at Goldwater, and then going to the NIH. There couldn't have been better choices for me. I don't think I could ever write a grant proposal that

would get me money. I have no idea what research I would do a year or two from now.

Flavin: So, your wife had still a long span after she retired from teaching?

Axelrod: Yes. She retired in '75 and she died in '92. Teaching is-- You sort of get burned out after a while. She was very sincere and very dedicated. She liked teaching. But after 20 years or so she got burned out.

Flavin: Did she have any special interests after she retired?

Axelrod: Yes. She taught illiterates. She was a member of the Literacy Council. She taught illiterates. She liked doing that. It had sort of an appeal. But Sally was retired and she didn't have those pressures of teaching and marking 25 papers every night.

I don't know what I can tell you anymore. The rest of it, I think, is either in the literature. I'm sure by talking to me these last 2 or 3 times you sort of get an idea of what kind of person I am, what kind of person I was.

Flavin: We've come very quickly to the part of your story that everybody already knows.

Axelrod: Yes. You know, it's hard for me to recall things, but I gave you the things that come to mind, the influences that come to mind. My intellectual background, being Jewish, which of course is conducive to this sort of thing, and love of reading. I still read a lot.

Flavin: Should I-- Suppose I say, Julie, what did you do today from the time you woke up?

Axelrod: What I did today? I had to write--I don't know whether you know--

Flavin: I mean the very beginning, when you woke up.

Axelrod: Oh, when I woke up?

Flavin: Did you have any dreams that you remember?

Axelrod: No. No. Actually we had a fire alarm at 12:00 o'clock in my apartment building. It was a false alarm. I had to get up. Anyway, I couldn't fall asleep so I took a sleeping pill, and I slept until about 6:30. I got up, washed, and usually in the morning I ate breakfast--I haven't got much of a breakfast--I have orange juice and cereal. And I rode my bike for 15 minutes, my stationary bike. And then I watched the news.

Flavin: Do you watch the TV during the bike riding?

Axelrod: No. I read during the bike-- I usually read the magazine section of *The New York Times* during that bike ride.

Flavin: I watch the TV in the morning, and that morning television is a disaster. And I'll watch anything. I watch the Greek news in Greek.

Axelrod: But what I-- I spent about-- After I get the news, the short news, and the weather, I usually watch C-Span. They have-- I don't know whether you watch C-Span. They have two people with opposite points of view about politics mainly answer questions and they have some very interesting people. Today, for example, they had an editor of a journal called *The Standard.* He was more conservative. And then a man by the name of Jonathan Podhoretz--

Flavin: This was after breakfast now?

Axelrod: Yes. After breakfast. I watched TV until about 8:30 and then I went to

work. I had to write a letter of recommendation for somebody's Lasker Award. Somebody asked for me for a supporting letter, and I wrote it, and spent most of the morning doing that. And I went to the library for about-- Let's see, what did I read in the library? I usually read some of the journals. I try to catch up. And I had lunch, a very fast one,-- I was at the Clinical Center and had a sandwich, and I went back and I read some of the journals. I get these newsletters, a lot of literature which some are interesting, some less interesting. And then I read the *PNAS*. I get free copies of the NIH journal.

Flavin: I see it.

Axelrod: Or *The Scientist*. I get that free. I have a lot of literature that comes across my desk. I talked to my colleague about the research problems. I talked to one of the technicians who is going to medical school about, well, she had this interview today and she was telling me what it was like. And I started to write another letter of recommendation--I get a lot of those--for somebody who wants to get a position at G.W.

Flavin: After you got home you wrote another letter?

Axelrod: I have a lot of--a big stack--of recommendations, so I usually copy one. I wrote before.

Flavin: Do you take the Metro?

Axelrod: No. I drive.

Flavin: You drive?

Axelrod: Yes. I drive. It's very short and I don't want to have the car sitting

around. I hate to drive. The only driving that I do is to the public library. I go to the library every Saturday morning. I still do.

Flavin: The NIH Library?

Axelrod: No, no. The Davis Library here, or the Kensington Library. Yes, I still do. I read the magazines, all kinds.

Flavin: Saturday mornings?

Axelrod: Saturday morning. It's been a habit for me for a long time. I do a lot of reading.

Flavin: That's the one that was closed for a while? (Kensington library)

Axelrod: Yes. At first it was closed. It was closed and I used to go there mostly. And then I went to Davis. I got so used to going to Davis that I go there now because I shop at Sutton Place which is right there--you know--at Wildwood. I get some of my food. I hate cooking. I get prepared food.

Flavin: Well--

Axelrod: Well, if I can help you in any way-- I don't know whether you can get much out of this. I think I told you I don't think you could. I can't go into in-depth study, you know. Being psychoanalyzed, I don't know, would be different, my personal--

Flavin: No, nothing like that. I think you have a lot of things that the NIH Historian would like to have.

Axelrod: I have a lot of it. And, you know, I never was asked. Really, I had a lot of interviews, actually interviews at the NIH, for somebody else. I had an interview by the Society of Neuroscience. I had interviews by four or

five people who were involved in the beginnings of the Neuroscience Society. And I had a lot of interviews, and several printed interviews. I can give you a stack of them. I think I gave you some of them.

Flavin: You gave me one and I've read it, but Victoria Harden, she wants the NIH to put these into print form and then the thing is she'll want you to correct the print.

Axelrod: Oh. About the most interesting thing is that book, or that article, I wrote, that one update I wrote, for the *Neuroscience*. I think it tells most of it.

Flavin: She'll probably want you to sign some form saying you release this information.

Axelrod: Are you working with her, with Harden?

Flavin: Not yet, but I will. When I give her these then it'll begin. So far it's just you and me.

Axelrod: You know, this is just my early life which has nothing--which is very--Again, I think the title of the chapter I wrote, "An Un-Expected Life in Science," is very appropriate. I always fantasized about being a scientist. I love to read about scientists. In fact, I get the biographical memoirs of the National Academy of Sciences and the Royal Society and I love reading those biographies.

Flavin: They are very short.

Axelrod: Yes. Well, some are short. Some are short and some fairly long.

Flavin: Yes. I had the idea that you might find it fun to really spend quite a large number of hours talking about incidents, memories, details of your very

early life. But perhaps now it doesn't seem that way.

Axelrod: No. I was approached to write it but I just-- I'm not a Lewis Thomas. I don't think that my life is that interesting. You know, maybe--it was interesting in a way. It gives a period, a milieu, of the time. Of course a great proportion of Jewish scientists led my kind of life. You know? Nine Nobel Laureates went to City College and led similar lives as mine. Of course, the new generation go to Harvard now. But, we have Varmus, or Klausner and they're the same sort of a background--But they have a more modern training.

Levin: A life story though I think is in the details.

Axelrod: Yes. Well, the devil is in the details, as they say.

Levin: Maybe we'd better quit with that one for today.

(Whereupon, the interview concluded.)