Frank Moore Oral History Interview, April 11, 2017

Title
“Studying Salamanders to Better Understand Ourselves”

Date
April 11, 2017

Location
Valley Library, Oregon State University.

Summary
In the interview, Moore discusses his upbringing in rural Ohio, noting in particular his early interest in nature. He then reflects on his undergraduate years at the College of Wooster, where he majored in Psychology and met the woman who would become his wife, Kathleen Dean. In recalling their meeting, Moore comments on Kathleen's family background and the shared interests that cemented their bond.

Next, Moore discusses the handful of years that he spent as a public school teacher, noting that he did so in order to prepare himself for a future career as a university professor. From there, he traces his path through graduate studies at the University of Colorado, focusing in particular on his shift to endocrinology, his intellectual influences as a budding young scientist, his research on the control of spermatogenesis in salamanders, and his wife's progression as a doctoral student.

The session then turns its attention to Moore's career at Oregon State University. In this, he describes the path that he and his wife took to securing employment at OSU, and shares his memories of the university and the community in the mid-1970s. He then details his discovery of the hormone vasotocin in salamanders and comments on the major importance of this finding. He likewise provides background and context on other research that he conducted relating to neurological systems in salamanders and his attempts to use this work to better understand human systems. Of particular note is Moore's discussion of a heavily cited paper, "A Corticosteroid Receptor in Neuronal Membranes." Moore likewise comments on the frustrations that he encountered in trying to clone hormone receptors, and reflects on the years that he spent as an administrator near the conclusion of his career.

The interview winds up with Moore's sense of the major impact made by OSU's Zoology/Integrative Biology program over the years; his perspective on his academic partnership with Kathleen Dean Moore; and his opinions on current attacks on science and denial of climate change. Moore concludes with thoughts on change in the College of Science and on OSU's positioning as it looks toward its 150th anniversary.

Interviewee
Frank Moore

Interviewer
Chris Petersen

Website

http://scarc.library.oregonstate.edu/oh150/mooref/

Transcript

Chris Petersen: Today is April 11, 2017, and we're in the Valley Library with Frank Moore, Distinguished Professor Emeritus of Zoology. We will talk to Frank a great deal about his career and his association with Oregon State University, but I'd like to begin by developing more of a biographical sketch of your life, and I'll ask you first where were you born?

Frank Moore: I was born in Ohio about 20 miles south of Lake Erie in a small town that had a population of about 16,000 but surrounded by farmland.

CP: What was the name of that town?

FM: Fremont.

CP: Is that where you grew up?

FM: I grew up in Fremont, yes.

CP: Can you tell me a little bit more about Fremont and the community life there?

FM: As I said, it's somewhat of a farming town, and there was some light industry there, but it was not an academic center by any means. But I grew up in a doctor's family. My father was a doctor, my grandfather was a doctor working as either general practitioners or general surgeons in that town. I had four siblings, there were five kids in the family, and since my father was working so much the five of us were raised by my mother mostly. I mean, he was a strong influence, but she had to do the day-to-day. I had a free reign for doing lots of outdoor things, either going out to farms, playing in hay lofts, and walking through the woods. Spent a lot of time fishing on a river that was nearby with other boys in the neighborhood.

CP: So nature was a real point of emphasis for you from early on?

FM: Very much so. I spent a lot of time fishing. But also not just sitting fishing. We explored the river. We turned over rocks and waded and caught things with our hands and waded through creeks and even used dip-nets to see what was there. We would have a quarry that had fish in them or salamanders or at one time I somehow captured about 2 dozen snakes and brought them home and had them as pets in a couple containers and aquaria, which when one of the snakes fell from a rafter and wrapped around my father's neck [smiles], those were abolished from the house [laughs]. Yeah, very much nature. A lot of bird watching. A lot of reading of field guides or nature books, too. That's how I ended up eventually as a biologist.

CP: Did you have an example, an older example, that helped prompt this, or do you think this just came from the larger community around you, or where do you think this came from?

FM: It was somewhat through the interest of relatives. This was back when lots of people did duck hunting and pheasant hunting, so they were hunters and always talking about animals and behaviors of animals and things like that. I think the seed of it probably came from being in a family that talked a lot about hunting and fishing too. My great uncles would take me fishing or hunting as a little kid. I think that was a big background for how I ended up with such a strong interest in the natural world. It grew as I matured, too, so I did a lot on my own. Even in high school I was a bird watcher. I would walk around with binoculars and identify the different species of birds, which back in the late '50s and early '60s was not very popular, but it was an interest that I had.

CP: This interest in nature, was there a corollary academic interest in science that was building at this point?

FM: Not a lot.

[0:05:00]

I had an exceptionally good biology teacher in high school. That was special. That carried me through very well. That was one of the few courses in my high school that was academically challenging and stimulating. The small town public

school system wasn't particularly strong. It wasn't an academically supported program. The biology program there, or the biology teacher, was exceptionally good and that helped a lot.

CP: Were you a strong student at this point?

FM: I was a strong student in a weak program in high school [smiles]. I didn't have to study very much. I just coasted through and got good grades.

CP: Can I assume that college was always in your sights?

FM: Yeah. College was always in my sights and because of my family being in medicine I went to college with the idea that I'd be premed and become a doctor. But I guess that wasn't a deep desire. That was just an easy explanation of what I wanted to do with my life. Because when I got to college it didn't stick very long, so I dropped the premed idea freshman year and started to look around for other things.

CP: Do I understand correctly that you went to Wooster Business College?

FM: No.

CP: Okay.

FM: That was a different school. Maybe an affiliate of that. It's called the College of Wooster. It's in Wooster, Ohio. And it's a liberal arts school ranked pretty well academically. Back then it was quite strong academically, and it claims it's the top research 4-year liberal arts college in the nation [smiles]. I don't know how they claim—what supports that. But they had a research program even when I went there, so that our junior and senior we had to do theses. We did 4-year research projects and then wrote them up as research papers that were like miniature master's theses. So that helped a lot for graduate school.

CP: How did you decide on Wooster in the first place?

FM: It was a nice—Ohio has a lot of 4-year liberal arts school. I was interested in that type of school and Wooster approached me with an offer of a basketball scholarship, and so I didn't really study the different schools and didn't study Wooster that much but I was happy to go there to play basketball and go to school there. I did play basketball for one year there and had a good year, but it was too much like a job [smiles], even though I had no desire to be a professional basketball player, so I dropped basketball at the end of my freshman year.

CP: That's something that you had been involved in in high school, obviously?

FM: Yeah, I was a jock [smiles]. I was an athlete in basketball and that was my main sport was basketball.

CP: A rare combination of jock and bird watcher.

FM: [smiles and nods] Yeah it was, it was.

CP: [Chuckles]. You mentioned when you went to Wooster you had this notion of pre-med but you switched to psychology, is that correct?

FM: I did. It was called experimental psychology, so we didn't do very much with clinical psychology or social psychology. A lot of it was experimenting with Learning Theory and laboratory rats and that type of psychology, which the subject content probably didn't help that much for my career, but the experimental design and rigors of designing experiments and coming up with good questions, tractable questions, it was an excellent major for that. I picked it in part because of my interests with behavior and animals and wondered how animal behavior and human behavior related, which I guess is a question that's stayed with me through my career.

[0:10:11]

Even though the—as I said, the subject content didn't relate to my Ph.D., the training was very good for it: experimentation and statistics and stuff. In fact, at that period of time experimental psychology was more sophisticated in experimental design and statistics than the biological sciences.

CP: This culminated in an undergraduate thesis.

FM: Yeah. I wrote a senior thesis on some aspect of learning theory using rats and a [B.F.] Skinner box. I can't remember what the question was that I studied. It wasn't very important.

CP: There was at least one important thing that emerged out of this 4-year experience. My understanding is that you met your wife there, is that correct?

FM: Yeah, Kathy went there, Kathleen Dean, was there, and we started dating the beginning of my senior year. We really fell in love at that time. She is two years younger, and so she was probably her beginning of her junior year and so we dated and got engaged and eventually we were married. We were married two years after I graduated from Wooster while I was teaching in public schools. But while she had just finished her junior year of college. She had another year of college while we were married, and she commuted from Cleveland, a suburb of Cleveland, where I was teaching down to Wooster several times a week to finish her degree.

CP: She is a very prominent name on this campus. I'm interested in knowing a little bit more about her background leading up to this point where you met.

FM: Well, she came from an academic family. Her father was a chairman of a biology department at Baldwin Wallace College, another 4-year liberal arts school in Ohio. And he was very much a dedicated biologist. He taught a lot of courses in field biology: plant identification or what we would now call plant ecology. Kathy grew up on field trips because he would prep his fieldtrips and she and her two sisters would go out with their mother and father and he would walk around the sites where he was planning on taking his students. She was exposed to a lot of natural history and a lot of biology at that time. In college she didn't want anything to do with sciences and instead she majored in philosophy and French. She did a complete double major in philosophy and French and when she graduated from Wooster she was certified to teach in public schools, teach French, at public schools. But she also had received an offer of an NRCDA or something like that, it's National Research—

CP: Research Council, I think.

FM: Research Council, but it had to do with [pauses], what was that thing called? It had to do with the safety of the United States.

CP: So civil defense?

FM: Kind-of military type fellowship. And that gave her four years of funding, complete funding, for a Ph.D. in philosophy at the University of Colorado. She went directly from Wooster College to start her Ph.D. in Boulder, Colorado. She's an exceptionally smart person [smiles].

CP: I have no doubt about that.

FM: [Laughs].

[0:15:00]

CP: Touching I guess on this early point of meeting her, I guess, I have to believe that the shared interest in nature cemented that bond early on.

FM: [Nods] Yeah, shared interest in nature. That was a lot of it. We just hit it off very well and had things in common. She liked the outdoors. She liked boating, which, and I grew up from high school through college as a sailor also. My father had a couple sailboats up on Lake Erie. I would spend a lot of my summers up sailing and some of it was cruising

and just messing around in sailboats but towards the end a lot of it was racing sailboats. I did a lot of that, and she liked that too.

CP: You finished up your undergrad and you taught public school for it looks like 3 or 4 years. Was that always the intention, or was that a solution to your fiancé being a couple years younger than you?

FM: No. I didn't know what I wanted to do after I graduated until maybe my junior year in college, and then I decided—and this had a lot to do with meeting Kathy because her father became my role model as a professor. One of the concerns I had about going into academics and being a teacher or professor was that I was quite shy in front of groups. I did not like to speak in public. It just scared—it was scary. It was very stressful, and I didn't have confidence in it. Part of my reasoning was well, if I'm thinking of becoming a professor and thinking of teaching, I should find out whether I enjoy it. In my junior year I decided to do that. I decided to add a teaching certificate and a minor in biology at Wooster College. I did student teaching in biology and then was hired and taught in Lakewood, Ohio, a suburb of Cleveland for two years teaching biology at the lower level—7th, 8th, and 9th grade—so I did that while Kathy was finishing up with school. Then she and I moved to Colorado and I got a teaching job in a public school in the suburb of Denver, so I would commute for 2 years between Boulder and Denver, again teaching biological sciences at a middle school, or junior high. During that time I also was taking biology courses during summer school to develop a background and the prerequisites to enter a Ph.D. program in biology. After two years I entered the Ph.D. program.

CP: That's very interesting. That's an unusual path to graduate studies, especially the teaching piece building up.

FM: I wasn't ready for graduate school right out of college. I just wasn't positive what I wanted to do and I wasn't—honestly my study skills weren't as developed as they needed to be. As a teacher that's an amazing way to learn study skills and also taking summer courses, graduate courses and stuff, during summer school helped that too. I became much stronger academically in terms of my skills of taking rigorous courses and stuff during the four years that I taught.

CP: By the time you actually made the transition you were ready?

FM: [Nods] Yes. I was very much ready for graduate school [smiles], and very excited about it and ready to do it.

[0:20:05]

I was interested in doing a Ph.D. in animal behavior, but at Colorado where I entered the Ph.D. I decided to work for a major professor who was an endocrinologist. My basic training at Colorado doing the Ph.D. was a combination of physiology, endocrinology – hormones – and also then in lots of animal behavior. That's how I ended up with the type of research program that I did.

CP: Was this by accident?

FM: The endocrinology was somewhat by accident, because my major professor was David Norris, and David Norris was a young endocrinologist at the University of Colorado at the time, a comparative endocrinologist. He was an expert in fish and amphibian hormones, but of course he also was very knowledgeable in mammalian endocrinology. And David Norris during that two years that I was teaching in the Denver-Boulder area I met Dave Norris through a connection with Kathy's father, my father-in-law, and Dave Norris was one of Kathy's father's undergraduate advisees. We just met socially at a dinner party and then became friends and I guess he was impressed with me academically because he accepted me as his grad student and that was the serendipity of the connection with endocrinology and Dave Norris and myself.

CP: Did you take to the shift eagerly and right away or was it something that took time?

FM: No. I really hadn't thought about endocrinology, hadn't thought about physiology and how hormones work and took the courses and the more I studied and learned about it the more interesting the field became. I became an endocrinologist and really loved it. The main reason was that the field was very exciting at the time because there were so many new things being discovered. I started in a field that had new discoveries, just enormous advances, every year. To be involved in that was exciting and fun. Sitting and reading a book on endocrinology wasn't as exciting as being in the field and watching the new things come out and know what that meant about what we knew about how the body worked [smiles]. That was a fun field to be in.

CP: It's safe to say Norris was an important figure in your career?

FM: Very much so. Yeah. He was a good person at that time for me. He and I aren't that different in age. We were friends, plus he was a good major professor. He had an active lab and at the time the University of Colorado had several labs doing endocrinology work, so there was a cohort that I was with of grad students that were very talented, so it was very stimulating to be in that group at that time.

CP: Talking about influences, I found a reference in which you mention the writings of Konrad Lorenz have made an impact on you at some point.

FM: I'm not sure when I read that. I think it was probably when I was in college, and that was a shift from experimental psychology to the study of behavior in free-living animals, or the wild animal, what we now call animal behavior. The behavior of biology.

[0:25:01]

His discoveries and the clarity in his thoughts about what they called ethology at the time were very stimulating. I liked that. Had that in mind probably when I entered graduate school. I wanted to do that type of research. As it turned out, that wasn't available to do that kind of research. It was more, intellectually I would have been on my own doing it and so I got a much better training by sticking with the endocrinology, and then later here at Oregon State University blending my interest in behavior with my training in endocrinology so that I could investigate how hormones controlled behaviors.

CP: What was your research topic as a Ph.D. student?

FM: It was the control of spermatogenesis in salamanders, which hormones controlled the development of mature sperm in the testes. In mammals that process occurs continuously. When you try to study that in a mammal you're faced with the problem that you have all stages of the development occurring so you can't easily tease out, well when does this hormone trigger this developmental shift from this type of cell to the next type of cell to the mature sperm? My thesis was looking at the salamander where all of the cells were at the same stage and they would develop *en masse* and so I could treat the testes with hormones at different stages of development and ask the question of which hormones had an effect on the transition from one stage of development to the next. It also had to do with interacting—because you don't have just one hormone doing that. You have multiple hormones, so a lot of the thesis was looking at more subtle interactions among a combination of hormones.

CP: By this point I'm guessing that you had decided that you could be an effective teacher? You were more comfortable in the lecture hall?

FM: Oh yes. I discovered that I really enjoyed teaching. I was pretty good at it. At Boulder as a graduate student I was a teaching assistant for all the time that I was there, so I had not only the four years of training in public school teaching but then I taught at the college level while I was earning the Ph.D. and that was instrumental in getting the job here at OSU was the strong background in teaching.

CP: Was there one more year as an instructor at Colorado?

FM: Well, it was a half a year. I was hired—they had offered me a job for a one-year position, but since it was only for the one year they said that if I had a job offer before the end of that one year they would be happy to relieve me from it. I taught physiology lectures I think it was for fall semester in Boulder, and during that time I was applying for jobs and was offered at job here at OSU to teach in the General Science department. I was offered the job because of my background and reputation as a teacher.

CP: How were you and Kathy negotiating this process of dual-career academic couple in very different disciplines trying to figure out what was next after finishing up their Ph.D.s.

FM: [Smiles]. That's a very good question. She was still working on her Ph.D. in philosophy and made the decision, which would have been my last year as a grad student, she made the decision to do a Ph.D. in jurisprudence in philosophy of law and decided that to do it right she needed to have training in law.

[0:30:28]

She applied to law school while she was still a grad student and got accepted to the University of Colorado Law School and did one year of law. That was the plan, was for her to do one year of law school and the law school knew what she was doing and allowed her to take some advanced courses in law and not just exclusively first-year law courses so that she could round out her background in law to write a thesis in philosophy of law. I finished up my Ph.D. and she finished up her law school and she and I had talked about it and she strongly encouraged me to take the lead on finding a job. She would follow and make it work as best as possible. She came to Corvallis with all of her coursework and all of her training finished and just the beginning of a thesis. I think she spent two years in Corvallis raising our daughter who was born the finals week of law school and she wrote her thesis here in Corvallis and defended it in Boulder and got her Ph.D. at that time.

CP: And was subsequently hired? Was there a job waiting for her? Or did she have to wait for a job to open up?

FM: No. Actually neither of us had regular jobs at OSU. I had a 3-year contract to teach in General Science for 3 years where they had faculty going on sabbatical and needed somebody to take their place and the teaching assignment was a non-majors biology course that had I think 1200 students in it. It was a heavy teaching responsibility that I took. Normally coming out of a field like endocrinology after a Ph.D. you would do 1, or 2, or 3, or 4 years of post doc. And Nixon was president at that time, and Nixon froze all funds for NSF and NIH funding, so essentially research funding was dried up completely that year in 1975. There were no post docs available. I thought, well, I'll do my own post doc. I took this teaching job and had assurances through the chair of General Science and the other faculty they would accommodate me doing research in their labs. I had no lab. I would just borrow lab bench space and run experiments and that three years extended to five, and I also was able to do research and I was able to publish papers and get grants coming in and get job offers from other schools, which I was interested in—I needed a real job, not a temporary. I was looking at the job market and eventually worked out that OSU wanted to keep me, but I had to shift from General Science to the Department of Zoology, and it's in the Department of Zoology where I had a tenure-track regular faculty position.

[0:35:08]

CP: You had an unorthodox path in a lot of ways.

FM: [Smiles]. A lot of ways. And then Kathy was also unorthodox in that her track to OSU was to teach in the Honors College. Margaret Mean would hire her whenever Kathy wanted to, and so I think generally she would teach one or maybe two or maybe three honors courses per year. Those were in philosophy. So the Philosophy Department then started sponsoring courses and she started to be an instructor in philosophy and eventually it just worked out that they realized how good she was and went from instructor to assistant professor all the way up to be chair of the department for 9 years.

CP: What do you remember about OSU in those early years? What were your impressions of that time period of the university?

FM: It was very much a—it felt more of a technical ag [agriculture] school than I was used to. There was a lot of influence by the applied fields of, not so much engineering back then, but it was more agriculture and animal science and forestry were pretty dominant compared to the sciences at that time. The sciences were there and there were some really good people there, but it was still growing. That's my impression is that it was more dominated, especially at the higher administration, by the schools of agriculture and forestry and animal science.

CP: How about Corvallis? What was Corvallis like in the mid-'70s?

FM: It was a nice place. It was a very nice place to be. Most big universities are in pretty big cities, and so Corvallis and OSU are an unusual setting where you have a quality university in a nice community. There are other examples, but there aren't as many as you would like. We were very comfortable in Corvallis and worked hard stay here, actually.

CP: You went through this process of a self-directed post doc, sort-of, and began to develop a research agenda, I guess. Can you tell me about how you were setting that up? You switched to Zoology and then it becomes a little bit more formalized?

FM: I switched to Zoology. At that time I also had been publishing papers on how hormones controlled the male reproductive behavior of a local salamander. The salamander is really common around here, it's called the rough skinned newt. When I first came to Corvallis we would do walks in the woods or hike and would see this animal in the ponds and I would see that males holding females' gripping hold of the female. When I first saw it I thought, "Wow, this is an amazing thing," because this animal isn't very frightened. It turned out it was highly poisonous. That was the reason it wasn't very frightened [smiles]. It was a very pronounced, robust behavior, one that was *the* beginning of courtship. I said, "Well, this thing would be an amazingly easy research question—does testosterone affect that behavior?" I knew the literature to know that there were no published papers anywhere in the world linking testosterone to any male behavior in any amphibian. I thought it was an easy publication.

[0:40:01]

I ran the experiment and then ran other experiments and then I measured testosterone, and it turns out there was no effect of testosterone on the behavior in my experiment. There was no correlation between testosterone levels in the blood and whether or not the male would show the behavior. I published two papers essentially with negative data saying testosterone isn't involved in activating this behavior. Shortly after those papers were published there was a paper that came out showing that testosterone affected male behavior in a South African frog. That bothered me a lot, that there was a conflict between my data and Darcy Kelly's data who published that paper. I thought, well, I have confidence that my experiments were well-done and that the results are repeatable, so what's going on? I decided that the best hypothesis was that there was another hormone, that testosterone was there and it clearly was needed, but it wasn't triggering it.

I ran experiments and discovered that there's an oxytocin-like hormone, that's called vasotocin, and that this triggers that behavior, that that is a very, very powerful hormone for turning on the male clasping behavior. That discovery, that this oxytocin-like peptide did this, was one of *the* first papers showing that in any animal. Nowadays oxytocin-like peptides are confirmed to affect maternal behavior, the bonding between the mother and the child. It affects even whether a father feels strong fatherly responses to their baby—if he sniffs a little oxytocin he'll spend more time playing with his baby and then all these other animals from mammals and birds and fishes and now even very primitive roundworm uses that peptide. So it opened up a field of how hormones—and that's, I guess, if anything about my career it's that using an animal model that has its own special powers, research powers, can give you new insights into what's going on.

That's one example. There were others in my career, too, but that's the beginning of it. Your question mentioned some post docs about my self-training post doc. I wrote up grants for studying vasotocin and had those grants funded and then I also wrote a fellowship grant that's called an RCDA—it's a Research Career Development Award, which gave me five years of my own post doc. So the first five years in zoology I was funding myself, so paid my own salary and was learning techniques and training myself basically doing in-house post doc to advance the research training that I needed.

CP: So this was a big deal. A real big deal.

FM: Back then I was a really big deal. It changed my career goal and made it possible for me to develop the research program that I did develop. It was a very good thing.

CP: Were the next handful of years in the early '80s was it primarily this process that you were talking about of building skills and then developing your knowledge about this specific hormone?

[0:45:07]

FM: Yes [nods]. During that time I had a lab I think and probably 5-7 graduate students, and it turns out that they were exceptionally good people and good students. It was a team effort bringing in new techniques into the lab, training them, they'd train each other. So we moved forward and got to the cutting edge measuring hormones and visualizing where hormones were, and that was the early '80s doing that.

CP: Am I correct in my interpretation of your publication list that around the mid-'80s that you started to become more interested in neurological systems?

FM: Yes. Well, it was that this hormone, what I was working on was this oxytocin-like hormone is in the salamander and this action of the hormone was localized in the brain. It was not, even though the peptide functions as a hormone it also

functions as a chemical messenger within the brain. It's released locally on a synapse and triggers a response across the synapse, so it can act locally in specific brain areas. Particularly in the limbic system where you control emotions, such as reproductive motivation and drive. That's how I got into working in the brain.

At that time there was a new technique where you can take an antibody to a hormone and use the antibodies attachment to the hormone to find out where the hormones were located within the brain. In the '80s we used this technique, immunocytochemistry, to identify where the different peptides, the different hormones, were located in the brain. Towards the late '80s I had a post doc, Linda Muske who was using that technique to look at another hormone, one that's called GNRH—gonadotropin-releasing hormone. This GNRH is a small peptide that controls reproductive cycles. The pituitary gland releases hormones in response to this little peptide, and she was looking at that peptide in a salamander brain and discovered that the cells that produced this peptide originate during early development in the olfactory placode. It develops in the nose of the animal, the embryonic animal, and those cells migrate through the brain to the hypothalamus where they're function.

This discovery was interesting because prior to that we didn't know that these nerve cells would migrate during embryonic development—one type of cell moving to another part of the brain. The model prior to that was like tube's convoluting and just growth this way [turning inward motion with hands]. But this particular hormone cell moved from the olfactory region back into the hypothalamus during development. That discovery was then confirmed in humans and mammals and explained a congenital syndrome that's in humans where they are born without the ability to smell and they're also infertile. They don't have any reproductive hormones. It turns out that these people don't have those cells—they don't migrate correctly [smiles]. So they have defects in their olfactory system and then it explains why there's a link between being anosmic and being infertile.

[0:50:17]

CP: There's a theme here of discoveries in amphibians being applied to a better understanding of humans.

FM: That's very true, and that's what worked out very well in my research life was using an animal that had a very primitive brain, very simple brain, and being able to see what was going on. Then once the scientist working on mammals saw what was going on in an amphibian then they would ask the question, "Does this also happen in a mammal?" And in most cases, yes, it does happen in a mammal. It gave insight and early evidence of what was happening there.

CP: Was that always an end-goal of yours or was it a byproduct?

FM: All of my grants argued that this was a good research model.

CP: [Laughs].

FM: I don't think it was a goal so much as realization that this was really a good model, a powerful behavioral model. The brain of the salamander, I was lucky in that a man about from 1920 to 1940 spent a career studying the anatomy of it. There's this thick book of the anatomy of a salamander brain, and it's far more detailed than other animals. Nowadays it wouldn't be, but back then it was probably the most detailed study of any invertebrate brain. We had a document, kind-of a bible, of neuro anatomy and could accurately identify brain areas. We knew that the brain areas of the salamander, even though they didn't have higher cortical development and more complex brain, had all of the brain areas there for the primitive part of the brain, the part of the brain that controls emotions and rapid responses without the higher thought processes. A salamander doesn't think in detail about anything. It's more a stimulus in a context of hormones and giving a response.

CP: You published a paper in 1991 that has been heavily cited: "A Corticosteroid Receptor in Neuronal Membranes." Perhaps this is, we've touched on this already, I don't know, but—tell me about this moment and its impact.

FM: Well, this is the paper and it was a student of mine, Miles Orchinik, Ph.D., and Miles was an extremely talented, brilliant young scientist. We came up with this idea, and when he came into the lab what the background for his thesis was that we had by then spent about 12 years or 15 years studying this male behavior. We would collect salamanders and bring them into the lab and test the behavior with different hormones and then we would release the animals. We knew that if we weren't super nice to the animals—so we would collect them and bring them into the lab and put them in a very

large, comfortable tank and feed them right away and make sure that they weren't crowded and made sure the temperature was right and they were well-fed. If we didn't do all that, they would not show any courtship behavior. So if we stressed them, stress would inhibit the behavior. Then we asked the question: "Which hormone is having an effect to inhibit the behavior?" At the time there were no publications answering that question.

[0:55:07]

We just looked at all the stress hormones, hormones in the stress response, and the major one that comes from our adrenal glands and the salamander adrenal glands, is glucocorticoid. In humans it's called cortisol and in salamanders it's corticosterone. It turned out that that hormone inhibited the behavior rapidly and very strongly and we did studies to show that not only injecting it, but if you stressed an animal the behavior would be inhibited. If you treated the animal with a drug that would block that particular hormone and stressed the animal, the behavior wouldn't be inhibited. We measured the hormone levels. We did lots of studies to convince ourselves that this hormone was inhibiting that behavior.

The reason it was surprise that that hormone did was that it was a steroid hormone. Steroids, like the cortisol, like the testosterone, like estrogen, progesterone—all steroids at the time of that study were modeled, so that their action would be to go through the blood, hit a target cell, go in the target cell, activate a gene, and a gene would then produce messenger RNA, and the RNA would produce a protein, the protein would then have some response in the animal. This takes days, if not weeks or months. Here we had a steroid that was inhibiting a behavior within two minutes. You couldn't explain it by the classic model for how steroids work.

So Miles Orchinik did studies to ask the question whether it was a particular kind of receptor that would be related to the fast-acting neurotransmitters in the brain. He ran studies and demonstrated that this salamander had a receptor, it was on the membrane of the neurons and that that receptor was involved in inhibiting the behavior. He ran a lot of studies with it to do it and got it published in Science. And that was the first real classification of a membrane receptor controlling a behavior. Another way of saying it is the first characterized receptor for a steroid that's in the membrane.

CP: Where did your research go from there? My understanding is a little less specific at this point.

FM: Well, we spent a lot of time trying to clone that receptor, because what we had was a characterization of the receptor. We knew it was in the membranes. We know it was a G protein, a particular class of receptor, G protein coupled receptor. But we didn't have the sequence or the biochemical characterization of the receptor. We didn't know what it looked like in terms of structure, and we didn't know what it looked like in terms of amino acid sequence. I had several graduate students and post docs working on that receptor, trying to clone it, tried to isolate it, and we made progress but we never did actually clone it.

[1:00:10]

Never could find it with a clone. We characterized it in terms of proteins and isolated the protein for it but couldn't get from there to the genes, and so one thing we discovered along the way was that the receptor had some responses that made us think it might be an opiate receptor, one of the opiate receptors: encephalin or beta endorphin naloxone. We cloned a lot of the opiate receptors and then would clone them and then express them in other cells in tissue culture and then we'd express the receptors in tissue culture and we would then be able to do binding studies on those cells to find out whether the corticosterone receptor was an opiate receptor, and I don't think it was. We got a lot of good data on opiate receptors [smiles], but we didn't find any evidence that the opiate receptor and the corticosterone receptor were one and the same. It's still a mystery of what the—nobody else has characterized that receptor either. That's where the research went.

Probably the most interesting follow-up on that membrane receptor was Emma Coddington did her Ph.D., one of my last grad students, and she asked the question: "What was the corticosterone doing during those two minutes before it inhibited the behavior?" Because if it's simply acting directly on this cell that inhibits the behavior than the timespan should be less than two minutes, it should be within seconds. We didn't have any evidence that it would act within seconds on the behavior. She asked the question what was essentially downstream of the corticosterone. You have corticosterone hitting a target cell in the brain and then you have this unknown substance that then hits the target cell that inhibits the behavior, and she worked on that and proved very convincingly that that link there, the downstream hormone, is the endocannabinoids, the internal marijuana of the brain and that this rapid response to corticosterone is mediated

through the cannabinoid system and that then shuts off the behavior. She took it a step further and discovered that the response wasn't always inhibited, that corticosterone or cannabinoids could enhance the male behavior in some contexts, and in other contexts it would inhibit it. This is consistent with what cannabinoids do in modifying an emotional state. It's real clear that the cannabinoids are involved in stress responses, and this is showing in this primitive salamander they're using that same system too. That's the last research that came out of my lab [smiles].

CP: You mentioned that the salamander that started it all was local. Did your fieldwork continue to stay around this area for the most part?

[1:05:00]

FM: Yeah. I personally stuck with the salamander for all 35 years of my career, and most of the experiments we did involved, for the behavior studies, involved catching the animal and treating them and running the experiments with the behaviors and then releasing them back into the same pond where we captured them. We did have to kill some of them for some studies, but they were very common, they still are a very common amphibian. I stayed with that one animal and it was a good animal. [laughs and smiles]

CP: [Laughs]. It must be pretty gratifying to be able to draw broad conclusions based on the study of an animal that's in your own backyard.

FM: Yeah, it is. It was an interesting career to do it that way.

CP: I have a teaching question for you. I came across a reference to a class that you co-taught with your wife, a philosophy major class that involved floating on a river.

FM: I ran support a lot for her [smiles].

CP: [laughs].

FM: The course, I don't think, is really team-taught. I wasn't the co-teacher. I was more the support troops. I would either row the boats or help set up the camp. She taught that course for quite a few years, and I would go up with the students up to the campground in the cascades and they would camp and she would teach philosophy of nature, environmental philosophy, up there with the students. It was a very rewarding course for everyone. I think it changed the lives of quite a few students. It was a real pleasure for her to teach. I really, technically, was not a co-teacher as much as just helping out on that.

CP: A couple of administrative questions. You had an association with the OSU Center for Gene Research and Biotechnology. Can you tell me about that?

FM: As my research progressed towards molecular biology I did more and more molecular approaches, everything from characterizing receptors pharmacologically to cloning genes and expressing them and stuff, so it was just natural that I would affiliate with it. I always viewed myself as a backdoor molecular biologist, because I wasn't trained as a molecular biologist. I trained myself a little bit on it and picked up techniques in molecular biology. But I did support that program and served, helped teach a course and then I taught scientific ethics course with Courtney Campbell, the two of us team-taught that for quite a few years to all of the first-year molecular cellular biology graduate students, and then I think one or two years I also helped coordinate a course in cell biology there too. That was the extent of what was going on in MCB.

CP: You took on a formal administrative appointment as well for the last three years of your career: associate dean of the College of Science.

FM: I worked for Sherm Bloomer and the deans office, associate dean. I'm not sure—I guess I just felt towards the end of my career I should do a little administration. I had been avoiding it most of my career for university administration. So I did that. I had a good job there, because my job was—I had a lot of jobs, but one of the big ones was to come up with the money for new hires. To hire a new faculty member in science is very expensive.

[1:10:05]

The research labs, facilities, and instrumentation is ridiculously expensive. Each new hire, my responsibility was to pull together the funds to find the money on campus that would put it together so that we could offer a startup package for the new faculty. For those three years I was rewarded by being able to get the money and hire some super faculty, OSU faculty, that we're hiring top-rate, some of the best in the world. That takes money and that was my job to find the money so that we could hire some of the best faculty in the world. There was a lot of reward doing that.

CP: Zoology is Integrative Biology now.

FM: Yeah.

CP: OSU has been a potent program for quite some time. I'm interested in some colleagues of yours or perhaps mentors, even, that at OSU have made an impact over the course of your career here of OSU people who have made an impact.

FM: You're right that Zoology has really powerful faculty. It was a wonderful place to be. We had some really strong intellects and some faculty that were very dedicated to their programs and research. It was stimulating to interact with Jane Lubchenco, and Bruce Menge, and Andy Blaustein, and Mark Hixon when he was here. That was very good for that. The people that influenced my career most, the chair of zoology for many years was Charles King, and he was very supportive and excellent chair. He was a major influence on me. Not so much discussing research or stuff, he could understand it, but mostly just supporting creating an environment where things were going well.

In my field the people that I interacted with that helped my—endocrinology at OSU was a very strong field in the '80s and early '90s with Fred Stormshak and other people in animal science doing really cutting edge research in endocrinology, reproductive endocrinology. And then Carl Schrek in Fisheries and Wildlife. He was a fish endocrinologist. The combination of those two labs plus some others plus my own lab we would hold weekly journal club meetings and would have as many as 30 people attending. Then there would be senior faculty, plus post docs, plus grad students. It was very stimulating that way to have that many people on campus working in the field. We stayed up to date. Taught each other a lot that way. I would have Carl Shack and Stormshak as other colleagues were very important in my career.

CP: Well I have a few concluding questions. The first one is circling back to a topic that we've been touching on throughout, and it's your academic partnership with your wife. I'm just interested in knowing what it's been like for you two very successful academics. Your wife is a very high-profile, it's probably been pretty heavy years together.

FM: We were a team for sure. At home we would discuss ideas, discuss issues, discuss politics of the campus. She would read my rough drafts, and I would comment on hers and [smiles] and so it was a team effort that way.

[1:15:08]

She was a regular philosopher and published papers and books in philosophy. I don't know what the date was, maybe early '90s or so, she was chairman of philosophy department and was interested in writing for the public, writing for the general public rather than other philosophers. She joined a writing group and published her first book called *River Walking*, and has published a lot of books since then. My role in this was mostly support for that. A lot of her writing has natural history in it, and most of that's coming from me. I'm in the background of a lot of the books. In more recent years her last two books are for climate change: *Great Tide Rising* and *Moral Ground*. Those books, plus the fact that she's an excellent public speaker, has put her in high demand. As things progressed I played more and more of a role of taking care of our life and supporting her. That's what I've been doing in part of my retirement. In a small way that's why I retired a little bit early. I retired at a younger age than most people do. Then I had that extra time to add more support for her work. Let's see, what else on that? We raised two kids, too.

CP: [Chuckles].

FM: [Smiles] She is not only a really good writer and speaker and teacher, but she's also a very dedicated mother. She took the bulk of the responsibility, especially early on raising the kids. She was stay-at-home until the '80s. Then after both kids went off to college then we had more of a team effort with just the two of us supporting her writing and speaking.

CP: Fast-forwarding to current day, in the interviews I've been doing, since January I've been asking people to comment on this moment in time that we're in. I have to imagine that conversations in your house have changed a little bit with science and climate awareness frankly under attack right now.

FM: Yeah, the attack of science and the denial of climate change is a big thing for us. Kathy has been a speaker all over the United States on explaining that there are moral obligations to do something about climate change so that future generations have a chance. My view of it is that this is what the current political situation that we're in with denying climate change is an extension of the tobacco industry where they were able to increase their profits or maintain high profits by denying the science that tobacco had any harmful health effects. That model has been used by the chemical industry to argue that the ozone layer was not affected by fluorocarbons, and so they denied the science for the ozone layer.

[1:20:06]

They still are denying the science and obstructing science for the effects of chemicals: pesticides, herbicides, fertilizers, flame retardants, and stuff. The chemical industry's proactive on obstructing and denying the science that those chemicals are having harmful effects on human health and on our environment. Now we have climate change and the petroleum industry has used the same model and invested money into creating institutes that deny the science of climate change and with this last election it's clear that there has been a what I like to call a hostile takeover of the United States government, where we now have the head of Exxon Mobil as a state department and Pruitt, head of EPA, a person who is paid for by the petroleum industry, and Rick Perry, another petroleum industry gopher. I think that we are in dire times, and it's where the public is not being served by the government but the large corporations who want to maintain profits are running things that are not in the best interest of the health and well-being of humans and of the world, the environment of the world. [smiles].

CP: Switching back to OSU as we finish up here. I have two final questions. The first would be your thoughts on change within the college that you were in, the College of Science, the changes you've seen over the time that you've been here.

FM: I think most of the changes, the major ones, occurred after my retirement [smiles and laughs].

CP: [Laughs].

FM: I saw gradual change in the College of Science with a little bit of growth, not a lot of growth. I saw a change where we were hiring consistently higher and higher quality scientists and mathematicians. That was a real plus for OSU to attract and retain those people. I think that's a trend that I've seen. For most of the years at OSU it was lean and mean in terms of funding for the science and for OSU academics. In retrospect I mostly think about how budget cuts with increased class size with decreased programs can have negative effects on the success of this university. It's a great university, but it would have been much greater if it had had reasonable funding in support of it. I guess I see the change across time as not always good [smiles].

CP: Well, where do you see OSU is sitting right now as it looks towards its 150th birthday?

FM: I think it's at a critical point where it can either move towards being an independent academic university doing the science that is basic and could be applied science, but do science for the good of the people and good of increasing our knowledge of the world. Or it could become part of the multinational corporate power, you know, that in many cases universities have lost their moral status by accepting the mission of corporations that are not always for the best intentions but more for the profit.

[1:25:28]

I think that we're at a turning point where the university could go either direction: could either become more coopted by corporations and dirty money [smiles] in a sense, or it could go more just building the strength of the university and do the better good for the citizens of Oregon [smiles].

CP: Well, Frank, thank you for this. I really appreciate you sharing your story with us. Best of luck with moving forward with everything.

FM: Thank you. Thank you. I've enjoyed it.

[1:26:18]