

THE FEMINIZING ENVIRONMENT: HOW ENDOCRINE DISRUPTING  
CHEMICALS MAY BE IMPACTING HUMAN REPRODUCTIVE DEVELOPMENT

by

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**Abstract**

This dissertation, in the form of a radio documentary, explores the growing body of research on a family of chemicals known as endocrine disruptors. These manmade chemicals are found in everything from pesticides used on crops to the plasticizers in baby bottles, and by mimicking the body's natural hormones, such as estrogen and testosterone, they may be having deleterious effects on human reproductive development. One birth defect in particular, known as Hypospadias, has shown an increased prevalence in the past several decades and some researchers think this common deformity of the penis may be an indicator of incomplete masculinization during fetal development, and could be caused by exposure to endocrine disrupting chemicals. This dissertation looks at scientific evidence in the animal kingdom regarding the feminizing effects of endocrine disrupting chemicals on wildlife and raises questions about what that research might mean for human reproductive health, specifically in relation to Hypospadias.

**The Feminizing Environment: How Endocrine Disrupting Chemicals  
May Be Disrupting Human Reproductive Development**

HOST INTRO: From the carpets in our living rooms to the liners of our canned goods we're exposed to manmade chemicals every day.

We need chemicals for everything from plastic products to pesticides.

But these chemicals eventually make their way from our households or industrial facilities into the environment – and into our bodies.

The truth is we're only beginning to understand how these chemicals may be affecting human health – reproductive health in particular.

Producer Ashley Ahearn reports.

[DOOR OF FROG LAB ROOM OPENS, VENTILATOR FAN RUNNING]

HAYES: So this is the South African Claw frog. Yup, Xenepis Levis.

[WATER SLOSHING IN TANK]

AHEARN: Tyrone Hayes peers into a large gray fiberglass tank like a little boy looking for critters in a tide pool. Below the surface, fat greenish-yellow frogs swim around–bulging eyes peering up at us through the water.

HAYES: So in this tank there are 40 brothers that are not exposed to atrazine and in this tank there are 40 brothers who were exposed to atrazine and so we can compare these two tubs and look at the number of homosexual pairs. This one has lots of gay males, homosexual pairs in it because it's a treated tank (Hayes).

AHEARN: That's right, homosexual frogs. One morning when one of Hayes' PhD students came in to feed the specimens at 7 AM she noticed some hanky panky going on between the male frogs in a tank that had been treated with atrazine – the second most commonly used herbicide in the U.S. (Hayes). Once Hayes heard about this he started collecting data. He exposed some of his frogs to the same level of atrazine that the environmental protection agency says is safe for drinking water, and he kept the rest of the frogs atrazine-free (Hayes).

HAYES: So what you can see is that there's a seven-fold difference in the atrazine treated animals.

AHEARN: Hayes found that exposed frogs are 7 times more likely to exhibit homosexual behavior and 10 percent become feminized (Hayes).

[FOOTSTEPS TO LAB]

To explain what he meant by “feminized” Hayes brought me back to his office and pulled up a picture on his laptop of a frog that had been exposed to the herbicide.

HAYES: This is an animal that looked like a female on the outside. But on the inside it had large testis and this is an oviduct, so this is the equivalent of a man with a uterus (Hayes).

AHEARN: These frogs aren’t just behaving like females – they’re actually producing eggs and when those eggs are fertilized by normal male frogs, the babies grow up to be seemingly normal frogs (Hayes). Let me say that again: the male frogs are having babies. And there are consequences.

HAYES:…because they don’t have a female chromosome the females that are genetically males can only produce other males so 100 percent of their offspring are males.

AHEARN: And more male frogs means fewer babies down the road. Hayes says this might be one reason that populations of frogs and other amphibians all over the world are going down (Hayes).

HAYES: In our work with frogs we can go into the field. We’ve done this, others have done this. There’s another study that just came out in Canada showing that if you go to an environment that’s contaminated with atrazine you find more hermaphroditic or abnormally developed males (Hayes).

AHEARN: The reproductive problems Hayes is seeing in his specimens aren’t limited to frogs. Studies on rats, reptiles and even human cells exposed to atrazine showed similar results (Hayes). Recently, scientists with the U.S. Geological Survey found intersex fish in one third of the waterways they tested across the United States (Hinck).

And atrazine is not the only chemical to blame for causing widespread reproductive health problems. It’s a member of a family of chemicals known as endocrine disruptors.

COLBORN: Well basically they’re chemicals that have been around for quite a while, we just didn’t know what they were doing.

AHEARN: Dr. Theo Colborn was one of the first to sound the alarm on endocrine disruptors and how they affect reproductive health and development when she co-authored the book “Our Stolen Future” in the late 90’s. At first, people saw her as a bit

of a radical but over a decade later the government is channeling more and more funding towards researching these chemicals and there's a new act in Congress that will require better testing of suspected endocrine disruptors.

Colborn says it's about time. We're constantly exposed to them.

COLBORN: They're in plastics. They're in our toys, the children's toys. If you go to your kitchen sink and under your bathroom sink and look at the cleaning compounds that are there. The cosmetics. The toiletries. They're just about in everything because they've made every one of these products much nicer. They last longer. They're preservatives. They're fire retardants (Colborn).

AHEARN: The endocrine system is made up of a series of glands throughout the body that control the hormonal messages that direct development. By imitating natural hormones— such as estrogen and androgen – endocrine disrupting chemicals prevent the body from sending and receiving those messages (Rosenthal).

Dr. Stephen Rosenthal, a pediatric endocrinologist at the University of California San Francisco, broke down some basic human developmental biology for me. He says in the womb, we all start out developing as girls.

ROSENTHAL: If you consider the gonads, which is the other name for the testis or the ovaries, in any baby - either boy or a girl - these gonads are pre-programmed to become ovaries unless there's an overriding signal that tells them to become testis.

AHEARN: If you're a boy that over-riding signal comes from a gene on your Y-chromosome. It tells your gonads to become testis, instead of ovaries, and to start producing testosterone and androgen. Those hormones then travel through the body and hook up with receptors in cells (Rosenthal).

ROSENTHAL: That sets off a chain of events inside a cell. 10:10 It's like if you need a key and an ignition to start a car right, so the key goes into the ignition and then the whole thing can turn and the car goes on (Rosenthal).

AHEARN: The car "going on" would equate to normal development of a fetus. Now picture some chewing gum in the ignition. The key won't fit. The car won't start – or, as Rosenthal explains - normal masculine development won't proceed.

ROSENTHAL: If there is some agent, some environmental disruptor that interferes with the normal functioning of the Androgen Receptor then it's very likely that in a male there will be incomplete masculinization of the external genitalia (Rosenthal).

[SOUND OF FROG TANK ROOM FADES BACK UP]

AHEARN: The atrazine-exposed male frogs in Tyrone Hayes' lab look just like females, which are much larger than the typical male African Claw Frog and have smaller breeding glands and differently formed feet and gonads.

Tyrone Hayes says just because frogs aren't people that doesn't mean we should ignore the warnings.

HAYES: People go, well, it's frogs. I go, yeah but look, the estrogen that works in this frog is exactly, chemically exactly the same as the estrogen that regulates female reproduction. Exactly the same testosterone that's in these frogs regulating their larynx or their voice box or their breeding glands or their sperm count is exactly the same hormone in rats and in us (Hayes).

AHEARN: So, what about us? Could endocrine disruptors be having feminizing effects in humans? No one knows for sure, but some believe that rising rates of one birth defect could be an indicator (Baskin and Ebbers).

[FADE UP CAFETERIA SOUNDS, PIANO PLAYING IN THE BACKGROUND AT OAKLAND CHILDREN'S HOSPITAL]

AHEARN: Dr. Laurence Baskin is a pediatric urologist with the University of California, San Francisco but he practices here at the Oakland Children's Hospital part of the time.

Today he's performing back-to-back surgeries - and a very specific type of surgery. Baskin specializes in correcting hypospadias - the second most common birth defect in the country behind heart disease (Baskin).

BASKIN: About one in 125 to one in 250 newborn males has an abnormality in their genitalia that could be described as hypospadias - and what I mean by that is penile curvature, abnormal urethra and an abnormal foreskin and putting that together that's what hypospadias is defined as (Baskin).

AHEARN: To put that in perspective, more babies are born with hypospadias than Down's syndrome or cleft palate. Only one or two percent of hypospadias can be explained by looking at people's genes (Baskin).

BASKIN: In other words, we have no idea what causes it (Baskin).

AHEARN: Baskin and some others in his field suspect environmental exposures may be at play.

Think back to the gummed up lock and key that Stephen Rosenthal described. All fetuses are programmed to develop ovaries unless they're told otherwise by certain hormones like testosterone and androgen.

Endocrine disrupting chemicals, like atrazine for example, could gum up the receptors for those hormonal messengers that tell a fetus to develop into a baby boy– or as Baskin explains – preventing the fetus from fully masculinizing.

BASKIN: The penis wouldn't develop. It would be arrested meaning that your urethral opening would be lower down in the penile shaft, the penis normally as it develops is curved and it straightens out so in Hypospadias it wouldn't have straightened out and the foreskin would only have formed on the top of the penis, wouldn't have come down to the bottom because that lock or that hormone receptor would be blocked or disrupted by the environmental toxin (Baskin).

AHEARN: Ok, so if Tyrone Hayes is finding feminizing effects in frogs who are exposed to atrazine – one of these environmental toxins that Baskin is talking about – are there some parallels to be drawn in human beings? Baskin pauses for just a split second before responding.

BASKIN: Humans clearly are not frogs, but the theory is clearly correct. And in this case we would agree with Dr. Hayes that an environmental disruptor, something in the environment, chemical toxin or medication could certainly be a risk factor for Hypospadias (Baskin).

AHEARN: Baskin says the majority of hypospadias can be fixed with a relatively quick surgery that can make life a lot easier for the child later on. (Baskin)

BASKIN: I think growing up as a teenager and not having normal genitalia would be tough enough, even if you have normal genitalia, for regular emotional and sexual development so that's really the major reason to fix it, so kids can be normal (Baskin).

[CAFETERIA SOUNDS FADE OUT]

[ELEVATOR DOOR, HALLWAY, PHONE RINGS]

AHEARN: But “normal” is a loaded term for some. Dr. Tiger Howard Devore is a sex therapist and clinical psychologist in New York City.

DEVORE: Isn't it great that some doctor can tell you what's normal? I love that. I understand that he has good intentions but I also understand that he has a knife in his hand and the fact is that because he has a knife in his hand, what he does is he cuts into human tissue and he creates scars and you gotta know, scars don't have feeling and scars are not pliable and scars don't have elasticity (Devore).

AHEARN: For Devore, this is a personal story.

DEVORE: One of my earliest memories is of being in a hospital and dealing with some physician taking bandages off of my genitals and watching my parents kind of respond in obvious fear about whatever it was that this guy was doing. I was probably maybe three or four, something like that. But I had my first surgery when I was three months old and I had at least one surgery every year after that until I was at least 12 (Devore).

AHEARN: Devore was born with severe hypospadias. All told, he's had 20 operations on his penis.

It wasn't until college that Devore came to terms with his condition and decided to devote himself to helping others born with Hypospadias.

As a psychologist, Devore says that if you follow Rosenthal and Baskin's logic and look at hypospadias as incomplete masculinization of the genitals...

DEVORE: ... the same thing probably happened in the brain in the areas where there's sexual differentiation of the brain. Now it doesn't make a person gay lesbian bisexual or transsexual but it certainly makes it easier for that person to be any of those things (Devore).

AHEARN: There is no peer-reviewed scientific research to back up Devore's claim about sexual orientation and hypospadias. However, the Hypospadias and Epispadias Association – a group which works to raise awareness about these two similar genital conditions - conducted an online survey of roughly 700 men – with hypospadias and without.

The survey found that men with hypospadias were 15 percent more likely to describe themselves as gay (Harrison).

I told Devore about Tyrone Hayes – the biologist at Berkeley with the homosexual and feminized frogs – and asked him what he thought about those findings in relation to people. He said the connection makes sense...

DEVORE: ...but we can't prove it because we can't experiment on human beings. We can certainly look at populational models and say this looks like it's pretty closely related, we probably should take some actions here to see if it is, but we can't say that we know the whole story yet (Devore).

AHEARN: Not only do we not know the whole story, but it would be incorrect and reductive to sum up a person's sexual orientation as a function of their environmental exposure.

DEVORE: This isn't just about where you stick your things. This isn't just about how you get good sensation in your body. This is about who you fall in love with. This is about a whole complex set of social factors (Devore).

[PAUSE]

[BOOTS ON WOODEN PORCH]

AHEARN: It's a rainy spring day in Massachusetts when I pull into Alice Twombly's dirt driveway and walk up the steps to her log cabin style home.

[KNOCKING ON DOOR]

ALICE: You found us out here in the woods.

AHEARN: Ethan, the Twombly's youngest son, is ready for after-school snack.

ETHAN: Where are the chocolate chips?

ALICE: Are you going to melt them? Ok.

[MICROWAVE DOOR OPENS AND SHUTS, BUTTONS BEEP AND MICROWAVE STARTS UP]

AHEARN: At seven years old, Ethan's red head is just above counter level.

[FINISHES BEEPS, DOOR OPENS AND SHUTS AGAIN]

ETHAN: Aaaaah. Done!

AHEARN: Ethan gets a spoon to mush the melted chocolate chips around, and comes back out to sit with his mom and me at the kitchen table.

ALICE: It's kind of a thing we talk about around him. I talk to him about it personally. He knows he has hypospadias and he's met other people that have it.

AHEARN: When Ethan was born the doctors recommended surgery.

ALICE: And I didn't get an answer as to why other than it was kind of like, "because that's what we do."

AHEARN: That wasn't enough of an answer for Alice Twombly so she got online and did some research. Ethan has moderate hypospadias – and his mom felt that unlike boys

with more severe cases where surgery can be necessary, for Ethan, this would just be surgery to make his penis look like everyone else's, as many hypospadias surgeries are.

ALICE: So if he doesn't have a functional problem aren't I telling him, by giving him surgery that he does have a problem? That he has something that needs to be fixed? What's the message I'm sending there? You're not good enough the way you are, even though there's no functional problem? I believe it's more than just a surgical issue. It definitely needs to be looked at from a social and emotional perspective in addition to the surgical (Twombly).

AHEARN: Twombly and her husband opted not to have the surgery done on Ethan. She says he's developing fine. He's not in any pain, and he can pee standing up – something the doctors in Boston told her would be impossible.

If Ethan wants surgery later on, Twombly says she fully supports him. But for now, she's encouraging him to be happy with his body the way it is.

Making playdough men beside us at the kitchen table, Ethan seems pretty content.

[ETHAN PLAYING IN BACKGROUND]

ETHAN: Help! I have no head! Aaaah! AAAAHHH! What happened to my head?

ALICE: Is it going to be ok if this guy is different from other guys?

ETHAN: Yes.

ALICE: Is it ok if he only has one arm?

ETHAN: Yes

ALICE: is it ok if he only has one leg?

ETHAN: Yes

ALICE: will he be just as important if he's missing an arm or a leg?

ETHAN: Yes

ALICE: What about if his skin is brown? Will he be just as important as everyone else?

ETHAN: Yes

ALICE: What if he has hypospadias? Will he be just as important as everyone else?

ETHAN: Yes

ALICE: That's right.

[PAUSE] (Twombly)

AHEARN: Since Ethan was born, Alice Twombly has been working to raise awareness about hypospadias. She also counsels mothers of kids with hypospadias. But she says more attention needs to be paid to figuring out what causes hypospadias, and communicating that information with the public.

ALICE: What concerns me the most is that the information is there, that these environmental estrogens are having effects... it's common sense, if this is what's happening, why isn't the information getting out there? I guess my big question that I have is why can't people talk about it? Why can't we talk about it as a society? (Twombly)

AHEARN: Hypospadias is the second most common birth defect in the country and some studies suggest that rates have risen in the last couple of decades.

According to the Centers for Disease Control and Prevention, Endocrine disrupting chemicals show up in the bodies of almost 100 percent of Americans (Needham).

So, given what we know about this widespread exposure, and the feminizing effects these chemicals have on animals, I asked Theo Colborn: Do you think we are feminizing our baby boys?

COLBORN: I definitely do. I think there's a certain percentage that are definitely being affected and there's no denying it (Colborn).

AHEARN: But on the broader scale when you talk about studying the ways environmental exposures could contribute to someone's sexual orientation later on in life – Colborn says this is an explosive issue. No one wants to touch that research.

COLBORN: If you were to ask for dollars for that you wouldn't get the money. I mean, you would be laughed out of your chair, believe me. It's that sensitive (Colborn).

AHEARN: Research dollars aren't wisely spent trying to figure out why some people are gay and some are straight, but there are some hard questions to be asked about how the chemicals in our daily lives may be affecting our reproductive health and development. Take Atrazine – the herbicide Tyrone Hayes uses on his frogs – it's a known endocrine disruptor and it's been banned in the EU. Yet it's the second most heavily applied herbicide in this country (Wu et al.).

Or look at Bisphenol A – another estrogen-mimicking chemical which turns up in the liners of canned goods and in many other plastic products. BPA has been shown to induce feminization in reptiles, amphibians and mammals. Canada has listed it as a toxic substance and banned it from use in baby bottles, yet it's still in products currently on the market in the U.S. (Colborn, Dumanoski, and Myers).

There is an extensive body of research showing the ways endocrine disruptors affect reproductive health in animals. Maybe it's time we look in the mirror.

In Los Angeles California, I'm Ashley Ahearn.

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## References

- Baskin, Dr. Laurence. Pediatric urologist with the University of California, San Francisco. Interview. 19 March 2010.
- Baskin, Laurence S., and Michele B. Ebbers. "Hypospadias: Anatomy, Etiology, and Technique." *Journal of Pediatric Surgery* (2006) 41, 463-472.  
<[http://cirugiauretra.grupoaulamedica.com/pdf/bloque1/b1\\_1.pdf](http://cirugiauretra.grupoaulamedica.com/pdf/bloque1/b1_1.pdf)>
- Colborn, Dr. Theo. President of the Endocrine Disruption Exchange. Interview. 16 March 2010.
- Colborn, Theo, Dianne Dumanoski, and John Peterson Myers. *Our Stolen Future*. New York: Penguin Books, 1997.
- Devore, Dr. Tiger Howard. Sex therapist and clinical psychologist. Interview. 30 March 2010.
- Harrison, Travis. Hypospadias and Epispadias Association Survey Results, 2003.
- Hayes, Dr. Tyrone. Interview. Hayes Lab, University of California Berkeley. 17 March 2010.
- Hinck, Jo Ellen. Widespread Occurrence of Intersex Bass Found in U.S. Rivers. U.S. Geological Survey Webpage. 24 June 2010.  
<<http://www.usgs.gov/newsroom/article.asp?ID=2305>>
- Needham, Larry, et al. "Levels of Selected Nonpersistent Endocrine Disruptors in Humans." *Analysis of Environmental Endocrine Disruptors*. American Chemical Society, 1999. <<http://pubs.acs.org/doi/abs/10.1021/bk-2000-0747.ch010>>
- Rosenthal, Dr. Stephen. University of California San Francisco Professor of Pediatric Endocrinology. Interview. 19 March 2010.
- Twombly, Alice. Interview. 9 April 2010.
- Wu, Mae, et al. "Still Poisoning the Well: Atrazine Continues to Contaminate Surface Water and Drinking Water in the United States." Natural Resources Defense Council Report, April 2010  
<<http://www.nrdc.org/health/atrazine/files/atrazine10.pdf>>