

## Feminization of Frogs

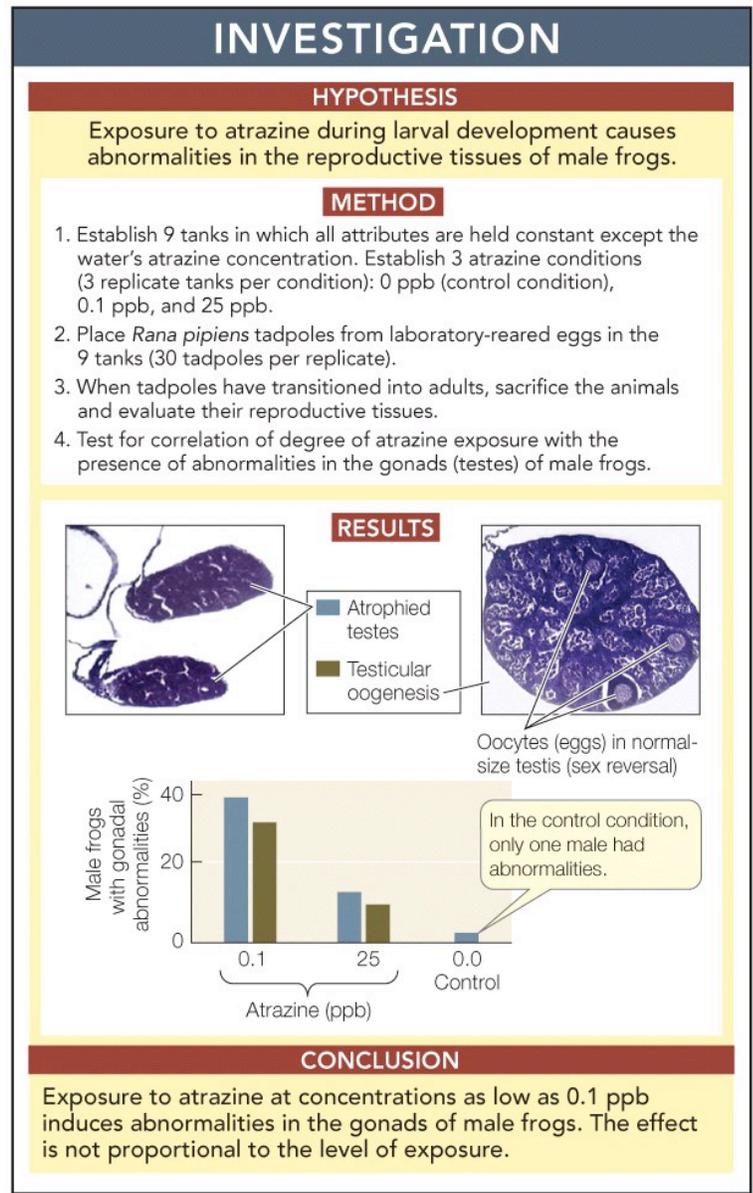
### Introduction

As described in Chapter 1, two environmental concerns that have received a lot of attention in recent years may intersect in the study of the effects of atrazine, the most commonly used herbicide, on animal species in areas where atrazine is applied. The first concern is the widespread decline of amphibian species and the second concern is that many compounds that we are putting in the environment may be “endocrine disrupters.” When people think of environmental toxins, what first occurs to them are things that kill organisms like the toxins associated with “red tides”, which can result in massive deaths of marine fish, birds, mammals, and other organisms. Endocrine disrupters are more subtle; they alter endocrine signaling pathways that typically control aspects of development, reproduction, or other physiological functions.

In the late 1990s, Tyrone Hayes was contracted by the producer of atrazine to do safety tests. The expectation was that atrazine at reasonable doses would not be lethal to frogs, and indeed it was not. However, Hayes noted that even in very small doses, smaller than considered safe in drinking water, reproductive abnormalities showed in the male frogs. Some had multiple sex organs, some had ova in their testes, and some had shrunken vocal structures that are normally used to attract females. The hypothesis that those results suggested was that atrazine was an endocrine disrupter that could be devastating to the reproductive capacity of amphibian populations.

### Original Papers

Hayes, T.B., A. Colins, M. Lee, M. Mendoza, N. Moreiga, A. Stuart, and A. Vonk. 2002. Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. *PNAS* 99: 5476–5480.  
<http://www.pnas.org/content/99/8/5476.full>



Working With Data from *Principles of Life* by Hillis

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffele, and A. Vonk. 2003. Atrazine-induced hermaphroditism at 0.1 ppb in American leopard frogs (*Rana pipiens*): Laboratory and Field Evidence. *Environmental Health Perspectives* 111: 568–575.

<http://ehp.niehs.nih.gov/members/2003/5932/5932.html>

## Links

(For additional links on this topic, refer to the Chapter 1 Investigation Links.)

*Website created by Dr. Tyrone Hayes with many useful links about atrazine and its effects*

<http://www.atrazinelovers.com/>

*Syngenta Corporate Website*

<http://www.syngentacropprotection.com/>

*Website provides access to information on amphibian declines, conservation, natural history, and taxonomy*

<http://www.amphibiaweb.org/>

Working With Data from *Principles of Life* by Hillis  
**Analyze the Data**

Hayes and his students organized a rigorous study to evaluate the effects of atrazine on sexual development in a model amphibian, the African clawed frog (*Xenopus laevis*). In their experiment, larval frogs (tadpoles) were raised in tanks with different concentrations of atrazine from 0.01 to 200 parts per billion (ppb). They measured their vocal structures (larynxes) and examined their gonads, producing the results shown below. They conducted their experiment twice to assess repeatability.

	Atrazine concentration (ppb)	Cross-sectional area of laryngeal muscle (mm <sup>2</sup> )	
		Males	Females
<b>Experiment 1</b>	0	0.085	0.060
	0.01	0.086	0.063
	0.1	0.084	0.060
	1	0.075	0.062
	10	0.075	0.052
	25	0.070	0.055
<b>Experiment 2</b>	0	0.100	0.075
	0.1	0.101	0.079
	0.4	0.102	0.079
	0.8	0.103	0.084
	1	0.088	0.077
	25	0.085	0.067
	200	0.086	0.065

**Question 1**

Plot the data from the two experiments on a bicoordinate graph that places the cross sectional area of the muscle (mm<sup>2</sup>) on the y-axis, and the atrazine exposure on the x-axis. Is there an effect of atrazine exposure on the size of the laryngeal muscle? Is the effect linear?

**Question 2**

Is there a difference in the effect of atrazine on males and females? Was the experiment repeatable?