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Sex, Gender, and the Brain: A Non-Majors Course Linking Neuroscience and Women's Studies

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This article describes a non-majors biology class linking neuroscience and women's studies. The class had 24 students from 13 majors. We met for three classroom hours and three laboratory hours each week. We used animal and human case studies to explore issues of gender, sexuality, hormones, anatomy, biochemistry, behavior and environment to explore the differences and similarities between male and female brains. Reading focused on two major texts, Roughgarden's *Evolution's Rainbow* and Hines's *Brain Gender*, and primary literature referenced within. Student performance was assessed

through exams, class participation, presentations of primary literature, and independent research projects with oral and written presentations. The cross-listing with women's studies improved the class because it led to a great richness of majors and experiences. Furthermore, these students were used to vehement discussion and careful analysis, which carried over to assessing the primary literature, to a surprising degree.

Key words: brain, feminist pedagogy, gender, interdisciplinary, neuroscience, non-major, sex, women's studies

INTRODUCTION

Genesis and overview of course

I had been casually interested in the differences between male and female brains for some time, but when Dr. Larry Summers, then president of Harvard University, made his infamous comments about female mathematics ability (*The Boston Globe* article January 17, 2005), I decided to start collecting material on sex, gender, and the brain. This material ultimately led to a course that I taught at Denison University in the spring of 2008 called "Sex, Gender and the Brain." The class ended up with 24 juniors and seniors with a variety of majors: Biology (1), Communication (5), East Asian Studies (1), Economics (3), English (3), History (2), Music (2), Political Science (1), Psychology (2), Religion (1), Spanish (2), Theater (1), and Women's Studies (2). Eighteen students took the class for Biology credit and six took the class for Women's Studies credit; the requirements were the same for the two groups. This class addressed topics such as how different or similar human males and females are biologically, the male and female brain, the neural origin of sex differences in the brain, and how social status affects sex hormones which then affect the brain. We met for lecture/discussion three times a week for 50 minutes, and had a weekly three-hour lab.

Complete description of course

While I wanted the main focus of the class to be on male and female brains, I realized that the wide range of sophistication among the students required us to clarify different definitions of "maleness" and "femaleness." I wanted us to spend a significant period of time examining biological, psychological, and behavioral bases of masculinity and femininity, including the effects of genetics, hormones, anatomy, social setting, history, and environment. Furthermore, I wanted to begin this exploration with animal models, both to facilitate lab work and to make this discussion of challenging ideas less

inflammatory or threatening. The learning goals that I devised are listed below in Table 1.

Part I: Non-human animals: why sex, different sex schemes

- understand the basic mechanics of sexual and asexual reproduction
- be familiar with mitosis and meiosis (forms of cell division)
- know some theories of why sex evolved
- know about parthenogenesis (virgin birth!)
- understand what a hermaphrodite is, why so common
- be familiar with multiple gendered systems

Part II: Sex determination and gender in humans

- understand sex vs. gender
- understand genetic, hormonal, and other physiological aspects of sex determination in humans

Part III: Brain gender

- role of anatomy, hormones, neurotransmitters
- sociobiology
- how brain affects behavior, how behavior affects the brain

Table 1. Learning goals. Parts I and II lasted between four and five weeks, and Part III lasted almost six weeks.

Part I: Non-human animals: why sex, different sex schemes

I drew heavily from Roughgarden's (2004) "Evolution's Rainbow" for this first part of the course. This text has short descriptions of many animals with fascinating life histories. Since these descriptions are extensively annotated in chapter notes with references to the primary literature, the book is both easy to read and useful as a reference for further study. Thus armed, we examined mating systems with different numbers of males and females, simultaneous and sequential hermaphrodites, asexual systems, parthenogenesis, and other fascinating topics. We found it particularly fruitful to examine the many

and varied types of mating systems in fish (Figure 1A and B), the different sex and power relationships among primates, notably bonobos (Figure 1C) vs. chimpanzees and orangutans, and sexual vs. asexual mating and its relationship to aggressiveness and to the environment in geckos and lizards (Figure 1D). Some of the papers read by the class in this section included Baeza (2007), Bales and Carter (2003), Leuck (1985), Miles et al. (2007), and Wilson and Martin-Smith (2007).



Figure 1. Different sexual life histories. **A.** Lunar wrasse *Thalassoma lunare*, some change from female to male, resulting in three genders. **B.** Potbelly seahorse. *Hippocampus bleekeri*, sex role reversal with atypical breeding structures and behavior. **C.** Bonobos, *Pan paniscus*, female highly sexual, homosexual and heterosexual, coalition building. **D.** Parthenogenetic whiptail species *Cnemidophorus uniparens* (c) C. S. Lieb, used with permission.

Laboratory experiences for this part of the class included observations and experimental manipulations of reproduction in many invertebrate and plant species, focusing on the myriad ways that organisms reproduce and how they respond to the environment. For example, students looked at parthenogenesis in rotifers, regeneration in flatworms, budding in hydroids, and the role of hormonal environment in determining sex in ferns (Table 2). We also visited the primate center at the Columbus Zoo and compared aggression in male and female crayfish (Mead 2008).

Part II: Sex determination and gender in humans (and other animals).

Material for this second portion of the class came from Roughgarden (2004), Hines (2004), selected pages from zoology, reproductive endocrinology, and developmental neurobiology textbooks, and primary articles referenced within these works. To analyze sex determination, we discussed genetic sex, gonadal and genital differentiation, and (especially) how diversity is generated through such means as lack of SRY absolutism and differential X inactivation, androgen insensitivity, and congenital adrenal hyperplasia. We also looked at the roles of *in utero* hormone exposure and its role in gendered behavior in

rodents (e.g. vom Saal and Bronson, 1980; vom Saal et al., 1983; vom Saal and Dhar, 1992;). We also looked into some ways that gender is expressed in other cultures, such as Indian Aruvani. Students had the opportunity to review the literature in an area of interest relating to these topics and to present their findings orally to the class.

Week	Lab	Description
Week 1-4	Weird invertebrate reproduction	Observe, draw, regenerate many common invertebrates
Weeks 2-5	C-Fern	Effects of hormone environment on fern reproduction (% males vs. hermaphrodites)
Weeks 3-5	Crayfish androgenic gland	Study, analyze aggressive behavior, remove androgenic gland, redo matches
Week 4	Trip to Columbus Zoo primate area	Bonobos vs. chimpanzees (different roles of males vs. females)
Week 6	Human physiology I	Sex differences in reflexes, ECG, EMG
Week 7	Human physiology II	Sex differences in sensory systems, memory
Week 8	Human physiology III	Sex differences in stress response monitored by cortisol EIA
Week 9	Student presentations	Presentations from primary literature
Week 10	Brains and nerves	Sheep brain dissection, earthworm axon, slides
Weeks 11-14	Independent projects	Planning, execution, and presentations

Table 2. Labs and field trips. Many of the earlier, animal-based labs required multiple weeks of set up, monitoring, and analysis.

Laboratory experiences for this part of the class included many traditional human physiological labs in which we used gender as an analytical category (Table 2). Students compared reflexes, blood pressure, pulse response to exercise, electrocardiograms, muscle strength, sensitivity, and response to electrical signal, lung function, sensory response and thresholds, memory, response to stress, and other parameters to identify possible male-female differences. Many of these laboratory explorations were modified from labs produced by AD Instruments (www.adinstruments.com). The stress cortisol lab was modified from Kalman and Grahn (2004). One goal of these experiments was to give students ideas for their independent projects, which occupied most of the last portion of the class.

Part III: Brain gender.

We started the last portion of the class with a provocative and encompassing review article about why sex matters for neuroscience by Cahill (2006). This paper's introduction and careful discussion of sex differences in brain anatomy, long-term potentiation (LTP), the response to stress, storage of emotional memories in the amygdala, the biochemistry of neurotransmitters, development, the

incidence and nature of disease, and other factors made it a great framework upon which to pin other, more specific research. A sheep brain dissection lab using resources developed in Grisham (2006) gave students a roadmap to the basic features of the mammalian brain. Then we alternated chapters in Hines with primary research articles. Students enjoyed bringing their own experiences and observations of family patterns into the discussions on sex and play (Fig. 2C) and sex and parenting. Although this unit focused on human brains, the greater ability to do manipulative experiments in animals rather than humans occasionally led us back to animal territory. For instance, the discussion of sex and aggression was enhanced by White et al.'s excellent work on how social environment can rapidly dictate changes in physiology and behavior in fish (White et al., 2002, Fig. 2A). The approach of final exams also led to a discussion of gender differences in memory (Tomizawa et al., 2003; Korol, 2004; Fig. 2B), and gender-specific responses to stress (Taylor et al., 2000; chapter from Lambert and Kinsley, 2004; Shors, 2002; Fig. 2D).

Labs for this portion consisted of independent projects. The two main criteria for the projects were that they had to be hypothesis driven, and that they had to use gender as an analytical category. The project topics included a survey of social activism as a function of gender and sexuality, sex differences in cold tolerance, toy choice and play habits in boys and girls, male-female differences in electrocardiograms, changes in electrocardiograms in response to sexual images, assessment of male and female attractiveness as a function of food journals, effect of gender on memory of word and number lists, male-female differences in blood glucose in response to exercise, the effects of Adderall on electrocardiograms in males and females already on Adderall, and an observation of children's interactions with peers and parents at public play places.



Figure 2. A. *Haplochromis burtonii* territorial and nonterritorial males www.stanford.edu/group/fernaldlab/MachoWimp.jpg, used with permission. B. Side view of brain featuring hippocampus. C. Gender and play. D. Gender-related responses to stress-tend and befriend.

RESULTS

In general, students seem to like the class, were intrigued by the topics discussed, and increased their knowledge (Table 3). At a recent Women's Studies open house, students asked that the course be offered again.

Parameter	Response
Interest increased	4.0 ± 0.83
Effort	3.8 ± 0.85
Knowledge increased	4.5 ± 0.83
Challenge	4.1 ± 0.68
Overall rating	4.2 ± 0.93

Table 3. Student evaluations. Student responses are from 1-5 and are self-reported anonymously on a campus-wide electronic form. The responses for the students taking the class for Biology credit (18) were combined with the responses for the students taking the class for credit in Women's Studies (6). Data reported are means ± standard deviations.

In addition to the general form whose results are summarized in Table 3, students also completed a course-specific evaluation form. Students were very positive about the lab experience, especially the zoo field trip, the human physiology labs, and the independent projects, which "allowed students the opportunity to form and explore their own research questions in relation to sex and gender roles, either biologically or socially" and "gave us a chance to actually be scientists, and for a non-major like me, that was really fun." Several students expressed opinions such as "I had worries coming into this class but ultimately had a lot of fun while learning a lot." Some students preferred the animal portion, some the material on humans. Suggestions to improve the class included increasing participation by creating study guides and study questions that students would complete before class, including a third text on policy and social science, and having more practice on statistics.

DISCUSSION

Is Sex, Gender and the Brain a neuroscience class?

While coverage within neuroscience was not broad, we managed to cover some critical topics in great detail. These included brain and nerve anatomy, action potentials and synapses, male-female brain differences including morphology, LTP, role of the hippocampus and amygdala, neurotransmitter biochemistry, memory, and response to stress. We looked at brain nuclei involved in sex determination and sexual behavior, and we analyzed extensively the interaction of hormones, the brain, and behavior.

Is Sex, Gender and the Brain a Women's Studies class?

Sex, Gender and the Brain is a women's studies class because we used gender as an analytical category in class discussions and in the laboratory. Furthermore, by looking at the multiplicity of genders in the animal world, we

questioned the common male-female gender construct. In addition, we read work by feminist and female scholars and incorporated a feminist pedagogy in the classroom. We created a collaborative learning environment in which student ideas were valued as contributions to knowledge and future directions were chosen together. We frequently discussed the backgrounds and social, political, and economic agendas of the scholars whose work we read, ensuring that we understood the stakes behind each theory, discovery, and presentation. Lastly, students taking the class engaged in feminist research by designing and carrying out projects that examined male-female biological differences. In some ways, because the course material was so interdisciplinary, the class could only have been offered in a way that valued discussion and shared contribution.

How did being cross-listed with Women's Studies improve this class?

Many of the students who took this class were used to questioning assumptions. This made it much easier than I expected to set aside commonly held assumptions about sex, sexuality, and gender. Students were very open-minded. Perhaps because students were all second semester juniors and seniors with extensive experience in upper-level analysis in their majors, their critical skills were applicable to the biology research papers and reviews. Students needed lots of help with the technical details, as expected, but were able to reason critically about the findings and implications in the papers. The interdisciplinary nature of Women's Studies and the frequency and variation in secondary majors led to a great richness of expertise and experience. Relative to science division students, these students were clearly used to and comfortable with vehement discussion. They were also confident that their individual views were valued and were comfortable expressing private opinions and feelings. Because most students had little or no lab experience since high school, there was a freshness and a sense of discovery in the lab. The artistic leanings of many students resulted in the most spectacular lab drawings I have ever seen in seven years of teaching. Most students were positively surprised at how engaging labs were, especially when we worked with large, charismatic organisms and humans. Cross-listing this class helped to provide data used to support a proposed (and approved!) shared position between Biology and Women's Studies. One student wrote that "the most important aspect of the class was that it tied together the biological and social aspects of sex and gender roles and examined how the two are interconnected, which is essential to understanding the roots of behavior for students in both fields of study."

How did the non-majors status make this class more challenging to teach?

I altered my teaching in some specific ways to accommodate non-major students. Because some students were not used to required or timely attendance, I found that I had to emphasize that lab was a required and necessary part of the class, with no make-ups or

substitutions. Lack of student lab experience meant that I had to plan on much more extensive prelab presentations, and that I needed to build in time for individual demonstrations of certain techniques such as pipetting, weighing small amounts, using a microscope, taking blood samples, any dissections or surgeries, and (especially) serial dilutions. Individuals who were detail-oriented and good at following instructions did great, but some procedures were challenging for a portion of the class. Since this was many students' only opportunity to take a college-level science class, I worked hard to simplify instructions and to make sure that students understood the hypothesis testing and controls embedded within each lab experience.

Conclusions

In spite of these challenges, and the difficulties inherent in designing new interdisciplinary classes, creating the course and teaching this class have been among my best experiences at Denison. It was exhilarating to create material and foster discussions in areas outside the usual purview of my teaching. There were certainly days when I did not do the subject matter justice, because my mastery was incomplete. In general, I think I paid tribute to the ideals of liberal arts education by exploring an exciting and relevant topic in a way that highlighted the value of an interdisciplinary approach. While some of my experiences could be specific to this particular class, I think that in general, non-majors supply a richness of experiences, rigorous discussion, excitement in the laboratory, and a surprising ability to access the primary literature. These very positive aspects of teaching non-majors must be "paid" for by vigilance in providing extra background, especially regarding experimental techniques, in papers and in laboratory sessions.

REFERENCES AND COURSE RESOURCES

- The Boston Globe January 17, 2005 accessed 1/28/09
http://www.boston.com/news/local/articles/2005/01/17/summers_remarks_on_women_draw_fire/
- Baeza JA (2007) Sex allocation in a simultaneously hermaphroditic marine shrimp. *Evolution* 61-10:2360–2373. This paper is tough going, but the resource allocation made it relevant to economics majors.
- Bales KL, Carter CS (2003) Developmental exposure to oxytocin facilitates partner preferences in male prairie voles (*Microtus ochrogaster*) *Behav Neurosci* 117:854–859. I chose this paper in part because of its clear example of the scientific method—very accessible to non-majors.
- Cahill L (2006) Why sex matters for neuroscience. *Nat Rev Neurosci* 7:477-484. AOP, published online 10 May 2006; doi:10.1038/nrn1909. This is a key paper with lots of great topics and references for further study.
- Carolina Biological Company C-Fern laboratory kits and booklets.
- Grisham W (2006) Resources for teaching mammalian neuroanatomy using sheep brains. *J Undergrad Neurosci Ed* 5:R1-R6.
- Hines M (2004) *Brain gender*. New York, NY: Oxford University Press. Professors think this book is great, but some students struggled.
- Kalman BA, Grahn RE (2004) Measuring salivary cortisol in the behavioral neuroscience laboratory. *J Undergrad Neurosci Ed* 2:A41-A49.

- Korol DL (2004) Role of estrogen in balancing contributions from multiple memory systems. *Neurobiol Learn Mem* 82:309–323. This is a very clever and clear paper.
- Lambert K, Kinsley CH (2004) *Clinical neuroscience*. Worth Publishers.
- Leuck BE (1985) Comparative social behavior of bisexual and unisexual whiptail lizards. (*Cnemidophorus*). *J Herpetol* 19:492–506.
- Mead KS (2008) Crayfish aggression and the androgenic gland in a behavior lab for non-majors. *J Undergrad Neurosci Ed* 6:A60–A63.
- Miles DB, Sinervo B, Hazard LC, Svensson EI, Costa D (2007) Relating endocrinology, physiology and behaviour using species with alternative mating strategies. *Funct Ecol* 21:653–665.
- Roughgarden J (2004) *Evolution's rainbow: Diversity, gender, and sexuality in nature and people*. Berkeley, CA: University of California Press. Most students found this book to be very interesting and at the right level of difficulty, but some found the author's style to be cloying at times, and others were annoyed by the political agenda.
- Shors TJ (2002) Opposite effects of stressful experience on memory formation in males vs. females. *Dialogues in Clin Neurosci* 4:139–147.
- Taylor SE, Klein LC, Lewis BP, Gruenewald TL, Gurung RA, Updegraff JA (2000) Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *Psychol Rev* 107:411–429.
- Tomizawa K, Iga N, Lu Y-F, Moriwaki A, Matsushita M, Li ST, Miyamoto O, Itano T, and Matsui H (2003) Oxytocin improves long-lasting spatial memory during motherhood through MAP kinase cascade. *Nat Neurosci* 6:384–390. This paper required extra effort, due to the many experimental techniques that required explanation, but it was worth it.
- vom Saal F, Bronson F (1980) Sexual characteristics of adult female mice are correlated with their blood testosterone levels during prenatal development. *Science* 208:597–599.
- vom Saal FS, Dhar MG (1992) Blood flow in uterine loop artery and loop vein is bi-directional in the mouse: Implications for transport of steroids between fetuses. *Physiol Behav* 52:163–171.
- vom Saal FS, Grant WM, McMullen CW, Laves KS (1983) High fetal estrogen concentrations: correlation with increased adult sexual activity and decreased aggression in male mice. *Science* 220:1306–1309.
- White SA, Nguyen T, Fernald RD (2002) Social regulation of gonadotropin-releasing hormone. *Journal Exp Biol* 205:2567–2581. Thought-provoking and excellent.
- Wilson AB, Martin-Smith KM (2007) Genetic monogamy despite social promiscuity in the pot-bellied seahorse (*Hippocampus abdominalis*) *Mol Ecol* 16:2345–2352.

Received February 24, 2009; accepted June 09, 2009.

I thank Brandi Abrams, Camille Britton, Heather Snook, Allyse Treiers and other students in Biology/Womens Studies 103.

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