Sex and gender: What does it mean to be female or male?
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Abstract
This lesson provides three activities to engage non-science major students in a discussion about sex, gender, gender identity, and sex determination. Students prepare for the lesson by reading a short article titled *Sex and gender: What is the difference?* and responding with research topics that would be most appropriate for one term over the other (sex vs. gender). This forms the basis of the first activity in which students brainstorm what it means to be female or male, and then identify whether each idea is related to a sex or gender characteristic, followed by a whole class discussion. The second activity is a clicker question with four published journal article titles, and students identify which is the least appropriate use of the term gender. The final activity involves a case study of María José Martínez-Patiño who failed a sex test in 1985 and was denied the right to compete as a female in the World University Games. In the case study, students grapple with the physiology of androgen insensitivity and what ultimately determines a persons’ sex and gender identity. Non-science major students find these activities accessible and engaging, and each activity serves as a formative assessment for both the teacher and student. Summative assessments evaluate the students’ level of confidence related to each of the three learning outcomes, and their understanding of terminology, context, and examples of sex and gender.

INTRODUCTION
We have found that non-science major students often enter our general education courses with rudimentary and inaccurate information about sex, gender, gender identity, and sex determination. For example, students use the terms sex and gender interchangeably and do not understand the differences between biological sex and societal constructs of gender. In addition to non-science majors, we have both taught anatomy and physiology to upper division and pre-health students and found that even those students often overestimate their understanding of sex and gender. One of us (Dawson) was invited by the local National Residence Hall Honorary to present a very popular public lecture on our campus for several years on the Anatomy and Physiology of Orgasm. The University Health Center then partnered with Dawson to create a YouTube video series based on the lecture, and one of the nine videos has over 345,000 views and demonstrated to us that students across campus were hungry for accurate and non-

Learning Goal(s)
• Students will understand, empathize, and celebrate sexual and gender diversity.
• Students will uncover common societal and cultural misconceptions about sex and gender.

Learning Objective(s)
• Students will be able to distinguish between sex and gender, and apply each term appropriately.
• Students will be able to compare and contrast levels of sexual determination.
• Students will be able to critique societal misrepresentations surrounding sex, gender, and gender identity.

Supporting Materials: S1. Sex and Gender-PowerPoint slides that support all three key activities for the lesson.

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judgmental sexual health information (1).

This lesson was designed as part of a larger course on the Science of Sex for non-science majors as part of our university’s Science Literacy Program. We developed a classroom-based lesson that is accessible to a wide range of non-science major students and addresses some of the underlying misconceptions students carry about sex, gender, gender identity, and sex determination. In this lesson, students use a pre-reading on the differences between sex and gender to set the stage to brainstorm what it means to be female and male, identify sex and gender characteristics, appropriately use the terms sex and gender, and discuss a case study related to sex determination and gender identity.

The case study we developed for this course is based on the story of María José Martínez-Patiño (2,3) who was disqualified from a world athletic competition when officials determined that her sex was not female. Martínez-Patiño’s story was particularly compelling to us given the first person narrative she wrote where she recounted her experience (2). Although Martínez-Patiño’s story is from the 1980’s, the discussion of sex and gender identity in sport continues to be a debated and relevant topic (4,5). Teachers may be interested to read other case studies that explore different aspects of sex, gender, and gender identity such as gender misassignment at birth, ambiguous genitalia, and athletes prohibited from sport participation due to sex testing (6,7). These and other topics are available on the National Center for Case Study Teaching in Science and HHMI BioInteractive, using the search terms sex and gender (6,7).

**Intended Audience**

The intended audience for this activity is non-science majors enrolled in a college science course at any institution. Although the lesson was not intended for a science majors course, if teachers wanted to adapt this lesson for science majors, they would need to update the learning objectives and expand the level of detail included in the lesson to better meet majors biology or genetics learning goals.

**Required Learning Time**

The activity as presented can be completed in 50 minutes.

**Pre-requisite Student Knowledge**

This activity requires no prior student knowledge, making it suitable for non-science majors. Readings at a level appropriate for non-science majors (8) and student homework are included in the lesson.

**Pre-requisite Teacher Knowledge**

Teachers should be familiar with the differences in the definitions for sex and gender as described in the student homework (8). This article defines sex as biological (chromosomes, hormones, etc.) and gender as a societal construct (psychological, gender norms, etc.). Teachers should also have superficial background knowledge in the physiology underlying sex chromosomes, hormones and receptors, and embryological development of sex organs and external genitalia, as relevant to Martínez-Patiño’s story, in order to field potential student questions that arise during the discussion. We suggest teachers read the references related to the case study, as well as sex and gender (2,3,8,9). Teachers also require a sensitivity regarding the personal nature of gender identity and the anatomical variations that can complicate sex determination.

**SCIENTIFIC TEACHING THEMES**

**Active learning**

Student activities include: pre-class reading and writing assignment, discussion of pre-class assignment, brainstorming with peers, small group discussion, whole class discussion, poll-re-poll clicker question, and case study.

**Assessment**

Teachers measure learning with formative assessments throughout the class based on discussion of the pre-class writing assignment (appropriate use of sex and gender), peer brainstorming and discussion, clicker question, and discussion of a case study.

The summative assessments are conducted at the end of the lesson and include both a confidence self-assessment and written responses based on the lesson learning objectives. For the confidence self-assessment, each of the lesson learning objectives are projected in the classroom and students are asked to rate their confidence (e.g.: Got it!—I’m almost there.—I’m confused.). Next, students are asked to write responses to the following questions, which are then submitted and graded for accuracy:

- What do the terms sex and gender each refer to?
- In which context is it appropriate to refer to a person’s gender? To a person’s sex?
- What is an example of an anatomical variation related to a person’s sex?

**Inclusive teaching**

Students are asked to engage with the material using multiple modalities (reading, writing, discussing) before and during class. A brainstorming session about female and male characteristics is designed to be accessible to all students by exploring a familiar topic without limits or expectations on the types of responses. The case study addresses one example of gender identity as related to sexual determination as a starting point to discuss diversity in gender identity and relevance beyond the classroom. The lesson makes transparent the very real diversity that exists in gender identity and sexual determination in human populations with the goal of increasing students’ awareness, empathy, and sensitivity towards all people.

**LESSON PLAN**

**Pre-Class Preparation**

As homework before class, students read an article titled *Sex and gender: What is the difference?* (8). After reading, we asked students to post written answers to the following questions on the course management system and bring a copy of their answers to class:

- What is the main distinction between the appropriate use of the terms sex and gender?
- Write four potential questions for a research project, with two examples appropriate for the term sex and two for the term gender. (Examples shared with students: Is there a sex bias in the rate of knee ligament injury? How does gender affect students’ perception of their academic performance?)
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Teacher Supplies

Teachers should have chart paper or white boards and markers. Students will work in groups of three to four and there should be enough pieces of chart paper or white boards for each group to use one. Half of the paper or boards should be labeled with the question “What does it mean to be female?” and half labeled with “What does it mean to be male?” If the teacher has access to clickers, these should be set up in the classroom to run simultaneously with the associated PowerPoint slides (S1).

Lesson Outline

To begin, students are introduced to the three learning objectives for the lesson:

- Distinguish between sex and gender and apply each term appropriately.
- Compare and contrast levels of sexual determination.
- Critique societal misrepresentation of sex, gender, and gender identity.

Students are then asked to self-select into groups of three or four, to take out the answers to their preparation assignment, and to discuss their answers. Once they have had enough time to share their responses, the teacher asks for a volunteer to share their group’s answer to question one. Then the teacher invites a few examples from other groups for research topics in which either sex or gender would be the most appropriate term to be included. The teacher’s next slide includes answers for both questions for clarity (S1).

Next, the students engage in a brainstorming exercise with their group that is recorded on chart paper or white boards. Half of the student groups answer question one “What does it mean to be female?” and the other half answer question two “What does it mean to be male?”. Students are encouraged to write anything they think of regardless of whether or not they agree, or if it is politically correct. We ask students to not sort their responses, but simply write down ideas, in list form, as they are generated. The goal is for each group to brainstorm a list with a great deal of variation. Responses typically include sex characteristics such as XX or XY chromosomes, penis, breasts, ovaries, estrogen, testicles, etc., as well as gender characteristics such as pink, skirts, high heels, bow ties, aggressive, father, long hair, etc. Once the brainstorming is done, and their lists are recorded, groups are asked to swap the chart paper or white board with a group with the opposite prompt (female or male). We briefly review with students that sex is biological and gender is a societal construct. They are then tasked with circling sex characteristics on the list and putting an asterisk next to gender characteristics. During this exercise students are challenged to think critically about the definitions of sex and gender while assessing each of the other group’s ideas. The teacher circulates in the classroom and encourages students to be ready to defend each of their labels with an explanation. Some characteristics could be classified as both sex and gender. For example, a societal gender norm is for men to have a hairy chest but growth of hair on the chest is also a physiological sex characteristic. When groups have completed this task, the teacher facilitates a conversation regarding what was discovered, and draws upon examples from the other groups’ list. The teacher asks if the students found information about chromosomes, internal organs, external characteristics, psychological characteristics, societal expectations or norms. Examples of characteristics that could be classified as related to sex or gender offer the class a chance to discuss the fine line between biology and societal expectations.

Students are then presented with a clicker question (in which actual clickers can be used or a “throat vote” in which students hold up 1, 2, 3 or 4 fingers in front of their throat so only the teacher can see). The prompt asks “In which title is the term gender least appropriate?” with four published research article titles listed:

1. Duration of breastfeeding and gender are associated with methylation of the LEPTIN gene in very young children. (10)
2. Man and woman, boy and girl: Differentiation and dimorphism of gender identity from conception to maturity. (11)
3. Relational aggression, gender, and social-psychological adjustment. (12)
4. Gender and leadership style: A meta-analysis. (13)

First, students are asked to vote silently on their own. Once everyone has voted (and the teacher notes the distribution of responses) students are invited to talk to their groups about their answers. After a minute of discussion, students are asked to vote again, and a group or two is asked to defend their answer. We always ask students to talk with their small groups before they are asked to speak before the entire class, and then we randomly select groups to share their reasoning - with any member of the group invited to volunteer to speak. Number one is the best response for this clicker question. The title of the article references biology/physiology (methylation of the LEPTIN gene), and therefore it is the sex of the children that is important, not whether those children identify with female or male social constructs (gender). The other three choices are all related to societal constructs of gender (gender identity, social-psychological adjustment, and leadership), and therefore the term gender is appropriate. There is a slide for the teacher to use while clarifying why number one is the least appropriate use of the term gender (S1).

The last activity of the lesson is a case study about María José Martínez-Patiño, a world-class athlete who failed a required sex test in Kobe, Japan in 1985 prior to the World University Games (2,3). The students are presented with a slide of Martínez-Patiño’s 1983 certificate from the Helsinki World Championship indicating she had passed an “approved modified test”, which “satisfies the International Association of Athletics Federations (I.A.A.F.) requirements for competition in Women’s athletic events”. We ask students: “How could she then fail a sex test two years later?”. Students discuss the prompt in their groups for a few minutes, and we instruct them to write down any ideas they have or questions that arise. After a short discussion in their groups, we allow students to ask clarifying questions or share ideas regarding the case. Students often ask if a different type of test was used, or if different professionals were involved, or if the athlete had experienced a change in gender identity. The teacher then shares that in 1983 athletes were subject to a sex determination test based on an examination of external genitalia alone. However, the 1985 test included a chromatin test (14), in which cheek cells are stained for Barr bodies (which appear if there are two X chromosomes) (15,16). Martínez-Patiño did not have Barr bodies because her chromosomes are XY (genetically male);
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However, her external genitalia are female (the embryological default). This intersex condition is due to androgen insensitivity. She has non-descended testes that produce testosterone; however, her cells have no receptors for testosterone. She has always identified as female, but she has no uterus and does not menstruate. At puberty, she developed breasts and a woman’s body. Although she had no ovaries to make female hormones, her body transformed some of the testosterone and androstenedione produced by the testes into the female hormone estradiol, and there was enough estradiol to trigger development of physical characteristics associated with the female sex (2).

Students typically ask questions related to how it is possible that she did not suspect something abnormal when she did not begin menstruation. The question provides an opportunity to discuss the “Female Athlete Triad” (17) in which women with a low energy balance (often due to exercise) have low estrogen production, leading to amenorrhea and possible decreased bone mass and risk for stress fractures or early onset of osteoporosis. Students will often wish to discuss whether or not Martínez-Patiño should have been able to compete in the 1985 games or not, and whether chromosomes, hormones, or receptors are the actual determination for a person’s sex. Depending on the teacher’s time and interests, lively debates can ensue with discussion of recent cases of sex determination and gender identity in other athletes (4,5,6,7). As a wrap-up to the lesson we ask the students to work in their groups to answer the question “Is Maria female or male?” and to be prepared to provide evidence for their answer. After 2-3 minutes of group discussion, we ask for a spokesperson from each group to share their responses and reasoning. After hearing from each group, we clarify that Martínez-Patiño’s gender is female since the social construct of gender identity is a choice. Martínez-Patiño’s sex is intersex (this the preferred term over hermaphrodite), since she has both male and female biological characteristics.

The lesson ends with two types of summative assessments. First, using their clickers, students are asked to rate their level of confidence with each learning objective individually. Next, students answer three written questions related to the lesson learning objectives. Student responses are handwritten and submitted for grading. See Table 1 (beginning on Page 7) for the recommended timeline for the lesson.

TEACHING DISCUSSION

The intended audience for this activity is non-science majors enrolled in a college science course at any institution. It centers around three active learning activities (female/male brainstorm and sex/gender categorization; clicker question; case study) all of which provide an opportunity for formative assessment, since both the student and the teacher will be able to gauge the learning from each activity. The lesson can also be successful without the preparation assignment, although it then requires an explanation at the start of the lesson describing the differences between sex and gender.

The brainstorming activity at the start of the lesson often needs some teacher encouragement or clarification. We have found that students with more science background immediately jump to examples that are mostly biological (sex) and need to be nudged to include societal (gender) examples too, which is key for the activity to play-out as planned. Also, students can be hesitant to write words/phrases that they recognize as stereotypical or potentially offensive to those around them. We remind the class not to judge others for their answers since we are simply brainstorming as many ideas as possible, not searching for the best answer. It is also important to tell the groups not to sort their ideas into sex or gender characteristics, but to write them in the order they are brainstormed. Otherwise, the second part of the activity (in which the words are categorized by sex or gender) is not possible.

The clicker question meets with different outcomes depending on the background of the group. Some students are confused by the details of the title to the first answer, believing that the word gender is associated with the breastfeeding mother, instead of the baby. After collecting clicker responses, we have found it helpful to go through each of the titles, having students share out why gender is an appropriate term for numbers two through four, in addition to why gender is not appropriate for title number one. They are often shocked at the fact that the paper is published, which opens up a great discussion about the fact that scientists do not always use the correct terminology when studying sex - which was the reason Torgimson & Minson (8) were compelled to write a paper about correct use of the term sex in the Journal of Applied Physiology.

The final case study regarding María José Martínez-Patiño provides the most flexibility for the teacher to provide more or less depth regarding the physiology of sex determination. Follow up activities that could be developed include:

- a discussion of the relationship between hormones, receptors, and intracellular changes;
- a lively debate regarding what determines an individual’s sex or gender; and
- an equally lively debate regarding the limitations for competing as a woman in a national sports competition and whether or not those should exist.

Regardless of the make-up of the group, students seem to find the three activities for the lesson compelling and engaging. We typically have to push the group forward onto the next activity, because they are interested in the topic and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately. We believe opening with a brainstorming activity that asks such a basic question (What does it mean to be female or male?) helps to draw in students and are engaged immediately.

SUPPORTING MATERIALS

- S1. Sex and Gender-PowerPoint slides that support all three key activities for the lesson.

ACKNOWLEDGMENTS

We thank Daita Serghi, Diane Lund, Katie Hoffman, Nori Yeung, and Clarissa Dirks and the 2013 West Coast Summer Institute facilitators at the University of Hawaii, Manoa.
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REFERENCES
1. Dawson S. Anatomy and physiology of an organ [Internet]. University of Oregon Health Center; 2013. [cited 2016 June 13]; Available from https://www.youtube.com/watch?v=ZdGJy-4tpJo&list=PLHRC0yg9RmK4GyQ6WuZe7DD...

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<th>Activity</th>
<th>Description</th>
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<th>Notes</th>
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<tr>
<td>Preparation for Class</td>
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<tr>
<td>Pre-class reading and writing assignment</td>
<td>1. Read: Sex and gender: What is the difference? (8)</td>
<td>45 minutes to read and answer questions</td>
<td>Students submitted responses prior to class via the Learning Management System as homework.</td>
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<td>2. What is the main distinction between the appropriate use of the terms sex and gender?</td>
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<td></td>
<td>3. Write four potential questions for a research project, with two examples appropriate examples for the term sex and two for the term gender.</td>
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<tr>
<td>Class Session</td>
<td>Introduce 3 learning objectives for today’s lesson.</td>
<td>1 minute</td>
<td>Lecture slides with notes are in Supporting File S1</td>
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<tr>
<td>Homework follow-up</td>
<td>Project questions from homework and have students share their responses to both homework questions in self-selected groups of 3-4. Review definitions of sex and gender as presented in the reading.</td>
<td>5 minutes</td>
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<tr>
<td>Brainstorm</td>
<td>In groups of 3-4, ask half the groups to brainstorm and list the answer to question one “What does it mean to be female?” and half answer question two “What does it mean to be male?”.</td>
<td>5 minutes</td>
<td>Groups record responses on large chart paper or portable white boards.</td>
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<td>Critique</td>
<td>Groups now swap chart paper or white boards (female prompt swap with group with male prompt).</td>
<td>5 minutes</td>
<td>Of the responses recorded, the group will circle SEX characteristics, and star GENDER characteristics.</td>
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<tr>
<td>Discussion</td>
<td>Teacher facilitates a conversation regarding what was discovered on the chart paper. Did the students find information about: Chromosomes! Internal organs! External characteristics! Psychological characteristics! Societal!</td>
<td>5 minutes</td>
<td>Teacher helps ensure there is clarity regarding which are SEX and which are GENDER characteristics and discusses characteristics that are both sex and gender.</td>
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Table 1. Sex and Gender-Teaching Timeline

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<th>Activity</th>
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| Clicker Question| 1. Student are asked to answer the clicker question first on their own with no discussion.  
2. Then they discuss in groups and revote.  
3. Then groups are solicited to defend their selection.  
Question: In which title is the term “gender” least appropriate? Following are four scientific journal article titles that include the word gender. | 5 minutes |                                                                      |
| Clarifying      | Slide with the main difference between sex and gender as described in the homework reading article.                                                                                                         | 1 minute |                                                                      |
| Case Study      | In 1985, world-class athlete María José Martínez-Patiño was disqualified from competition for failing a sex test prior to World University Games.  
Question: How might this happen? Students discuss in groups.  
Groups share out their ideas and ask follow-up questions.  
Instructor Mini lecture:  
The 1985 test included a chromatin test, in which cheek cells are stained for Barr bodies (which appear if there are two X chromosomes). Martínez-Patiño did not have Barr bodies because her cells are XY (genetically male).  
Maria was born with testes which produced testosterone but has no receptors for testosterone. Anatomically, she has non-descended testes and external female genitalia but no uterus or ovaries. This intersex condition is due to androgen insensitivity.  
Group discussion: “Is Maria male or female?” Students instructed to be prepared to provide evidence for their answer.  
Groups discuss and share their responses and reasoning.  
After hearing from each group, instructors clarify that Maria’s gender is female. Maria’s sex is intersex, since she has both male and female biological characteristics. | 10 minutes | Reference with the details from María José Martínez-Patiño’s story are found in the reference list (2,3). |
| Summative Assessments | Confidence Check-in: Learning objectives are projected in the classroom and students asked to rate their confidence (e.g. Got it!—I’m almost there.—I’m confused.).  
Written summative assessment: Students write responses to the following questions, which are then submitted and graded for accuracy:  
A. What do the terms sex and gender each refer to?  
B. In which context is it appropriate to refer to a person’s gender? To a person’s sex?  
C. What is an example of an anatomical variations related to a person’s sex? | 10 minutes |                                                                      |