

The Male Fertilization Fantasy: Gendered Language in Biology Textbooks

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Abstract

This article explores the extent to which gender-biased language is used to describe fertilization in high school textbooks, akin to the stories with fairytale tropes that are heard during childhood about fertilization. After analyzing the relevant sections from four high school level biology textbooks by major publishers, three patterns were found: passive language used for the female reproductive system and active for the male, stereotypical male personification of sperm and the sole perspective of the sperm, and contrastive theta roles in the semantic and syntactic structure with the sperm as the agent and the female body as anything but. The four textbooks were then evaluated in these categories from least to most biased; one textbook was much more neutral than the other three. The conclusion is that there is still much improvement necessary to ensure the objectivity and accuracy of textbooks, which are often authoritative in a classroom; implicit sexist writing is harmful to both male and female students.

Introduction

When children ask adults how babies are made, they are likely to hear a story about the race of millions of sperm, of which the strongest and most valiant becomes the one to enter and fertilize the awaiting egg, creating a zygote—the beginning of new life. However, it is just that—a story, or even a fairytale, with the egg often characterized as the “damsel in distress,” saved and courted by the sperm as “the knight in shining armor.”

Since gender norms are prevalent in how every part of society is understood, they must inevitably affect the way biology is understood and taught as well, even though biology is supposed to be a scientific field that is objective and uninfluenced by social constructs. Gender norms can draw focus to certain scientific topics, thereby excluding others, as well as cause scientists to interpret findings and observations in a biased manner.

Fertilization requires mutual, active participation by both gametes (egg and sperm), but portraying these equally important participants as aligning with dominant gender norms is dangerous, suggesting that even the biological process of reproduction provides evidence for the validity of these societal norms. Examining gender bias in human biology textbooks is insight-

ful because it requires description of both the male and female body and is an important process that carries on human existence. While simplified models for children to understand fertilization may be oversimplified and overflowing with gender stereotypes, this study investigates if high school textbooks also use gendered, misleading language to explain *in vivo* fertilization (fertilization that occurs inside the body). High school is the first-time children are exposed to advanced and detailed science since they are at an age where they can better grasp complex concepts. These higher-level explanations of natural processes can leave lasting impressions on their understanding of the world. Gender tropes would be even more uncalled for in these textbooks compared to simplified explanations for younger children. Determining the degree of objectivity and equality in writing meant to teach accurately and precisely is crucial. Since many adults still have this fairytale-like impression of fertilization even after learning about it in high school, the hypothesis is that these textbooks do contain problematic gendered language.

This topic was first explored over thirty years ago by Emily Martin in her groundbreaking 1991 article published in *Signs: Journal of Women in Culture and Society*, “The Egg and the Sperm: How Science Has Constructed a Romance Based on Stereotypical Male–Female Roles,”

where she found substantial gender stereotyping in biology textbooks on fertilization. In 2013, Lisa Campo-Engelstein and Nadia Johnson similarly examined biology textbooks of all levels in an article called “Revisiting ‘The fertilization fairytale:’ an analysis of gendered language used to describe fertilization in science textbooks from middle school to medical school,” in which they found some improvement since Martin’s work. We referenced both articles in order to be aware of previously detected biases while aiming to discover new ones. Since gender norms have been seriously questioned in recent years, particularly online, this study is an extension of the previous two to see if the new awareness of gender norms and feminism has flowed into scientific writing as well. Therefore, we suspect older textbooks use more gendered language than newer ones, which could be evidenced by further improvement since Campo-Engelstein and Johnson’s article.

A Brief Overview: Human Fertilization

In order to evaluate the degree of bias within a textbook’s descriptions of fertilization, we will provide a brief description of the process, avoiding as much bias as possible through consulting and amalgamating information from multiple credible sources¹ and specifically searching for neutral language and the role of the egg. The description of human fertilization from “Revisiting ‘The fertilization fairytale:’ an analysis of gendered language used to describe fertilization in science textbooks from middle school to medical school” was used as a start-off point.

Fertilization is the union of two gametes, the female’s egg and the male’s sperm, both haploid, meaning they carry 23 chromosomes, into a new unique cell with the genetic material of both partners, called a zygote, which is diploid, containing 46 chromosomes. Cell division begins to form an embryo after fertilization. Many physiological and biochemical processes are involved in fertilization. Beforehand, an ovarian follicle releases a fully-grown egg into the fallopian tube.

¹ All sources consulted are included in the References. It was created through a combination of and confirmation from several sources, which complicates in-text citations.

For ejaculated sperm to be capable of fertilization, they must undergo capacitation, which includes protein modifications, hyperactivation of motility, and the acrosome reaction. When the egg and sperm meet in the fallopian tube, the sperm travels through the egg’s zona pellucida to bind with its plasma membrane, releasing a sperm-specific protein into the egg cytoplasm. In response to this protein, the egg releases calcium transients from internal stores and initiates the exocytosis of zinc. These metal fluxes cause egg activation, which prevents additional sperm from fusing with the egg’s plasma membrane that would be lethal to the zygote due to an abnormal number of chromosomes and initiates embryonic cell division.

Methodology

We examined four American high school level biology textbooks—Human Physiology: An Integrated Approach (Edition 8, 2019) by Dee Unglaub Silverthorn, Principles of Human Physiology (Edition 6, 2017) by Cindy L. Stanfield, Biology: The Dynamics of Life by Alton Biggs et al. (2004), and Campbell Biology by Lisa A. Urry et al. (Edition 11, 2017). Campo-Engelstein and Johnson studied the first three of these textbooks (published in 2007, 2008, and 2007 respectively) in their paper, and found significant gender biased language. A decade later, we looked at much more recent editions of the first two textbooks listed to see if this problem was addressed since then, possibly resulting in a decrease of prominent sexist language. Campo-Engelstein and Johnson looked at a 2007 edition of the Biggs et al. textbook, and we looked at its very first edition, published in 2004, to determine if the section’s language was edited in the future edition. From personal anecdotal experience, the last textbook, by Urry et al., is prominently used in Advanced Placement Biology classes. The four texts were all published by major textbook companies like McGraw Hill and Pearson, so the likelihood of them being widely distributed to students is high, as well as their representativeness of U.S. high school biology textbooks’ use of gendered language in general. We examined the language in the sections on human reproduction, specifically fertilization, in each textbook, in order to determine how much gendered language was present and any patterns they followed. We paid attention to syntactical and lexical features and

the strategies used to explain the process, as well as any other substantial language components that were a sign of gender bias.

We found four patterns: passiveness vs activeness, personification/perspective, and theta roles², which will be explored in the following section. After the analysis, we quantitatively scored the four textbooks based on the proportion of biased instances in their descriptions of fertilization, per category and then in total.

Results

After analyzing the language on fertilization in each of the textbooks, we separated the gender-biased language into three main categories, which we will elaborate on and provide examples for individually: passiveness vs. activeness, personification/perspective, and theta roles. The associated tables provide pertinent examples which will be referenced in each section respectively.

Passiveness vs. Activeness

Characterization of eggs as passive and sperm as active in both lexical and syntactical ways is a salient trend, as demonstrated in the passages in Table 1. All four textbooks use syntactic structures like “the sperm fertilizes the egg” or “the egg is fertilized by the sperm,” which implies that the sperm is the active participant acting upon the passive egg. This gives the sperm the credit of fertilizing and asserts that the egg is merely where the process takes place. The egg tends to be the object and the sperm the subject, and rarely the reverse, which indicates the same false notion of the sperm as the actor and the egg as the acted upon.

In addition, in Table 1, the authors describe sperm with verb phrases like “swim,” “deliver,” “penetrate,” and “break down [the barriers],” or terms like “self-propulsion,” indicating an independence and active physical effort to achieve the goal of fertilization. On the other hand, passive verb and adjective phrases like “receive,”

“are always sexually receptive,” “are present,” “has receptacles,” and “remain” are used for the female, conveying that the egg is resigned to the action of the male sperm and does not actively contribute to ensure the success of fertilization. Also, passive syntactical structure is used, such as “is swept,” where the object—the egg or the uterus—becomes the subject of the sentence but is still not active, only acted upon by another force. It is not difficult to convert these sentences into active ones with some rephrasing or additional information. For example, fertilization could be described as “the egg and sperm fuse.” Urry et al.’s Passage 2 of Table 1 could be rewritten as, “[...] often stores eggs in receptacles and delivers sperm to mature eggs.”

One of the only times the female body is said to do something active is when it “destroys” sperm due to its acidity and impedes fertilization in Biggs et al.’s passage 3 in Table 1 (Biggs et al., 2004). This relates to how the female reproductive system is often described as being a hindrance to fertilization, such as a “barrier” (Stanfield, 2017), even though these mechanisms are for protection and optimization. Also, while the vagina is said to be hostile due to its acidity, semen actually protects sperm from the male’s own acidic urinary tract as well, which is unmentioned, painting the female body in an unfair negative light. The favorable conditions of the cervix for sperm to survive hours and the many ways that the female body aids sperm transport—muscular contractions of the vagina, cervix, and uterus; ciliary movement; peristaltic activity; and fluid flow in the oviducts (Monroy, 2020)—are also less acknowledged.

In Silverthorn’s passage 5 and Stanfield’s passage 3 from Table 1, the authors do acknowledge the active and important role of the female reproductive system in fertilization and reproduction, but they are one-off occasions. Although Urry et al. also use the “the sperm fertilizes the egg” or “egg is fertilized by the sperm” constructions, they write the female and male reproductive system with more equal, active responsibility in fertilization, evidenced by the passages in Table 1.

² Theta roles are the formal device for representing syntactic argument structure, which is the number and type of noun phrases required syntactically by a particular verb and its meaning.

Table 1. Example passages from each textbook relevant to passive and active language to describe fertilization.

	Biggs et al.	Silverthorn	Stanfield	Urry et al.
active language for the male body/sperm	1. “delivery” (995) 2. “only one fertilizes the mature egg... survive... The surviving sperm swim up the vagina into the uterus... penetrate the egg” (1005).	1. “place sperm in the receptacle” (823). 2. “which enables the sperm to swim rapidly and fertilize an egg” (820). 3. “To fertilize the egg, a sperm must penetrate [...]” (827). 4. “destined” (807).	1. “produce sperm and deliver them into the female for fertilization” (668). 2. “producing sperm and delivering them to the female”(675). 3. “Sperm deposited in the vagina move by self-propulsion” (685) 4. “reach the oocyte and work together to break down the barriers to fertilization... penetrate the corona radiata, they bind to sperm-binding proteins” (685).	1. “fertilize eggs within the tract” (1020). 2. “delivers” (1021). 3. “First, sperm dissolve or penetrate any protective layer surrounding the egg to reach the plasma membrane. Next, molecules on the sperm surface bind to receptors on the egg surface, helping ensure that fertilization involves a sperm and egg of the same species”(1042). 4. “produce both sperm and reproductive hormones, accessory glands that secrete products essential to sperm movement, and ducts that carry the sperm and glandular secretions” (1023).*
active language for the female body/egg	1. ” destroy most of the delicate sperm” (1005).	1. “Fluid movement created by the cilia and aided by muscular contractions transports an egg along the Fallopian tube toward the uterus” (818).*	1. “responsible not only for the production and transport of ova, but also for everything else that must occur to enable a new human being to be brought into the world” (675).*	1. “Molecules and events at the egg surface play a crucial role in each step of fertilization... Finally, changes at the surface of the egg prevent polyspermy, the entry of multiple sperm nuclei into the egg” (1042). 2. “produce eggs and reproductive hormones, and a system of ducts and chambers, which receive and carry gametes and house the embryo and fetus” (1024).*
passive language for the male body/sperm	No relevant instances	No relevant instances	No relevant instances	No relevant instances
passive language for female body/egg	1. “The egg is present” (1005).	1. “an internal receptacle for sperm” (823). 2. “Once an egg is released from the ruptured follicle, it is swept into the Fallopian tube by beating cilia” (820). 3. “Fertilization of an egg by a sperm” (827). 4. “women are always sexually receptive” (801).	1. “remain...fertilized by the arriving sperm” (665). 2. “fate” (681).	1. “has receptacles for storage and delivery of sperm to mature eggs” (1021). Note: Asterisks indicate that the passage has low bias.

Personification/Perspective

Table 2. Example passages from each textbook relevant to personification/perspective in language on fertilization.

	Biggs et al.	Silverthorn	Stanfield	Urry et al.
Perspective of the sperm	1. "Sperm enter the vagina of the female's reproductive system when strong, muscular contractions ejaculate semen from the male's penis. Between 300 and 500 million sperm are forced out of the male's penis and into the female's vagina during intercourse" (1005). 2. "The surviving sperm swim up the vagina into the uterus. Of the sperm that reach the uterus, only a few hundred pass into the two oviducts. The egg is present in one of them. The head of the sperm contains enzymes that help the sperm penetrate the egg" (1005).	1. "Now let's follow the path of sperm deposited in the vagina during intercourse" (815). 2. "To fertilize the egg, a sperm must penetrate both an outer layer of loosely connected granulosa cells (the corona radiata) and a protective glycoprotein coat called the zona pellucida. To get past these barriers, capacitated sperm release powerful enzymes from the acrosome in the sperm head, a process known as the acrosomal reaction. The enzymes dissolve cell junctions and the zona pellucida, allowing the sperm to wiggle their way toward the egg" (827).	1. "Sperm deposited in the vagina move by self-propulsion through the cervical canal into the uterus, where they move along the uterine wall and eventually enter the opening to the uterine tube. Sperm migration is also aided by vaginal and uterine contractions that occur during sexual arousal. Of the millions of sperm that are deposited, only a few hundred typically reach the uterine tube; the others die along the way" (685). 2. "During sperm migration, several sperm may reach the oocyte and work together to break down the barriers to fertilization—namely, the corona radiata and zona pellucida. Once sperm penetrate the corona radiata, they bind to sperm-binding proteins in the zona pellucida." (685).	No relevant instances
Personification of Sperm	"strong, muscular... surviving...penetrate" (1005).	"penetrate...wiggle" (827).	"die...work together...penetrate" (685).	No relevant instances

In the fertilization section, Biggs et al., Silverthorn, and Stanfield either explicitly or implicitly decide to focus on the path of the sperm for the process of fertilization, evidenced in Table 2. While writing through the perspective of sperm itself is not very problematic, the omission of the perspective of the egg from fertilization (except in separate designated sections on the female reproductive system) is. It implies that the sperm is the one that does the fertilizing and is therefore the more intriguing and important participant.

Whereas the textbooks portray egg release and transport as a passive and dull process, Biggs et al., Silverthorn, and Stanfield write the sperm's release and transport as an adventure, shown in Table 2, which gives agency to sperm and seems to subtly parallel the heroes of quest myths who travel to new lands, defeat enemies, marry the princess, and reform society.

The authors use the verb "penetrate" very often in their description of how the sperm enters the egg, which is

a parallel to how in heterosexual intercourse, the male penis is said to “penetrate” the female vagina, particularly during rape or aggressive sex. It is a personification of sperm during fertilization as the male himself during sex. In addition, “penetrate” has the semantic connotation of a violent, unwelcome intrusion when used to refer to biological or military contexts, which implies women are the weaker partner that can be dominated and abused. There are alternatives, such as Stanfield writing, “the first sperm to reach the oocyte binds to a receptor on the plasma membrane, which precipitates transport of the head of the sperm into the egg’s cytoplasm” (685), or using other verbs like “dissolve” or “enter” instead, but “penetrate” seems to be preferred in most instances. In addition, Biggs et al. write sperm are “forced from the man’s penis and into the woman’s vagina during intercourse” (1005), which suggests non-consensual sex by using the term “force,” as if the man is forcing sex onto the powerless woman and his semen into her for the sake of reproduction—an antiquated, unhealthy way of looking at sex.

Other words that usually describe people like “strong,” “muscular,” “powerful,” “wiggle,” “die,” “survive,” and “work together” also personify the sperm, making the sperm’s path in fertilization seem human. Given the context, “survive” anthropomorphizes the sperm by connoting that they are soldiers fighting for their lives and the prize, which is the chance to recreate with an objectified woman. Although these words are not exclusively used for people and are acceptable in scientific texts, they are used more often for sperm than for eggs. The same texts instead describe eggs with objective scientific words such as “intense” for “strong, muscular” and “disintegrate” or “degenerate” for “die” (Silverthorn, 2019), (Stanfield, 2017), and (Biggs et al., 2004).

Additionally, only the male orgasm is mentioned during fertilization. While female orgasm is not necessary like the male orgasm for fertilization to occur, the lack of information on it incorrectly suggests that the sole purpose of sexuality is biological reproduction and elevates the man’s sexual and reproductive importance.

Theta Roles

Theta roles are the semantic relations of the syntactic arguments of a verb. The “agent” (intentionally) carries out the action of the verb; the “experiencer” undergoes

an emotion, a state of being, or a perception expressed by the verb; the “theme” directly receives the action of the verb or is the topic of the verb; the “source” is the direction from which the action originates; the “goal” is the direction towards which the action of the verb moves; and the “location” is where the action of the verb takes place. There is a trend (shown in Table 3), particularly in Biggs et al., Silverthorn, and Stanfield’s writing, where the male reproductive system and sperm have the theta role of agent in a sentence, while the female reproductive system and egg are the experiencer, theme, goal, or location. Urry et al.’s writing is the exception, where both the female and male reproductive systems are agents and both the sperm and egg are themes.

The sperm being coded as the agent conveys that it actively and purposely works toward the goal of fertilization. If the egg is the experiencer or theme, it experiences fertilization or undergoes the action of the sperm but does not act on its own. The uterus and egg are also frequently the source or location, which is not misleading in it of itself, as fertilization does take place in the uterus. However, the lack of the theta role “agent” for the egg and uterus makes them seem like merely the destination upon which fertilization takes place, instead of an active participant in the process.

Discussion

The data show that it is common for the sperm to be described as the main actor and focus of fertilization in biology textbooks, with the egg as the backdrop for the process instead of an equal partner. Using the perspective of sperm in descriptions of fertilization leads to a lack of information on the female reproductive system, which implies that the biology of the male participant is more complex, interesting, or important. It conforms to traditional gender roles by giving the male body agency—conferring higher value to it than the female body—and by anthropomorphizing sperm with expected male traits and actions from fairy tales or harmful gender myths. All the textbooks use language like “the egg is fertilized by the sperm,” where the active, powerful sperm is responsible for fertilizing the passive egg (which has no movement or mission on its own and is merely the object in which fertilization takes place). Other contrasting verbs, adjectives, and syntactic struc-

Table 3. Example passages from each textbook relevant to theta roles in language on fertilization.

	Biggs et al.	Silverthorn	Stanfield	Urry et al.
Agent	1. "Sperm", "strong, muscular contractions" (1005). 2. "only one", "fluids secreted by the vagina are acidic and destroy most of the delicate sperm", "Yet, some sperm", "The surviving sperm", "The sperm" (1005).	1. "Sperm swimming upward through" (818). 2. beating cilia", "sperm deposited in", "the sperm" (826). 3. "a sperm", "capacitated sperm", "The enzymes", "the sperm" (827).	1. "the arriving sperm" (665). 2. "sperm deposited in the", "only a few hundred", "the others" (685). 3. "several sperm" (685). 4. "The first sperm to reach" (685).	1. "sperm deposited in or near" (1020). 2. "Molecules and events at the", "sperm", "molecules on the sperm surface", "changes at", (1042). 3. "gonads", "accessory glands", "ducts" (1023). 4. "gonads", "a system of ducts and chambers" (1024).*
Experiencer	1. "the mature egg" (1005).	1. "an egg" (826). 2. "the egg" (827).	1. "Ova" (665).	1. "eggs within" (1020).
Theme	1. "fluids secreted by the vagina... most of the delicate sperm", "The egg", "the egg" (1005).	1. "The Fallopian tubes" (818). 2. "an egg" (826). 3. "Fertilization of an egg" (827) 4. "an outer layer of loosely connected granulosa cells (the corona radiata) and a protective glycoprotein coat called the zona pellucida" (827).	1. "the barriers to fertilization—namely, the corona radiata and zona pellucida" (685).	1. "any protective layer surrounding the egg" (1042)* 2. "both sperm and reproductive hormone", "products essential to sperm movement", "the sperm and glandular secretions" (1023). 3. "eggs and reproductive hormones", "gametes", "the embryo and fetus" (1024).*
Goal	1. "the vagina of the female's reproductive system" (1005). 2. "the uterus" (1005).	1. "the egg" (827).	1. "the cervical canal into the uterus", "the opening to the uterine tube", "the uterine tube" (685). 2. "the oocyte" (685).	1. "the plasma membrane" (1042).*
Location	1. "the vagina" (1005)	1. "the uterus" (818). 2. "the female reproductive tract" (826)	1. "vagina", "uterine wall" (685)	1. "the female reproductive tract", "the tract" (1020). 2. "egg surface", "the surface of the egg" (1042).*
Source	No relevant instances	1. "its cavity" (818).	No relevant instances	No relevant instances

Note: Theta roles are not labeled for all arguments of each verb, only the relevant ones. In addition, noun phrases in adjuncts as well as arguments may receive a theta role, though by convention only arguments do. Asterisks indicate that the passage has low bias.

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tures for the male and female body fortify this notion as well. It aligns with the social norms of how men are supposed to act, and women react, and how historically men hold positions of power and decision-making while women stay home and accept male decisions. This should be substituted with equal language, like fertilization as “the union of sperm and egg” (Urry et al. 2017). While passive sentence structure is common in science, it becomes problematic when it is used unequally between two similar objects of scientific inquiry by creating a discrepancy in influence and sovereignty. The male body holding the theta role of agent while the female body is the experiencer, theme, source, or goal, makes the male the actor and the female the acted upon or the setting of fertilization, unrightfully disempowering the female partner.

After taking all of this into account, we scored the four

analyzed textbooks in their degree of bias, shown in Table 4 below. The calculations were rounded to the hundredth decimal point. Every violation as well as every sentence or instance of the phenomenon (biased or not) in Tables 1 through 3 were counted, and a ratio of the number of violations to the number of all examples was created to find a score for each category, per textbook.³ Therefore, scores can range from 0 (0% violations) to 1 (100% violations). Then, the three category scores per textbook were averaged to create a final score for the textbook. Excerpts that had parallel structure to describe male and female roles—e.g. Stanfield’s passage 3 in Table 1, Urry et al.’s passages 3, 4 and 5 in Table 1, and Urry et al.’s passages 2-4 in Table 3—were considered neutral and counted only for the total number of instances. For example, active language for the male body would not be considered a violation if active language for the female body was used in a parallel fashion.

Table 4. *Category and Total Quantitative Scores for the Four Textbooks (regarding the amount of bias).*

	Passiveness vs. Activeness	Perspective/ Personification	Theta roles	Total Scores
<i>Biology: The Dynamics of Life</i> by Alton Biggs et al. (2004)	8/9 = 0.89	9/9 = 1.00	12/14 = 0.86	0.92
<i>Human Physiology: An Integrated Approach</i> (Edition 8, 2019) by Dee Unglaub Silverthorn	8/8 = 1.00	6/6 = 1.00	18/19 = 0.95	0.98
<i>Principles of Human Physiology</i> (Edition 6, 2017) by Cindy L. Stanfield	6/7 = 0.86	9/9 = 1.00	14/14 = 1.00	0.95
<i>Campbell Biology</i> by Lisa A. Urry et al. (Edition 11, 2017)	1/10 = 0.10	0	8/23 = 0.35	0.15

The higher the score, the more bias present. Table 4 indicates that *Biology: The Dynamics of Life* by Alton Biggs et al. (2004), *Human Physiology: An Integrated Approach* (Edition 8, 2019) by Dee Unglaub Silverthorn, and *Principles of Human Physiology* (Edition 6, 2017) by Cindy L. Stanfield have a similarly high proportion of biased instances, with scores in the 0.90s. However, *Campbell*

Biology by Lisa A. Urry et al. (Edition 11, 2017) stands out with by far the lowest proportion of biased instances—a score of 0.15. While the quantity of violations does not comprehensively determine the impression a textbook imparts, it gives a good idea of the amount of bias present.

There is not a clear correlation between publication year and amount of bias in the data as initially hypothesized: while one of the newer textbooks has the lowest bias, both old and new textbooks could have high bias scores. There was not an improvement in neutrality in newer editions of the textbooks Campo-Engelstein and Johnson examined either, nor differences compared to older editions, which points to stagnation or ignorance on this issue in textbooks that have already written, re-

³ To specify, in Table 1, for each textbook, the number of sentences with active male and passive female language was divided by the total number of sentences. In Table 2, the number of instances of male personification and sentences with male perspective were divided by the total number of instances of personification plus the total number of sentences. In table 3, the number of instances of the male body being an agent and a female body having any other theta role was divided by the number of total relevant instances of theta roles.

ardless of edition updates.

Further evidence beyond language in fertilization was also discovered to support gender bias in biology textbooks. In all four, the section on the male reproductive system was before the one on the female reproductive system. While it might seem like a coincidence, it is likely a reflection of a patriarchal society if it is such a consistent pattern, implying the male is primary and standard, and the female is secondary or an afterthought, even if these beliefs are unconsciously held by the authors. Furthermore, Silverthorn included a section on male sexuality (Silverthorn, 2019), where she mentions male libido, without one on female sexuality, propagating the myth that men innately have high libido and women minimal libido. This misconception could be used to absolve men from blame for their sexual aggression towards women or minimize the prioritization of female pleasure.

Implications

The results show that recent textbook publications from 2017 (*Principles of Human Physiology* by Stanfield) and 2019 (*Human Physiology: An Integrated Approach* by Silverthorn) can still endorse societal gender norms in their language on fertilization, while other recent textbooks can be relatively unbiased as well, such as *Campbell Biology* by Urry et al. from 2017. As society questions and rejects social gender roles in modern times, scientific writing should also reflect this. Authors must reevaluate their past work, be cognizant of their own biases, and then be careful not to reflect them in their writing. Some textbooks clearly need revision to remove implicit perpetuation of the supposed superiority of the male and prejudice and discrimination towards the female. In sections on fertilization, there must be equal agency for and information and focus on the female body and its contributions, compared to the male body.

Though these patterns of gender inequality within language may be subtle to readers, there is a powerful adverse effect from repeated exposure to gender bias, particularly in educational biology writing, which should strive to be as objective and informative as possible and is therefore assumed to be. Unfortunately, human partiality is always a possibility. Sexism in writing on biology is especially dangerous because these so-called comprehensive facts can then be used to prove that gen-

der norms agree with biology, being valid and innate in humans, and should therefore continue to be perpetuated and used to determine societal structure, hierarchy, expectations, and views. They are detrimental and restrictive to both male and female students and undermine the ability of the teachers using these textbooks to teach accurately and impartially themselves.

Limitations and Future Research

Since there was no systematic random sampling of the most popular textbooks, it is uncertain if this is a representative sample of all high school biology textbooks in America, which would require further research, from sales data or surveys for example.

While this study focused on the text itself and took into consideration the date of publication (of the edition), a deeper analysis of the textbook authors and editors' backgrounds, the dates of initial publication, and details of textbook usage and circulation could provide deeper insight into the results.

It is important to note for future research that making progress on this issue should involve several intersecting disciplines, such as anthropology, linguistics, biology, science and technology studies, gender studies, sociology, pedagogy, etc.

Conclusion

Presenting science with a gendered narrative in educational institutions may create pressure for young people to conform to these norms. Boys may feel the need to have high agency and dominance, while girls feel that they should be demure and submissive, which according to their biology textbooks, their own bodies encourage. The notion that boys should assertively act and girls should compliantly react limits both in their potential for self-expression and their future roles and careers in life. It may even dissuade girls from enjoying and pursuing careers in science.

Textbooks are an authoritative source of information for students, so they rarely question them nor are asked to do so by teachers, which makes this bias so problematic.

These textbooks can undermine the ability and worth of the egg and female reproductive system, while over-emphasizing the potency and agency of the male sperm and semen during fertilization. However, not all hope is lost with faulty textbooks. Teachers may actually point out the bias present in the text and use it to teach about sexism and gender norms, as well as ask students to reflect on their dangers. Only then will students notice them in the textbook and then think of examples of similar prejudices that they have witnessed. In addition, textbooks like *Campbell Biology* by Lisa A. Urry et al. (Edition 11, 2017) demonstrate that it is possible to write with neutrality and accuracy in reproductive biology without sacrificing clarity, information, or understandability.

This article has shown that normalized gendered language still exists in very recent editions of biology textbooks by big publishers that would be used in classrooms today, and how it can sustain gender stereotypes in our minds and in our society. There seems to have been an improvement from decades ago when Martin wrote her pioneering article on this topic in 1991, but the degree of bias in these findings seems similar to those of Campo-Engelstein and Johnson's from 2013. Clearly, almost a decade later, there is currently still a long way to go, also evidenced by the fact that most people still remember and think about fertilization in this story-like, gender-biased way. Impartial language is imperative in science, especially in reproductive biology, which easily falls into gender tropes. Only then can we further dismantle sexism and its prevalent prescriptive, heteronormative, feminine and masculine expectations that are toxic and restrictive for all parties involved.

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