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Heroes and Helpmeets

Visions of Gender in Italian Instructional Resources on Gametes, Reproductive Systems, and Human Evolution

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Abstract

Despite a decline in sexist language, traditional gender beliefs remain embedded in scientific literature on reproductive biology and consequently continue to distort knowledge, encumber the learning process, and reinforce gender essentialism. This article analyzes the enduring force of gender stereotypes in Italian middle-school science textbooks and a highly popular education film. It identifies a consistent set of stereotypes and assumptions running through textual and visual content regarding fertilization, reproductive anatomy, and human evolution. In addition, the article demonstrates congruence between these materials and students' understandings of fertilization through words and drawings elicited by a worksheet. Findings are examined within the context of pervasive gender stereotypes in textbooks and journal articles on reproductive biology, science and technology textbooks in general, and schoolbooks across subjects. The study shows that assigning gender traits to sex cells, reproductive systems, and ancestral humans misrepresents human biology, endorses a heteronormative vision of femininity and masculinity, and objectifies girls and women. Removing gendered representations from science textbooks is both more challenging and more urgent compared to other textbooks, given that their association with natural truth shields science textbooks from critical scrutiny as well as challenges to conventional conceptual frameworks.

Keywords: Gender stereotypes · Science education · Fertilization · Human biology · Instructional resources

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1 Gender narratives in reproductive biology

1.1 Persistence and impacts of gender stereotypes in scientific literature

Despite a decline in sexist language, traditional gender stereotypes remain embedded in the textual and visual content of technical literature on human biology. Students consequently receive a particular vision or ideology of society, nature, and human nature as if it were finished knowledge rather than contingent and culturally shaped. Inspired by Emily Martin's (1991) work on fertilization narratives in English-language scientific literature, we analyze science textbooks and a highly popular educational film in the context of present-day Italy. Our study identifies a consistent set of assumptions about inborn gender traits and social roles running through discussions not only of fertilization and reproductive anatomy, but also human evolution. In addition, we demonstrate congruence between the vision of gender and society embedded in educational materials and students' gendered understandings of fertilization through an analysis of words and drawings produced by students in two Italian middle schools. These aspects of the study allow us to demonstrate the persistence of gender stereotypes in educational literature, the extension of a particular vision of gender and society beyond discussions of human reproduction, and the impact of gender metaphors on student learning.

The fertilization adventure story described by Martin (1991) and evident in the instructional resources analyzed below contrasts determined, courageous sperms against an inert, dependent, resisting egg.[1] The egg is an object of desire or conquest: a Sleeping Beauty, damsel in distress, or plunder of warfare. It is precious, pure, and even mystical, as suggested by terms such as the "vestments" surrounding it. In contrast, the sperm cell is a subject: an autonomous, resolute individual endowed with specialized parts for mobility and physical penetration of the egg. Eggs are made by a complicated, degenerative, interdependent reproductive system; sperms by an independent, boundlessly productive one. The same symbolic opposition between female passivity and male activeness undergirds explanations of human evolution, which showcase vigorous, enterprising males while limiting females to reproduction and domesticity. Presented as a scientific version of evolutionary events and timeless sex-determined characteristics, this gender binary appears elemental, seemingly independent of cultural beliefs and values.

Table 1 summarizes a single set of gender expectations and stereotypes running through descriptions of reproductive systems, cells, and human evolution in the textbooks and educational film.

Table 1 Characterizations of reproductive systems, cells, and human evolution

	FEMALE	MALE

[1] For simplicity and brevity, we use the terms, "egg/s" or "ovum/a," and "sperm/s" or "spermatozoon/oa," regardless of the cells' state of development or maturation. Translated passages maintain the term "egg cell" if used in the original, for reasons discussed below.

	Descriptions	**Descriptions**
Reproductive system	Complex; obscure; cyclical; internal; degenerative; wasteful; resisting; vulnerable; multiple fragmented parts; location imagery (passageways, shelters, seats, sources of nourishment); dependent on the brain	Straightforward; transparent; linear; external; productive; active; efficient; reliable; functional; energetic; successful; made up of few, rationally organized components; independent of the brain
Cells	Energetically costly; limited in number; immobile; passive; inert; helpless; sacred/mystical; secretive; scarce; degenerative; dull; dependent; unreliable; resisting; reactive; empty and undifferentiated; without will or individuality; alone *Variation: aggressive, grasping, spider-like; traps and devours*	Efficient; innumerable; mobile; active; energetic; specialized; amazing and interesting; clever; motivated, purposeful; reliable; courageous; competitive; heroic; resilient; fast; strong; takes the initiative; composed of multiple useful parts; unique individual; part of a team or squadron
Human ancestors	Long hair; rounded physique; carry children and food; passive, dependent, and uninteresting; limited range from home	Hirsute; muscular; armed with tools and weapons; active, ingenious, and industrious; travel far and wide, and for long periods
	FEMALE	MALE
	Verb forms	**Verb forms**
Reproductive system	Is formed by, hosts, receives, allows, contains, nestles, protects, nourishes, ceases to function	Is, enters, deposits, produces, completes, reaches
Cells	Degenerate, have, are formed, are released, are incapable of movement, serve to, are fertilized, nourish, are transported, harden, thicken, block entry	Go on the attack, crowd around, undergo, complete, reach, ascend, move, climb, swim, advance, transport, enter, succeed, surround, knock down, penetrate, perforate, fertilize
Human ancestors	Reproduce, take care of children, gather food, stay in village or nearby areas	Guarantee resources for survival, hunt, create, paint, travel far for many days
	FEMALE	MALE
	Gender roles/traits	**Gender roles/traits**
Reproductive system	Secondary, dependent, weak; source of nourishment and nurturance; responsible for STIs, risks in pregnancy, infertility; shuts down in middle age	Standard/primary form; active, rational, efficient achiever; unceasing activity and reliable productivity throughout life
Cells	Secondary, dependent; passive; stationary; inert; provide nourishment	Primary, independent; active; mobile; in control; create new organism
Human ancestors	Secondary food producers; helpmeets and nurturers; constant childbearing and childrearing; confined to domestic sphere	Primary food producers; leaders of family and group; hunters/warriors; not engaged in childrearing; protagonists of history

The following analysis shows that assigning gender traits and roles to sex cells, reproductive systems, and ancestral humans misrepresents human biology, interferes with learning, and naturalizes a heteronormative vision of femininity and masculinity that objectifies girls and women. The persistence of gender metaphors in scientific literature attests to the latter's association with unfiltered truth, which shields textbooks and scientific articles from critical scrutiny and bolsters conventional conceptual frameworks against theoretical and empirical challenges. Outmoded and erroneous beliefs about sex and gender consequently may endure in spite of evidence about the behavioral and cognitive traits of actual people, past and present. Besides distorting what students are taught about both gender and human biology, gendered explanations make current inequalities appear permanent and natural, limiting young people's expectations and opportunities. Gender stereotypes in textbook narratives and images encumber the learning process and affect future interest in particular school subjects. These ongoing effects of gender stereotypes in scientific literature point to the urgency of further and faster progress towards the elimination of gender stereotypes from literature for young readers.

1.2 Heroes and homebodies in scientific accounts of fertilization

The fertilization story of romantic conquest has conflicted with scientific knowledge for many decades. Since at least the middle of the last century, it has been known that sperms are sensitive to conditions inside the female reproductive tract; that an egg must be alive for sperms to cross its exterior layers and reach the plasma membrane; and, that changes to the egg membrane prevent the entry of multiple sperms after fusion with a sperm or upon mechanical perforation. By the time of Martin's writing, additional discoveries cast further doubt on sperm independence and highlighted the role of the egg and female reproductive tract (1991, p. 493-494). For instance, contrary to the image of purposeful swimming, the sperm's flagellum propels it side to side with ten times more force than its forward movement. Cervical mucus protects sperms against phagocytes, filters out defective ones, and transports them to the upper reproductive tract, increasing their viability from hours to days or as much as a week (see Foo & Lim, 2008). Specific cross-linked molecules bind the sperm to the egg's filamentous zona pellucida. Rather than piercing the egg, the sperm body rests laterally against it and the flagellum ceases beating. As the two cells' plasma membranes fuse, sperm contents are drawn into the egg by microvilli lining the egg's plasma membrane, whereupon the egg's nucleus migrates towards the sperm's chromosomes.

Subsequent advancements include more precise knowledge of the mechanisms that bring egg and sperm together. The egg is actively moved into and through the oviduct by muscular contractions of the oviduct's fingerlike projections that sweep around the ovary as well as the current created by the beating of cilia lining their surface. Muscular contractions of the cervix and uterus push sperms towards the oviduct. Mediated by maternal factors such as progesterone, glucose, and oviduct proteins, the sperm capacitation process that begins in the vagina and continues in the upper reproductive tract increases sperm motility and brings changes to the sperm's membrane and internal chemistry necessary for reaching and interacting with the egg. Sperm-binding proteins in the oviduct epithelium stall sperms until capacitation enables them to detach. It is not competition but capacitation that permits about 200 sperms to respond to a thermal gradient along with chemoattractant substances such as progesterone secreted by the egg and its cumulus cells (see Eisenbach & Giojalas, 2006).

The interdependent processes involving egg and sperm that lead to fertilization include the release of enzymes by the sperm that degrade the egg's outer layer of cumulus cells and subsequently its zona pellucida, where cross-binding of egg and sperm proteins has anchored the sperm and sparked the acrosome reaction (see Gupta et al., 2009). The fusion of the acrosomal membrane to the sperm's plasma membrane exposes molecules on the inner acrosomal membrane for further cross-binding, while the release of enzymes brings the sperm into contact with the egg's plasma membrane. The plasma membrane's microvilli contain additional specific proteins that link to partner proteins on the sperm plasma membrane; areas that lack microvilli do not bind sperms (see Primakoff & Myles, 2007). Fusion of the two cells' plasma membranes causes a rapid depolarization of the egg membrane along with a series of chemical reactions that subsequently bring the release of enzymes and water into the space above it, blocking other sperms from

participating in fertilization (see Tsaadon et al., 2006). The vigorous trashing of the sperm's flagellum, which has loosened its densely packed DNA, stops, the microvilli retract, and the sperm's contents enter the egg. The sperm's nuclear membrane dissolves, its loose DNA condenses, and a membrane produced by the egg's endoplasmic reticulum encloses the paternal chromatids in a pronucleus. Fusion meanwhile prompts the egg to complete meiosis, splitting its chromosomes into an extruded vesicle and a pronucleus. Built upon materials provided by both egg and sperm, structures form which guide the two pronuclei to the center of the cell and create the scaffolding for mitosis once the two pronuclear membranes have dissolved (see Schatten & Sun, 2009).

Notwithstanding these discoveries, scientific writing on reproductive biology has continued to incorporate traditional stereotypes about femininity and masculinity into descriptions of gametes and reproductive systems. Martin (1991) notes that, in the late 1980s, eggs were portrayed as a heavy investment, even though a man who has two or three children produces more than a trillion sperms per child, compared to a woman's 200 eggs (p. 489). Only the female reproductive system was described as involving interdependent, complexly coordinated structures and processes, even though sperm delivery and survival depends on reflexive shutting of the urinary sphincter, secretions in the urethra to protect against urine, muscular contractions, and seminal liquid for propulsion and protection against the vagina's immunities and acidic environment (p. 490). Researchers either portrayed the egg in the usual way, or drew upon an equally inopportune cultural construction of femininity: the devouring, spider-like, aggressive *femme fatale* or oppressive mother. Newly-discovered molecules were given names that contravened scientific convention to conform with gender stereotypes: the protruding glycoproteins in the egg's zona pellucida were named "receptors" instead of ligands, such as ZP3, the "sperm receptor," and ZP2, the "secondary sperm receptor;" whereas the pocketed carbohydrate-linking protein on the sperm surface that links to ZP3 became known as an "egg binding protein," to avoid using the word "receptor" (Martin 1991, pp. 495-496).

For a recent example, a pair of interlinking proteins on the egg and sperm plasma membranes have been named Juno, after the Roman goddess of fertility, and IZUMO, after a Japanese shrine honoring the Shinto god of marriage. With the discovery of Juno, "IZUMO1 finally finds his mate" (Anifandis et al., 2014, p. 12983). Gendered reasoning is so entrenched that the language used to describe cells may flip as scientific research reveals properties misaligned with their previously-assigned gender. For instance, in neurology, glial cells are now known to regulate synapse formation and consequently to play a key role in intercellular communication. No longer supportive "housekeepers" or "nursemaids," they have become "architects" and "masters" of the brain (Upchurch & Fojtová 2009, pp. 5-9).

Since the time of Martin's writing, fields such as gynecology and anatomy have moved away from sexist language and overt anthropomorphization of sex cells, and towards mutualistic terms such as "unite" or "meet" in reference to fertilization. Nonetheless, through textual and visual elements, scientific articles and textbooks on reproductive biology continue to incorporate traditional stereotypes about gender differences in behavior, cognition, and social roles (Campo-Engelstein & Johnson, 2014; Giacomini et al., 1986; Loughlin, 2018; Metoyer and Rust, 2011; Parker et al., 2017). In line with the assumption that female derives from male, the standard human body continues to be

presented primarily as a male body while the female body is discussed and illustrated primarily, if not exclusively, in relation to reproduction. The male reproductive system is prioritized as more interesting and important than the female, and therefore treated with greater enthusiasm, accuracy, and detail. Male comes before female in sentences, images, and the order of arguments: sperm before egg, male before female reproductive system. The male reproductive system is described in positive terms as linear, external, and indefatigable, whereas discussions of the female system emphasize complexity, degeneration, and dependence on the brain. Sperms consequently appear to be unfailingly produced and perfect in quality, rather than dwindling in amount with advanced age and vulnerable to diseases, toxins, and progressively increasing numbers of genetic mutations throughout adulthood (Kong et al., 2012; Punab et al., 2017).

Passive verbs depict female gametes and reproductive organs as locations or destinations which provide service and support, whereas active verbs describe male gametes and reproductive parts in terms of function, action, and purpose. Ignoring current knowledge, the literature continues to imply that embryonic development requires an active developmental program only in the case of males. It overstates the activity and importance of sperm and semen, and downplays those of the egg and cervical mucus. Sperms are credited with accomplishing fertilization, the sperm nucleus with directing the fusion of maternal and paternal chromosomes. In contrast, the cervix is portrayed as a mere location or conduit, its mucus an inert substance or environment, if not a threat or obstacle to the free movement of self-propelled sperms. In the words of a recent scientific journal article, the number of sperms dwindles as they "swim towards" the uterus and oviduct, "in an attempt to make it through the mucus" (Georgadaki et al. 2016, p. 979).

In sum, scientific literature on reproductive biology continues to express traditional gender stereotypes, male-orientation, and resistance to new information, which has long yielded mistakes and lacunae in knowledge that undermine women's medical care and reproductive health (see Metoyer and Rust 2011, p. 198). In reality, the male body is not simply a marvelous factory that produces flawless cells capable of fertilizing an egg on their own and without error or waste. Contrariwise, the female body is not simply a vessel for an empty egg, a minefield for sperm cells pursuing their destiny, or an obscure, complicated, and uniquely wasteful and vulnerable system. Both eggs and sperm are produced by complex reproductive systems, and both participate in fertilization.

2 Italian middle-school biology instruction

2.1 Materials and techniques of analysis

Our analysis concerns an educational film, twelve middle school science textbooks, and a set of worksheets filled out by four classes of students at two public middle schools in the region of Emilia-Romagna. The popularity of the animated film is the reason it is included in the analysis. The textbooks were provided by a middle school teacher, who collected the third-year science books used at the school along with those sent by publishers for marketing purposes. We chose to focus on the sections of textbooks for the third year of middle school that deal with reproduction

and human evolution because those discussions are particularly steeped in gender metaphors and visions of human nature compared to treatments of geology, ecosystems, mammalian biology, and other topics covered in middle school science courses. Didactic resources such as the textbooks and film analyzed in this article are central to science instruction, as shown by the importance attributed to them by science teachers (see Shymansky et al., 1991).

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We received 66 completed worksheets, split evenly between girls and boys, from four middle-school classes at two public schools in the region of Emilia-Romagna, Italy. The students who filled out the worksheet were between 13 and 15 years of age. Participation was voluntary. Written parental permission was obtained in advance.

The worksheet asked students to describe the female and male reproductive systems; the composition of egg and sperm, using three adjectives; and the fertilization process, including a drawing. Background questions asked for age, sex/gender, favorite school subject, desired profession, and most likely profession.

Our analysis is based on a Feminist Critical Discourse Analysis (FCDA) approach to the study of texts as products of a reciprocal relationship between language and society (Lazar 2007; Van Dijk, 2001). Educational materials are a form of public discourse through which power relations and structures of social dominance are communicated and constituted. The goal of FCDA is to render visible the hegemonic essentializing ideologies which are embedded in language and which help to naturalize inequality to the detriment of disadvantaged groups such as women. Of the components of FCDA, we focus primarily on language use (text structure, word choice, grammar) and social impacts of discourse (children's understandings of fertilization), leaving aside the production and distribution of the texts under consideration as beyond the scope of our analysis (Fairclough 2013). In addition, our analysis incorporates elements of the Discourse-Historical Approach (see Wodak 2015), such as attention to discursive strategies for characterizing actors and situations and for attributing positive and negative traits to actors.

All translations are our own, based on a translation strategy focused upon conveying the structure, tone, and rhetoric of the original text. The Italian versions are not included due to space constraints.

2.2 Educational film: "This is How We Are Made"

Our analysis begins with the 25-minute episode, "La nascita" ["Birth"], of a 26-part animated film series, *Siamo fatti così* [*This is how we are made*]. Originally *Il était une fois…la vie* [*Once upon a time there was…life*] (Barillé, 1987), the series has been broadcast in Italy since 1989. It has been translated into more than a dozen languages and is available at newsstands, by subscription, and online. Over 42 million copies have been sold in Italy alone, accompanied by a book series published by De Agostini, *Esplorando il corpo umano* [*Exploring the human body*] (Giaretta, 2014).[2] The series uses anthropomorphized characters - from bone cells to neurons, basophils to DNA - to teach children and adults about human biology in a way that is "fun, without relinquishing scientific rigor" (Giaretta,

[2] During our lectures at the Università di Bologna, Forlì campus, several classes of thirty or more students have told us that they all remembered seeing the episode.

2014). A male narrator recounts the story with the help of three red blood cells: a sage and elderly male, Globus; a girl named Globina; and, a boy called Emo.

The episode on human reproduction opens with a progression by which an amphibian evolves into a generic mammal, monkey, and, finally, male human. The narrator's voice announces, "Here is man." A female figure with long hair appears at the edge of the screen and walks to the man: "Here is woman." The two embrace and turn into a modern woman and man: "Here is the couple."

The film then presents fertilization as a heroic military mission involving multitudes of purposeful, determined sperms drawn with well-defined body parts and faces partially covered by helmets. Accompanied by adventurous music, the sperms swim in orderly lines as they "go on the attack" and take on an "extraordinary obstacle course." Sperms are shown braving enormous waves and scary tentacles. The narrator explains that most "will die of exhaustion in the uterine cavity or fall into the traps of the fallopian tubes." Shouts of joy accompany the 1% that "succeed in crossing the barrier of the cervix."

A castle wall protects the egg, which, unlike all the other characters in the cartoon, is a shapeless mass completely devoid of human characteristics. Standing vertically on their tails, sperms shoot laser beams at a wall surrounding the egg. It crumbles, revealing a round door. A sperm shoots at the door to force it open and swims through. The door closes upon its flagellum, which falls off. "Only one has been admitted into the sanctuary, and the secret entrance vanishes, disappears," explains the narrator.

Once inside the egg, the victorious sperm appears without a helmet, revealing its face. The sperm deposits its chromosomes inside the egg's nucleus: these are in the shape of Xs and Ys, all wearing a bowtie and hat. The egg's chromosomes, all in the shape of an X, have long eyelashes but no accessories. Over the chatter of male and female voices, a female voice says, "here come our complementary chromosomes." After greeting each other with a bow, a female X and male Y begin to dance.

The film then describes the development of the fertilized egg as a process run by three men in a control tower: a wise man with a long white beard dressed in a white lab coat, and two military officers with hats and military stripes. The three characters issue orders over an intercom, explaining, for example, that "Order and discipline" are necessary for the success of "Operation Mitosis." The image of a factory with active smokestacks occasionally flashes on the screen. Enzymes wearing blue uniforms work on an assembly line. The nucleotides, smiling children with differently shaped heads, play and argue. They are removed if they do not match up with the appropriate partner: "Do you want to cause a genetic error?"

White blood cells drawn as police officers armed with clubs oversee the migration of the various types of cells that will constitute the new body. Bone cells shown as caravans of cowboys sporting a bone-shaped nose piercing are

encouraged to head “west, towards the humerus” where “there are virgin lands to conquer.” Others are admonished to go towards the forearm in search of additional “territories to conquer.” Finally, amidst the assembling of a human body out of numerous anthropomorphized elements, there appears the reassuring image of a mother who, after a hasty and confusing depiction of childbirth, comforts the child in her arms.

Beyond anthropomorphized characters, the film conveys gender stereotypes by giving female voices to cells which cry out *en masse* but male voices and features to cells shown in their uniqueness, such as bone cells, sperms, and white blood cells. Male characters display human characteristics such as joy, pain, courage, enthusiasm, and camaraderie. Individual female characters are placed in secondary roles, such a female spaceship captain who addresses her co-pilot as “commander” as they monitor the immune system. Female characters such as Globina do not make decisions or show themselves to be knowledgeable. They ask to be instructed, but are never asked for information in return. The very dearth of female characters gives the impression that the creation of a human being is entirely the product of male genius, heroism, and effort. This work requires a martial organization, as evidenced by military uniforms, weapons, and vehicles. The soundtrack is replete with terms such as “troops,” “commanders,” “lieutenants,” “columns,” and “provisions,” along with expressions such as “On the assault,” “In position, attack!” and “Operation completed successfully.”

The egg stands apart from the adventure story as a featureless glob, a spoil of war or sacred resource to capture. The walls, stormy waters, tentacles, and traps presented by the woman’s reproductive system likewise do not have human characteristics; they are generic, unpredictable, irrational forces that stand in the way of the sperm’s will. Devoid of specialized structures and functions, the female body waits passively for the arrival of the paternal chromosomes, and its limited activities have a negative value. The film thereby presents both models of femininity identified by Martin: one the one hand, passive and nurturing; on the other, voracious, aggressive, and malignant. These models recapitulate traditional cultural visions of Nature itself as both a benevolent source of bounty and an indecipherable, intractable, capricious force. That is, both egg and Mother Nature throw up obstacles and difficulties but ultimately allow themselves to be dominated by masculine intelligence and determination.

2.3 Middle school science textbooks: reproductive systems

In contrast to the cartoon, the textbooks do not openly anthropomorphize the egg and sperm, yet they nonetheless present the material through the same gender constructions. The following discussion summarizes general tendencies across twelve Italian textbooks for middle school students in the region of Emilia-Romagna. We focus on the arrangement of topics, use of language, and form and content of visual images.

All of the books follow a male-first ordering of topics. The same tendency generally applies to the placement of male-referenced images as well as the naming of gametes and reproductive parts within sentences. To illustrate, a 14-page chapter on “Reproduction” contains 39 instances of male before female in the body of the text compared to 3 cases of

female before male, all of which appear in the section on the female reproductive tract. All of the images and captions central to the narrative respect the male-first rule, but female sometimes appears before male in 4 boxes outside the main text, 3 of which concern fertilization in other animals (Leopardi & Gariboldi, 2002, pp. 140-153).

The books consistently present the male form as the standard for all human bodies and associate the female body with reproduction. The header on the odd-numbered pages of one book's chapters on reproduction and evolution is the word, "Man;" the header on the even-numbered pages is a photograph of a pregnant woman next to the words, "The reproductive tract," and "The origins and evolution of life," respectively (Flaccavento & Romano, 2010). An entire book on human biology presents a male body in 70 out of 87 images. Of the remaining 17 images, only 4 represent a generic anatomical system – although without any labelled parts - while the other 13 show women in one or more of three ways: in underwear, in relation to a male body, or as a reproducer (Banfi & Peraboni, 2017).

The books consistently use the generic "man" (*uomo*), even where it is awkward or unnecessary. For instance, beneath a diagram that compares gametes of various species, one book asks, "Where do mammals (including man), keep their eggs?" (Berti et al., 2014, p. 140) Another book states that, "Unlike the majority of other animals, which have large litters, man usually gives birth to one child at a time" (Pietra et al., 2014, p. 321).

The books imply absolute difference between male and female, avoiding topics such as intersex conditions, the concept of gender as distinct from sex, or the shared embryonic basis of female and male reproductive organs. Where a book notes anatomical homology, the male remains the prototype for the female version. For instance, the labia majora "correspond to the scrotum in man" (Vacca et al., 2014, p. 167). The clitoris is a "little organ" (Berti et al., 2014, p. 146; De Capitani et al., 2011, p. 124; Flaccavento & Romano, 2011, p. 204; Vacca et al., 2014, p. 167), "similar in structure to the penis but very reduced in size" (Pietra et al., 2014, p. 315), like a "penis in miniature" (Leopardi & Gariboldi, 2002, p. 145).

The female reproductive system is frequently described as "more complex" or "much more complex" than the male, and predominantly, if not entirely, internal as opposed to the mainly external or mixed male system (see De Capitani et al., 2011, p. 123; Flaccavento & Romano 2010, p. 229; Flaccavento & Romano, 2011, pp. 203-204; Leopardi & Gariboldi, 2002, p. 144; Negrino & Rondano, 2010, p. 162; Pietra et al., 2014, p. 314; Serani et al., 2015, p. 178; Vacca et al., 2014, pp. 166-167). The books characterize the female system as composed of multiple fragmented parts whose cyclical activity is orchestrated by the brain; the male as made up of rationally organized structures that operate in a linear manner independently of the brain. Compared to lengthy explanations of the menstrual cycle and the maturation of an egg, replete with complicated diagrams that include the brain (for ex. Acquati et al., 2014, pp. 138-140; Flaccavento & Romano, 2011, pp. 206-207; Serani et al., 2015, pp. 179-180), there is scant discussion of reproductive hormones in males aside from the role of the hypothalamus during puberty (for ex. Acquati et al., 2014, p. 135; Leopardi & Gariboldi, 2002, p. 143; Negrino & Rondano, 2010, p. 160). No book includes a drawing of the

brain in its discussion of the male reproductive system, although one section on puberty includes a diagram of the two reproductive systems that shows the brain in both bodies (Flaccavento & Romano, 2010, p. 228).

Whereas male reproductive anatomy is described in terms of action and function, female structures and gametes are represented as locations: passageways, shelters, or sources of nourishment. "The penis…is the organ that, entering into the female body during copulation, deposits its spermatozoa there" (Vacca et al., 2014, p. 166; see also Berti et al., 2014, p. 148; Pietra et al., 2014, p. 318; Serani et al., 2015, pp. 178, 181). The vagina's impressive elasticity during copulation and childbirth (see Berti et al., 2014, p. 146; De Capitani et al., 2011, p. 124; Flaccavento & Romano, 2011, p. 204) allows it to "host" the penis (Vacca et al., 2014, p. 167). It is a "canal" that "has the double task of receiving spermatozoa…and allowing the passage of the child during birth" (Acquati et al., 2014, p. 137). The ovarian follicle provides "protection and nourishment" to the ovum during its maturation process (Pietra et al., 2014, p. 316). The ovum, in turn, "contains nutritious substances that serve…for the development of the future embryo" (Pietra et al., 2014, p. 315). The oviduct is the "seat where the meeting between the egg and the sperm happens" (Flaccavento & Romano, 2010, p. 230). The uterus "hosts," "shelters," and "nourishes" the new being (see De Capitani et al., 2011, p. 123; Flaccavento & Romano, 2010, p. 229), "nestling the child during its development" (Acquati et al., 2014, p. 137). The amnios and chorion are "two membranes destined to protect and nourish the embryo" (De Capitani et al. 2011:131), while the placenta passes "nutritive substances and oxygen" from mother to embryo and waste products from embryo to mother, "who will see to eliminating them by way of the lungs and kidneys" (De Capitani et al. 2011:131).

The female reproductive system is described as periodically drawing down a limited store of eggs, unlike the male's boundless productivity. To begin with, the process of meiosis generates four spermatozoa, whereas from an oocyte "there will only form one ovum because the other three cells degenerate" (Negrino and Rondano 2010: 162). At birth, a female has a "very set number" of eggs "that does not increase again over the lifetime of the woman" (Flaccavento & Romano, 2011, p. 204). Of hundreds of thousands "theoretically capable of transforming themselves" into ova (Serani et al., 2015, p. 179), "at most 500" (Vacca et al., 2014, p. 168) will complete maturation during puberty, when girls become "potentially able to generate children" (Banfi & Peraboni, 2017, p. 210).

For a male, by contrast, puberty brings failsafe sperm maturation processes and seminal liquid production, as suggested by verb forms including "undergo," "complete," and "reach" (e.g., Banfi & Peraboni, 2017, p. 206; De Capitani et al., 2011, p. 122; Leopardi & Gariboldi, 2002, pp. 143-144; Pietra et al., 2014, p. 314; Vacca et al., 2014, p. 166). The male's "numerous seminiferous tubules" (Serani et al., 2015, p. 177) produce sperms "in enormous quantities, several hundreds of millions at a time, constantly and without interruption for the entire lifetime, starting at puberty" (Negrino & Rondano, 2010, p. 161). In short, abundant, lifelong sperm production is never in doubt, with the exception of infrequently-discussed topics such as faulty descent of the testicles in early life (Acquati et al., 2014, p. 135), or the damaging effects of overheating the genitals and other potential causes of male infertility (Acquati et al., 2014, pp. 135, 139; Berti et al., 2014, p. 145).

Expressions of awe and admiration for the male system may even be accompanied by exclamation points. For instance, the seminiferous tubules "produce…about 8,000 billion spermatozoa!" over a man's lifetime (Berti et al., 2014, p. 145). Alternatively, "[t]he number of spermatozoa produced in the testicles is truly amazing: on average 100 million per day!" (De Capitani et al., 2011, p. 122). Notwithstanding these huge numbers of cells, some texts attribute wastefulness to the female system with statements such as, "the energetic cost of producing an egg is very high…[t]o produce sperms, instead, a smaller investment of material and energy is necessary" (Berti et al., 2014, p. 140). A few pages on, the same book announces that "every ejaculation contains on average 300 million spermatozoa" (Berti et al., 2014, p. 145).

In keeping with the idea that sperms emerge fully formed and perfect for their task, the textbooks do not mention the capacitation process that occurs inside the female body, and rarely speak of cervical mucus. For instance, the reduction in numbers from millions to hundreds of sperms that reach the vicinity of the ovum is attributed not to failure to survive conditions in the female reproductive tract or complete capacitation, but competition during the "long journey" (De Capitani et al., 2011, p. 128; see also Serani et al., 2015, p. 181; Vacca et al., 2014, p. 170). In a section on the male reproductive tract, one of the texts notes that "substances produced by the female organs" subject sperms to "strong selection" as a way to emphasize that only the strongest "succeed in surviving" (De Capitani et al., 2011, p. 124). By omitting information about the female reproductive tract's role in facilitating sperm movement through mechanical, thermal, and chemical forces, the books leave the impression that seminal liquid conducts sperms to the oviduct rather than being shed or dissolving as sperms pass into the cervical mucus: "The spermatozoa, deposited by the penis in the vagina…ascend the uterus and the tubes moving themselves in the seminal liquid" (Pietra et al., 2014, p. 318).[3]

The books uniformly suggest that sexual and reproductive health is a female concern by placing discussions of contraception, infertility, personal hygiene, and sexually transmitted infections (STIs) within or at the end of the section on the female reproductive system. Girls and women predominate in the illustrations, sometimes to the exclusion of boys and men (e.g., Acquati et al., 2014, p. 139). Books which discuss women's reproductive cancers do not mention testicular cancer (e.g., Banfi & Peraboni, 2017, p. 208; Banfi & Peraboni, 2017, p. 215; Flaccavento & Romano 2010, p. 236; Negrino & Rondano, 2010, p. 171; Pietra et al., 2014, p. 323). Discussions such as the benefits of immunization against HPV are directed entirely at girls (Pietra et al., 2014, p. 323), although some books note potential effects of STIs on male as well as female fertility (e.g., Flaccavento & Romano, 2011, p. 213).

The equation of the female body with disease and danger is particularly clear in the illustrations accompanying a two-page discussion of STIs, breast and uterine cancer prevention, and harmful influences on fetal development: three

[3] According to one of the texts, sperms manage to traverse a distance 4,000 times their length within thirty minutes (Vacca et al., 2014, p. 170), assuming sperm length of 0.005 cm (including the tail, which is some 10 times longer than the cell body) and female reproductive tract length of 20 cm (for mammalian sperm size in measurements, see Gu et al., 2019).

electron micrographs of sexually-transmitted microbes and a large photograph of a pregnant woman gazing downward (Flaccavento & Romano 2010, p. 236). That is, the female body is not only vulnerable to disease but a threat to others through sexually transmitted infections as well as behaviors and exposures that imperil the developing fetus. The books admonish pregnant women not only to avoid infectious diseases, alcohol and cigarette smoke, medicines, and chemicals in the workplace (see Acquati et al., 2014, p. 142; Berti et al., 2014, p. 148; Flaccavento & Romano 2010, pp. 235-236; Negrino & Rondano, 2010, pp. 169-170), but also to maintain a proper diet, practice moderate physical activity, and conduct a "tranquil life far from situations that could cause stress or nervous disorders" (Negrino & Rondano, 2010, p. 168).

Discussions of reproductive senescence likewise associate degeneration and disease with the female body only. From puberty to menopause, the woman's reproductive system "methodically prepares itself to carry out its task" (Acquati et al., 2014, p. 137), but if the egg is not fertilized the ovum "dies" and the mucosa, "no longer useful, dies" (Pietra et al., 2014, pp. 317, 328). At around age fifty, "little by little the ovaries cease to function" (Vacca et al., 2014, p. 169). With menopause, the woman's "reproductive capacity ends" (Negrino & Rondano, 2010, p. 162) and she "can no longer have children" (Serani et al., 2015, p. 180). One text alludes to unspecified adverse consequences by stating that hormonal treatments may be used to "slow down the effects" (Banfi & Peraboni, 2017, p. 211). In contrast, the male reproductive system is not described as one that prepares itself continually for an event that may never happen and is fatally shut down by the aging process. To the contrary, men are assured lifelong fertility, vitality, and relevance, as seen in the caption to a photo of a grandfather and grandson that accompanies a discussion of ten biological aging processes: "Not everyone feels the passage of time in the same way. Many men have achieved great works even in old age" (Vacca et al., 2014, p. 177).

2.4 Middle school science textbooks: egg and sperm

Like the female and male reproductive systems, eggs and sperms are presented through contrasts and oppositions. Eggs are scarce, nebulous blobs that perish unless saved by fertilization; sperms are abundant, unlimited, specialized voyagers that die heroically by exhaustion on a quest only one of them can complete. In contrast to the hydrodynamic sperm in which "everything is reduced to the essential" (Pietra et al., 2014, p. 314), the ovum is invariably described as lacking independent movement, even "incapable" of moving itself (Flaccavento & Romano, 2011, p. 205). Although it may be mentioned that the oviduct's cilia contribute to the egg's movement (e.g., De Capitani et al., 2011, p. 123; Flaccavento & Romano, 2011, p. 204), in general the egg appears only to float. The sperm, in contrast, "climbs," "advances," and "swims" (e.g., Acquati et al., 2014, p. 138; Berti et al., 2014, p. 148; De Capitani et al., 2011, p. 128; Negrino & Rondano, 2010, p. 164; Pietra et al., 2014, pp. 314, 326).

The active/passive opposition translates into different verb forms applied to the two cells and reproductive systems. For instance, one book's section headings are "The main organs of the male reproductive tract *are*…" and "The female reproductive tract *is formed by*…" (De Capitani et al., 2011, pp. 122, 123; emphasis added). Similarly, "The male

reproductive tract *produces* spermatozoa," whereas "*In* the female reproductive tract egg cells *are formed* and a new individual originates" (Banfi & Peraboni, 2017, pp. 206, 208; emphasis added). Sperms "enter," "climb," "succeed," "encircle," "crowd around," "penetrate," "perforate." Eggs: "have," "are released," "are fertilized," "serve to," "nourish," "are transported." The egg occasionally appears somewhat active, but only for the purpose of making the sperm's task more arduous. For instance, "[t]he membrane that surrounds the ovum possesses a sort of barrier that opposes itself to penetration by spermatozoa" (De Capitani et al., 2011, p. 128).

Most of the books favor the female-gendered term, *cellula uovo* [egg cell], although it may be used alternately with the male-gendered *ovulo* [ovum] or *ovocita* [oocyte]. In line with the tendency for illustrations to remain more conservative than textual material (see below), some photo and diagram captions contain the term *cellula uovo* even if *ovulo* or *ovocita* appears in the text (e.g., Berti et al., 2014, p. 143; Flaccavento & Romano 2010, p. 230). None of the books ever describes the male gamete as a *cellula spermatozoo* [sperm cell], for that would be a female-gendered, dependent noun. The word for sperm, *spermatozoo*, stands on its own, without modification.

Colorized drawings and electron micrographs reinforce the gender associations implicit in the textbooks' use of language. Pink/red versus blue/purple tones mark women versus men's clothing, maternal and paternal chromosomes, female and male reproductive systems, and eggs and sperms (see Banfi & Peraboni, 2017, pp. 206, 208; Berti et al., 2014, pp. 145, 147; Pietra et al., 2014, pp. 312, 314-318, 335, 355, 361). One text invites the reader to underline the sentences concerning the egg in red, those regarding the sperm in blue (De Capitani et al., 2011, p. 119).

The books deny autonomy and subjectivity to the egg while highlighting the sperm's individuality and autonomy through photo captions such as, "Spermatozoa crowding around an egg cell" (Leopardi & Gariboldi, 2002, p. 145); "A spermatozoon is fertilizing an egg cell" (Pietra et al., 2014, p. 314); "A spermatozoon tries to enter the inside of an egg cell" (Banfi & Peraboni, 2017, p. 207); and, "Only one of all the spermatozoa that reach the egg cell will be able to fertilize it" (Pietra et al., 2014, p. 318). In addition to discussions of eggs, these photo captions appear in sections on the female reproductive tract. For instance, an image of "Hundreds of spermatozoa surrounding an egg cell" appears within a section on the menstrual cycle (Acquati et al., 2014, p. 138). Other captions deny subjectivity to the egg by emphasizing other elements in the picture besides sperms, as in "An egg cell encircled by cells from the follicle that nourish it" (Pietra et al., 2014, pp. 316), and, "coating of cells derived from the ovary" (Flaccavento & Romano, 2011, p. 205).

The textbooks consistently furnish more detailed descriptions of the sperm's than the egg's structure and organelles such as mitochondria, which may not be mentioned at all in the case of eggs (e.g., Banfi & Peraboni, 2017, pp. 207-209; De Capitani et al., 2011, p. 119; Flaccavento & Romano 2010, pp. 229, 230; Leopardi & Gariboldi, 2002, p. 143; Pietra et al., 2014, pp. 314-316; Serani et al., 2015, p. 176; Vacca et al., 2014, pp. 166-167). One text dedicates a single sentence to the ovum and a half page to the spermatozoon (Banfi & Peraboni, 2017, pp. 207, 209); another devotes three times as much text to the sperm than the egg, accompanied by an enormous labelled drawing of the

sperm's multiple parts and a small electron micrograph of an egg devoid of components (Pietra et al., 2014, pp. 314-316). The egg's lack of definition extends to its surface, which is frequently drawn as a smooth line (e.g., Serani et al., 2015, p. 176), although some books show the egg's complex outer strata (e.g., Flaccavento & Romano 2010, p. 230) and others provide electron micrographs that, however, are not labelled (e.g., Negrino & Rondano, 2010, p. 162).

Echoing the traditional image of woman as a fertile field for man's seed, one book gives the sperm's function as "simply that of transporting the genetic material of the nucleus to the egg cell to fertilize it" (Pietra et al., 2014, p. 314). The egg may even appear empty of chromosomes, as in a pair of drawings in which the label "23 chromosomes" points to the sperm and not the egg (Flaccavento & Romano, 2011, p. 205). The complement to another labelled diagram of a multipart sperm containing a nucleus with 23 chromosomes is an electron micrograph of an ovulated egg inside its follicle, with no tags indicating internal or external components (Leopardi & Gariboldi, 2002, pp. 143-144).

The image of mechanical force runs through descriptions of fertilization, reinforcing the idea of penetration and the notion that the egg passively resists secondary fertilization through physical alterations. As one text puts it, the enzymes released by the sperm's acrosome have the task of "knocking down the protective barriers of the egg cell" (Banfi & Peraboni, 2017, p. 207). Upon fertilization, the egg "hardens" or "thickens," becoming a "barrier" that "blocks" the entry of other sperms (Acquati et al., 2014, p. 138; Banfi & Peraboni, 2017, p. 212; De Capitani et al., 2011, p. 128; Pietra et al., 2014, p. 318), although some texts mention chemical alterations (e.g., Flaccavento & Romano, 2011, p. 205; Negrino & Rondano, 2010, p. 164).

Continued use of the terms, "head," "neck," and "tail," instead of available alternatives, endows sperms with mammalian characteristics. Drawings of sperms often include altered shapes and proportions that contradict electron micrographs included in the same books, such as a shortened flagellum to suggest a tail (Acquati et al., 2014, pp. 131, 133, 138; Banfi & Peraboni, 2017, pp. 203, 206, 207; Berti et al., 2014, pp. 140, 141, 145; Flaccavento & Romano, 2011, pp. 203, 205; Pietra et al., 2014, pp. 312-314, 318; Vacca et al., 2014, pp. 166, 170), or a sharply pointed head to imply that it pierces the egg (Acquati et al., 2014, p. 133; Leopardi & Gariboldi, 2002, pp. 143, 145; Pietra et al., 2014, pp. 313, 314, 318). Drawings present spermatozoa proceeding straight toward the ovum and pushing against it perpendicularly, as if physically penetrating it (e.g., Banfi & Peraboni, 2017, p. 203; Flaccavento & Romano 2010, p. 232; Flaccavento & Romano, 2011, pp. 205, 208; Negrino, 2018, p. 79), even though electron micrographs show them positioned laterally against the surface of the egg (e.g., Acquati et al., 2014, pp. 130-131, 133, 138; Pietra et al., 2014, pp. 314, 318). Some illustrations emphasize the idea of mechanical pressure against the egg with an illuminated area around the sperm (Banfi & Peraboni, 2017, pp. 203, 207; Berti et al., 2014, p. 140; Pietra et al., 2014, p. 314), or lines suggesting fractures on the egg surface (Acquati et al., 2014, pp. 130-131).

The protagonist of the fertilization drama is decidedly the sperm, as seen in section titles such as "The route taken by spermatozoa" versus "The production of female gametes" (Berti et al., 2014, pp. 145, 147); "The formation and voyage of the spermatozoon," versus "The maturation and story of an ovum" (Negrino & Rondano, 2010, pp. 161, 162); and,

"The route taken by spermatozoa" but no corresponding title or section on eggs (Serani et al. 2015, p. 178). The fact that "only one" of hundreds of millions of sperms will succeed in "penetrating" the egg is repeatedly emphasized (e.g., Flaccavento & Romano 2010, p. 232; Pietra et al., 2014, p. 318; Serani et al., 2015, p. 181), in one case twice on the same page (De Capitani et al., 2011, p. 128). Words such as the "victorious one" (Acquati et al., 2014, p. 139), the "most resilient and vigorous" (Berti et al., 2014, p. 148), and the "strongest and most adapted" (De Capitani et al., 2011, p. 124) suggest a contest of talent and willpower, if not a Darwinian competition: "only the strongest and fastest succeed in reaching the tubes, while the weaker ones die along the journey" (Negrino & Rondano, 2010, p. 164). The egg's course through the female reproductive tract, in contrast, is never described in terms of bravery or the obstacles and dangers faced by "only one" superb egg out of the multitudes that could have been released by the ovary.

The sperm's agency and motility appear to remain intact even after the cell "abandons" its flagellum (Vacca et al., 2014, p. 170). Upon entering the egg, the sperm "sets out" (De Capitani et al., 2011, p. 128) to swim across the cell until it "fuses its nucleus with that of the egg" (Vacca et al., 2014, p. 170), as shown by a diagram with an arrow pointing from the surface to the center of the egg (Flaccavento & Romano 2010, p. 232). The sperm thereby transfers its vitality and mobility to the zygote. "Moving itself towards the uterus, [the zygote] quickly begins to divide itself" (Acquati et al., 2014, p. 141). "Relocating" itself, the zygote "attaches," "implants itself," (Berti et al., 2014, p. 148), "deeply penetrates" and "burrows into" the expectant uterine mucosa (Flaccavento & Romano, 2011, p. 208). The zygote thereupon "takes the name of embryo" (Berti et al., 2014, p. 148) and "nourishes itself," "breathes," and "carries out other vital functions" by way of the placenta (De Capitani et al., 2011, pp. 130, 131). After nine months, the fetus is "ready to abandon the maternal womb and begin autonomous life" (Berti et al., 2014, p. 149). The newborn will then "nourish itself" at the maternal breast (Flaccavento & Romano, 2011, p. 212). Masculine vigor has transformed the indolent egg into an autonomous human being.

2.5 Middle school science textbooks: human evolution

Just as the textbooks' chapters on reproduction present the egg as a field of action for masculine enterprise, discussions of human evolution associate femininity with passivity, dependence, and motherhood while equating masculinity with action, initiative, and productivity. The use of the words, "*uomo*" ["man"] and "*uomini"* ["men"] instead of available substitutes such as "person," or "humankind," together with images that feature far more males than females, render males the protagonists of human evolution. All of the textbooks' evolutionary progressions of hominid species show only males, with males of more recent species carrying a club or spear (e.g., De Capitani et al., 2011, p. 334; Flaccavento & Romano 2010, pp. 270-271; Negrino, 2018, p. 278; Pietra et al., 2014, p. 252). One of the books covers the image with a large X to correct the view of evolution as a line instead of a tree or bush, not to criticize the practice of representing all ancestral species in male form (Banfi & Peraboni, 2017, p. 253).

The textbooks imply that, like sperms in the fertilization drama, prehistoric males were responsible for everything: they made tools and houses, fought animals, controlled fire, and started agriculture; they brought humankind greater

ease, comfort, and safety; and, they set the stage for modern advancements (see De Capitani et al., 2011, p. 335; Pietra et al., 2014, pp. 248-253). Male representatives of humankind sit atop temporal sequences that begin with species from distant epochs, such as dinosaurs, and end with modern men such as a businessman and an astronaut (e.g., Vacca et al., 2014, pp. 110-111). In the exceptional case of a temporal sequence that culminates with two women – their gender signaled by long hair – the drawing assigns them stereotypically feminine roles: one stands with a load of grain in her arms; the other, seated, kneads bread (De Capitani et al., 2011, p. 325).

Images of males are juxtaposed against text that attributes all of humankind's accomplishments to "man." For instance, a drawing of two bearded men speaking to each other carries the caption, "Language is born and develops" (Negrino, 2018, p. 273). Alongside a reconstruction of a *H. sapiens* male, one book explains that "Among *Homo sapiens* there were the first men to create cave paintings, musical instruments, and objects of high-value production" (Banfi & Peraboni, 2017, p. 255). Another discussion of "man's" marvelous discoveries and inventions is sandwiched between two photographs of cave paintings and an evolutionary progression that includes a chimpanzee and seven bearded male representatives of successive species (Flaccavento & Romano 2010, pp. 270-271).

The origin and production of art is directly attributed to males through drawings of ancestral males painting (e.g., Negrino, 2018, p. 277) and captions to photographs of cave paintings such as "Around 35,000 years ago…men, using natural pigments…started painting on cave walls" (Banfi & Peraboni, 2017, p. 256). The implied or stated purpose was to improve males' chances at big-game hunting (see Banfi & Peraboni, 2017, p. 256). Hunting and warfare are repeatedly evoked through drawings of males carrying or using tools and weapons while wearing serious, if not threatening, expressions on their faces (see Flaccavento & Romano 2010, p. 271; Negrino, 2018, pp. 275-278; Vacca et al., 2014, pp. 220-222). Among the various species represented through reconstructed portraits, only Lucy the australopithecine looks peaceful, her eyes unthreateningly averted to the side (see Banfi & Peraboni, 2017, p. 259; Pietra et al., 2014, p. 249).

The relatively few females in illustrations concerning human evolution are predominantly shown in passive poses. Those presented in active poses perform tasks associated with femininity, especially child care but also food collection and preparation, weaving, and carrying food or firewood (e.g., De Capitani et al., 2011, p. 335; Negrino, 2018, pp. 276-277; Vacca et al., 2014, pp. 217, 221). Projecting these gender roles across all time, one text explains that men in both ancestral and contemporary foraging societies "dedicate themselves to the hunt, going away for many days," while the "women take care of children and stay in the village or nearby, where they dedicate themselves to the gathering of food" (Pietra et al., 2014, p. 251). Even australopithecines living millions of years before the emergence of hunting technology are depicted as housewives and hunters, as seen in a drawing of daily life that shows a female with little body hair, a rounded physique with wide hips, and a baby in her arms, approaching a muscular, hairy male who is sharpening the point of a long stick (Vacca et al., 2014, p. 217).

Echoing widespread misconceptions about sex determination of skeletal remains as both straightforward and sufficient for interpreting people's identities, activities, and social roles, one chapter on human evolution opens with a sidebar that begins, "In the skeleton of woman the pelvis is slightly wider relative to that of man" (Banfi & Peraboni, 2017, p. 248).[4] Another text joins ancient male ingenuity and industriousness to the assumption of a biological imperative for female dedication to motherhood and service to the family: "When man's actions and discoveries began to guarantee more abundant resources for survival, woman was able to reproduce during all parts of the year and found herself simultaneously taking care of more children of different ages" (Berti et al., 2014, p. 139). In sum, procreation and associated duties emerge as the universal, eternal, and entire essence of female existence, rendering the lives of males all the more enthralling.

3 Worksheets on human reproduction

Through words and drawings, the students who filled out our worksheet described fertilization in roughly the same way as the textbooks and film: a unique sperm acts upon an empty, anonymous egg and makes it come alive. Given that this is a common trope in popular culture - as seen in films, novels, jokes, and everyday conversation - the following discussion is not meant to imply that science class is necessarily or the only source of the students' understandings of fertilization. We discuss their answers concerning reproductive biology as a whole, given that their descriptions did not differ by gender, but consider them separately with respect to the background questions.

Passive and compound verbs typify the students' descriptions of eggs and female reproductive anatomy: "become fertilized," "is fertilized," "let pass," "nestle," "serve to," "contain," "maintain," and the reflexive words "corrode" and "harden;" but also, "bring to maturity," "permit," and occasionally, "produce." In contrast, active verbs predominate in reference to male equivalents: "fertilize," "produce," "carry," "put into action," "infuse," "arrive," "give," "permit," "dissolve," "go," "make grow," and the reflexive verbs "activate," "detach," "form," and "move;" but also the occasional "serve to," "help," and "meet."

Descriptive terms used in reference to eggs include "round" and various synonyms, "pink," "small," "large," "immobile," "expendable," "fixed number," "decomposition," and "gelatinous." One student's description of an ovum is a sentence about sperms: "They must be fertilized by spermatozoa." In contrast, descriptors for sperms emphasize mobility and activity: "mobile," "agile," "white," "fast," "endowed with a tail," and "numerous" and "minute" and various synonyms.

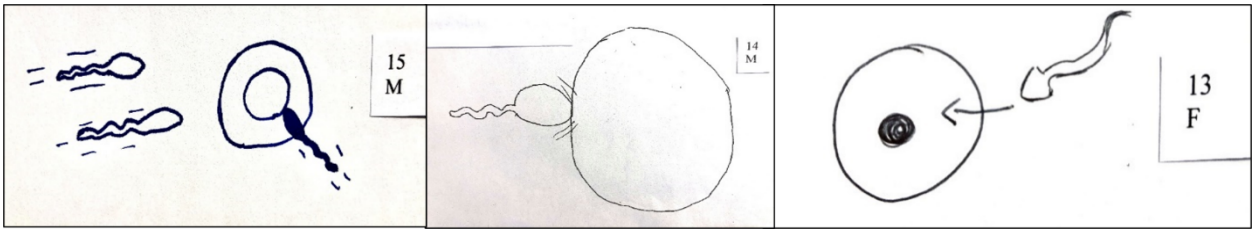
[4] In reality, sex determination is far from straightforward. Average pelvic measurements between females and males encompass overlapping ranges of data points. Modification of the pelvic parts due to childbearing provides more clues but diminishes in older age, meaning that older females may be mistaken for males. In short, a sex difference in the width of the hips is not the most clear-cut feature of ancient skeletal remains. Moreover, other kinds of information are needed to draw conclusions about the lives of individuals in any society (Geller 2014).

Eggs and the female reproductive system are described as locations, as in the textbooks, whereas in reference to males this imagery is limited the occasional "sperms contain chromosomes." The egg "must take into its own inside a single spermatozoon;" "contains the nucleus;" "keeps the male's spermatozoon and in this way a child is created;" and, "is formed by an external barrier which the spermatozoon has to surmount for fertilization." Descriptions of female reproductive organs include, "in the ovaries the egg cells mature;" "in the vagina the spermatozoon must be injected;" "in the uterus the embryo implants," and, the uterus "contains the new individual." Joining location imagery to the passive/active opposition, one student describes the female system as "very important because it is the place where the neonate forms;" whereas "the likewise important male system…serves to create the neonate inside the woman."

Students tend know more about sperms than eggs. Whereas descriptions of eggs name only the cytoplasm, nucleus, and membrane, descriptions of sperms name 7 parts: tail/flagellum, the flagellum's axoneme, neck, head/body, acrosome, chromosomes, and mitochondria. Students are more likely not to provide any description of eggs than sperms (28 versus 18 cases), and to dedicate fewer words to eggs than sperm. Of 36 descriptions of both cells, 17 contain fewer words for eggs, 10 contain a similar number, and 9 contain more. In 10 cases there is no description of the egg, but an average of 6 words for the sperm; in contrast, in 2 cases there is no description of the sperm, and a 1- or 2-word description of the egg.

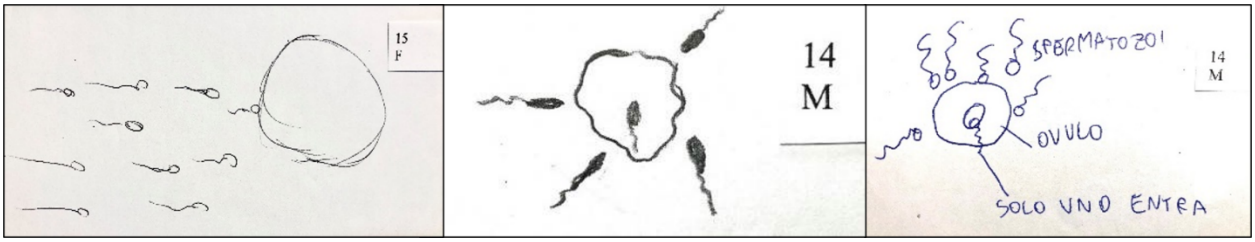
The students' drawings emphasize the sperm's purposeful mobility with beating flagella, lines, and arrows. The sperm's perpendicular position to the egg surface indicates mechanical penetration. In one case, force is suggested by slanted lines at the point of contact.

Figure 1 Student drawings: movement and force



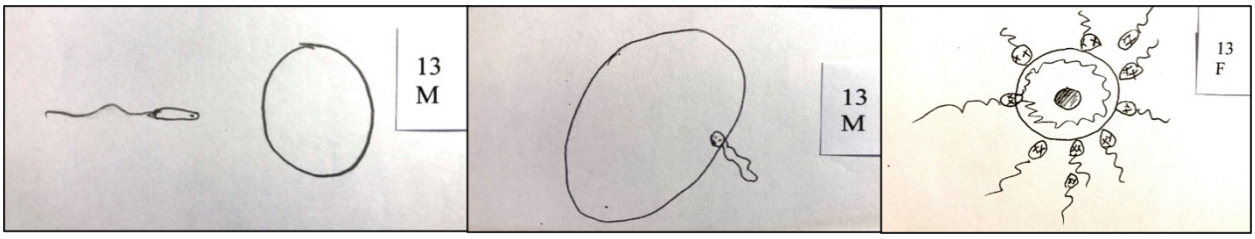
Multiple sperms are shown surrounding the egg or moving towards it as a group in 31 of 53 drawings. In In 15 of these drawings, there is a single sperm inside the egg. The words, "only one," appear in two of the drawings. The remaining 22 drawings contain a single sperm.

Figure 2 Student drawings: one sperm among many



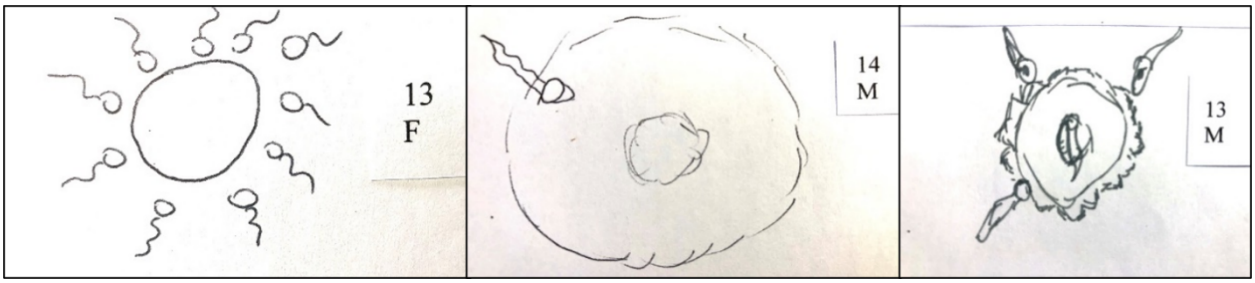
Further highlighting the sperm's vitality and individual identity, 12 of the drawings include a nucleus, chromosomes indicated by Xs and Ys, or facial features.

Figure 3 Student drawings: personality and individuality



The ovum, in contrast, generally takes the form of a circle. It is empty in 36 drawings, contains a nucleus in 12, and exhibits a large inner ring representing either a nucleus or the plasma membrane in another 5. The egg surface is drawn as a smooth line in 43 cases, a wavy line in 6, and something more complex in 4.

Figure 4 Student drawings: egg membrane



The language in the descriptions of fertilization that accompany the drawings reinforces the notion of a passive, floating egg, as in, "the ovum is still and the spermatozoa enter." Verbs highlighting the sperm's active efforts include "arrives," "enters," "tries to," "goes" [through/into/towards], "exits," "heads for," "traverses," "travels," "reaches," "leaves," "fertilizes," "produces," and "penetrates;" more passive verbs include "happen," "occur," "be let into," and the reflexive "mature." Many of the descriptions grant agency and individuality to the sperm, as in "Those which will

go to the wrong tube will die, those which instead choose the right one will meet the egg;" "all of them die but sometimes 1 succeeds in entering the egg and fertilizing it;" and, "the sperm corrodes its [the ovum's] walls with its head and grants fertilization creating the fetus."

On the other hand, some of the descriptions are more balanced: "The eggs and spermatozoa meet and in this way fertilization begins;" "The ova go from the ovaries to the fallopian tubes and the spermatozoa reach them…and they meet in the tubes;" "The eggs go along the fallopian tubes, in the meantime the sperm goes towards them;" and, "The 2 things meet and a child is born."

An analysis of the students' answers to our background questions indicates little difference in girls' and boys' preferred school subjects, with physical education a favorite of a large portion of both (11 out of 40 answers provided by girls, 11 out of 36 provided by boys). There was some divergence with respect to "desired" versus "likely" careers. The girls provided 39 total responses, the boys 48. Both sets of responses included 26 specific professions. More than one-fourth (11 of 39) of the girls' choices were in the retail, personal care, or hospitality industries. The rest were distributed among farming; education; professional volleyball, dance, and tennis; creative professions (translator, journalist, actor, painter, cartoonist); computer science; and, professions including banking, veterinary, forest service, medicine, psychology, and space exploration.

In contrast, only 3 of the boys' choices were in service professions (shop assistant, cook, personal trainer). Nearly a third (15 of 48) were either mechanic or professional soccer player. The rest were in other professional sports; farming; trades; computer science; office work; politics; military; science and engineering; forest service; and creative professions (musician, composer, film producer). Many boys named rare or unlikely professions such as YouTuber, Formula One driver, professional athlete (10 of 48 answers), film producer, and theoretical physicist, whereas girls stuck to a more realistic range of professions, with the exception of astronaut and Japanese-cartoon artist.

Nearly half of the students (14 girls, 15 boys) listed a desired profession that differed from their probable profession. Among the girls' choices, there were 3 cases of roughly equivalent professions, 2 cases of reduction in salary/prestige due to the desired profession being a professional sport, and an additional 9 cases of reduced salary/prestige such as veterinarian v. receptionist, or physician v. fast-food cashier. Among the boys' responses, 7 cases involved professions of approximately equivalent salary/prestige, such as office worker v. engineer or forest service v. chemist. The remaining 8 implied a reduction in salary/prestige, all but one of which (movie producer v. shop clerk) involved professional sports as the desired profession.

These limited data indicate that many girls and boys expect to pursue traditionally gender-appropriate professions, although both girls and boys aspire to a range of professions and are not strictly confined to professions or school subjects culturally defined as feminine or masculine. In addition, girls are less likely than boys to aspire to highly remunerative and prestigious careers. These patterns are consistent with the literature on the development of children's

knowledge of the work world and development of vocational preferences, which shows that girls are more likely than boys to eschew gender-inappropriate pursuits (Porfeli et al., 2008). Children's educational environment plays an important role in the development of their gender identity and academic and professional aspirations (see Haywood and Mac an Ghail, 2006). Exposure to images of people (or anthropomorphized cells, animals, and objects) of children's same gender depicted in traditional roles and professions contributes to the internalization of cultural beliefs about gender differences in intelligence, initiative, and natural social/professional roles (Olsson and Martiny, 2018). Their appearance in science textbooks lends these beliefs extra weight as finished, undisputed, culture-free knowledge, helping to channel girls and boys towards gender-appropriate pursuits.

4 Resilience and repercussions of gender representations in science and other textbooks

The foregoing analysis has shown that Italian middle-school biology textbooks deliver a vision of masculinity and femininity as unequal opposites. The animated film's evolutionary progression to modern "man" and the subsequent arrival of "woman" from the sidelines neatly encapsulates the idea that males are the natural protagonists of life, females their dependent reproducer-helpmeets. Similarly, the fertilization narrative celebrates the sperm cell's leadership and determination in pursuing its object, an inert egg. The anthropomorphized characters, and the military and industrial metaphors for embryonic development, express an anthropocentric vision of the relationship between humans and the natural environment. The textbooks likewise describe gametes, reproductive systems, and human ancestors through contemporary gender stereotypes and an historically specific sociopolitical ideology. Aside from being highly limiting for both girls and boys, this kind of imagery interferes with scientific knowledge production and communication, contributes to an environment that discourages girls from studying science, and naturalizes the objectification of girls and women.

The continued incorporation of gender stereotypes into biology textbooks not only generates errors concerning fertilization, as noted above, but also legitimizes unsubstantiated or mistaken beliefs about the alleged evolutionary basis for inborn gender traits and roles. Evidence from ancestral species and contemporary foraging societies calls into question the idea that tools were invented 2.5 million years ago and developed thereafter by males and mainly for hunting and warfare; the assumption that hunted meat was the principal or exclusive source of food; the notion of perpetual, universal patrilineal kinship; the image of females with hordes of little children and only a marginal role in food collection, confined to plants; the idea that males ranged far but females stayed close to the cave; the cave itself as a dwelling; the notion that groups were territorial and violent; and, the idea that males invented everything including creative arts and spirituality, but took no interest in children (Arthur, 2010; Gettler, 2010; Whitaker, 2017).

Cross-cultural data likewise challenge heteronormative assumptions about sexual and reproductive behavior, the universality of simple (nuclear) family organization, and biological sex differences in mate preferences, economic productivity, parenting, and cognitive abilities (Collier et al., 1997; Eliot, 2009; Whitaker, 2017). In particular, ethnographic and laboratory evidence contradicts the allegedly permanent effects of presumed ancestral sex roles on

competitiveness (Andersen et al., 2013) and the spatial versus verbal/relational abilities of women and men (Berry, 1966; Leeners et al., 2017). To the contrary, gender differences in cognitive skills and brain anatomy can be traced to socially and culturally prescribed differences in training and use (Feng et al., 2007; Maguire et al., 2000), while both the brains and actual behaviors of the vast majority of individuals are mosaics of female-typical and male-typical traits (Joel et al., 2015).

The foregoing has shown that these concepts are slow to enter textbooks and professional literature on reproductive biology. As "bearers of the discipline's status quo," textbooks are particularly prone to omitting information and discoveries that conflict with conventional narratives (Metoyer and Rust, 2011, p. 180). For instance, current evolutionary biology textbooks as well as newer editions of textbooks published in series continue to present outdated and misleading male-oriented explanations of sexual selection. Besides content at odds with current scholarship, there are more images of males, more concepts illustrated with images of males, and images of women and men in stereotypical gender roles (Fuselier et al., 2018).

On the whole, science, math, and technology textbooks lag behind other textbooks with respect to gender neutrality. Males remain overrepresented in both text and images (Moser & Hannover, 2014), misconstruing the actual numbers of women in science and technology (see Wood et al., 2020). The disproportion in images rises in step with the age of the people pictured and the target age group of readers (Elgar, 2004; Kerkoven et al., 2016). Moreover, women predominate in images of people engaged in teaching or service, whereas more men appear images representing scientific activity (Norén & Björklund Boistrup, 2016; Papadakis, 2018). Where women appear as scientists, they are presented in lower-status roles and activities, their knowledge, abilities, and contributions devalued relative to men's (see Caldwell & Wilbraham, 2018).

While young children envision scientists in a variety of ways, during middle school they come to align their view with that of their textbooks and teachers. Regardless of the ethnic composition of their country or the gender and ethnic composition of its scientific workforce, children draw a scientist as a bespectacled white man in a lab coat (El Takach & Yacoubian, 2020). For girls, the representation of science as a masculine activity interferes with comprehension of science lessons (Good et al., 2010). It also dampens interest in scientific subjects (Hannover and Kessels, 2004), whereas lessons that counteract essentialist beliefs about sex differences in intellectual aptitudes bring increased interest (Donovan et al., 2019). Girls tend to underestimate their own career-relevant abilities whereas boys tend to do the opposite - independently of actual proficiency as measured by test scores – especially with respect to fields requiring math competence (Correll, 2004).[5] Textbooks that uphold gender and other stereotypes consequently reduce the pool of potential scientists, to the detriment of both individuals and society given that diversity fosters insights and innovation (Kerkoven et al., 2016).

[5] This same tendency contributes to upward comparison threat, whereby girls exposed to counterstereotypes such as female surgeon and male nurse may respond in the same way as they do to gender stereotypes, with reduced leadership self-concept and interest in male-associated professions (Rudman & Phelan, 2010).

It is not just science books that expose young readers to gender stereotypes. Story books and school books across subjects continue to express gender biases through male-oriented topics and male-first words and images, inconsistent use of balanced language, and images that conserve stereotypes to a greater degree than the text (Lee & Collins, 2010; Moser & Hannover, 2014; Potter & Rosser, 1992). Female people and animals are often depicted in terms of passivity and introversion, service, indoor or domestic settings, victim roles, and socially-approved occupations such as teacher or nurse. Males, in contrast, tend to be associated with activity, leadership, prestige, professional settings, and a much wider range of occupations (Islam & Asadullah, 2018; Sovič & Hus, 2015).

To illustrate, an analysis of Italian elementary school textbooks on grammar and literature demonstrates that for every 10 female characters there are 16 male characters (Biemmi, 2011). Female characters are described in terms of either kindness and modesty, or vanity and envy; males in terms of courage, initiative, and self-assurance. Fixed in a timeless domestic role, female characters are shown in 15 professions – including fantastical ones such as queen or witch – and limited to indoor spaces or a garden or porch. In contrast, males take part in the grand sweep of history, representing 50 professions - from pre-industrial cobbler to high-tech computer scientist - and occupy a wide range of outdoor environments from the high seas to the harsh desert. Counter-stereotypes exist but often carry offsetting negative messages, such as the working mother who fails her family by serving frozen foods for dinner. The illustration to a story about a woman and a girl who tire of city life and build a treehouse using hammers and saws shows them smiling in spotless aprons inside the completed treehouse, one sweeping while the other prepares tea.

For students who speak a language with gendered nouns, such as the feminine *cellula uovo* and masculine *spermatozoo*, symbolic gender associations attach not just to people but all objects. Experiments conducted in English with bilingual speakers of German or Spanish indicate that the same object may be perceived in opposite ways if defined as feminine in one language but masculine in the other: in the first case, the object is beautiful, delicate, placid, and small; in the second, it is strong, energetic, active, and bulky (Boroditsky et al., 2003). That is, the properties of objects are aligned with those culturally associated with femininity and masculinity, regardless of the actual properties of objects or people. In other words, language creates a conceptually-consistent perceptual world unified by a single set of gender associations, which children internalize by second grade (Sera et al., 1994). Learning a language with gendered nouns has the same effect (Boroditsky et al., 2003).

By depicting eggs and ancestral females in decorative or domestic roles, science textbooks transform culturally-constructed gender oppositions into biological truths and thereby naturalize gender inequalities. The objectification of women appears normal and inevitable, with harmful effects on both women and those who objectify them. Objectification deprives the target of personhood, negating their subjectivity, agency, and autonomy (Loughnan et al., 2010). It blocks empathy, suppresses concern for psychological or physical distress in the objectified other, and legitimizes aggression and violence (Bandura, 2002). Drawing attention to women's physical appearance causes both men and women to view women as less competent, moral, and intelligent (Heflick & Goldenberg, 2009).

Objectification generates negative emotions and diminishes social participation (Saguy et al., 2010); even relatively empowered women such as scientists falter when casually discussing their work with men (Holleran et al., 2011). For girls and women, objectification dampens motivation and impairs performance beginning in the very first years of school (Quinn et al., 2006). In addition to these effects, self-objectification results in acceptance or approval of gender inequalities and suppresses gender activism (Calogero, 2012; Winn & Cornelius, 2020).

The film and textbooks analyzed above portray eggs and women as interchangeable objects of conquest, made for a common destiny of service and support. In contrast, sperms and men are depicted as unique subjects, equipped to pursue their own glorious path in the world. This construction draws upon an entrenched conceptual opposition that disparages female-associated emotion, personal knowledge, and compromise, while exalting male-associated reason, abstract knowledge, and willpower. The same opposition undergirds cultural expectations about women's duty to obey men versus men's freedom from even having to listen to women (Anderson 1995, p. 63). Like the inertness and emptiness of the egg in the fertilization adventure story, women's objectification, silencing, and marginalization appear to spring directly from nature.

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