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Introduction

SEX BIOLOGY IS INTERESTING

IMAGINE YOU are a fish called the bluehead wrasse, living off the coast of Florida. As you grow up, you, just like all to the other bluehead wrasse your age and size, develop one set of reproductive organs. You are what we'd call female, so you produce eggs. There is only one very large member of your group, and they are the group male, so produce sperm. But over the next few weeks you grow really fast, becoming the second-largest fish on your reef. Then the male gets eaten. Almost immediately your body starts to change, your reproductive organs mold, shift, and alter their form. *You* become the group's sperm producer. As a bluehead wrasse, you can have one body and one set of DNA, but multiple forms of reproductive biology across your lifetime.

Bluehead wrasse reproductive biology is not the most common pattern in the animal kingdom, but it's also not that weird. When most people think of the biology of reproduction, they typically envision two fixed kinds in each species: female and male. This is (mostly) right when it comes to the reproductive organs themselves, but not accurate for entire bodies and lives.

Most species do have two types of reproductive organs, and they are often found in two slightly different forms of that species' body plan. But not always. As with the wrasse, many fish start out with one set of reproductive organs, and once they grow to a certain size, they redo their anatomy and develop a new set of reproductive organs. Each earthworm's body has both types of its species' reproductive organs. Bees have two kinds of reproductive organs across three kinds of bodies. All mammal mothers lactate, but in some species of bat, fathers do too. And, as in the two different types of orangutan male, one with big face flanges and the other without, there can also be quite a bit of variation in bodies and behavior even among those individuals within the same species that have the same reproductive organs.

There is an explosion in research on the biology of reproduction—what we'll call sex biology—in the animal kingdom. While we continue to find that there are important differences in reproductive biology producing female, male, and sometimes intersex bodies in any given species, there is also a lot of variation, and overlap, in the actual biology and behavior that make up these categories. The variation we observe across the animal kingdom doesn't represent unusual exceptions to some kind of rule of sex; rather, this spectrum of variation tells us that females and males are not two different kinds of thing. Sex biology is not about two distinct kinds, a binary; instead, it's about patterns of variation in bodies, behavior, and lives that differ, overlap, and intertwine. Sex biology, as it turns out, makes life quite interesting.

The explosion in research is not limited to how other animals "do sex." There is also enormous investigation into human bodies, reproductive processes and patterns, health, hormones, genitals, genetics, behavior, and other related topics. For

example, we now know that human brains don't come in "male" and "female" versions. Also, unlike some other mammals, all human caretakers (regardless of their reproductive organs) can undergo changes in their brains, bodies, and behavior when they take care of babies. Fascinatingly, human sexual behavior, including the targets of attraction and arousal, is not necessarily linked to what kind of reproductive organs one has. And, most importantly, human sex is never just about biology; we have gender too.

In short, there is a lot going on in science regarding sex and gender in humans. Unfortunately, there is also a ton of misunderstanding in society about what biology, especially sex biology, tells us and what it doesn't tell us. And there is lack of awareness of just how diverse and variable humans are. To better understand biology and sex in humans, we need to learn about our bodies, histories, cultures, and behavior. We have to understand what it means that everything about humans is a supercomplicated blend of biology and culture. We need to combine our knowledge of biology, sex, and the human experience into a new narrative. My goal in this book is to put forward this new narrative and show how the biology of sex actually works, what it does and does not tell us, and how we might incorporate this knowledge into our education, lives, and laws.

To do so, I will first summarize what is currently known about the biology of sex in animals and how, and why, that relates to humans. This is important because understanding animal biology is at the heart of understanding human biology (we are, after all, animals). From there, I will illustrate what we know about sex, in biology and behavior, in the human past and present, across the last two million years of our lineage's existence and among the eight billion humans living today. What this knowledge from the animal world, the human past, and the

human present shows us is that biology as it relates to sex is not binary, meaning that it does not come in two distinct kinds: male and female. This is not to say that females and males are the same. They aren't. Nor is it that biological variation related to sex does not matter. It does. It's just that not all humans fit neatly into the categories of female or male, and biological measures of human bodies rarely segregate into two nonoverlapping categories. Neither "female" nor "male" describes a uniform or distinct biological type.

I will conclude by discussing why a binary view is a detrimental way to think, and talk, about sex biology and the human experience. Reproductive biology is an important structuring part of human lives; however, producing ova or sperm, having XX or XY chromosomes, or having a clitoris or a penis, does not tell us nearly as much biologically as many believe. Nor does it consistently or accurately inform us about an individual's childcare capacity, homemaking tendencies, interest in literature, engineering and math capabilities, or tendencies toward gossip, violence, compassion, or a love of sports. By contrast, placing reproductive biology in the context of the rest of the body, and in relation to behavior, history, society, and experience, we are much better prepared to ask, and answer, questions about health, habits, proclivities, happiness, and the many ways to successfully be human.

However, at its core, biology is about evolution, and evolutionarily speaking there is a lot of variation in sex biology and behavior, both across and within species. So, to really understand how biology and sex work in humans, we need to start not with us today but right back near the start of life on earth, with the evolution of sex.

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The Evolution of Sex

IN THE BEGINNING . . . There was no sex. The earliest life forms on earth reproduced asexually, internally copying their key biological material and then dividing into two versions of themselves.[1] These organisms were, and remain, the prokaryotes, that is, microscopic single-celled organisms most people call bacteria (which scientists divide into archaea and bacteria)[2] and blue-green algae (cyanobacteria). Then, somewhere around two billion years ago, evolutionary changes resulted in what we call "protoeukaryotes" that evolved into the common ancestor of all eukaryotic organisms, including animals and plants. Eukaryotes have DNA in the form of chromosomes contained within a nucleus. Eukaryotes mostly reproduce via a process of combining genetic information from two different individuals to create a new individual, or, as that process is commonly called: sex.

The process by which sex evolved is complex but basically involved restructuring of the ways in which DNA is packaged and copied, the internal structuring of the cell's physiology, and the ways in which cells divide and fuse. A main challenge for sex is the ability to create a copy of one's genetic material and package it so that it can meet up and fuse with another of your same kind of organism's genetic material and create a new organism.

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