

Exploring an Alternative Model of Human Reproductive Capability: A Creative Learning Activity

● ABOUT H. CHERIF, DIANNE M. JEDLICKA

ABSTRACT

Biological and social evolutionary processes, along with social and cultural developments, have allowed humans to separate procreation from pleasurable/recreational sexual activity. As a class learning project, an alternative, hypothetical reproductive scenario is presented: “What if humans were biologically ready to conceive only during one period each year?” Discussion is followed by small-group or individual research on the possible effects of this scenario on human reproductive response and its further effects on human life, society, and civilization. An important purpose of the activity is to stimulate active learning through small-group interaction, communication, and research.

Key words: *Biological evolution; reproductive evolution; active learning.*

○ Interdiction

The proposed learning activity is designed for senior high school and lower-division college biology classes and for students with some biology background. It seeks to stimulate active learning by providing different modes of exploration through small-group interaction, communication, and research.

The alternative model of human reproductive capability used in this activity is based on a number of similarities and key differences between humans and primates, and on some basic philosophical, as well as physiological, considerations. Engaging students in questioning norms, thought processes, common behavior, and the status quo generally, is one of the effective approaches in challenging the mind and its “mindset” to free the imagination to come up with unexpected alternatives. This effort becomes pedagogically even more powerful when it can be approached through formal curriculum and educational activities designed for such purposes. Hence, the proposed learning activity begins with a challenge to the imagination: conceiving an alternative scenario, researching and investigating the topic, and predicting the possible outcomes. So, *if humans were biologically ready to conceive only during a particular period each year, what effects would this have on human life, society, and civilization?*

As far as we know, humans are the most intelligent primates, given our ability to store, retrieve, and process information in

complex ways and apply the information to alter our lives and the environment in which we live. The ability to change our lives beyond those that might have evolved through nature alone is one feature that distinguishes us from other animals. Our cultural behavior, “our languages, societies, belief systems, norms of behavior, and scientific knowledge – all attest to these abilities” (Park, 1999, p. 141). Our bodies and body systems are also well developed to maintain homeostasis and participate in the survival of the individual. But unlike all other human body systems, the “normal functioning of the reproductive system is not aimed at homeostasis (that is, stability in the internal environment) and is not necessary for survival of an individual, but it is essential for survival of the species” (Sherwood, 2013, p. 734). In addition, and unlike many other aspects of physiology, reproduction is very dynamic – it can be turned on and off at different stages of life in the process of participating in perpetuating the species.

Furthermore, hundreds of thousands of years of biological and social evolutionary processes, along with cultural and social development, have allowed humans to separate procreation from pleasurable sexual activity.

Other primates and many mammals generally engage in sexual activity only when it can lead to reproduction, but humans engage in sexual activity for more than just reproductive purposes (Park, 1999, p. 67). Humans have evolved biologically, intellectually, socially, and culturally to be able to engage in sexual activity independent from reproduction, for purposes of “social bonding as well as reproduction – recreation as well as procreation” (Barash, 1986, p. 67). This separation, in turn, has shaped human life, society, and civilization.

The separation of pleasurable sex and reproductive sex was made possible for a number of reasons, including the fact that biological evolutionary processes enabled us to develop mental capacity that could be applied to consideration of the sexual process and its consequences. In addition, physiologically, we have evolved to the point that, on average, the human male produces up to 100 million sperm every day, which are destroyed/recycled and replaced if not released, and the female menstruation process (cyclic sloughing of

Humans are the most intelligent primates.

the endometrial lining) can last from 3 to 7 days every 30 days, over many years. Humans no longer perceive reproduction as the main purpose of sexual activity, nor are the organs of the human reproductive system only capable of producing the sex cells and organs and transporting and nurturing their development. As a result,

Humans... have lost the signals of estrus, a condition sometimes referred to as “concealed ovulation.” Human males don’t automatically know when a human female is fertile. This may seem a rather inefficient way to perpetuate the species, but, as we are all aware, humans have replaced unconscious, innate sexual signals with sexual consciousness. Sexuality has become part of our conscious behavior that we have toward other members of our species and toward ourselves. You might say we are potentially continually in estrus. Although humans exhibit the most extreme example of this form of reproductive behavior, [it can be seen in some of our close relatives, the primates]. (Park, 1999, pp. 140–41)

In the activity presented here, we ask students to conceive a new scenario and predict its possible consequences. What primary effects would be created, and how would human life be affected, in the following suggested areas of consideration: biological, pathological, gynecological, emotional, intellectual, social, cultural, economic, commercial, legal, linguistic, and recreational?

○ Reproduction, Sex, & Human Beings

Reproduction and reproductive capability are among the indispensable criteria for life. Unlike all other systems in the human body, the “normal functioning of the reproductive system is not aimed at homeostasis and is not necessary for survival of an individual, but it is essential for survival of the species” (Sherwood, 2013, p. 734). Indeed, biological evolution by natural selection depends on the ability to pass on genes to next generations through the process of differential reproduction whereby individuals that are well adapted to their environment are able to pass on more of their attributes to the next generation. Reproductive capability is the ability to “generate new organisms by either sexual or asexual means from existing organisms” (Rudin, 1997, p. 319). Higher organisms reproduce sexually, and their reproductive organs, cells, and hormones are all involved in the reproductive process.

The reproductive cycle begins with fertilization/conception and extends through gestation (development) and parturition (birth). Unlike all other physiological activities, sexual reproduction requires a significant investment of time and energy to produce gametes and then to find and court a prospective mate. Some of the energy expenditure is wasted. Although organisms that have internal fertilization achieve a higher rate of success, energy investments are still required in other ways, such as in courtship activity; this is time and energy that could be better spent directly on one’s offspring (Borrell, 2010; Garrett, 2012). Yet evolution, which is concerned with differential reproductive success, has selected sexual over asexual reproduction because of the benefit of genetic variation, which provides a higher survival rate of offspring (Barash, 1986; Rudin, 1997). There are different selective pressures that act upon the sexes of a species because egg production in all animals

requires more metabolic energy and resources than production of the much smaller sperm (Barash, 1986). In addition, and with the exception of the amount of the genetic materials, the content and the chemical make-up of the egg and sperm are noticeably different. And unlike sperm, “once fertilized, an egg must receive massive subsequent investments from the mother’s body” (Barash, 1986, p. 71).

Yet numerous biological, anthropological, and psychological studies have concluded that sex is a relatively unimportant part of normal behavior for many primates and other animals. In addition, sexual interest is generally limited to periods of fertility, which these animals can precisely identify, and intercourse is actually quite rare among animals in nature. According to Barash (1986):

Among human beings, however, sexuality is unique in that despite its dangers and disadvantages, copulation is not limited to times when reproduction is likely. (In fact, under many circumstances it is limited precisely to times when it is unlikely.) This seeming anomaly is extended when we realize that sexual behavior in *Homo sapiens* has been liberated from the purely reproductive function that it serves in nearly every other animal. Just as George Bernard Shaw once said that youth is so wonderful it’s a shame that it’s wasted on the young, human beings found sex too wonderful, or useful, to be wasted on reproduction alone. It has been modified to serve a “higher” function: maintaining and strengthening the bond between adults. (pp. 62–63)

Many higher nonhuman organisms cannot afford the energy, time, and resources needed to engage in sexual activity except to produce offspring. Indeed, as far as we know,

Evolution has not provided nonhuman animals with much of a capacity to contemplate past or future environments or to wonder about the completeness of their worldviews. Why should it, since neither activity could help in their main enterprises, survival and reproduction?... Evolution is frugal; it would never favor organisms that invested energy in sensory frills if that same energy could be used to enhance reproduction. Successful reproduction, passing on one’s own kind of genetic materials, is what natural selection, the creative force in evolution, is all about. The genes of the next generation are of those individuals that survived and reproduced. (Ornstein & Ehrlich, 1989, pp. 19–20)

Yet the human condition is different. By serving both social bonding and reproduction – recreation as well as procreation – human sexuality has developed independently from reproduction to play a unique role in human life and in shaping human societies and civilizations (Barash, 1986). As widely noted, human sexual arousal is a complex process that involves both psychological and physical aspects.

○ Learning Activity

In this learning activity, students conduct library research, study the topics investigated, and examine their own understanding to address the questions derived from the imagined scenario: What effect would

the altered reproductive conditions have on human life, society, and civilization? One objective of this activity is to help students understand how biological evolution and social and cultural development have shaped human reproductive behavior and, in turn, human life and society. Associated questions to consider are:

- What roles have biological evolution and social and cultural development played in the reproductive process and behavior of humans?
- How has the ability to engage in non-reproductive sexual behavior transformed our lives?

A second objective of the activity is to actively engage students in library investigation, conducting a literature search, and collaborating in group work not only to achieve understanding, but also to retain new information and apply what has been learned to different situations. The aim is to provide an opportunity for students to become deep learners by engaging in active learning. As Houghton (2004) has argued, deep learning promotes understanding and application for life and “involves the critical analysis of new ideas, linking them to already known concepts and principles, and leads to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts” (p. 5).

○ Pedagogical Strategies

The activity can be assigned as a group research project, individual term paper, and as a group or individual class presentation. In addition, if feasible, students might be asked to communicate with scholars in related fields, such as anatomy and physiology, anthropology, biological anthropology, psychology, embryology, sociology, sociobiology, behavioral biology, zoology, medicine, etc., and the activity can be conducted in courses teaching such subjects. Here, we describe one of the suggested strategies, which is to use the assignment to produce a group paper and presentation.

○ Procedure

The learning activity can last 2 hours or 2 weeks, including preparation and presentation time. Both time frames work well. The class is divided into groups of three students. Each group is asked to generate as many hypotheses as possible to answer the question “If humans were biologically ready to conceive only during one period of each year, what effect would this have on human life and society?” Members of each group then re-examine and logically analyze their own individually generated hypotheses and keep only those that could not be eliminated by the power of logic alone. Next, each group selects two of its remaining hypotheses to investigate. To do so, each group must research and study the reproductive system. They must (1) provide a description, in writing, of the morphological and anatomical structure and the mechanical and physiological function of the system and its main organs and parts; (2) provide a description of specific functions of the whole system as well as of each organ and part within the system; and (3) identify the relationship between the structure and the function of the whole system as well as each part

Table 1. Hypotheses to answer the investigative question are entered in a table like this.

Investigative Question	Generated Hypotheses	Hypotheses Surviving Initial Logical Scrutiny	Final Selected Hypothesis for Investigation
What effect would conceiving only during a particular period of each year have on human life and society?			

within it. Additionally, if feasible, they communicate with at least one scholar in a related field. (The scholar could be a scientist, a science teacher, a medical doctor, or a Ph.D. candidate in the field.) Thus, as outlined in Table 1, each group of students generates at least four hypotheses on the effects of conceiving only during one particular period of each year.

To conduct their research and prepare for presentations, each group is asked to fill out the agreed-on categories and subcategories in Table 2. Adding more or different subcategories should be encouraged as well.

○ Class Presentations

Before the Presentations:

1. Give the students 2–3 weeks (or more or less) to conduct their research and to prepare for their written paper, hand-outs, and class presentation.
2. Ask the groups to do the following:
 - a. Research and prepare a well-considered written paper, providing information and convincing arguments.
 - b. Be well prepared to engage in meaningful discussion and provide sound evidence to convince classmates of their point of view.
 - c. Have a well-researched handout to be distributed to classmates before the presentation, as well as an illustrated poster, poem, song, cartoon, etc. that can help convey the group’s rationale for and support of its reconsideration of the selected part, organ, or body system.
 - d. When possible, integrate the use of technology in the presentation, such as PowerPoint, animations, interactive activities, as well as songs/poems, etc., to present the reconsideration and the rationale behind it.
3. At every class meeting, make sure that students are working on their assignments. For example, give 10–15 minutes to the members of each group at the end of the class meeting to sit together and reflect on the progress they have made toward their research, written paper, posters, additional aids, and the oral presentation.

During the presentation:

1. The members of each group take turns presenting their research findings, interpretations, and conclusions. The other students in the class question each group by asking at least three questions after a group completes its presentation.

Table 2. Effects on humans from the standpoint of various categories and subcategories.

Category	Subcategory	Possible Effects on Humans	
		Description	Additional Notes
Biological	Anatomy		
	Physiology		
	Behavioral biology		
	Neurology		
	Endocrine system (hormones)		
Pathological	Pathophysiology		
	Epidemiology		
	Immunity		
Social	Sexual behavior		
	Marriage		
	Interaction with opposite sex		
	Interacting with society		
	Peer pressure		
Cultural	Rituals		
	Religion		
	Social behavior		
	Cultural behavior		
Economical	Currency/money		
	Costs/benefits		
	Business activity		
Emotional	Love		
	Passion		
Intellectual	Rationality		
	Logic		
	Curiosity		
	Inquiry		
Linguistical	Language		
	Nonverbal communication		
Entertainment	Art		
	Form and function		
	Pleasure		

After the Presentations – Discussion Questions:

These questions can be used by the instructor to lead students to higher thought processes and other creative possibilities. Use “reflection time” here after posing a question to let an idea sink in.

1. What determines the evolutionary success of human males and females?
2. Biologically speaking, and from your answer in question 1, which sex (male or female) has experienced better evolutionary success? Explain.
3. What is the advantage of females producing far fewer eggs than males do sperm?
4. Are there any parts of the male or female reproductive organs that, at least for now, serve no reproductive purpose?
5. A number of sociologists and behavioral biologists have argued that the female orgasm is currently nonadaptive and serves no reproductive purpose. Do you agree or disagree? Explain.
6. What types of radical shifts are needed in our intellectual assumptions in order to change the currently accepted paradigms of gender privilege, gender oppression, and/or stereotypes regarding gender potentialities?
7. Compare and contrast reproduction as the production of surviving children and reproduction as a sexual act.
8. In talking about the women’s movement, the sociologist Sarah Hardy (1994) wrote, “The [human] female with ‘equal rights’ never evolved; she was invented and fought for consciously with intelligence, stubbornness, and courage” (p. 23). What do you think Dr. Hardy meant by this statement?
9. If our hypothetical reproductive condition were true, how do you think magazines such as *Redbook* or *Cosmopolitan* would look today?
10. If our hypothetical condition were true, how stable would human life be? (Refer to selection processes used in evolution.)
11. Compare and contrast sexual and asexual reproduction on advantages and disadvantages for the production of life and the richness of biological diversity.

2. After all groups finish presenting their cases, the instructor can ask more questions to all the groups. The students can also ask questions that the instructor must consider in his or her final judgment for awarding grades.

12. How has the Y chromosome developed into its current state?
13. Genetically and pathophysiologically, what are the advantages and disadvantages of individuals with the Y chromosome in the human population?

14. Differentiate the hormonal mechanisms that regulate male and female reproductive functions.
15. Describe the process of sexual fertilization and its role in the process of evolution by natural selection.
16. It has been said that the way a contraceptive pill works is by “tricking the brain” into thinking a woman is pregnant. Explain what this means.
17. It has been said that alternation of homeostasis puts the body in a not-at-ease condition, which is often called “disease.” Explain what homeostasis is and what mechanisms the human body uses to regulate and achieve homeostasis?
18. Does evolving to be able to engage in sex for purposes other than reproduction help humans to have big brains, symbolic thought, and other human characteristics? Is it the other way around? Or does no relationship exist? Explain.
19. The fossil record has shown that most species that have lived on Earth have died out and are now extinct. Is the ability to have sex for purposes other than reproduction something that saved humans from extinction or contributed to the success of humans in other ways? Explain.
20. Robert and Susan have been married for almost 40 years. After Robert’s recent heart troubles, his medical doctor has advised him to slow down in his sexual activities. Susan has been very shy and reluctant to ask the doctor why. You are Susan’s close friend to whom she came for advice and explanation. Conduct library research to learn more about how sexual activities in their physiological phases of arousal, plateau, orgasm, and resolution affect the heart and health generally. You should also look into how sex affects heart and health as people age. What would you say to Susan to explain what the doctor said to Robert?

○ Homework Assignments

The following are homework assignments designed to help students reinforce their understanding of concepts learned during the human reproduction activity. Instructors may select those that best meet their own teaching objectives and styles.

1. Who really needs males?

In 2011, scientists in Dubai discovered that eggs of female sharks that had been totally isolated from males were able to hatch and produce female sharks (Anonymous, 2011). They are sure that those eggs were not exposed to male sharks and, thus, were not fertilized by male sperm. Both workers and scientists were shocked but excited by the event. Scientists from various countries rushed to Dubai to study the phenomenon and conduct their own experiments to confirm the findings. If you were one of those skeptical scientists, what type of scientific experiment would you conduct and why?

2. Ability to be turned on and off at different stages of life

It has been stated that unlike many other aspects of physiology, reproduction is very dynamic – it can be turned on and off at different stages of life. Furthermore, unlike in all other systems in the human body, the “normal functioning of the reproductive system is

not aimed at homeostasis (that is, stability in the internal environment), and is not necessary for survival of an individual, but it is essential for survival of the species” (Sherwood, 2013, p. 734). Do you agree or disagree with this statement? Explain.

3. Ways and means of contraception`

In the absence of any type of contraception and if lactation is brief or entirely absent, human females may have 10–20 successive pregnancies. However, in addition to abstinence from intercourse during the woman’s fertile period, there are a number of methods of contraception that are available for both male and female. Methods of contraception can be grouped into three main categories based on the means by which they prevent pregnancy: blocking sperm transport to the ovum, preventing ovulation, or blocking implantation. Conduct research to identify several methods under each of these three categories. Then compare and contrast the benefits and risks of using each method for both male and female. What is the average failure rate with each of the methods? (Students could be given Table 3 as a starting point for their research.)

4. Human vs. other mammalian species

Unlike in humans, in many mammalian species the reproduction of offspring occurs at times that maximize the survival of offspring. This means that sexual behavior and mating are restricted to particular times of the year, with birth following at some later time. Explain why this restriction no longer applies to our human species.

5. Homeostasis

The human body is remarkable in its ability to maintain a constant physiological environment that is often mediated by collective communication and feedback regulation involving the nervous system and various hormones (Neighbors & Tannehill-Jones, 2009). This state of sameness or normalcy of internal conditions within a narrow, stable physiological range maintained by the body is called “homeostasis.” When homeostasis is disrupted, the body’s functioning becomes irregular, which could be conducive to the risk of disease. Conduct research to explain the collective communication and feedback regulation occurring within the human body that allows it to maintain a desirable constant physiological environment.

Table 3. Average failure rate of various contraceptive techniques (Sherwood, 2012, p. 780).

	Contraceptive Method	Average Failure Rate (Annual Pregnancies/ 100 Women)
1	None	90
2	Natural (rhythm) methods	20–30
3	Coitus interruptus	23
4	Chemical contraceptives	20
5	Barrier methods	10–20
6	Intrauterine device	4
7	Oral contraceptives	2–2.5
8	Implanted contraceptives	1

6. Four physiological areas of the reproductive system

The reproductive system consists of organs that participate in perpetuating the species. It is a unique body system in that its organs differ between the two sexes and yet work toward the same goal: creating new life. To achieve this common goal, the physiology of male and female reproductive systems each involves four areas. Conduct research to explore and then compare and contrast these four physiological areas.

7. Period of dependency and time to maturity in species

Conduct research on variations in the period of dependency and time until maturity within at least 3 species (besides humans and chimps). Then complete Table 4.

8. Embryological growth and development

Automixis is a term that covers several reproductive mechanisms. Conduct library research to learn more about at least three of the following: parthenogenesis, apomixis, gynogenesis, pseudogamy, facultative parthenogenesis, cyclical parthenogenesis, heterogony, thelytoky, arrhenotoky, parthenocarp, and apomictic parthenogenesis. For each term, define the mechanism and provide one example. Then construct a meaningful conceptual map that shows the relationship among all of them.

Table 4. Periods of dependency and times to maturity for selected species.

Species	Term of Pregnancy	Sexual Maturity	Physical Maturity	Time Span of Female's Reproductive Life
Human	280 days	13 years	21 years*	
Chimpanzee		9 years	12 years	

*Women mature by about 18, or even earlier. Some studies have shown that girls are having first menses (menarche) at ages 10 and 11.

Table 5. Advantages and disadvantages of pregnancy at certain ages.

Categories	Ages 10–19		Ages 20–29		Ages 30–39		Ages 40–49	
	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons
Biological								
For Fertility								
Gynecological								
Psychological								
Social								
Financial								
Cultural								

9a. When should I get pregnant?

It has been stated that younger women's eggs are less likely than older women's to have genetic abnormalities that could result in Down syndrome and other birth defects. Because of this, it has been advised that women who would like to have babies might consider having them at a younger age rather than later. Conduct research to find out why older women's eggs are more likely to have higher possibilities of genetic abnormalities that could result in Down syndrome and other birth defects. Does the freezing and storing of human eggs for later use help address this concern? What type of ethical, social, moral, and/or legal issues might arise if the female donor dies or divorces? In agriculture, people may use bull or hog sperm that has been frozen for over 50 years. There are seed banks that collect dried and frozen seeds (heirloom seeds), yet people have no significant objection or ethical issues in using them when needed. Why do you think this type of double standard exists even though the mechanisms and the goals are the same for human reproduction and agriculture?

9b. When should I get pregnant? (part 2)

It has been stated that pregnancy at any age comes with distinct advantages and disadvantages (Matthiessen, 2010). Conduct research to learn more and then compare and contrast the distinct advantages and disadvantages of getting pregnant and having a child at ages 10–19, 20–29, 30–39, and 40–49. Consider the pros and cons biologically, psychologically, financially, socially, and culturally. Use Table 5 for your answers. Again, does the freezing and storing of human eggs for later use help address this concern? What type of ethical, social, moral, and/or legal issues might arise if the female donor dies or divorces?

10. Sexually transmitted diseases that can have lasting health effects

It has been reported that more than 2 million people in the U.S. acquire sexually transmitted diseases (STDs) every year as a result of sexual contact. Historically, the most notorious STDs were gonorrhea and syphilis, both caused by bacteria and now treatable by penicillin and other antibiotics; today, chlamydia, genital herpes, and AIDS have taken more attention and center stage (Daniels et al., 2007; Neighbors & Tannehill-Jones, 2009; McConnell & Hull, 2011) Conduct library research to learn more about STDs. Then:

1. Identify at least two more STDs in addition to those in Table 6, and compare and contrast them.
2. Using the hypothetical reproductive scenario of the current activity, from your perspective what biological and evolutionary effect would this have on the relationship between humans and STDs?

Table 6. Examples of sexually transmitted diseases.

STDs		Caused by	Symptoms	Number of People Infected Yearly		Available Treatments
				In USA	Worldwide	
1	Chlamydia					
2	Genital herpes					
3	AIDS					
4						
5						
6						

Table 7. Human egg and sperm facts (Daniels et al., 2007, pp. 296, 304).

	Sperm Facts	Egg Facts
1	Sperm cells are the smallest in the body. They measure 0.002 inches.	The egg is the largest cell in the human body.
2	The male body creates 300–400 million sperm cells per day.	The size of a pinhead, it is the only human cell that can be seen with the naked eye.
3	Formation of mature sperm cells takes 64–72 days.	The release of eggs does not alternate between the two ovaries.
4	A milliliter of semen contains 50–130 million sperm cells.	After ovulation, an egg is available to be fertilized for 12–48 hours.
5	Sperm cells live only 48 hours after ejaculation.	Adult women may produce about 400 eggs during their lifetimes. But few of the ova are actually used, and at least one ovum, or egg, is released each month from the beginning of menstruation until menopause.
6	Male sperm is suspended in a nutrient-rich alkaline liquid.	Vaginal fluid is acidic, which is potentially lethal to sperms.

two individuals of the opposite sex from the same species can succeed in mating. This is because

Compounds on the surface of an egg can detect sperm from a different species and keep them from penetrating the cell wall. Or, if a sperm does enter an egg, the chromosomes may be incompatible and fail to produce an embryo. Finally, even if a hybrid organism is born, it may be sterile, as in the case of mules, born from the union of horses and donkeys. (Olson, 2002, p. 23)

Conduct library research to learn more about how human male and female reproductive systems complement each other anatomically and physiologically, and how these types of complementary characteristics play an important role in perpetuating the species, and as reproductive isolating mechanisms. Use Table 7 as a starting point in your research.

11. Evolution and sexual reproduction

As Borrell (2010) wrote,

Sexual reproduction is the preferred method for an overwhelming portion of the planet's species, and yet from the standpoint of evolution it leaves much to be desired. Finding and wooing a prospective mate takes time and energy that could be better spent directly on one's offspring. And having sex is not necessarily the best way for a species to attain Darwinian fitness. If the evolutionary goal of each individual is to get as many genes into the next generation as possible, it would be simpler and easier to just make a clone. (p. 48)

- Conduct library research, and then compare and contrast the procedures, methods, outcomes, and evolutionary advantages and disadvantages of cloning and sexual reproduction.
- Do you agree or disagree with Borrell's statement? Why?

12. Complementary systems

The anatomy and physiology of human male and female reproductive systems complement each other, and thus each cannot act alone. For each system to fulfill its primary function, it must interact with the complementary system of another person. Under normal circumstances, only

○ Conclusion

As Daniels et al. (2007) stated in their book *Body: The Complete Human*, "No scientific discussion of human reproduction can ignore sexuality; the two infuse and drive each other" (p. 308). While all other human body systems work together to maintain homeostasis, which ensures survival, the reproductive system works to ensure that we pass on our genes and, thus, that our species survives. And if this is the case, one can easily agree that the ultimate goal of our existence is reproduction. Yet humans have evolved biologically, intellectually, socially, and culturally to be able to engage in sexual activity independent from reproduction, for purposes of "social bonding as well as reproduction – recreation as well as procreation" (Barash, 1986, p. 67).

Our learning activity asks students to engage in library or computer research, study the reproductive system in detail, and develop and present an informative and persuasive argument for the efficiency of their final modified hypothesis. Students learn to make choices, organize their thoughts, gather information, improve their social skills, and, most of all, reinforce their understanding of the makeup and functioning of the reproductive system and its organs and the interrelationships of these organs in the survival of humans as a species in particular societies, cultures, and civilizations.

Once the groups have given their presentations, the instructor needs to reinforce the concepts of evolution, the role of reproduction in the continuation of life, the diversity of life forms, the role of genetics, and the development of human life and civilization. Teachers must also emphasize the role of evolutionary processes and natural selection in the development of species. Deep learning and creativity are areas that the instructor should focus on. These elements will be important parts of designing the experimental procedures and conceiving various hypotheses.

In short, this hypothetical scenario is designed to challenge students' thinking and motivate them to think creatively to solve problems so that they gain a deeper level of understanding of the reproductive system's role in shaping and influencing our lives. Deep learning involves the critical analysis of new ideas by linking them to known concepts or principles (Houghton, 2004; Cherif et al., 2010). This linked knowledge leads to better understanding as well as long-term retention of concepts. The new ideas, now linked to familiar concepts, can be used for solving problems that are presented in unfamiliar contexts.

○ Acknowledgments

We thank all the teachers and instructors who provided us with valuable feedback and suggestions to improve various aspects of the activity. In addition, we thank Dr. Maris Roze, Dr. Farahnaz Movahedzadeh, Dr. JoElla Suidia, and Ms. Erica Solamon for their help and support.

References

- Anonymous. (2011). Jaws drop at Burj Al Arab aquarium's virgin birth. Arabstoday.net, 16 December. [Online.] Available at <http://en.arabstoday.net/2011121669042/jaws-drop-at-burj-al-arab-aquariums-virgin-birth.html>.
- Barash, D.P. (1986). *The Hare and the Tortoise: Culture, Biology, and Human Nature*. New York, NY: Viking Penguin.

- Borrell, B. (2010). Is sex really necessary? *Scientific American*, 303(2), 48–49.
- Cherif, A.H., Jedlicka, D., Al-Arabi, A., Aron, R. & Verma, S. (2010). Effective understanding of the human body organs: a role-playing activity for deep learning. *American Biology Teacher*, 72, 447–450.
- Daniels, P.S., Stein, L. & Gura, T. (2007). *Body: The Complete Human*. Washington, D.C.: National Geographic Society.
- Garrett, L.K. (2012). *Get Ready for A&P*. Boston, MA: Pearson.
- Hardy, S. (1994). An interview with Sarah Hardy. In T. Bass (Ed.), *Reinventing the Future: Conversations with the World's Leading Scientists*. Addison-Wesley.
- Houghton, W. (2004). Deep and surface approaches to learning. In Houghton, W. (Ed.), *Engineering Subject Centre Guide: Learning and Teaching Theory for Engineering Academics*. Loughborough, U.K.: HEA Engineering Subject Centre.
- Matthiessen, C. (2010). Age and fertility: getting pregnant in your 20s. [Online.] Available at http://www.babycenter.com/0_age-and-fertility-getting-pregnant-in-your-20s_1494692.bc.
- McConnell, T.H. & Hull, K.L. (2011). *Human Form, Human Function: Essentials of Anatomy & Physiology*. Philadelphia, PA: Wolters Kluwer.
- Neighbors, M. & Tannehill-Jones, R. (2009). *Human Diseases*, 3rd Ed. Clifton Park, NY: Delmar Cengage Learning.
- Olson, S. (2002). *Mapping Human History: Discovering the Past through Our Genes*. Boston, MA: Houghton Mifflin.
- Ornstein, R.E. & Ehrlich, P. (1989). *New World New Mind: Moving toward Conscious Evolution*. New York, NY: Doubleday.
- Park, M.A. (1999). *Biological Anthropology*, 2nd Ed. Mountain View, CA: Mayfield.
- Rudin, N. (1997). *Dictionary of Modern Biology*. Hauppauge, NY: Barron's Educational Series.
- Sherwood, L. (2013). *Human Physiology: From Cells to Systems*, 8th Ed. Belmont, CA: Brooks/Cole.

ABOUT H. CHERIF is National Associate Dean of Math & Science at DeVry University, 3005 Highland Parkway, Downers Grove, IL 60515; e-mail: acherif@devry.edu. DIANNE M. JEDLICKA is Professor of Anatomy & Physiology at Columbia College Chicago, 600 S. Michigan Ave., Chicago, IL 60665; e-mail: djedlicka@devry.edu.

The Best Kept Secret In Science Supplies!

Great prices, fast shipping, and high quality products. Check out Home Science Tools for all of your biology and science needs.

 **10% off** your entire order!
Use Code **BIOLOGYZ38**
Expires 01/31/2013

 Lifetime Microscope Warranty

 Dissection Specimens and Kits

HOME SCIENCE TOOLS
THE GATEWAY TO DISCOVERY
100% Satisfaction Guaranteed!

www.HomeScienceTools.com/ABT
800-860-6272 | 665 Carbon St. Billings, MT 59102

We have digital cameras, too!