(May 2014)

[2] Yes, we’ve reached that point in the Biology 3 course to discuss the birds and the bees. Personally, I’ve never really understood that euphemism – humans don’t have sex like birds or bees, let me assure you! But one characteristic that all the sexually reproducing organisms do share is the need to produce some special cells when it comes time to reproduce.

[3] Remember last week when we discussed mitosis – the reproduction of body, or somatic cells? The cells started off as diploid and produced two identical diploid cells. Almost every cell in your body possesses the same complement of chromosomes – 22 autosomes and a pair of sex chromosomes. It is critical that your somatic cells have a full complement of two sets of chromosomes to function normally. Answer the review questions regarding mitosis before we go on.

[4] Today however, we’ll look at the process of producing some rare cells in your body – the sex cells or gametes. This process is called meiosis and although we will be using all the same cellular structures as we saw in mitosis, the resulting cells will be very different indeed. Record the definition of meiosis, then answer the next few questions in the lab as we go along.

[5] The cells produced by meiosis are produced only in the gonads – either the ovaries or testes. We’ll look at these specialized sex organs later in the

[10] Sexual reproduction, however insures that the offspring are different than either of their parents. This is because of those haploid gametes produced in the gonads – only half the genes are being passed on from either parent, and those genes are combined with another individual’s genes through fertilization to produce that new unique individual. Having two parents means new combinations in every generation and this is great benefit to species in the long term.

[11] There is a progression of these two types of cell reproduction. Meiosis produces the haploid gametes, the gametes join to form a diploid zygote, then the zygote grows into an adult organism, which then starts producing the haploid gametes with meiosis once again. Think of the proverbial chicken and egg question – as long as we think of it being a cycle, we won’t lose too much sleep over the answer.

[12] Study the differences in the summary diagram in your book and answer the questions below the diagrams before you continue.

[13] Before we jump into the process of meiosis, there are certain chromosomes that we’ll be on the lookout for, because they will interact in a way we did not see during mitosis. These chromosomes are called homologous chromosomes. Please draw these chromosomes and record the definition before we go on.

[14] Remember the pairings of chromosomes you saw last week in the karyotypes? Diploid organisms such as humans have two sets of chromosomes, one set from each parent, and we can pair them up because of their similar size and shape. These chromosomes carry the same *kind* of genetic information, but by no means *identical* information.

[15] Here is one of the pairs, chromosome pair number eight,

[27] That's right – these two cells are now haploid. We've got both a long and short chromosome in each cell, so we know we have a full complement of genes in each cell, but what about the configuration of the chromosome? We can't have a viable gamete with the chromosomes still composed of two chromatids. Those will have to be separated from each other with our next division. Make sure your drawing of telophase I is complete before you continue.

[28] These two cells will now undergo the second meiotic division. The good news is that it will look very familiar because is almost exactly like mitosis. We don't need to replicate the DNA here, we just need to divide up those chromatids. Complete your drawing of interphase II, even though most cells spend very little time at that

[39] For this part of the lab, you'll move the chromosome models around your booth to simulate the process of meiosis. You'll have to imagine the margins of the cell, or you can just use one of the white boards in the lab that shows the outlines of the cells, if you wish. Pay attention to the movements of the chromosomes, because in Section 4 of today's lab you'll be asked to demonstrate the entire process to the lab instructor. Sounds fun, huh?!

[40

chromosomes, so that’s 2 to the 23rd possibilities or over 8 million different types of gametes produced by a single person.

[50] Remember that every cell starting meiosis in an individual has the same 46 chromosomes, but the process of meiosis in

[69] So based on these very simple patterns and remembering all the combinations that are possible, how many types of gametes could ***you*** produce? We would have to keep track of your 46 chromosomes and tens of thousands of genes - it's too much to think about right now, isn't it? But for now, read over the summary at the end of Section 6 and make sure you understand the mechanism behind each statement.

[70] You now have a good idea about where, why and how meiosis happens in general, but now let's look specifically at humans. To do this, we'll have to take a peek into the gonads. Ready? Here we go…

[71] In human males, sperm is produced in the seminiferous tubules of the testes. This specific type of meiosis is called spermatogenesis, which translates as "sperm making". Here you can see a cross-section of this very specialized tissue. Remember, this is a type of cell division found nowhere else in the human body.

[72] Meiosis in human males takes about 3 days. From the seminiferous tubules, the sperm travel to the epididymis where it will take a few more weeks before these cells are mature and fully functional as sperm.

[73] Spermatogenesis usually begins at about 12 years of age and continues for the rest of a man's life. Several hundred million sperm cells are produced daily by healthy young adult males, and between 200 and 600 million sperm cells are normally released in each ejaculation.

[74] Gamete production in males is rather straight-forward – one diploid cell produces four haploid sperm as shown in the diagram at the beginning of Section 7. In human females, however, it's quite a bit more complicated both in the structures and the timing. Egg production is called oogenesis and it happens only in the ovaries. But do you see something different in the summary diagram of oogenesis compared to spermatogenesis? Take a look at telophase I.

[75] Did you notice how uneven the cytokinesis was in telophase I? Both cells will have a haploid number of chromosomes, but only one cell garnered all the cytoplasm. Look ahead to telophase II and you'll see the same unequal cytokinesis. There is an important reason for this - the resulting egg has a much better chance at survival, because it is the egg which supplies the embryo with nutrients until it implants on the uterus several days after fertilization. Answer the question about why the cytokinesis is different before we go on.

[76] Look closely at the end of telophase II. Notice the little leftover cells from the unequal cytokinesis? These cells are called polar bodies and they would never be able to function as gametes – they have no cytoplasm. So is the single egg that is produced still a haploid cell? Yes, and it's because of those polar bodies. These leftover cells contain chromosomes from the meiotic division, but no cytoplasm, so the number of chromosomes in the egg is correct.

[77] What about all the variation we learned about between gametes? Well the variation is still possible, because the variation we refer to is based on the lifetime production of eggs, so a human female would have the same huge variety of eggs possible due to independent assortment and

crossing over, just like a male. It's just that the female doesn't produce as many gametes at a time as a male does.

[78] The timing of meiosis in human females is quite complicated as well. Before a girl is born, her future eggs in her ovaries begin meiosis, but stop after prophase I. They remain in this suspended state of division until puberty, when hormones will signal the continuation of meiosis.

[79] Each month, a single egg is released into the fallopian tubes at ovulation. But the other strange thing is that this "egg" has not actually finished the final division of meiosis – that won't happen until a sperm penetrates the egg and signals that it's time to finish up meiosis and the true final egg and last polar body are produced.

[80] Here you can see a photograph of a human egg at the moment of ovulation. Like all eggs, it is a relatively large cell – much larger than most of the other cells of the body and much larger than sperm, which must be quick and nimble swimmers to reach the egg.

[81] So human egg and sperm production is quite different. Look over the two summary diagrams for meiosis in males and females and click on the answer to this question.

[82] Regardless of how gamete formation may differ from sex to sex or from species to species, all gametes have one role: to participate in fertilization and produce the next generation.

[83] Remember at the beginning of the lab when I said that the two processes of mitosis and meiosis were parts of a larger cycle? Well we've covered both topics thoroughly enough by now that I don't think you'll have too much trouble filling in this summary diagram. Drag the labels to the correct parts of the diagram and fill them in on your lab book when you have them all correct.

[84] Let's look at an organism with a very simple strategy for reproduction, the sea urchin. Sea urchins don't even have to be near each other to have sex – the male and female simply release their gametes out into the open ocean and it's all a matter of chance whether or not the eggs get fertilized. To make this successful, both the male and female must produce thousands of gametes and do it with rather precise timing.

[85] This photo shows the sea urchin sperm swarming around the as yet unfertilized egg. Remember that all of these cells are haploid. Now what would happen if two or more sperm entered the egg? That would be genetically disastrous

[87] The sea urchin system of reproduction may seem a little haphazard, but urchins don't have to spend any time or energy raising the kids. Once the gametes are released, mom and dad urchin are done.

[88] The reproductive strategy for humans is quite different for obvious reasons – human females can get away with producing just one egg a month because the egg could only be in one place – inside the female. With internal fertilization found in mammals

[96] As development and differentiation continue, a free swimming larval stage called a pluteus larva forms. Since this stage will probably not be in your microscope slide, we have placed a pluteus larva stage on a demonstration scope in the lab, or you can draw this one on the screen. At this stage the larva feeds and grows, but notice it doesn't look anything like a starfish at this stage. This is true of many organisms – the embryonic stage can be dramatically different than the adult organism. Make sure you have found and sketched all the starfish stages before you continue.

[97] Let's finish up today by making sure you appreciate the significance of the process of meiosis. All sexually reproducing organisms have an incredible genetic variety. When a sperm fertilizes an egg, the genes of each combine in a way that has probably never existed before.

[98] Remember the 8 million kinds of gametes that every human can potentially produce even without involving crossing over?   Well that unique gamete is combining with another person's unique gamete. This unique genetic identity doesn't just apply to how a person looks; it also determines everything about their physiology. Can they tolerate lactose? Are they allergic to certain substances? What type of blood do they have? Will they develop arthritis early or late in life?

[99] The results of these unique combinations will be the subject of next week's lab - patterns of