Rieder - Genetics
Worksheet 9: **THANKSGIVING EDITION!**
Due: 11/28/17 at the beginning of class

Name: ____

About how long did this homework take you? ______________________________

I consulted/worked with: ______________________________________

I will not accept late homework. Special exceptions will be made **only** in the event of illness or if you contact me at least 24 hours ahead of when the assignment is due (at my discretion).

POINTS: / 50

TURKEY

In 2010, scientists sequenced the genome of the domestic turkey, *Meleagris gallopavo*. Its genome is similar to that of it's relative, the chicken (*Gallus gallus domesticus*).

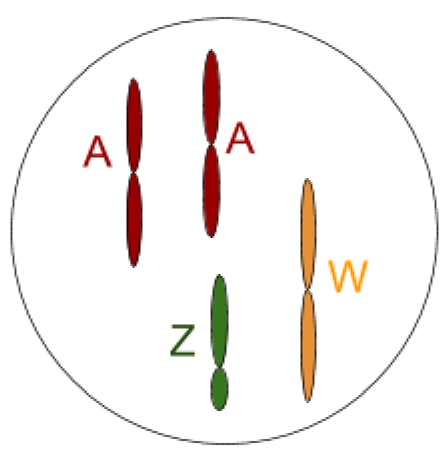
In 1960, breeders managed to cross a chicken and a turkey, producing **F1 hybrid** animals that earned the unfortunate name "churks," but the hybrids were all male and quite sickly. Breeders were experimenting by crossing turkeys and chickens because they wanted to create **parthenogenetic** chickens: hens whose **eggs** would hatch without fertilization by a father's sperm (See "Lost to History: 'the Churk'" from Science News). You learned about lizard parthenogenesis from one of your previous homeworks.

Some turkeys are indeed **parthenogenetic**! Female turkeys, who have **ZW sex chromosomes**, can have incomplete **meiosis**: meiosis halts after **meiosis I**, before **meiosis II**.

1. During meiosis I,
____ are separated (1 pt).

To the right is a **diploid** turkey cell from a female that is about to undergo incomplete meiosis to make **embryos**.

Turkeys have 11 **autosomes**, but here I've simplified to one (A).



2. Draw the first two stages of **meiosis** from this turkey cell. Remember that the **sex chromosomes** act as **homologs** during **meiosis I** (4 pts):

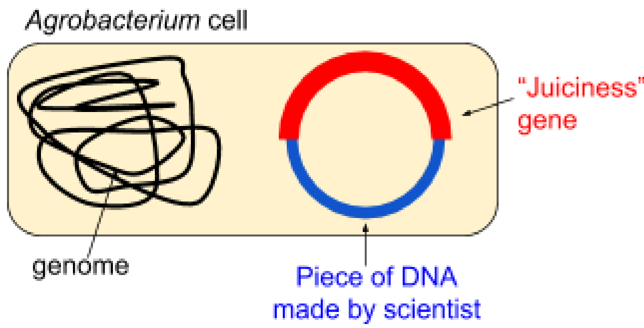
3. Are the resulting **embryos haploid** or **diploid** (1 pt)?______________________________

4. What is the **sex ratio** of embryos from turkey parthenogenesis? You may want to review bird sex chromosomes (3 pts)?

SWEET POTATOES

In the last few weeks of class we are going to focus on how scientists make genetically modified organisms (**GMOs**). GMOs have pieces of DNA in their genomes that came from other organisms. GMOs are often considered "unnatural," but nature has been genetically modifying organisms forever! Take the sweet potato. Long ago, the bacterium *Agrobacterium* inserted its own genes into the sweet potato's genome, and this action may have made the sweet potato edible (see "Natural GMO? Sweet Potato Genetically Modified 8,000 Years Ago" from NPR).

If scientists want to insert particular genes that encode desirable **phenotypes** into a plant genome, they often use *Agrobacterium*! This Thanksgiving, we want amazing sweet potato casserole, so we need to modify the sweet potato genome to carry a gene we know confers extra juiciness (we got this gene from a peach genome). First, we will give the Agro*bacterium* a new piece of DNA carrying the peach "juiciness" gene:

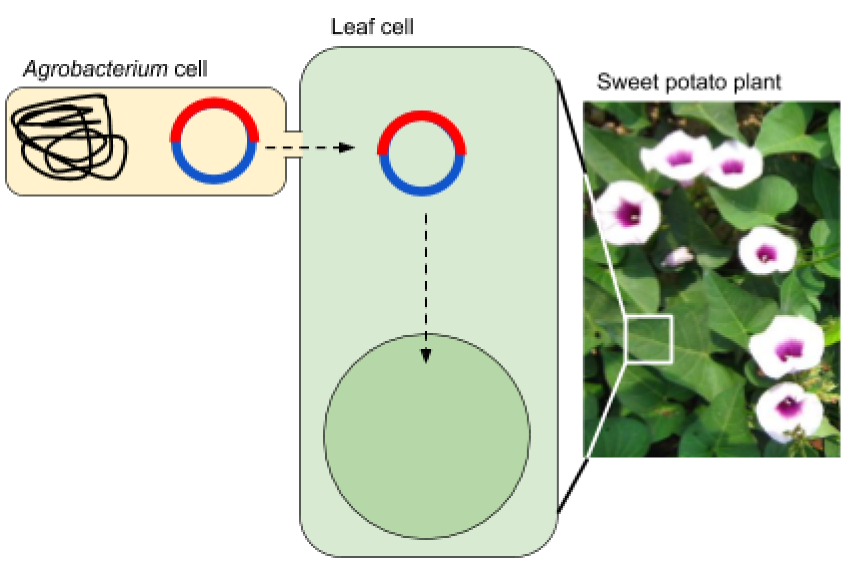


5. Are *Agrobacterium* **prokaryotes** or **eukaryotes**? Do they have nuclei (2 pts)?

6. When this bacterial cell divides through **mitosis**, will the two **daughter cells** be genetically identical to each other (Y/N) (1 pt)?

____

Now, we are going to use the genetically modified (because it has the foreign "juiciness" gene) *Agrobacterium* to insert the "juiciness" gene into the sweet potato genome. If we allow the bacteria to infect ***leaf*** cells of a sweet potato plant, the bacteria will inject their DNA, which now carries the "juiciness" gene, into the plant cells. The DNA will become incorporated into the plant cells' genomes!

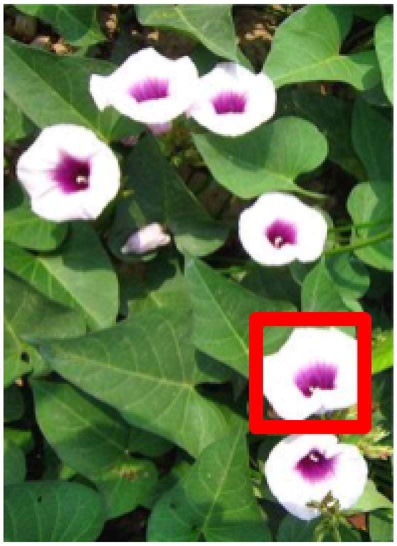


7. Are sweet potatoes **prokaryotes** or **eukaryotes**? Do their cells have nuclei (2 pts)?

8. By allowing *Agrobacterium* to infect the sweet potato's leaves, we have genetically modified the leaf cells. The juiciness gene is now in the genomes of the infected leaf cells. Will this gene be passed down to the next generation of sweet potatoes? Why/why not (3 pts)?

9. Will genetically modifying the leaves of the sweet potato plant make the root (the part we eat) juicier (Y/N) (2 pts)?

To genetically modify all the cells in an organism, scientists use *Agrobacterium* in a procedure called a "floral dip." Instead of infecting the plant's leaves, scientists DIP the plant's FLOWERS into a mixture containing the modified *Agrobacterium*.



Our goal here is not to modify the petals, but to modify specific cells in the flower. Think about Mendel and his peas.

10. Do you think **somatic cells** or **germ cells** are the intended target of the floral dip procedure (2 pts)?

Let's say an *Agrobacterium* successfully injected its modified DNA (carrying the juiciness gene) into the **egg** cell within a flower. We now pollinate the flower, which fertilizes the egg with a sperm from a **wild-type** plant to produce a **seed**. A seed is actually a plant **embryo** that has undergone a little bit of development and stopped.

11. Is the sweet potato embryo **haploid** or **diploid** (1 pt)? ______________________________

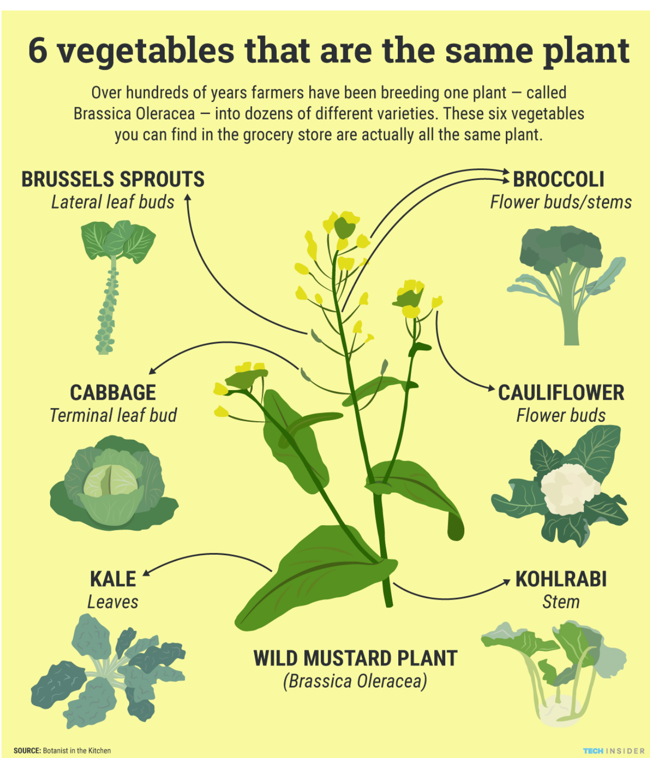
12. When planted, the embryo's cells will divide through ______________________________ (1 pt) as it grows into a multicellular sweet potato plant.

13. What percent of the multicellular sweet potato plant's cells will have the "juiciness" gene (2 pts)?

14. Will the sweet potato plant be **homozygous** or **heterozygous** for the "juiciness" gene (3 pts)?

BRUSSELS SPROUTS (and others)

Brassica oleracea is a single species that gives us cabbage, broccoli, cauliflower, kale, Brussels sprouts, collard greens, and others delicious greenish things. These vegetables are all **cultivars** (short for "cultivated varieties") of the same species. Several thousand years ago, farmers began to domesticate *B. oleracea* by selectively breeding individuals with desirable characteristics. This is called **artificial selection** (in contrast with Darwin's **natural selection**).



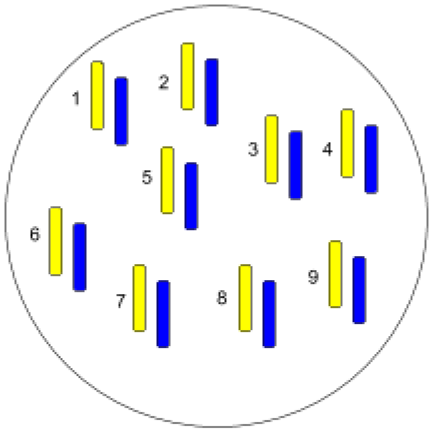
This is similar to how dogs all share a common ancestor, but there are many breeds of dogs that look very different.

15. A **diploid** kale cell has 18 chromosomes. How many cells does a cauliflower **gamete** have (2 pts)?

____

"Kalelettes" are the product of a **hybridization** between kale and Brussels sprouts. "Broccoflower" is the **hybrid** offspring of broccoli and cauliflower, while "broccolini" is the offspring of broccoli crossed with Chinese broccoli.

Below is a hybrid cell from a kalelette. Chromosomes from its kale parent are in **blue**, while those from its Brussels sprout parent are **yellow**. Below, **homologs** are shown next to each other for clarity. Assume all homologs carry different **alleles**.



Due to Mendel's **Law of Independent Assortment**, a cell with 3 pairs of chromosomes (6 total) can create $2^3 = 8$ different gametes (ignoring recombination/crossing over).

16. How many different gametes can a kalelette make (2 pts)?

____

17. Is the kalelette **true-breeding** (Y/N)(2 pts)?

____

APPLES

Like *Brassica oleracea*, most apples are **cultivars**: they are all the same species (*Malus pumila*) and can **hybridize** with each other to create new varieties!

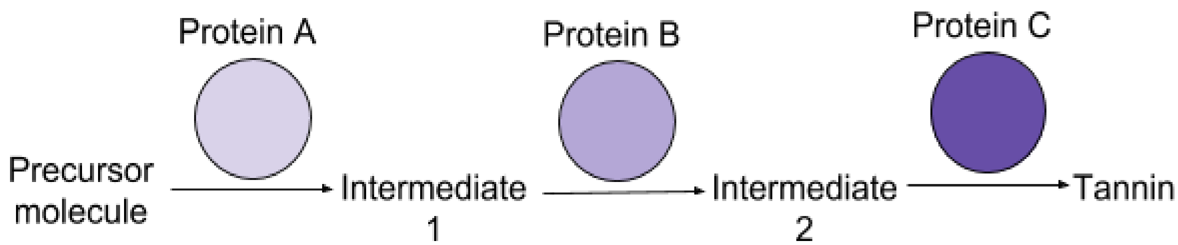
For example, the University of Minnesota created the Honeycrisp apple and introduced it to eager buyers in 1991 (See "Beyond the Honeycrisp Apple" from the NY Times). The Honeycrisp is likely the product of a hybridization between two apple cultivars (maybe Macoun and Honeygold, maybe others...).

Because apples are hybrids, cultivars cannot be propagated by seeds. Instead apples are usually propagated by grafting a branch from the desired cultivar onto another apple tree (like transplanting a whole limb!). In addition, apples cannot **self**-- they must be **outcrossed** in order to produce seeds and fruit.

18. If a grafted branch from a Honeycrisp apple tree is pollinated by a nearby Jonagold (another apple variety) tree, all the fruit from the Honeycrisp branch will be Honeycrisp. Why (3 pts)?

CRANBERRIES

Cranberries (*Vaccinium macrocarpon*) are very tart! This is due to production of chemical compounds--called tannins--that make our mouths pucker. Tannin synthesis is a multi-step process that involves many proteins (that are produced by many genes):



Imagine a cranberry plant has a **dominant loss-of-function** mutation in the gene that encodes Protein A. The plant produces sweet(ish) cranberries because tannins are not produced!

19. What would be the likely **phenotype** of a different plant that has a **dominant loss-of-function** mutation in the gene that encodes Protein B (1 pt)?

20. What would be the likely **phenotype** of a different plant that has BOTH a **dominant loss-of-function** mutation in the gene that encodes Protein A, as well as a **dominant loss-of-function** mutation in the gene that encodes Protein B (1 pt)?

21. What is the **phenotypic** ratio (sweet vs. tart) of the cranberry plant offspring that are produced by the **selfing** of a plant that is **heterozygous** for the **dominant gain-of-function** allele at the Protein A gene locus, and **heterozygous** for the **dominant gain-of-function** allele at the Protein B gene locus (3 pts)? You may draw a Punnett square, but it is not necessary.

22. What is the relationship (between the Protein A gene locus and the Protein B gene locus) called (1 pt)? You should recognize it from our in-class activity. Here specifically name one of the four types:

____

CORN

In 1983, Barbara McClintock received the Nobel Prize in Physiology or Medicine "for her discovery of mobile genetic elements" (see [Press Release, 1983, Nobel Prize committee]). Many of McClintock's important discoveries occurred through her study of *Zea mays* (corn). Impressively, McClintock made her discoveries before the genetic code was broken! The structure of the DNA **double helix** was also still unknown!

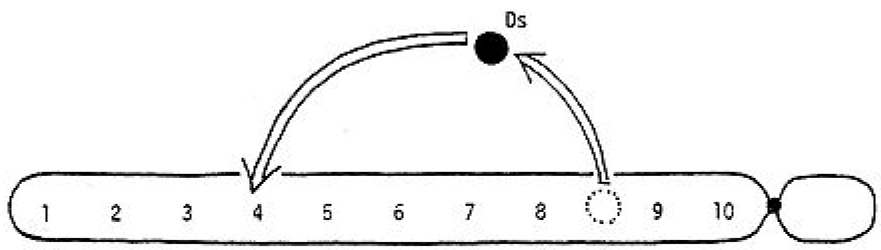
23. Each corn kernel is a **seed**--the product of a single independent **fertilization** event. A kernel is basically an **embryo** that has begun to divide through **mitosis** to create a multicellular organism. Are all the corn kernels on a single cob **genetically identical** (Y/N) (1 pt)?

McClintock studied the following corn **alleles** at a **locus** on corn chromosome 9:

C: **dominant allele** that prevents color expression
c: **recessive allele** that leads to brown color

She bred corn plants to be **heterozygous** for the C/c **locus**. In theory, corn kernels from these plants should all be "colorless" (which looks yellow). However, McClintock observed some spotted kernels that were producing pigment in a subset of their cells:

What McClintock eventually discovered is that there is a "mobile genetic element," which in the future would be named a **transposon** or **transposable element**, that "hops" from one location in the genome to another. If it hops near a gene, it can inactivate it (the gene will *not* produce its product). We will talk more about **transposons** in class.



From the Nobel Prize website: A **transposon** ("Ds") "hopping" on chromosome 9.

24. Do the <u>pigmented cells</u> in the corn kernels have an <u>active</u> copy of the **dominant** C allele (Y/N) (1 pt)?

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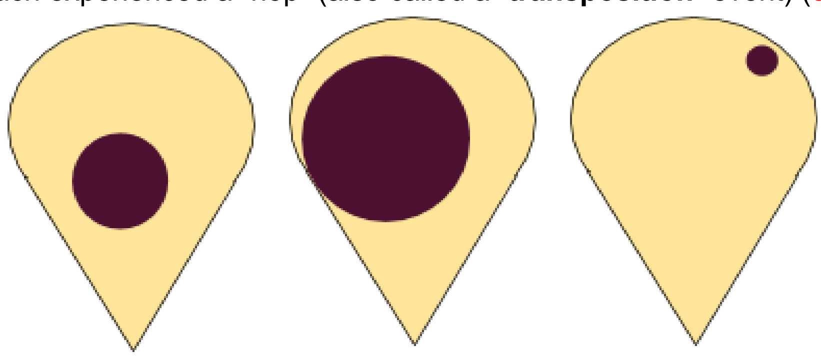
25. Explain McClintock's observations from her **heterozygous** corn: most kernels were colorless (yellow), but some had spots of color. In other words, <u>where</u> did the **transposon** "hop" in the genomes of the pigmented cells (2 pts)?

26. Below are three corn kernels from the same cob. A single **transposon** "hopped" within each kernel's genome <u>at some point during development</u>. Order the kernels, from early to late, to indicate when each experienced a "hop" (also called a "**transposition**" event) (3 pts):



________________ ________________ ________________

McClintock was also one of the first to propose the basic concept of **epigenetics**: <u>heritable changes in gene expression that are not caused by DNA sequence</u> (as in, no change/mutation in the DNA sequence). Forty years later, other scientists would begin to study epigenetics. McClintock was ahead of everyone!

Extra Credit (3 pts)**:**

Pick a plant/animal from your Thanksgiving table (traditional or non) and research anything about its genetics that you find interesting.

Tell me about it below!