INVESTIGATION 10

Mosaic Cats

Purpose

To investigate the effect of X-inactivation on the phenotype of an organism.

Concepts

- Sex chromosomes
- X-inactivation
- Mosaicism

Background

Of the 23 pairs of chromosomes in humans, 22 pairs are perfectly matched in both males and females and are called autosomes. The remaining pair, the sex chromosomes, consist of two similar chromosomes in females and two unlike chromosomes in males. The Y chromosome in the male is highly condensed and bears few functional genes. Because few of the genes on the Y chromosome are expressed, alleles that are present on the single X chromosome of males have no active counterpart on the Y chromosome. Some of the active genes on the Y chromosome do determine the "maleness" of the individual.

Although males have only one X chromosome and females have two, females do not produce twice as much of the proteins encoded by genes on the X chromosome. Instead, one of the X chromosomes in females is inactivated early in embryonic development, shortly after the embryo's sex is determined. Which X chromosome is inactivated varies randomly from cell to cell.

In 1949, Murray L. Barr and E. G. Bertram described a small darkly staining body that was present in the somatic cells of female cats. Further studies found this dark staining body in the somatic cells of human females as well. It was named the "Barr body" and could be observed most easily in cells scraped from the lining of the mouth. It was found to be an X chromosome which was inactivated.

In 1962, Mary Lyon proposed an explanation for this phenomenon. According to her hypothesis, at about the 32-cell stage in the process of early development, an X chromosome becomes inactivated at random and stays inactivated for the life of the cell. Any daughter cells derived from that original cell also maintain the X as inactivated. In some cells the inactivated X may be paternal and in others the inactivated X may be maternal. Since each female is made of a mixture of cells with randomly inactivated X chromosomes, the female is a mosaic for all of the genes found on the X.

There is a phenotype in female cats called "tortoise." Since X-inactivation does not occur until the 32-cell stage, female cats have coats that are a mosaic for the black and orange coat colors, and therefore, at random, each female cat has a different pattern of black and orange markings. The male cats are either black or orange; they are never tortoise (a patchwork coat of multiple colors).

Materials

One coin
Colored markers

Safety

There are no particular safety concerns for this activity, but follow all normal laboratory safety rules.

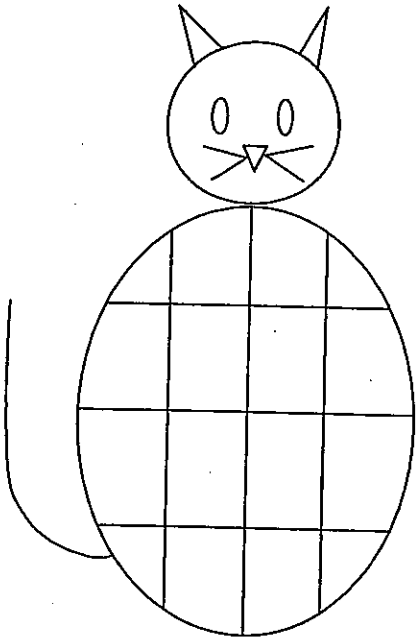
Procedure

1. A particular cat experiences X-inactivation at the 16-cell stage. At this stage of cell division either the black X will inactivate or the orange X will inactivate.
2. The cats on the Mosaic Cats Worksheet are divided into 16 sections. These represent the 16 cells of the embryo that were present when inactivation occurred. (Recall that this usually occurs later, but 16 cells will be used for simplicity.) Simulate the random inactivation of the X by the flipping of a coin. Heads will equal inactivation of the black gene, and tails will represent the orange gene.
3. Record the results of flipping the coin in the table on the worksheet. Color the sections of the cat that represent the black genes and the orange genes. (If black and orange markers are not available, use the colors that are available and make a key for the color used.)
4. Repeat this process again for the second cat.
5. Compare your cats to someone else's at the same lab table.

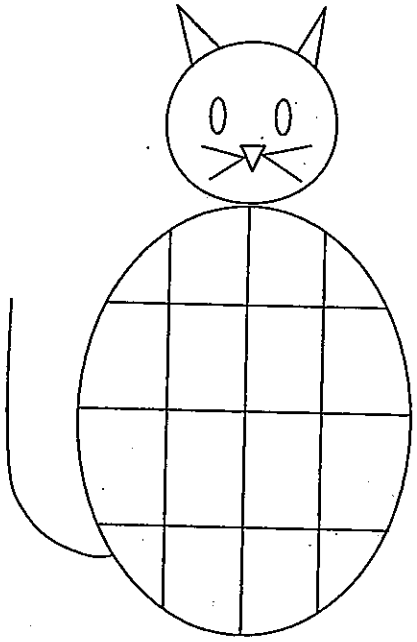
Name: _____

Mosaic Cats Worksheet

Trial	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cat 1																
Cat 2																



Cat #1



Cat #2

Table 1. Results of flipping coins

Analysis and Conclusions

1. For this simulation, what is the probability of getting an all black female cat ? Show your calculations!

2. For this simulation, what is the probability of getting an all orange female cat? Show your calculations!

3. When a female tortoise cat is bred to a male cat which is black, what will be the ratio of possible offspring? (do a Punnett square)