Garriga lecture notes 3/2/09
Read pp 221-230; 73-75

Chromosomes
Chromosomes can be detected by staining with dyes cells in mitosis, the stage of the cell cycle where the chromosomes are condensed. There are three parts to the chromosomes. The ends are known as telomeres, the place where microtubules attach are called centromeres, and everything in between is called an arm. The centromere is particularly important for our discussion because the microtubules move the chromosomes around in mitosis and meiosis.

Amniocentesis is used to determine whether a fetus has a normal complement of chromosomes. Fluid is removed from the amniotic sac, fetal cells are cultured and mitotic chromosomes are stained. Human somatic cells have 46 chomosomes: 44 autosomes and two sex chromosomes. The complement of chromosomes in a cell is referred to as a karyotype.

Meiosis
You have covered meiosis, but as a reminder, this process occurs in the germline and produces either sperm or eggs, each with 22 autosomes and one sex chromosome. What's new here is our discussion of what happens when errors are made in meiosis.

In meiosis I, homologs disjoin, and in meiosis II, sister chromosomes disjoin. When either a pair of homologs fails to disjoin in meiosis I, or when a pair of sister chromosomes fail to disjoin in meiosis II, gametes are produced that have either an extra or a missing chromosome (Figure 1). These errors in meiosis are referred to as nondisjunction because the chromosomes fail to disjoin normally, and they result in aneuploidy. Aneuploid embryos or fetuses can be missing a chromosome (45 chromosomes-monosomic) or have an extra chromosome (47; trisomic).

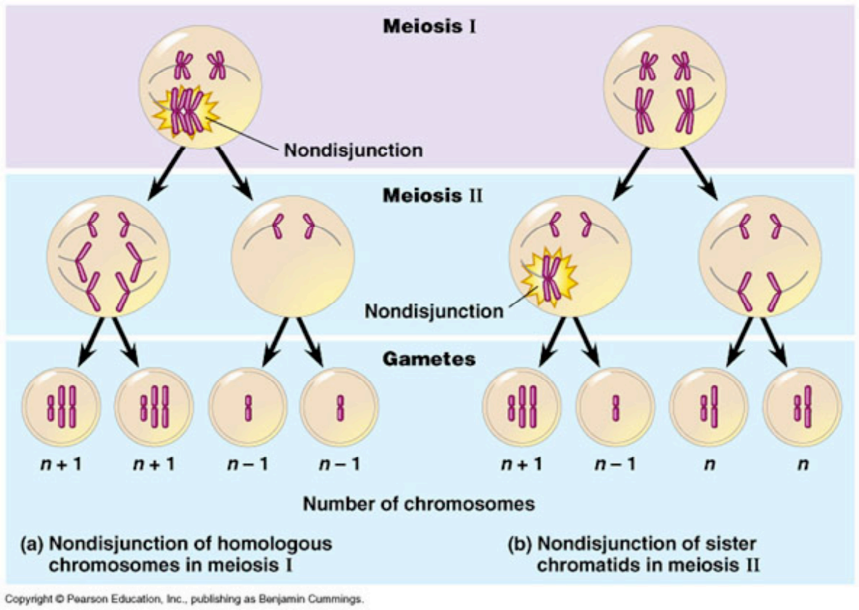

Figure 1

Most aneuploid fetuses with a missing or extra autosome die in utero, resulting in spontaneous abortions (miscarriages). The exception is trisomy 21 or Down syndrome. Individuals with Down syndrome can live into middle age. The reason than autosomal aneuploidy causes so many problems is that 1000s of genes are either underexpressed in monosomics or overexpressed in trisomics. The reason that trisomy 21 is less deleterious is because 21 is a small chromosome with fewer genes.

Sex chromosome aneuploidies are different. Individuals that are X0, XXX, XXXX, XXY, XXXY, XYY all exist and can be relatively normal. Because differences in chromosome dose of the X chromosome are tolerated, the mechanism that allows this is referred to as dosage compensation.

Lots of organisms have dosage compensation mechanisms, and they can differ. In mammals, the mechanism for dosage compensation is called X inactivation. In early embryos up to about 1000 cells, genes from the maternal X are expressed in males, and genes from both the maternal X and paternal X are expressed in females. In male embryos, expression from the single X chromosome continues. In female embryos at this stage, each cell inactivates one X chromosome randomly. Only genes from the other chromosome will be expressed (Figure 2). The inactivated X chromosome is visible by light microscopy and is referred to as a Barr body. So mammalian females are mosaics, with some cells expressing the maternal X chromosome and other cells expressing the paternal X chromosome. Even if XX females are mosaics, we can't see the mosaicism unless molecular markers are used or allelic differences that reveal themselves. A calico cat was used as an example of the latter that result in mosaic fur color when the female is heterozygous for the orange and black fur alleles.

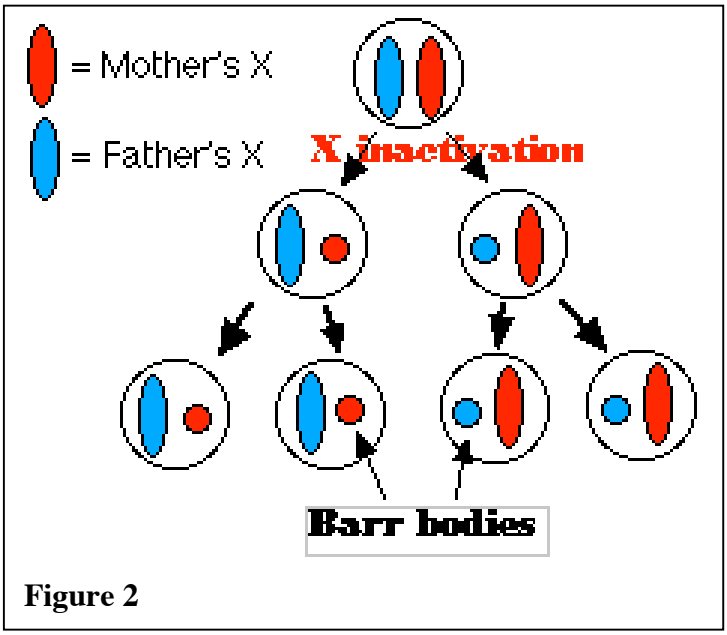

Figure 2

Some things to think about
A female calico cat is a mosaic. XY males are never calico. Can a XXY male cat be calico?

Two parents have a XXX daughter. Using molecular markers, it is determined that one of the X chromosomes comes from the mother and two from the father. In what parent did the nondisjunction event occur.