THE CELL CYCLE

BIO 101

Chromosomes and Karyotypes

The most important structures in the cell during division are the chromosomes. This is because they are responsible 'for the transmission of the hereditary information from one generation to the next. They do this because they contain DNA, the molecule of inheritance. Between divisions of the nucleus each chromosome contains one DNA molecule. Before the nucleus divides a copy of this DNA molecule is made so that at nuclear division the chromosome is a double structure, containing two identical DNA molecules. The two parts of the chromosome are referred to as chromatids. Each **chomatid** of a pair contains one of the two identical DNA molecules.

Each species has a characteristic number of chromosomes in each cell. In humans this is 46. The number is very variable between species. For example, fruit flies have only eight chromosomes whereas a small butterfly from Spain, *Lysandra*, has 380 chromosomes. Cats have 38 and dogs have 78. Most species have between 12 and 50 chromosomes per cell. The units of inheritance, the genes, are arranged along chromosomes as indicated very diagrammatically in **fig 23.2**. In humans there are about 100 000 different genes.

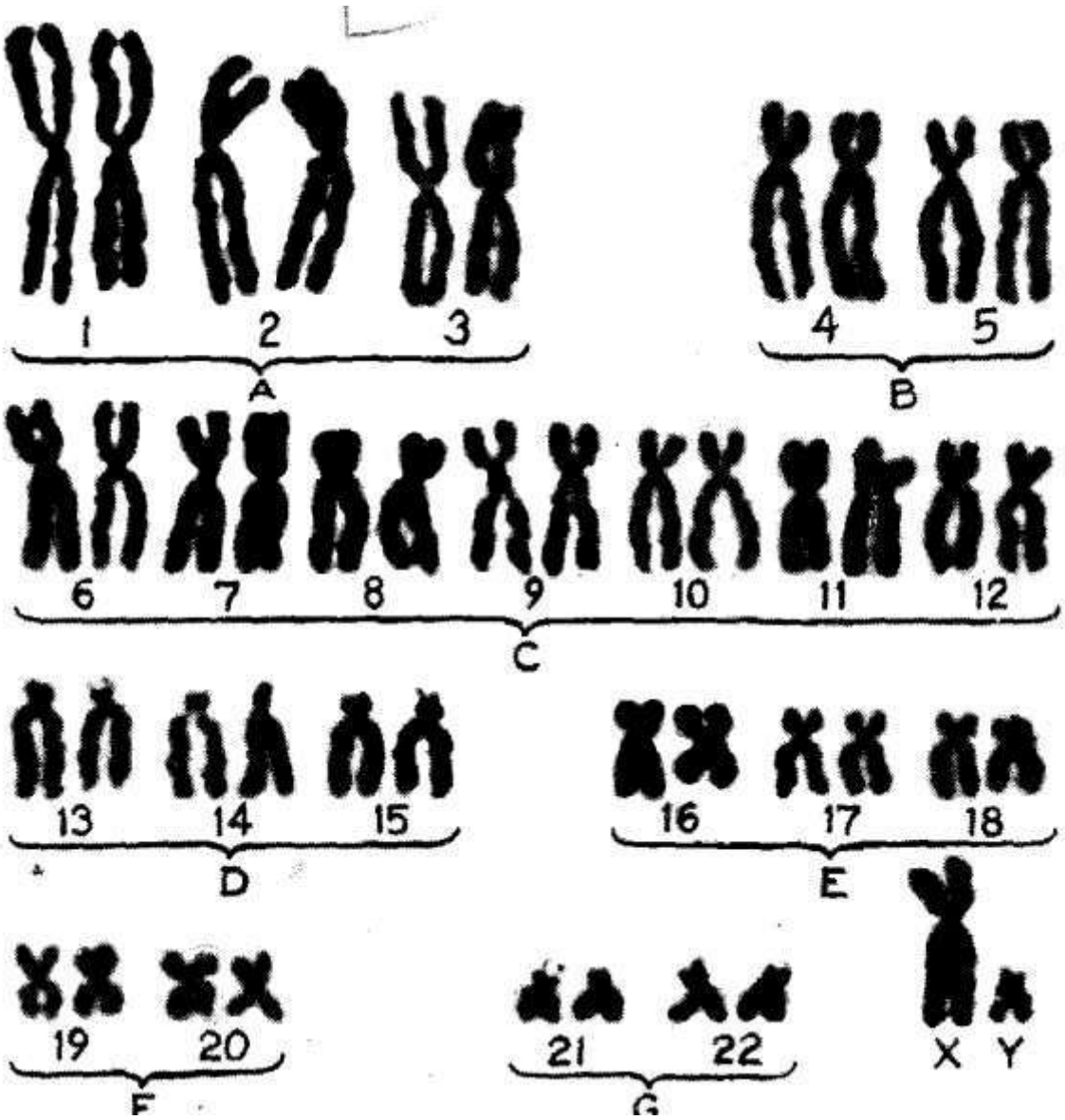
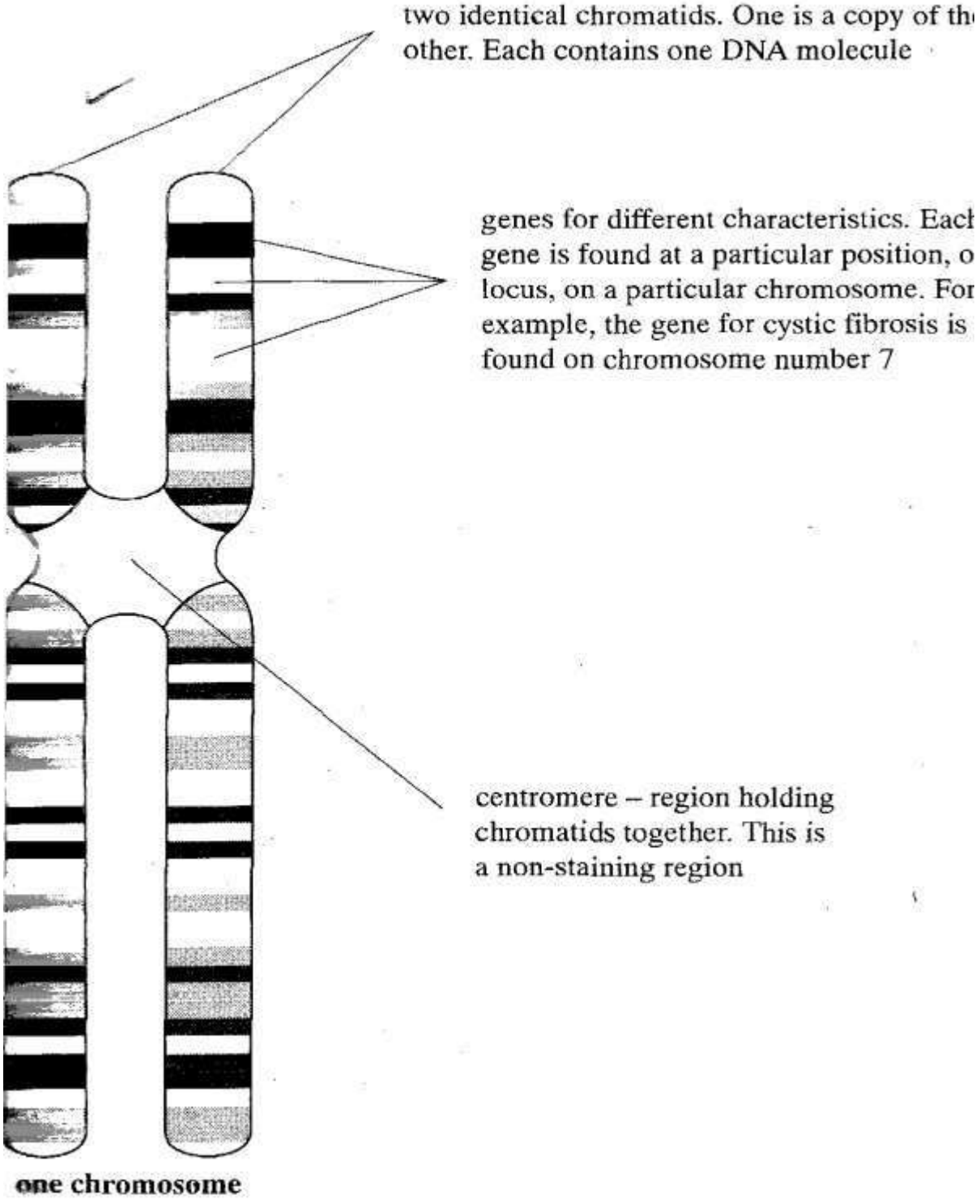


Fig 23.3 Karyogram of a human male, Non-sex chromosomes (autosomes) are placed in groups of similar size (A to G). The sex chromosomes are placed separately. X, female, ‘r male. Note there are 22 pairs of autosomes and one pair of sex chromosomes. Genes on the autosomes are described as autosomal. Genes on the sex chromosomes are described as sex-linked.



If the

Fig. 23.2

If chromosomes are cut out from a photograph such as fig 23.1 and lined up according to size it can be seen that there are in fact pairs of chromosomes. These are referred k as **homologous pairs** because they are similar in structure. A photograph of such an arrangement of human chromosomes is shown in **fig 23.3**. Such a photograph is called a **karyogram** and the set of chromosomes is called **karyotype**. There are 23 pairs of chromosomes in fig 33. The reason that there are pairs of chromosomes is that one set comes from the female parent by way of the egg, and one set comes from the male parent by way of the sperm. When the sperm fuses with the egg at fertilization, the resulting cell, the zygote, has two sets of chromosomes.

You will notice that there is an odd pair of chromosomes in **fig 23.3**, labelled X and Y. These are the sex chromosomes. The male, or Y, chromosome is shorter than female, or X, chromosome. Normally, homologous pairs of chromosomes have genes for the same characteristics. The person whose karyotype is shown in fig 23.3 is a male (XY). A female would have two X chromosomes (XX).

Haploid and Diploid Cells

Species in which there are two sets of chromosomes as described above are referred to as **diploid,** given the symbol 2*n*. The great majority of-animal species and about half the plant species are diploid, with two sets of chromosomes per nucleus or cell. A few simple organisms have only one set of chromosomes and are referred to as **haploid** (symbol n). In addition, gametes are haploid. Some organisms, including many plants, have three or more sets and are referred to as **polyploid**, but we shall ignore these in this chapter.

The advantages of possessing two sets of chromosomes are two-fold:

(1) Genetic variation is increased. Each individual will have a mixture of characteristics from both parents.

(2) If a gene on one chromosome of a pair is faulty, the second chromosome may provide a normal back-up.

The Cell Cycle

The sequence of events which occurs between one cell division and the next is called the **cell cycle**. It has three main stages.

(1) **Interphase.** This is a period of synthesis and growth. The cell produces many materials required for its own growth and for carrying out all its functions. DNA replication occurs during interphase.

(2) **Mitosis**. This is the process of nuclear division.

(3) **Cell division.** This is the process of division of the cytoplasm into two daughter cells.

The length of the cycle depends on the type of cell and external factors such as

1) Temperature

2) Food

3) Oxygen supplies

Bacteria may divide every 20 minutes, epithelial cells of the intestine wall every 8—10 hours, onion root-tip cells may take 20 hours whilst many cells of the nervous system never divide.

Mitosis and Meiosis- Introduction

Mitosis is the process by which a cell nucleus divides to produce two daughter nuclei containing identical sets of chromosomes to the parent cell. It is usually followed immediately by division of the whole cell to form two daughter cells. This process is known as **cell division**.

Mitosis with cell division results in an increase in cell numbers and is the method by which growth, replacement and repair of cells occurs in eukaryotes. In unicellular eukaryotes, mitosis results in asexual reproduction leading to an increase in population size.

Meiosis is the process by which a cell nucleus divides to produce daughter nuclei each containing half the number of chromosomes of the original nucleus. An alternative name for meiosis is **reduction division** since it reduces the number of chromosomes in the cell from the diploid number ($2n$) to the haploid number (n). The significance of the process lies in the fact that it enables the chromosome number of a sexually reproducing species to be kept constant from generation to generation. Meiosis occurs during gamete formation in animals and during spore formation in plants. Haploid gametes fuse together during fertilization to restore the diploid number of chromosomes.