**Plant Genome**

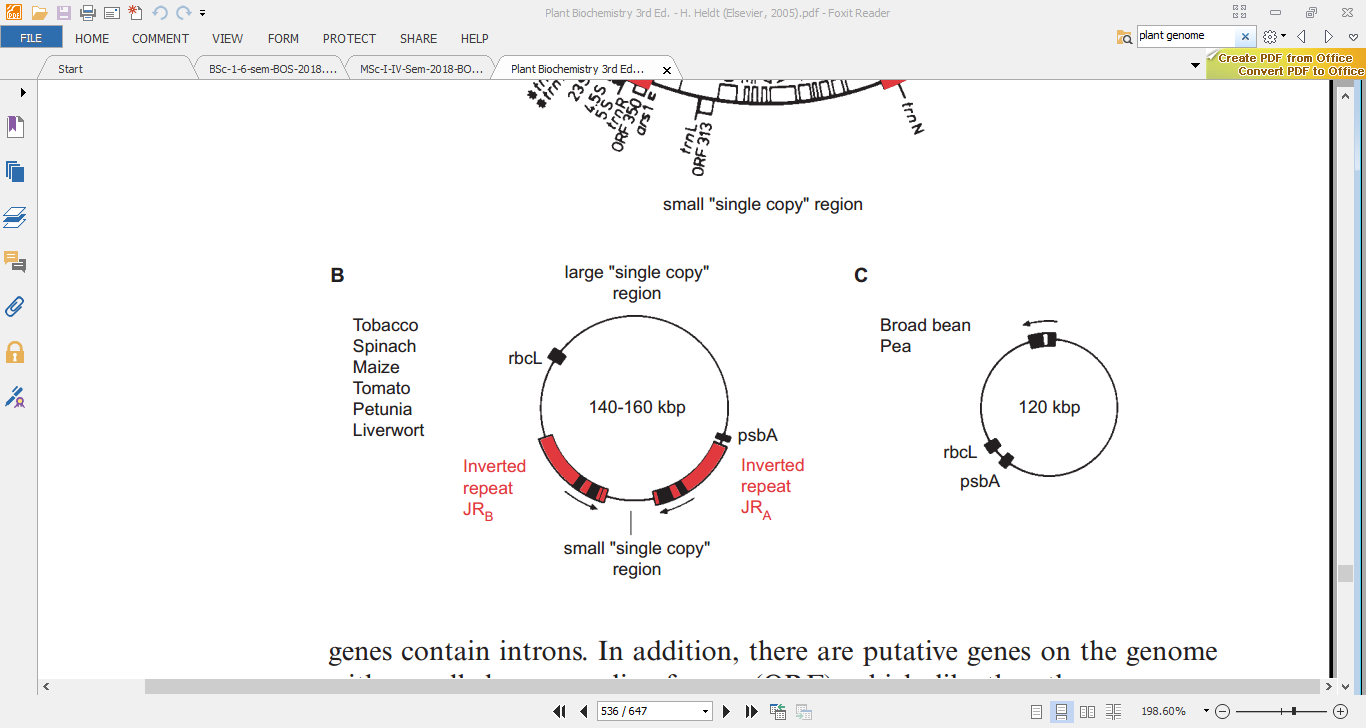
A plant cell contains three genomes: in the nucleus, the mitochondria, and the plastids.

The size of the genomes is given in base pairs (bp). The genetic information of the mitochondria and plastids is located on one circular DNA double strand (although sometimes on several), with many copies present in each organelle. During the multiplication of the organelles by division, these copies are distributed randomly between the daughter organelles.

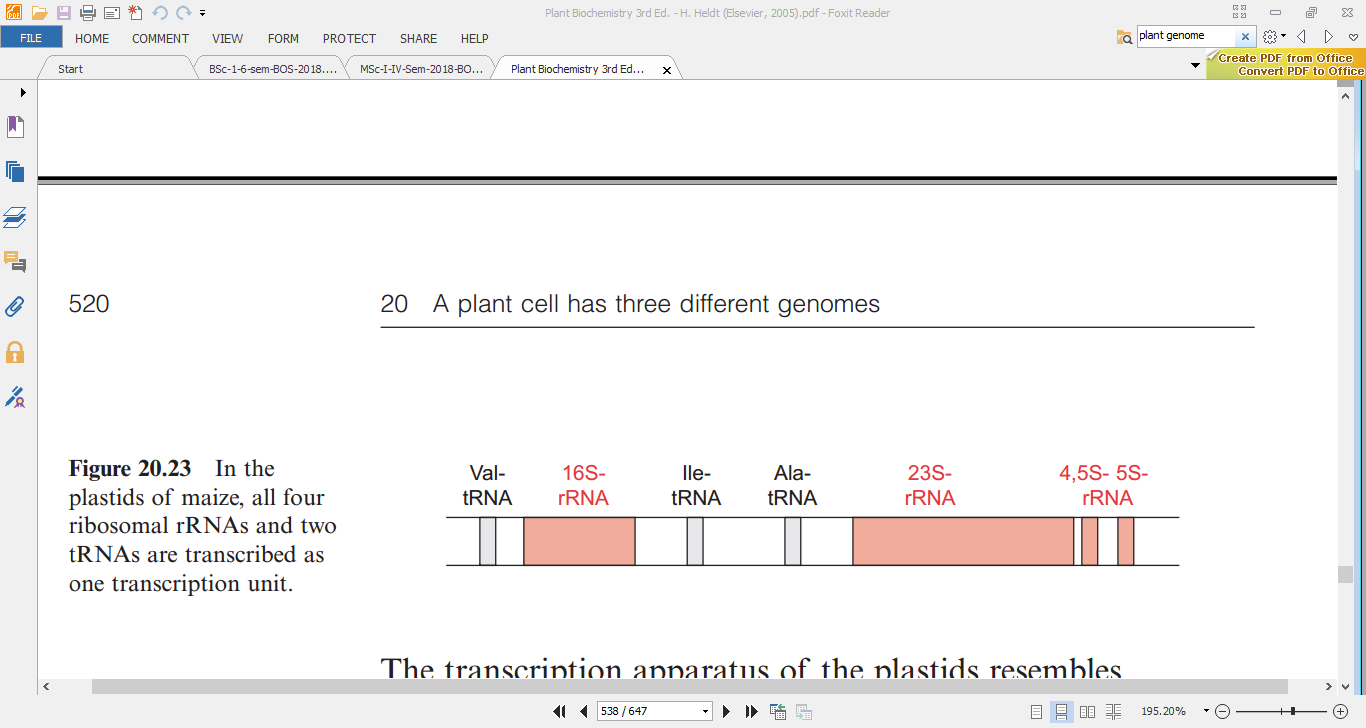
Each cell contains a large number of plastids and mitochondria, which also are randomly distributed during cell division between both daughter cells. In this way the genetic information of mitochondria and plastids is inherited predominantly maternally from generation to generation, where the large number of inherited gene copies protects against mutations.

**Plastid genome:**

Plastids possess a circular genome. The circular genome of the plastids is similar to the genome of the prokaryotic cyanobacteria, although much smaller. The DNA of the plastid genome is named ctDNA(chloroplast) or ptDNA (plastid). The circular plastid genome has the size of 120 to 160 kbp. The cell contains many copies of the plastid genome for two reasons. First, each plastid contains many genome copies. In young leaves, the number of ctDNA molecules per chloroplast is about 100, whereas in older leaves, it is between 15 and 20. Second, a cell contains a large number of plastids, a mesophyll cell for instance 20 to 50. Thus, despite the small size of the genome, the plastid DNA can amount to 5% to 10% of the total cell DNA.



Figures 20.22B and C show schematic representations of the plastid genomes of different plants. The plastid genome of most plants contain so-called inverted repeats(IR), which divide the remaining genome into large or small single copy regions. The repeat IRAand IRBeach contain the genes for the four ribosomal RNAs as well as the genes for some transfer RNAs, and can vary in size from 20 to 50 kbp. These inverted repeats are not found in the plastid genomes of pea, broad bean, and other legumes (Fig. 20.22C), where the inverted repeats probably have been lost during the course of evolution. On the remainder of the genome (single copy region), genes are present usually only in a single copy. The ctDNA sequence of tobacco revealed that the genome contains 122 genes (146 if the genes of each of the two inverted repeats are counted). The gene for the large subunit of ribulose bisphosphate carboxylase/oxygenase is located in the large single copy region, whereas the gene for the small subunit is present in the nuclear genome. The single copy region of the plastid genome also encodes subunits of F-ATP synthase, whereas the remaining genes of F-ATP synthase are encoded in the nucleus. Also encoded in the plastid genome are part of the subunits of photosystem I and II, of the cytochrome b6/f complex, and of an NADH dehydrogenase and furthermore, proteins of plastid protein synthesis and gene transcription. All four rRNAs, which are constituents of the plastid ribosome (4.5S-, 5S-, 16S-, and 23S-rRNA) are encoded in the plastid genome. The plastid ribosomes (sedimentation constants 70S) are smaller than the eukaryotic ribosomes (80S) contained in the cytosol, but are similar in size to the ribosomes of bacteria. As in bacteria, these four rRNAs are contained in the plastid genome in one transcription unit. Between the 16S- and 23S-rRNA is situated a large spacer, containing the sequence for one or two tRNAs.



**The transcription apparatus of the plastids resembles that of bacteria**

In the plastids two types of RNA polymerases are active, of which only one is encoded in the plastid genome and the other in the nucleus.

1. The RNA polymerase encoded in the plastids enables the transcription of plastid genes for subunits of the photosynthesis complex. This RNA polymerase is a multienzyme complex resembling that of bacteria. But in contrast to the RNA polymerase of bacteria, the plastid enzyme is insensitive to rifampicin, a synthetic derivative of an antibiotic from Streptomyces.

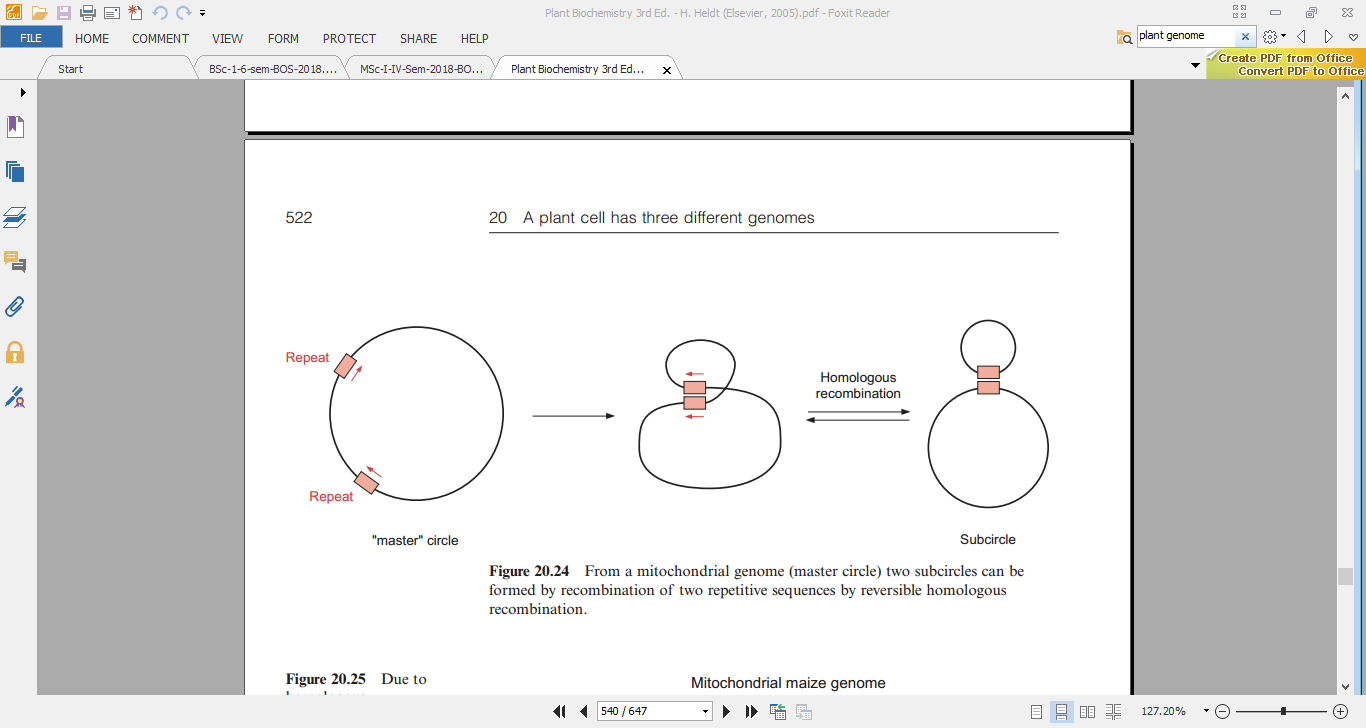
2. The plastid RNA polymerase, which is encoded in the nucleus, is derived from the duplication of mitochondrial RNA polymerase. This “imported” RNA polymerase is homologous to RNA polymerases from bacteriophages. The nucleus-encoded RNA polymerase transcribes the so-called housekeeping genes in the plastids. These are the genes that have general functions in metabolism, such as the synthesis of r RNA or tRNA.

**Mitochondrial genome**

In contrast to animals, plants possess a very large mitochondrial (mt) genome. In Arabidopsis it is 20 times, and in melon 140 times larger than in humans. The plant mitochondrial genome also contains more genetic information: The number of encoding genes in a plant mt-genome is about seven times higher than in humans. The mitochondrial genome in plants often consists of one large DNA molecule and several smaller ones. In some mitochondrial genomes, this partitioning may be permanent, but in many cases, the fragmentation of the mt-genome seems to be derived from homologous recombination of repetitive elements (e.g., maize contains six such repeats). An interaction of two repeats can lead by homologous recombination to a fragmentation of a DNA molecule into two parts.

The 570 kbp mt-genome of maize is present in the form of a master circle as well as up to four sub circles. The recombination of DNA molecules can also form larger units. This may explain the large variability in the size of the mitochondrial genome in plants.

The recombination of DNA molecules can also form larger units. This may explain the large variability in the size of the mitochondrial genome in plants.





The mitochondrial genome encodes parts of the translation machinery, including 3 rRNAs, about 16 tRNAs, and about 10 ribosomal proteins. These are involved in the formation of various hydrophobic membrane proteins, which also are encoded in the mt-genome, e.g. some subunits of the respiratory chain of F-ATP synthase and also at least three enzymes of cytochrome-c synthesis. Considering that mitochondria have derived from endosymbionts, it must be assumed that the greatest part of the genetic information of the endosymbiont genome has been transferred to the nucleus. Such gene transfers occur quite often in plants; the gene content in the mitochondria can vary between the different species. But a gene transfer apparently has also occurred from the plastids to the mitochondria. From their base sequence, several tRNA genes of the mt-genome seem to originate in the plastid genome.