What's in a Name — Is all DNA the Same?

Why We Care About Genetics Vol.7

Genetic information is commonly recognized as residing in DNA (deoxyribonucleic acid) and genes (a section of DNA that codes for a recognizable or measurable trait). DNA does not float freely within the cells: it is packaged in compartments — the nucleus and organelles. In plants and animals, DNA is found in the nucleus and mitochondria (mtDNA). In plants, DNA is also in a third compartment — the chloroplasts, the site of photosynthesis (cpDNA). The amount of DNA varies greatly among species. Also, the DNA in each of these three compartments has a different structure. Mitochondria (usually many per cell) contain DNA that is typically in

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small circular molecules while cpDNA is typically structured as one circular molecule. In the nucleus, DNA is further organized into units called chromosomes. The chromosomes of a species are comprised of two complementary sets, one coming from each parent. If the parental set of chromosomes can't be subdivided with respect to gene content, then the species is considered a diploid. If the parental set of chromosomes can be divided into two or more subsets, each with comparable gene content, then we consider the species a polyploid. For example, a diploid species will have a relatively low chromosome number, say 24, 12 chromosomes from each parent. A related species with 48 chromosomes would be considered a polyploid, 24 chromosomes (or two sets of 12) coming from each parent.

Polyploidy is rare among animals (a few exceptions are some fish, nematodes, leeches, insects, and salamanders) but is common among plants (especially ferns and flowering plants). Most grass species are polyploids. Among conifers, however, polyploidy is rare, coast redwood (*Sequoia sempervirens*), a hexaploid, is one of the exceptions.

Usually a species is characterized by a single chromosome number, but sometimes there is variation in ploidy levels within the same species. Fireweed (*Chamerion angustifolium*) is an example of a plant species within which both diploid and tetraploid individuals can be found. In nature, these different ploidy types (called 'cytotypes') may co-occur, or sometimes don't overlap geographically. They may have different adaptations. Because of the uncertainty of the biological significance of cytotypes for most species, it is best to mimic natural patterns in restoration projects: not planting different cytotypes together unless they naturally co-occur, and keeping the cytotype ratio approximately the same in cases where they do. Sometimes there are easily observable morphological differences between cytotypes and sometimes not.

The current understanding of DNA — its constituents and how it functions as the design center for higher-level body structures — has changed dramatically from the

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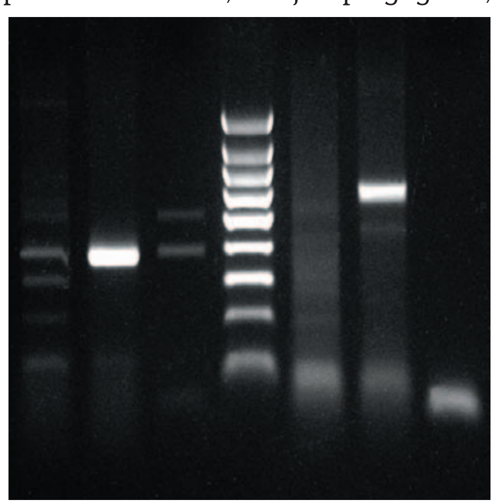
early "beads on a string" model. First, DNA is known to have diverse expressions — some of the DNA provides directions for structural or functional components; some is involved in the regulation or expression of other genes but has no direct product itself; some appears to be redundant; and some seems to have no apparent function, but that may be a matter for further study to determine. Second, DNA is no longer considered to have a strictly "linear" expression, with each gene independently being copied directly and translated into its product. More complexity is increasingly discovered, such as effects from neighboring genes that may turn on or off or modify a particular gene's expression. Finally, DNA is much more dynamic than previously thought. In what was a revolutionary finding, it was discovered that the genomes of most species have many sections of DNA that seemingly jump around from one location to another! Called mobile elements, transposable elements, or jumping genes, these elements are now classified as one of two types: those wherein a master sequence of DNA is copied and inserted elsewhere in the DNA, a "copy and paste" activity (especially common in higher organisms); and those that literally move by cutting themselves out of one location and reinserting in another location in the genome (more common in bacteria and lower organisms). As more is learned about the nature of these mobile elements, they are becoming increasingly useful in studying the evolutionary history of species and genetic diversity within them.

[polyploidy is rare among animals but is common among ferns and flowering plants]



The way DNA is passed on from one generation to the next (inheritance) shows differences among species and among sources. In most species, the offspring inherit nuclear DNA from both parents. In animal species and most, but not all, plant species, offspring inherit mtDNA from their maternal parent. In plants, cpDNA is transmitted maternally in most species, biparentally in some, and paternally in others. In many pine species, cpDNA is transmitted paternally and mtDNA maternally. In coast redwood, however, both cpDNA and mtDNA are inherited paternally. These different modes of inheritance for the different sources of DNA give rise to potent research opportunities. For example, this allows one to look separately at the way that genes are spread in a species through seed (maternal) and pollen (paternal). And finally, there are also differences in the rate at which the DNA in these three sources typically changes (accumulates mutations) over time. This allows researchers an opportunity to look at species relationships on different timescales.

In summary, among species the amount of DNA, the number of chromosomes, the ploidy level, and even the manner in which the DNA in different organelles is inherited can differ. As the genomes of more and more species are sequenced, there is increasing information about other ways in which species differ and are the same. ■

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