Basic Cytogenetics (Chromosome Sets and Fertility)

When working with hybrids between irises of different types (arilbreds, say, derived from tall beardeds and arils), an important consideration is the number and type of chromosome sets the irises have.

Each chromosome set contains all the genes necessary to make an iris. Many plants and most animals are **diploids:** they have two sets of chromosomes, one inherited from each parent. If one set of chromosomes contains all the plant's genes, why are two needed? They are not strictly necessary (there are some organisms that have only one set), but they are very advantageous. With two copies of each gene, it is possible to one plant to carry two different alleles of that gene. (See the file "Basic Genetics 1—Dominant and Recessive"). This means that each seedling can get a randomly selected mix of alleles, and thus be different from its parents. This genetic diversity allows plants to adapt more easily to varied conditions. In a population where many different combinations of genes are found in different individuals, there are improved odds that at least some of those individuals will have a combination of genes that allows them to better survive some unexpected environmental stress.

As plants and animals grow, their cells divide in a process called **mitosis.** Mitosis basically makes two copies of everything in the cell, which then splits to become two cells identical to the original.

Meiosis and Gamete Formation

But when plants and animals make sex cells or **gametes** (ovules and pollen grains in the case of irises), a different process called **meiosis** must be used. Only *half* the total number of chromosomes must go into each sex cell (*one* full set for diploids). Without this special division and reduction of chromosomes to just one set, the seedling would end up with twice as many chromosome sets as the parents! You can see that in a few generations, the number of chromosome sets would proliferate ridiculously. But through meiosis, each parent produces gametes with just a single set. The gametes from the two parents then merge to form an embryo with two sets, one from each parent, a normal diploid plant just like the parents.

For the plant to pull off this meiosis to make gametes, there must be a way to ensure that each gamete gets exactly one copy of each chromosome, not zero and not two. To make sure this process works, the chromosomes *pair* before going off into separate gamete cells. Each chromosome finds its counterpart, and they separate in such a way that one of them goes into each gamete, ensuring that each gamete receives exactly one copy of each chromosome: a single full set.

In tetraploids, with four sets of chromosomes, meiosis works the same way, but now each gamete gets two sets of chromosomes rather than one. When fertilization takes place, the gametes from the parents merge, each bringing two sets of chromosomes, to make a new plant with four sets, another tetraploid just like its parents.

Fertility Barriers

If the chromosomes in an iris cannot pair during meiosis, viable gametes cannot be produced, and the iris will be sterile. Why would this happen? If the iris is a hybrid between two very different types, each of those parents will have given it a very different set of chromosomes. The chromosomes may be different in shape or in size or in which genes they contain. There may even be a different number of chromosomes in the set from one parent than in the set from the other parent. This is why hybrids between very different types of irises (or other plants or animals) are often sterile.

Consider a diploid tall bearded iris, *Iris pallida.* It has two sets of chromosomes; there are 12 chromosomes in each set. So we can write it as 12+12. If we don't care about the actual number, we can just call a single tall bearded set *T,* so Is *TT,* two *T* sets of 12 chromosomes each.

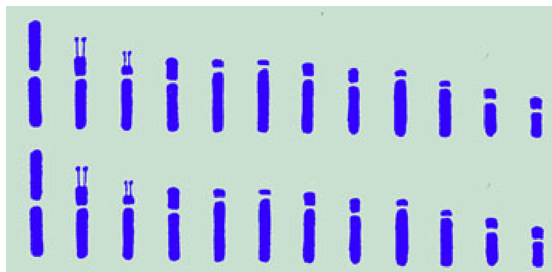

Diagram of the chromosomes of *Iris pallida,* two sets of 12.

An oncocyclus aril iris, *Iris iberica,* also has two sets of chromosomes, but they are not like the TB chromosomes. Their sizes and shapes are different, and there are only 10 of them. We can represent *I. iberica* as 10+10, or *AA,* where *A* stands for a set of 10 aril chromosomes.

I. pallida can produce fertile gametes because its two chromosome sets can pair and divide: *TT* → *T, T*

I. iberica can also produce fertile gametes the same way: *AA* → *A, A.*

But a hybrid of *I. iberica* x *I. pallida,* with one set of chromosomes from each parent, *AT,* cannot produce fertile gametes, because *A* cannot pair with *T,* and so it cannot "know" which chromosomes to send into each gamete to bestow a single complete set.

Tetraploidy to the Rescue

The infertility of hybrids between different types of iris can be overcome if the plants are tetraploid. How is this possible?

Consider a tetraploid tall bearded like *I. mesopotamica.* It has four sets of 12 chromosomes, 12+12+12+12 or *TTTT.* It is fertile because *TTTT* → *TT, TT.*

Likewise the tetraploid Regelia aril iris *I. stolonifera* is *AAAA,* and it is also fertile: *AAAA* → *AA, AA.*

A hybrid of *I. stolonifera* x *I. mespotamica,* with two sets from each parent is *AATT.* This *can* produce fertile gametes, because the *A* set can pair with the other *A* set, and the *T* set can pair with the other *T* set: *AATT* → *AT, AT.*

This hybrid is an example of a type of tetraploid called an **amphidloid** (“double diploid”), because it can act like a diploid with two “big sets” of similar chromsomes, each “big set” being *A* and *T* together. Every chromosome in one *AT* “big set” can find a counterpart to pair within the other *AT* “big set”.

This is one of the greatest advantages offered by tetraploidy: it allows wide crosses to produce fertile hybrids. Note that this only works if there are exactly two sets of each type. One of one type and three of another does not allow this facile pairing to take place.

A Chromosome Configuration Crib Sheet

Among bearded and aril irises, there are three basic types of chromosome sets: dwarf bearded sets as found in *I. pumila,* each with 8 chromosomes, which can be written as *P,* and the *A* (10 or 11 chromosomes) and *T* sets (12 chromosomes) discussed above. It is interesting that although some arils (oncocyclus) have sets of 10 chromosomes and others (Regelias) have 11, these two types are still similar enough to pair, so we treat them as the same basic type, *A.*

Here is a list of different types of bearded, aril, and arilbred irises and their chromosome configurations. These are generalizations; it is possible to find particular irises that are exceptions. I have limited the list to types of at least some historical or horticultural significance.

type of iris	chromosome configuration (symbolic)	chromosome configuration (numeric)	total chromosome count	expected fertility
		diploids:		
diploid TBs and BBs, *I. pallida, I. variegata,* etc.	*TT*	12+12	24	fertile
diploid MTBs	*TT*	12+12	24	fertile
I. suaveolens, diploid *I. reichenbachii*	*TT*	12+12	24	fertile
I. attica, I. pseudopumila	*PP*	8+8	16	fertile
oncocyclus, diploid Regelia, diploid arils	*AA*	10/11 + 10/11	20–22	fertile
diploid arilbreds	*AT*	10/11 + 12	22–23	sterile
		triploids:		
triploid TBs	*TTT*	12+12+12	36	limited
triploid arilbreds (OGB+) from arilbred x diploid aril breeding	*AAT*	10/11 + 10/11 + 12	32–34	limited
arilbred dwarfs (OGB-) from SDB x diploid aril breeding	*APT*	10/11 + 8 + 12	30–31	sterile

full tetraploids:				
tetraploid TBs and BBs	*TTTT*	12+12+12+12	48	fertile
tetraploid MTBs	*TTTT*	12+12+12+12	48	fertile
I. aphylla, tetraploid *I. reichenbachii*	*TTTT*	12+12+12+12	48	fertile
I. pumila, MDBs from pure *pumila* breeding	*PPPP*	8+8+8+8	32	fertile
tetraploid arils, *I. hoogiana, I. stolonifera*	*AAAA*	10/11 + 10/11 +10/11 + 10/11	40–44	fertile
amphidiploids:				
SDBs and MDBs from pure SDB breeding, *I. lutescens*	*PPTT*	8+8+12+12	40	fertile
"C. G. White type" arilbreds (OGB)	*AATT*	10/11 + 10/11 + 12 + 12	44–46	fertile
arilbred dwarfs (OGB) from tetraploid aril x *pumila* breeding	*AAPP*	10/11 + 10/11 + 8 + 8	36–38	fertile
unbalanced tetraploids:				
MDBs from SDB x *pumila* breeding	*PPPT*	8+8+8+12	36	limited
IBs	*PTTT*	8+12+12+12	44	limited
"Mohr type" arilbreds (OGB-)	*ATTT*	10/11 + 12 + 12 + 12	46–47	limited
tetraploid arilbreds from arilbred x tetraploid aril breeding	*AAAT*	10/11 + 10/11 + 10/11 + 12	42–45	limited
arilbred medians from SDB x arilbred breeding	*APTT*	10/11 + 8 + 12 + 12	42–43	limited

Those noted as "limited" fertility have two sets of similar chromosomes that are able to pair, which may sometimes allow gametes to be produced, with unpaired chromosomes distributed randomly among the gametes. Those that end up with approximately complete sets may be viable.

For more detailed information, see the Telperion Oasis web site.

Other Types of Irises

These principles can be applied to all types of irises; I have used bearded and aril irises for example because they are most familiar. It is just a matter of finding out what the different types of chromosome sets are, and sorting plants into diploids, triploids, full tetraploids, amphidiploids, and unbalanced tetraploids according to what sets of chromosomes are present.

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