A practical method of chromosome classification on the basis of centromere position

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Abstract

Chromosomes have been classified into six categories based on centromere position – *M, m, sm, st, t, T,* of which only *M* (isochromosome) and *T* (telocentric) can be identified quickly with certainty. A template is illustrated which can be used to place any chromosome immediately into its correct category without the need to measure arm length.

Introduction

In the description of karyotypes in plants and animals the relative length of chromosomes is an important factor, but more fundamental is the morphological identification of the chromosome types in order that they may be classified into groups. In any morphological classification system the location of the centromere is the most useful reference point, and is one which is normally characterised by great constancy within a species. Levan *et al.* (1964) suggested a standardized nomenclature for centromere position which is now used widely. They reviewed the most important developments in the history of the terminology used in centromere location and stressed the importance of a uniform system of chromosome classification. Their nomenclature did not take secondary constrictions or satellites into account, but these were discussed fully by Battaglia (1955).

In the nomenclature proposed by Levan's group six categories for the position of the centromere in a chromosome were established: *M* (median, *sensu stricto,* as in isochromosomes), *m* (median region), *sm* (submedian region), *st* (subterminal region), *t* (terminal region) and *T* (terminal, *sensu stricto,* as in telocentric chromosomes).

Of these the two extreme forms *M* and *T* can be defined precisely and there can be no doubt when one or the other is encountered. The remaining four were identified by Levan's group on the basis of a limited range of chromosome arm ratios for each one. Although the latter were defined precisely there remains a tendency among many workers not to follow the scheme closely, but to assign the terms to particular chromosome types in an arbitrary and sometimes incorrect manner which can lead to confusion when different sets of observations are compared.

The method set out below is based on the data established by Levan's group and can be used to give a rapid and accurate classification of any chromosome without the necessity of measuring arm length and calculating ratios.

Method

The long arm: short arm ratios proposed by Levan's group to delimit *M, T* and the four variable chromosome types are set out in Table 1, which is based on a chromosome divided into 8 equal units. In assigning chromosomes to particular types difficulty arises when the arm ratio is exactly 5:3, 6:2 or

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Table 1. Range of long arm:short arm ratios in the six nomenclatural types of chromosome.

Chromosome type	Long arm:short arm
M	4:4 only
m	4.01:3.99 → 5:3
sm	5:3 → 6:2
st	6:2 → 7:1
t	7:1 → 7.99:0.01
T	8:0 only

7:1, which are the three boundary or transition ratios separating the four intermediate chromosome types *m*, *sm*, *st* and *t*. Chromosomes with these arm ratios must be classified as *m-sm*, *sm-st* or *st-t* intermediates respectively. In a random sample of chromosomes very few will fit exactly into these transition categories; most will be included in one of the six types identified above and in Table 1.

Figure 1 illustrates the three transition arm ratios 5:3, 6:2 and 7:1 over a range of overall chromosome lengths from zero upwards. It can be used as templates to classify any drawn or photographed chromosome as follows, provided that the chromosome is straight:

(1) Photograph or trace the figure onto transparent film or paper;
(2) Align any of the three templates comprising the figure over the chromosome such that the chromosome is vertical and has its shorter arm uppermost.
(3) Move the template to the right or left until the ends of the chromosome touch the upper and lower guide lines.
(4) The third line, between the guide lines is the centromere line. If the centromere falls exactly on this line the chromosome is an exact intermediate between two of the six chromosome

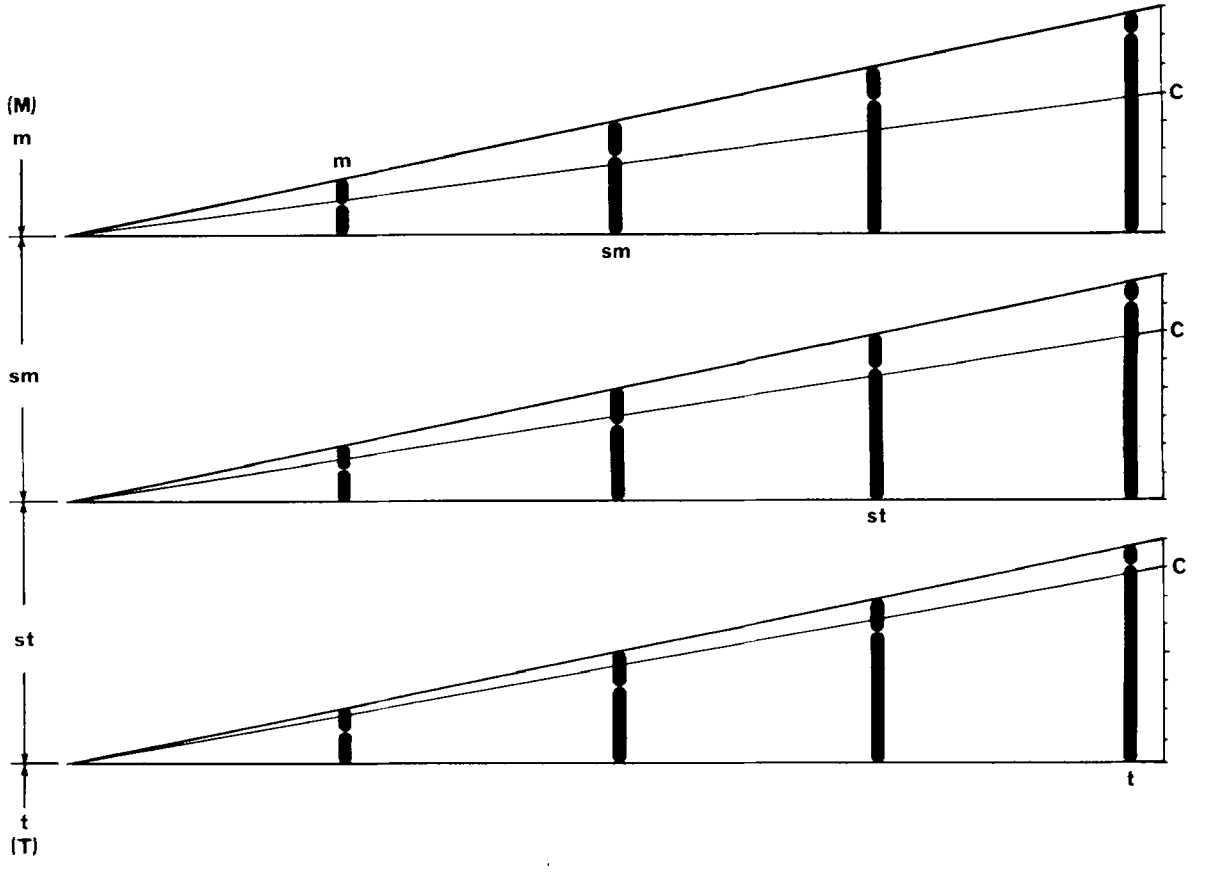

Fig. 1. Templates for classifying chromosome types. Each one can be used for a range of chromosome lengths. They represent the precise intermediates between (from the top downwards) *m-sm*, *sm-st* and *st-t*. *m*, *sm*, *st* and *t* chromosomes of different lengths are superimposed on each template to demonstrate the use of the templates in chromosome classification. C = centromere line.

types and must be classified as such. Normally this will not be the case and the centromere will be above or below the centromere line. If it is below the line templates higher in the series should be used until it falls above the line. On the other hand, if the initial test shows the centromere above the centromere line the chromosome should be matched against lower templates until the centromere appears below the line.

(5) The two templates between which the centromere changes from a position above to one below the centromere line define the chromosome type to which the test chromosome should belong; *sm* and *st* types will be at once recognized in this way.

(6) If the centromere falls below the centromere line in all three templates the chromosome is an *m* type, unless it is an isochromosome *M* type which will be recognized readily. If it falls above the centromere line in all three templates the chromosome is a *t* type, provided that it still has a short arm; otherwise it is a telocentric *T* type.

In Figure 1 four chromosomes are drawn in each of the three templates to demonstrate their use more clearly.

One problem in the use of this technique is the secondary or nucleolar constriction which in some cases can be very long, even in metaphase chromosomes. This will exaggerate the true length of the chromosome arm, and we suggest that it should be ignored when the chromosome is classified, only the terminal satellite (if any) being taken into account.

References

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