APPENDIX 1

PROBLEMS AND STUDY QUESTIONS

INTRODUCTION

1. What morphological characters may be available by which the chromosomes of a genome may be distinguished?

2. At what points in the life cycle can each of these differences be most easily or accurately studied? What tissues have been used for cytological study in plants? in animals?

3. From the sporocytes in plants as seen under the microscope, what are the gross features by which the major stages of meiosis may be distinguished?

4. Assume that in the triple heterozygote $\frac{A\ B\ d}{a\ b\ D}$ there is 4% recombination between A and B, and 10% between B and D. Considering only the kinds of crossovers and non-crossovers, what are the expected kinds of gametes and their frequencies; first, with no interference, then with a coincidence value of .25?

5. In the triple heterozygote in problem 4, assume cytological crossing over occurs in region 1 (A-B) in 8% of the cells and in region 2 (B-D) in 20% of the cells.
   a. If there is no interference between cytological crossovers (i.e., no chiasma interference) in the two regions:
      (1) What are the expected kinds and frequencies of chromatid tetrads?
      (2) What are the kinds of gametes expected and their frequencies?
      (3) What would the percentages of recombination in the two regions be if these were the frequencies of backcross phenotypes?
      (4) From these frequencies, calculate the coincidence value.
   b. Do the same for a coincidence value of .25 between cytological crossovers in the two regions. Compare the coincidence values for cytological crossovers with those calculated from the backcross phenotypes in problem 4.
   c. How would chromatid interference affect the results, e.g.:
      (1) If the same strands are less likely to be involved in the second crossover, a probability of .2 that either will be involved. Calculate the expected frequencies of the various genotypes.
      (2) If the strands are more likely to be involved in a second crossover, a probability of .8 that either will be involved.

6. Chromatid tetrads with multiple crossovers also produce chromatids with fewer crossovers. Assuming no chromatid interference, these relations are as follows:

Number of cytological crossovers	Frequency of recovered strands with different numbers of crossovers			
	0	1	2	3
0	1			
1	1	1		
2	1	2	1	
3	1	3	3	1

For the 8-point control data for chromosome 3 of Drosophila, as summarized on page 3, calculate the frequencies of primary oocytes with different numbers of cytological crossovers that will account for the data. The same may be done for individual regions, using the original data. For examples in which this has been done, see Brown (1940).

7. In spinach, chromosome 1 has a different morphology in certain strains:
   a. standard, which is heterobrachial (one arm shorter than the other),
   b. isobrachial, by addition of a segment to the short arm,
   c. giant, which appears to have a segment added to one arm of the isobrachial stock; actually added to what is the long arm of the heterobrachial stock. A cross was made between the stock with the "giant" chromosome 1 and one with the standard; the F_1's were selfed and the F_2 plants were analyzed for their chromosomal constitutions. The following were the numbers of the various types (L and S refer to long and short arms):

-homo. standard	5	stand./giant L, stand. S	4
-het. giant/stand.	7	" /isobrachial	5
-homo- giant	2	giant/giant L, stand. S.	4
-homo. isobrachial	4	giant/isobrachial	6
-homo. giant L stand. S	1	giant L/isobrachial stand. S/	3

   Can the above results be explained by crossing over? If so, calculate the percentage of recombination.

CHANGES IN CHROMOSOME STRUCTURE

8. In this problem, abc.defgh, ijkl.mnop, and qrstuv.wx represent three normal chromosomes in a diploid organism. The dot in the sequence represents the centromere. In A and B only the constitutions of the aberrant chromosomes are given, but the normal chromosomes are to be added. In C both members of the pair are shown.

A.
1. abfgc.deh
2. abgfc.deh
3. abjkc.defgh, il.mnop
4. abkjc.defgh, il.mnop
5. abkjc.defgh

B.
1. ars.defgh, ijbc.mnop, qkltuv.wx
2. abcbc.defgh
3. abccb.defgh
4. abcdef.gh

C.
1. ac.defgh, abc.defgh
2. abc.dba, hgfec.defgh

For each of the above:

   a. What term is applied to describe the type of change and how it might have arisen?
   b. What will the pachytene configuration be in F_1 if homologous parts pair?
   c. What new types may occur (1) as a result of crossing over (2) or as the result of a new combination of chromosomes?

9. A plant is heterozygous for a given pair of genes, Dd, (d = dwarf) and the chromosome carrying D also carries a duplication (Dp). The duplication reduces the ability

of the pollen carrying Dp to compete by .9. Also, there is 20% recombination between Dp and D, d. What are the expected kinds and frequencies of : (a) the different kinds of gametes? (b) the different kinds of zygotes from a cross on dd normal ♀? (c) a cross as ♀ with dd normal ♂ .

10. How could an experiment be planned using X-rays or other means to produce a duplication for a particular gene and to test for its presence?

11. Show how a tandem duplication (reverse repeat type) might be used to produce deficiencies.

12. What is the fate of the bridge chromosome with two centromeres? Is it the same for all tissues?

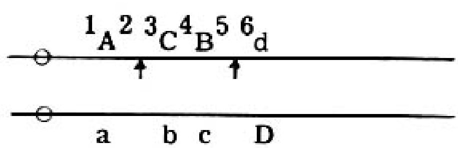
13. What is the explanation for the lower ♀ sterility in paracentric inversion heterozygotes? Does this always occur, even in the same species?

14. The following backcross data were obtained in maize from a three-point test involving the genes v_4 (virescent seedling), B (plant color booster), and pollen sterility (16.5%) associated with a paracentric inversion in chromosome 2, In2R.

+ B partially sterile	-	100
+ B fertile	-	16
+ b partially sterile	-	36
+ b fertile	-	6
v_4 B partially sterile	-	9
v_4 B fertile	-	37
v_4 b partially sterile	-	16
v_4 b fertile	-	84

Calculate the recombination and coincidence values and construct a linkage map.

15. An individual heterozygous for a, b, c, and d and for an inversion with breaks between regions 2 and 3 and 5 and 6, as shown below, is crossed with a normal stock homozygous for these same recessives:



x aa bb cc dd

a. What recombinations would one expect to recover in the offspring if crossovers occurred only in regions 2 and 4? Only in regions 3 and 4?
b. What relation should there be between the ~~frequency~~ occurrence of double bridges at anaphase I and the recovery of certain of the above crossovers?

16. If in the previous problem crossing over occurred only in regions 2, 3, and 4; if cytological crossing over in these regions is 6%, 10%, and 8% respectively, with no interference; what kinds of offspring would be expected and what would be their frequencies? In plants, what percent of pollen abortion would be expected?

17. In corn, In2R is a paracentric inversion with its distal break between v_4 (virescent 4) and Ch (chocolate, a dominant pericarp color). Show how to plan a test to determine if a deficiency for the segment distal to the inversion is viable.

18. Show how isochromosomes might be used to produce ring chromosomes.

19. Show by diagrams the expected results from crossing over in the various segments in a cross between two paracentric inversions involving the same chromosome in which one is included within the limits of the other. How would the results [redacted] be changed if one break of one inversion is at a point identical with one break point of the other? Note which crossover will produce duplications without deficiencies.

20. Crossing over in certain inversion and interchange heterozygotes results in pairs of chromatids of unequal length. Show how experiments might be planned to test their effect on chromosome behavior and genetic segregation.

21. By means of diagrams, show the configurations expected from crossing T1-4 (1L. 3, 4L.4 ~~2L. 4~~) with T5-7 (5S. 2, 7L. 7), first at diakinesis, then at pachytene. Do the same for the cross of T1-4 (1L. 3, 4L. 4) with T4-6 (4S. 2, 6S. 1).

Majors: Do the same for T1-4 (1L. 3, 4L. 4) crossed with 4-7 (4L. 8, 7S. 6). Compare this configuration with that in the previous intercross. Note the differential and interstitial segments.

22. From the following results of intercrosses between a group of seven interchanges, show the steps in assigning temporary letters to identify the chromosomes. No genetic information is available.

Interchanges as ♂

		1	2	3	4	5	6	7
Interchanges used as ♀	1	10 II	2⊙4	⊙6	2⊙4	2⊙4	2⊙4	2⊙4
	2		10 II	2⊙4	2⊙4	⊙6	⊙6	2⊙4
	3			10 II	2⊙4	2⊙4	⊙6	2⊙4
	4				10 II	2⊙4	2⊙4	⊙6
	5					10 II	2⊙4	2⊙4
	6						10 II	2⊙4
	7							10 II

23. The observations in the body of the following table were made at diakinesis in plants from crosses between 10 unknown interchanges and a set of six tester interchanges whose chromosomes have been identified. The set used included 1-2a, 2-4d, 3-7c, 5-7c, 8-9b and 8-10b; selected because as heterozygotes they seldom show anything but rings at meiosis.

Unknown T#	Cytology of heterozygote	tester interchanges					
		1-2	2-4	3-7	5-7	8-9	8-10
1	⊙4	⊙6	2⊙4	⊙6	2⊙4	2⊙4	2⊙4
2	⊙4	2⊙4	2⊙4	2⊙4	⊙6	⊙6	2⊙4
3	⊙4	⊙6	⊙6	⊙6	2⊙4	2⊙4	2⊙4
4	⊙4	2⊙4	2⊙4	2⊙4	⊙6	⊙6	⊙6
5	⊙4	⊙6	⊙6	2⊙4	2⊙4	2⊙4	2⊙4
6	⊙4	2⊙4	2⊙4	2⊙4	2⊙4	⊙6	⊙6
7	⊙4	2⊙4	2⊙4	⊙4	⊙6	2⊙4	2⊙4
8	⊙4*	2⊙4	2⊙4	2⊙4	2⊙4	⊙6	⊙6
9	⊙4*	2⊙4	2⊙4	2⊙4	2⊙4	⊙6	2⊙4
10	⊙4	2⊙4	2⊙4	2⊙4	2⊙4	10 II	⊙6

* attached to the nucleolus, others not.

a. What chromosomes were interchanged in the unknown?

One approach is to list the information furnished by each cross, i.e. which chromosomes are not involved, then which ones might be, then the possible combinations between these. Which one do the results fit?

24. The observations made on five ⊙6 stocks and on the hybrids between them and the tester set are summarized in the following table:

Unknown No.	Cytology of heterozygote	Tester interchanges 1-2	2-4	3-7	5-7	8-9	8-10
11	⊙6	⊙6 ⊙4	⊙8	⊙6 ⊙4	⊙8	⊙8	⊙8
12	⊙6	⊙8	⊙6 ⊙4	⊙8	⊙8	⊙6 ⊙4	⊙6 ⊙4
13	⊙6*	⊙6 ⊙4	⊙6 ⊙4	⊙8	⊙8	⊙8	⊙6 ⊙4
14	⊙6	⊙6 ⊙4	⊙6 ⊙4	⊙4	⊙6	⊙6 ⊙4	⊙6 ⊙4
15	⊙6	⊙8	⊙8	⊙8	⊙8	⊙8	⊙8

* Ring attached to nucleolus, others not.

What chromosomes were interchanged in the unknowns?

25. In barley, crosses between a tester set of interchanges and two different ⊙8 stocks from X-raying a homozygous 3-5-6 interchange stock gave the following results:

Unknown	1-5	1-6	1-7	2-4	3-4	3-6
T177	⊙6	2 ⊙4	⊙10	⊙8 ⊙4	⊙10	⊙6
T149	⊙8	⊙8	⊙10	⊙8 ⊙4	⊙10	2 ⊙4

For each unknown, what chromosome had been added to the ring of six? Can any additional conclusions be drawn?

26. In a species with 7 pairs designated a, b, c, d, e, f, g, will the four interchanges a-b, b-c, d-e, e-f be sufficient to identify any possible unknown with a ⊙4? If not, what additional one or ones are needed?

27. Two maize stocks heterozygous for the shrunken (sh) and waxy (wx) endosperm genes on chromosome 9 and for two different chromosomal interchanges were backcrossed to a normal plant homozygous for these recessives. The resulting seeds were classified for the endosperm characters, planted separately, and the plants from the different classes were classified for pollen sterility, giving the following results:

		# 1	# 2
+ +	normal	82	14
	semisterile	6	77
wx +	normal	40	0
	semisterile	205	13
+sh	normal	171	13
	semisterile	17	3
wx sh	normal	3	39
	semisterile	49	13

Break in 9:

in #1 = 9L.4
in #2 = 9S.8

What were the genetic constitutions of the parental gametes from which these two semisterile parents came?

Calculate the recombination values for each. Plot the linkage maps in relation to the interchange points. Also plot the relative positions of genes and break points on a cytological map.

28. In barley there is linkage between partial sterility (due to interchange) and a certain qualitative character determined by one factor pair. Derive the expressions for the frequencies of the four phenotypes in F_2.

Calculate the numbers expected for .10 recombination in repulsion. Do the same for coupling.

29. In barley, two homozygous interchange stocks were crossed with zebra (zb). The F_2 plants were classed for partial sterility and for normal vs. zb, the results being:

	3-4 interchange	2-4 interchange
+ - fertile -	29	35
+ - partially sterile -	61	39
zb - fertile -	14	9
zb - partially sterile -	7	12

Using tests for independence, what conclusions can be drawn from the data? Calculate the recombination values.

30. In an experiment involving interchange 2-4 and a new albino seedling character, the F_2 results were:

green - fertile	35
green - semisterile	90

Is there evidence of linkage? Both classes were grown in F_3, giving the following results:

partially sterile	- not seg. albino	- 4	F_3 lines
"	- seg. "	- 57	"
fertile	- not seg. "	- 25	"
"	- seg. "	- 6	"

Do these results indicate linkage? Calculate the percent recombination.

31. What form does the linkage map take in an interchange heterozygote? What are the effects of an excess of alternate segregation from the ring on genetic recombination and spore abortion in plants, zygote abortion in animals?

32. In a linkage test between semisterility and corn borer reaction, the susceptible translocations were crossed with a resistant line, the F_1 backcrossed to a susceptible stock; and the resulting progeny were grown and classified for pollen sterility and corn borer reaction. The following results were obtained (Ibrahim, 1954).

Interchange and Break Positions		Leaf Feeding Classes No. of Plants 1	2	3	4	5
3-9c (3L.2 9S.2)	Fertile	4	55	19	3	
	Semisterile	1	45	32	10	1
8-9d (8L.2 9S.2)	Fertile	1	35	40	15	1
"	Semisterile	0	27	27	11	4

What conclusions can be drawn from the above data?

33. In Drosophila, the results from the backcross involving genes in two linkage groups:

II $\frac{+\quad +\quad +\quad +\quad +}{al\ \ dp\ \ b\ \ pr\ \ c}$ III $\frac{Sb}{+}$ ♀ x al dp b pr c ♂ were as follows:

Sb	566	wild type	164
al dp b pr c	303	al dp b pr c Sb	87
al Sb	13	al	2
dp b pr c	8	dp b pr c Sb	4
al dp Sb	9	al dp	5
b pr c	9	b pr c Sb	6
c Sb	203	c	47
al dp b pr	133	al dp b pr Sb	41
al c Sb	4	al b pr c Sb	2
dp b pr	3	al c	3
al dp c Sb	5	dp b pr Sb	5
b pr	6	al dp c	4
		Total	1632

How can the results be explained?

Plot the recombination values in a linkage map.

34. What methods might be used to determine recombination values between genetic markers and an interchange in Drosophila? In mice? or in a plant species with directed segregation from the rings?

35. In Drosophila, assume there is an interchange between chromosomes 2 and 3 at the points indicated, but close to B and E:

The interchange stock is crossed with a b c d e f and (1) the F_1 is backcrossed as the ♂ to the multiple recessive, (2) the F_1 is backcrossed as the ♀ parent to the multiple recessive. Assuming the following recombination values, A-B = .10, B-C = .05, D-E = .08, and E-F = .04, what are the expected results from the two crosses?

Note: Those linkages observed in the interchange heterozygote, but in neither type of homozygote, have been termed pseudolinkages.

36. Assume that two heterozygous stocks of the interchange used in problem 35 are available, one homozygous for A B C D E F, the other for a b c d e f. If these are crossed, what phenotypes are expected in F_1? Note: In animals, deficient gametes are functional but deficient zygotes are usually lethal. Compare with the expectations in a diploid higher plant species.

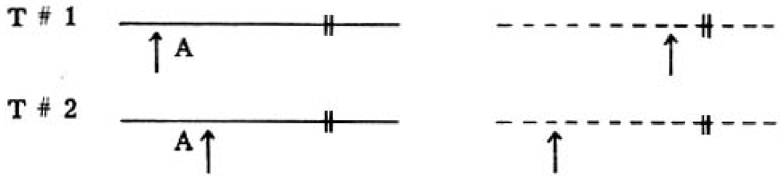
37. In an interchange heterozygote (⊙4) in maize there were 904 spore quartets with no spores having a diffuse nucleolus, 346 with two diffuse, and 112 with one diffuse in the quartets. The observed pollen abortion was 47.6%. What was the probable frequency of each of the different kinds of segregation from the ring of four?

38. Use the following assumptions as to chromosome behavior in an interchange heterozygote: 90% alternate segregation in non-crossover meiocytes, and 50% alternate: 50% adjacent-1 segregation in crossover meiocytes (i.e. crossing over in one or both interstitial segments).

a. If 10% of the meiocytes cross over in one interstitial segment (a) what percentage of the spores (gametes in animals) would be deficient? (b) if a locus at the centromere and one at the interchange break point were heterozygous; and the individual were crossed with the double recessive, what would be the percentage of observed recombination for that region? Compare with the value that might have been expected in a species in which alternate segregation is always 50%.

b. Do the same assuming 10% cytological crossing over in each of the two interstitial segments.

39. Assume a cross of two homozygous translocations involving the same chromosome but with breaks at different positions as indicated in the diagram below:



a. What are the chromosome combinations expected in the spores of the F_1? Which of the combinations between the translocated chromosomes of T # 1 and T # 2 are likely to be viable? i.e. without a deficiency?

Note: Construct the translocated chromosomes to scale, then consider the chromosome constitution of the possible combinations in relation to any duplication or deficiency they may carry.

b. Assume that translocations 1 and 2 are homozygous for A at the locus shown in the diagram, and that the F_1 between the two translocations is back crossed with a translocation #1 stock that is homozygous for aa. What is the expected gametic ratio from the new backcross plant type produced by the viable duplication carrying gamete referred to in part 1? Does this have any possible use?

40. In a linkage test with one genetic marker, B vs b in a self-pollinated crop such as barley, what is the expected ratio of partially sterile to fertile plants in the B and b phenotypic classes in F_2?

41. What are the special features of the behavior of interchanges in maize between a supernumerary "B" chromosome and one of the primary chromosomes?

42. In Oenothera what is the effect of a large ring on genetic segregation for several qualitative markers? What is the effect on segregation for quantitative characters? Compare with the results in a newly synthesized big ring in maize.

43. What is the effect of crossing over in a differential segment in a large ring? What are some possible applications of multiple interchange stocks?

CHANGES IN CHROMOSOME NUMBER

44. What are the different kinds of trisomics? Compare the configurations observable at pachytene, diakinesis and metaphase I of meiosis. How can the different types be identified?

45. For the primary trisomics in plants compare in general the rates of transmission through pollen and ovules, for different chromosomes and for different species. How may some of this variation be explained? Are there any methods by which the transmission rate can be increased?

46. What types of offspring are expected from the various kinds of trisomics?

47. What methods can be used in attempts to obtain the various types of trisomics for study in a particular species?

48. In corn, chromosome 6 carries the factor pair for Yy (yellow vs. white endosperm, close to the centromere probably). A homozygous white endosperm plant trisomic for chromosome 6 is crossed as ♀ with a pure yellow stock. Trisomic and normal plants are selected in F_1 (by root tip counts or sporocyte examination), self-pollinated and crossed reciprocally with a normal yy stock. Assuming that in the progeny from selfing a 2n + 1 or crossing it as ♀ only 26% of the plants are 2n + 1; what ratios (not %) are expected in the progeny from each of the two kinds of plants?

49. If in the first part of the previous problem the white endosperm plant trisomic for 6 had been crossed with a plant which was YY and homozygous for waxy endosperm (wx) in chromosome 9, what phenotypes and ratios would there be on the trisomic plants when self-pollinated?

50. In barley, a plant trisomic for chromosome 7 was crossed with a stock with short rachilla hairs(s). In F_2 among the 2n + 1 plants there were 45S and 2s plants, and among the 2n plants 100S and 9s plants.

a. Show how the above observed ratios within the two chromosome types can be explained.
b. What ratios do the data fit if the trisomics could not have been identified?

51. In corn, there were 235 purple and 59 red aleurone seeds on a trisomic plant that had been crossed as ♀ with a pr pr v_2 v_2 diploid. When the seeds were grown, there were 175 green and 79 virescent seedlings. Explain the two results.

52. In tomatoes, an F_2 from plants trisomic for chromosome 2 segregated 143 tall and 15 dwarf. The trisomic for chromosome 4 segregated 146 tall and 57 dwarf. Explain the above results. What assumptions give the best fit to the first ratio?

53. In a species with n chromosome pairs, n linkage groups have been established by genetic methods. Show how it is possible to determine if these represent independent linkage groups, each located on a different chromosome.

54. Show how the various kinds of polysomics can be used to determine linkage map orientation, and gene position in the chromosomes.

55. Select a genus and check the chromosome numbers reported for the various members. For plants, consult Darlington and Wylie's Chromosome Atlas. For animals consult the Chromosome Atlas by Makino.

56. Assume that in an autotetraploid species there are two lines, each homozygous for a simply inherited character (on non-homologous chromosomes). How would you proceed to produce a stock homozygous for both recessives? Give the genotypes expected at each step. Assume both genes are close to the centromeres, and that the characters give no special interactions.

57. What is the best method of determining that the genotype of an autopolyploid is actually ++++ and not +++v?

a. With no crossing over (or very little) between the gene and the centromeres.
b. with crossing over between the gene and the centromere. Assume that the homozygous recessive stock is not available for part 1 or 2.

58. In an experiment in maize planned to recognize haploids genetically, what are the other types that also resulted from irregular behavior? Are any of these potentially useful?

59. What influences or determines the gametic ratios in an autotetraploid?

60. What are the possible methods of measuring the frequency of double reduction?

61. In barley, assume an α value of .18 for the locus being tested for trisomic ratios. Also assume that the trisomic plants have been distinguished from the diploids. For the RRr genotype, what ratio of rough: smooth awned (r) plants would be expected in F_2 among the trisomics?

62. Assume that immediately after fertilization in a cross of Lg Lgx lg lg (liguleless) chromosome doubling occurred. Assume an α (total double reduction) value of .12, what gametic ratio is expected?

63. If in the previous problem the probability of a cytological crossover between the gene and the centromere between any two of the four chromosomes is .2 what gametic ratio might be expected?

64. What is the probable significance of duplicate factors in diploids and in allopolyploids?

65. Discuss Lammerts' results from a study of segregation in Nicotiana paniculata x rustica hybrids backcrossed to paniculata and to rustica.

66. What is the significance of the increased frequency of multivalents in nullisomic 5 wheat plants?

67. Two diploid species are each segregating 3 normal:1 dwarf. The cross of the two dwarfs gives a tall F_1 that is sterile. Chromosome doubling has restored the fertility.
    a. What ratio would you expect in the F_2 progeny if one dose of each of the two dominants gives the tall phenotype, and the two genes are adjacent to the centromere?
    b. If for each gene, α is .1, what is the expected gametic ratio for the doubled F_1?

68. Show how a case of duplicate factors might originate in an allopolyploid.

69. Durum wheats have 14 pairs of chromosomes, vulgare wheats have 21 pairs. Assume that both reciprocal crosses have produced at least a few seeds with embryos. In each case, what are the chromosome numbers of the endosperm and of the embryo? Compare these with the chromosome numbers from the two possible intraspecific crosses. If the crosses differ as to the success of getting hybrid seed, which is usually the more successful?

70. In vulgare wheat, a monosomic plant shows approximately the following gametic transmission frequencies: through the female, 75% n-1 and 25% n; through the male about 4% n-1 and 96% n. What kinds of progeny are expected from self-pollination and what would be their frequencies if for this particular monosomic female transmission is 65% n-1 and 35% n, male transmission 4:96%?

    To locate factors for rust reaction, the monosomics (in the Chinese variety) are crossed with varieties having the contrasting reaction. For example, in one test the variety Frontana is resistant to race 56 of stem rust, Chinese is susceptible.

In the test, resistance was dominant. If one factor were concerned, in what generation could you determine if the factor were in the univalent chromosome? What ratios would it be necessary to differentiate?

71. In wheat Redman has two factors and Kenya Farmer one that are complementary for dwarf. Show how these factors could be located by using the Redman series of monosomics. Do the same for a character segregating 13:3 in F_2.

72. Could monosomics be used to establish tester stocks for these same characters?

73. In vulgare wheat a recessive virescent character located on chromosome 3B is expressed only when homozygous. The hemizygous condition is green. What are the expected results in F_2 and F_3 from the normal Chinese monosomic 3B crossed with virescent?

74. In vulgare wheat, the reaction of Frontana to stem rust race 56 in crosses with Chinese spring is controlled by duplicate factors, resistance being dominant. Monosomics have been used to locate one of these factors. What ratios are expected if there is no hemizygous effect?

75. A stock is designated as being monosomic for a particular chromosome. How can this be verified cytologically and genetically?

76. In most cases the monosomics cannot be distinguished except by cytology and even then non-disjunction for other chromosomes may occur giving rise to plants monosomic for a different chromosome from the one supposed to be in the stock.

Set up a breeding scheme by which the monosomics might be recognized genetically in each generation.

77. A liguleless sugary 4n maize was crossed with perennial teosinte, a 4n species. If the % of autosyndesis is 75% for each of the chromosomes, what is the expected ratio in the backcross to liguleless sugary? Note these two genes are on different chromosomes.

78. What were the special features of Sears' transfer of the leaf rust resistance of Aegilops umbellulata to a vulgare type wheat?

79. In asparagus the male is the heterogametic sex. (Thus far no detectable cytological difference between the members of this pair has been found.) Occasionally in certain stocks a male plant has a few flowers which are capable of functioning as ♀. If a cross is made between these and a normal male, give the kinds of offspring expected, and the ratio.

80. In spinach the male is the heterogametic sex. If a diploid female is crossed with a tetraploid ♂ (produced by doubling a diploid male), what kinds of offspring are expected? And in what ratio?

81. The cross of normal ♀ x trisomic male in spinach gave the following results:

Trisomic used as ♂	Number of offspring	
	staminate (♂)	pistillate (♀)
star (chrom. 3)	191	247
reflex (chrom. 1)	74	143
oxtongue (chrom. 2)	169	173

Explain the results.

82. In pigeons, sex cannot be determined until maturity. Assuming two sex-linked recessive characters a and b which are distinguishable in the young squabs, if an a male is mated to a b female: show how a breeding plan can be set up to distinguish the sexes in each successive generation. (ref. in Jour. Hered. 33:135-140. 1942).

83. In Lychnis alba the cross of a broad-leaved ♀ with a narrow-leaved ♂ produced ♂ and ♀ that were broad-leaved. In F_2 the ♀ were all broad-leaved, part of the males were broad-leaved, part were narrow-leaved.

Show how these results can be explained on the basis of an XY mechanism for sex determination.

84. Assume a particular dominant character is Y-linked, its allele being on the X chromosome. Show how such a character is inherited in crosses of XX with XY.

85. What is the cause of seedlessness in Citrus?

86. Show how somatic segregation might occur as a result of somatic crossing over followed by normal chromosome behavior in somatic cells.

87. Tetraploid Bahia grass is apomictic. When crossed wih an induced tetraploid of 2n Pensacola Bahia, the F_2 included 9 apomictic and 267 sexual offspring. If the aaaa gentoype is the only one that is apomictic, what ratios might be expected from the various genotypes among the sexual offspring?