

## A rat genetic linkage map and comparative maps for mouse or human homologous rat genes

J. Yamada, T. Kuramoto, T. Serikawa

Institute of Laboratory Animals, Faculty of Medicine, Kyoto University, Sakyo-ku, Kyoto 606-01, Japan

Received: 6 July 1993 / Accepted: 13 October 1993

The rat (*Rattus norvegicus*) is used in a broad field of biomedical research, and numerous animal models for human diseases have been developed. The rat genetic map, however, remains poorly documented. Hedrich (1990) described a rat linkage map consisting of 13 groups, of which only 6 were assigned to chromosomes. Levan and coworkers (1991, 1992) collected mapping information from the literature, including their own works. Their tables and figures contain gene chromosomal assignments, cytogenetical localizations, and comparisons of the rat G-banding pattern with those of mice and humans, but do not include any information about gene orders or distances.

Recently, an informative rat genetic linkage map has been reported by Serikawa and colleagues (1992b). It is based on the segregation of 125 polymorphic markers in seven rat backcrosses and two F<sub>2</sub> crosses, and all of the linkage groups are assigned to particular chromosomes. The linkage map and the information on microsatellite markers became a great help for genetic studies with rat models for human diseases. Since then, a considerable amount of new data for the rat linkage map has appeared in several publications. We, therefore, have collected mapping data published up to the middle of 1993, including our recent reports, and have summarized it here in a list of mapped loci. This genetic map, constructed by combining several linkage data, and two comparative maps for mouse or human homologous rat genes should be very informative to many researchers working on genetic studies in rats, mice, or humans.

### Rat genetic linkage map

Table 1 lists in alphabetical order 539 rat loci assigned to a particular chromosome and 8 loci that were not yet as-

signed to any chromosomes and remained in linkage groups (LG III, XI, XII, and XIII of Hedrich's map). There are now 547 entries; a substantial increase from the 214 of Levan's 1991 and 370 of their 1992 list.

A rat genetic linkage map is shown in Fig. 1. Out of 539 loci assigned to particular chromosomes, 276 are located on each linkage map. The loci assigned to chromosomes by methods other than linkage analysis are listed separately and alphabetically under each chromosome. The numbers of loci on each chromosome are as follows: (no. loci located on the linkage map/no. loci assigned to the chromosome in total), Chr 1, 40/69; Chr 2, 18/33; Chr 3, 21/40; Chr 4, 19/35; Chr 5, 16/38; Chr 6, 10/23; Chr 7, 6/23; Chr 8, 11/26; Chr 9, 2/17; Chr 10, 20/32; Chr 11, 4/10; Chr 12, 7/11; Chr 13, 8/19; Chr 14, 20/28; Chr 15, 0/9; Chr 16, 3/5; Chr 17, 5/16; Chr 18, 14/17; Chr 19, 27/31; Chr 20, 15/34; Chr X, 10/22; Chr Y, 0/1. On Chrs 6, 8, 11, 12, and 14, respectively, two, three, two, two, and two linkage groups are seen. As for Chrs 4, 8, 14, 19, 20, and X, two linkage groups aligned in parallel because of discord in the locus order, distance in the references, or absence of anchor loci by which the orientations of maps are determined.

### Comparative mouse map

For the discussion of comparative mapping, we have applied the chromosome terminology of ISCN (1978); that is, rat chromosomes are designed by the prefix RNO (*Rattus norvegicus*), mouse chromosomes by MMU (*Mus musculus*), and human chromosomes by HSA (*Homo sapiens*). As shown in Fig. 2, we assigned mouse homologous rat genes on the mouse chromosomes, and they are shown by the mouse symbols. Location of the mouse loci have been referred from the mouse locus map of Hillyard and associates (1993). With a few exceptions MMU2, 3, 4, 6, 7, 8, 9, 11, 12, 14, 15, 16, 18, and X were homologous with

**Table 1.** A list of mapped loci in the rat.

Locus symbol	Locus name	Chr.	Mode	References
<i>A</i>	agouti	3	L	Castle, King (1949); Moutier et al. (1973a)
<i>A2M</i>	alpha-2-macroglobulin, liver	4	L, S	Yasue et al. (1992); Hilbert et al. (1991); Serikawa et al. (1992b)
<i>A2UG</i>	alpha 2U globulin	5	L, S	Serikawa et al. (1992b)
<i>A39</i>	hepatocyte antigen	13	S	Perrotez et al. (1989)
<i>ABL</i>	Abelson viral oncogene	3	A	Takahashi et al. (1986)
<i>ACADM</i>	medium-chain acyl-CoA dehydrogenase	2	S	Szpirer et al. (1989a)
<i>ACE</i>	angiotensin I converting enzyme, (RD31)	10	L, S	Hilbert et al. (1991); Jacob et al. (1991); Serikawa et al. (1992b); Cash et al. (1993); Kuramoto et al. (1993a); Kondo et al. (1993)
<i>ACO1</i>	aconitase 1	5	L	Adams et al. (1984); Cramer et al. (1986); Kondo, Yamada (1983)
<i>ACP1</i>	acid phosphatase 1	6	S	Yasue et al. (1991)
<i>ACP2</i>	acid phosphatase 2	3	L, S	Bender et al. (1986); Yasue et al. (1991)
<i>ACR</i>	proacrosin, spermatid-specific	7	S	Adham et al. (1991)
<i>ACRM</i>	acetylcholine receptor, m3 muscarinic	17	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>ADA</i>	adenosine deaminase	3	S	Yasue et al. (1991)
<i>ADH</i>	alcohol dehydrogenase	2	S	Fulchignoni-Lataud et al. (1992)
<i>ADRA1B</i>	adrenergic receptor, alpha-1B	10	S	Serikawa et al. (1992b)
<i>ADRB2</i>	adrenergic receptor, beta-2	18	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Remmers et al. (1993b)
<i>AEP</i>	anion exchange protein (kidney band 3)	10	L, S	Serikawa et al. (1992b); Kondo et al. (1993); Kuramoto et al. (1993a)
<i>AFP</i>	alpha-fetoprotein	14	L, S	Szpirer et al. (1984); Gal et al. (1984); Hilbert et al. (1991); Serikawa et al. (1992b); Remmers et al. (1993a)
<i>AGL</i>	antigen L	20	L	Lynch, DeWitt (1978, 1980)
<i>AGT</i>	angiotensinogen	19	A	Mori et al. (1989)
<i>AHD2</i>	aldehyde dehydrogenase 2	5	L	Cramer et al. (1986); Serikawa et al. (1992b); Kuramoto et al. (1993b)
<i>AHDC</i>	aldehyde dehydrogenase C	13	L	Cramer et al. (1986)
<i>AK1</i>	adenylate kinase 1	3	S	Levan et al. (1986)
<i>AK2</i>	adenylate kinase 2	5	S	Yoshida (1979, 1982)
<i>AKT</i>	thymoma viral proto-oncogene (v-akt)	6	A	Bellacosa et al. (1993)
<i>AKP1</i>	kidney alkaline phosphatase 1	(XI)*	L	Adams et al. (1984); Cramer et al. (1986)
<i>ALB</i>	serum albumin	14	L, S	Shumiya, Nagase (1982, 1988); Szpirer et al. (1984); Hilbert et al. (1991); Remmers et al. (1993a)
<i>ALDOA</i>	aldolase A	1	L	Goldmuntz et al. (1993)
<i>ALDOB</i>	aldolase B	5	S	Szpirer et al. (1990)
<i>ALR</i>	aldose reductase (ALR-P-I)	4	S	Graham et al. (1991)
<i>ALRP1</i>	aldose reductase, pseudogene 1 (ALR-P1)	3	S	Graham et al. (1991)
<i>ALRP2</i>	aldose reductase, pseudogene 2 (ALR-P2)	4	S	Graham et al. (1991)
<i>ALRP3</i>	aldose reductase, pseudogene 3 (ALR-H)	6	S	Graham et al. (1991)
<i>AMD1A</i>	S-adenosylmethionine decarboxylase A	20	S	Pulkka et al. (1993)
<i>AMD1B</i>	S-adenosylmethionine decarboxylase B	20	S	Pulkka et al. (1993)
<i>AMDP</i>	S-adenosylmethionine decarboxylase, pseudogene	X	S	Pulkka et al. (1993)
<i>AMD3</i>	S-adenosylmethionine decarboxylase, related	3	S	Pulkka et al. (1993)
<i>AMPP</i>	amplicon, Py-induced	4	L, S	Serikawa et al. (1992b)
<i>AMY1</i>	amylase, pancreatic	2	L, S	Mizuno, Suzuki (1978); Serikawa et al. (1992b)
<i>AN</i>	lethal anemia	5	L	Castle, King (1941, 1944, 1947)
<i>APEH</i>	acyl-peptide hydrolase (RIK)	8	L, S	Erlandsson et al. (1991); Serikawa et al. (1992b)
<i>APOC3</i>	apolipoprotein C-III, (apoa02)	8	L, S	Serikawa et al. (1992b); Kobayashi et al. (1992b)
<i>AR</i>	androgen receptor	X	L, S	Gumbreck (1964); Serikawa et al. (1992b)
<i>ASGR</i>	asialoglycoprotein receptor, (ASGR1)	10	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Remmers et al. (1992)
<i>ATP1A1</i>	ATPase alpha-1, (nkaa1b)	2	L, S	Yasue et al. (1992); Kunieda et al. (1992a); Zha et al. (1993)
<i>ATP1A2</i>	ATPase alpha-2, (atpa2s)	13	S	Yasue et al. (1992); Kunieda et al. (1992a)
<i>ATP1A3</i>	ATPase alpha-3	1	S	Yasue et al. (1992)
<i>B</i>	brown	5	L	Nikaido et al. (1982); Cramer et al. (1986)
<i>B1</i>	hepatocyte antigen	11	S	Perrotez et al. (1989)
<i>B2M</i>	beta-2-microglobulin	3	L, S	Yasue et al. (1992); Kondo et al. (1993)
<i>BSIS</i>	brain specific identifier sequence	1	L, S	Serikawa et al. (1992b)
<i>BSP</i>	bone sialoprotein	14	L	Remmers et al. (1993a)
<i>C</i>	albino	1	L	Castle, King (1944)
<i>C3</i>	complement 3	9	S	Szpirer et al. (1987, 1988b)
<i>C4</i>	complement 4	20	L, S	Watters et al. (1987); Locker et al. (1990)
<i>C4BPA</i>	C4 binding protein, alpha	13	S	Anderson et al. (1990)
<i>C4BFB</i>	C4 binding protein, beta	13	S	Anderson et al. (1990)
<i>C6</i>	complement 6	(XI)*	L	Granados et al. (1984); Cramer et al. (1986)
<i>CALC</i>	calcitonin	1	S	Levan et al. (1986)
<i>CALM3</i>	calmodulin III	1	S	Serikawa et al. (1992b)
<i>CAMK1</i>	calmodulin-dependent protein kinase II	2	L	Zha et al. (1993)
<i>CAT</i>	catalase, liver	3	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>CBPI</i>	calcium-binding protein, intestinal, vitamin D dependent	X	L, S	Serikawa et al. (1992b)
<i>CBS</i>	cystathionine beta synthase	20	S	Locker et al. (1990)
<i>CEAR</i>	carcinoembryonic antigen-related protein (CGM4)	1	L, S	Serikawa et al. (1992b)
<i>CEBPA</i>	CCAAT/enhancer binding protein (DBPCEP)	1	S	Szpirer et al. (1992a); Serikawa et al. (1992b)
<i>CEBPB</i>	liver-activating protein (TCF5)	3	S	Szpirer et al. (1991b)

Table 1. Continued.

Locus symbol	Locus name	Chr.	Mode	References
<i>CHGA</i>	chromogranin A	6	S	Simon-Chazottes et al. (1993)
<i>CK2B</i>	Ca-calmodulin-dependent protein kinase, beta	14	S	Levan et al. (1991, Brom et al.)
<i>CKB</i>	creatine kinase, brain	6	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>CLATP</i>	ATP citrate lyase	10	L	Remmers et al. (1992); Cash et al. (1993)
<i>CPAI</i>	carboxypeptidase A1, (D4MIT3)	4	L, S	Serikawa et al. (1992b); Jacob et al. (1992); Dissen et al. (1993)
<i>CPB</i>	carboxypeptidase B	2	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>CPBR</i>	carboxypeptidase B related	1	L	Goldmuntz et al. (1993)
<i>CRYA1</i>	alpha crystallin 1	20	L	Skow et al. (1985)
<i>CRYG1</i>	gamma crystallin 1	9	L, S	Donner et al. (1985); DenDunnen et al. (1987); Hilbert et al. (1991); Serikawa et al. (1992b)
<i>CRYG2</i>	gamma crystallin 2	9	S	Donner et al. (1985); DenDunnen et al. (1987)
<i>CRYG3</i>	gamma crystallin 3	9	S	Donner et al. (1985); DenDunnen et al. (1987)
<i>CRYG4</i>	gamma crystallin 4	9	S	Donner et al. (1985); DenDunnen et al. (1987)
<i>CRYG5</i>	gamma crystallin 5	9	S	Donner et al. (1985); DenDunnen et al. (1987)
<i>CRYG6</i>	gamma crystallin 6	9	S	Donner et al. (1985); DenDunnen et al. (1987)
<i>CSI</i>	catalase, erythrocyte	(XIII)*	L	Yamada et al. (1981); Kendall (1985)
<i>CSF1R</i>	colony stimulating factor-1 receptor	18	L	Remmers et al. (1993b)
<i>CSNA</i>	alpha-casein	14	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>CT</i>	cell surface alloantigen	20	L	Marshak et al. (1977)
<i>CSPMO2</i>	cell surface protein (MRC OX-2)	11	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>CTRB</i>	chymotrypsin B	19	L, S	Serikawa et al. (1992b)
<i>CUI</i>	curly 1	5	L	Castle, King (1944, 1947)
<i>CYP1A1</i>	cytochrome P450 C6	8	S	Levan et al. (1991)
<i>CYP1A2</i>	cytochrome P450 Q42	8	S	Levan et al. (1991)
<i>CYP2B1</i>	cytochrome P450 b	1	L	Rampersaud, Waltz (1987)
<i>CYP2B2</i>	cytochrome P450 e	1	L	Rampersaud, Waltz (1987)
<i>CYP11B1</i>	cytochrome P-450, subfamily (steroid 11-beta hydroxylase)	7	L, S	Cicila et al. (1993)
<i>CYP11B2</i>	cytochrome P-450, subfamily (aldosterone synthase)	7	L, S	Cicila et al. (1993)
<i>CYPBE</i>	cytochrome P450b/e	1	S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>CYPE</i>	cytochrome P450e	1	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>D1CEP1</i>	DNA segment, pASC-Ha-2	1	L	Hilbert et al. (1991)
<i>D1CEP2</i>	DNA segment, YNH24-Ha-6	1	L	Hilbert et al. (1991)
<i>D1CEP3</i>	DNA segment, YNH24-Hi-3	1	L	Hilbert et al. (1991)
<i>D1CEP4</i>	DNA segment, STMS (2B1)	1	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Goldmuntz et al. (1993)
<i>D1KYO1</i>	DNA segment, (mouse Ckmm)	1	S	Kondo et al. (1993)
<i>D1N40</i>	DNA segment, STMS	1	L	Goldmuntz et al. (1993)
<i>D1N64</i>	DNA segment, STMS	1	L	Goldmuntz et al. (1993)
<i>D2CEP1</i>	DNA segment, pASC-Hi-3	2	L	Hilbert et al. (1991)
<i>D2KYO1</i>	DNA segment, RAPD	2	S	Serikawa et al. (1992a)
<i>D2N1R</i>	DNA segment, RAPD	2	L	Zha et al. (1993)
<i>D2N2R</i>	DNA segment, RAPD	2	L	Zha et al. (1993)
<i>D2N28</i>	DNA segment, STMS	2	L	Zha et al. (1993)
<i>D2N35</i>	DNA segment, STMS	2	L	Zha et al. (1993)
<i>D2N91</i>	DNA segment, STMS	2	L	Zha et al. (1993)
<i>D3KYO1</i>	DNA segment, STMS	3	L, S	Kuramoto et al. (1993b)
<i>D3KYO2</i>	DNA segment, STMS	3	L, S	Kuramoto et al. (1993b)
<i>D3KYO3</i>	DNA segment, (mouse D0Nds33)	3	L	Kondo et al. (1993)
<i>D3KYO4</i>	DNA segment, (mouse-II-1a)	3	L	Kondo et al. (1993)
<i>D3KYO5</i>	DNA segment, (mouse II-1b)	3	L	Kondo et al. (1993)
<i>D4CEP1</i>	DNA segment, YNZ22-Hi-1	4	L	Hilbert et al. (1991)
<i>D4CEP2</i>	DNA segment, YNZ22-Hi-21	4	L	Hilbert et al. (1991)
<i>D4KYO1</i>	DNA segment, (mouse D6Nds6)	4	S	Kondo et al. (1993)
<i>D4MIT2</i>	DNA segment, STMS	4	L	Jacob et al. (1992)
<i>D4MIT5</i>	DNA segment, STMS	4	L	Jacob et al. (1992)
<i>D4MIT6</i>	DNA segment, STMS	4	L	Jacob et al. (1992)
<i>D4RP1</i>	DNA segment, MMU4 homolog	5	S	Szpirer et al. (1989b, 1990)
<i>D5CEP1</i>	DNA segment, STMS (A8)	5	L, S	Hilbert et al. (1991)
<i>D5GOT1</i>	DNA segment	5	A	Klinga et al. (1990)
<i>D5KYO1</i>	DNA segment, STMS	5	A, L, S	Kuramoto et al. (1993b)
<i>D6CEP1</i>	DNA segment, INS310-Hi-11	6	L	Hilbert et al. (1991)
<i>D6CEP2</i>	DNA segment, pMV10.2-Ha-10	6	L	Hilbert et al. (1991)
<i>D6CEP3</i>	DNA segment, pMV10.2-Ha-11	6	L	Hilbert et al. (1991)
<i>D6CEP4</i>	DNA segment, pMV10.2-Hi-4	6	L	Hilbert et al. (1991)
<i>D6CEP5</i>	DNA segment, pMV10.2-Hi-6	6	L	Hilbert et al. (1991)
<i>D6CEP6</i>	DNA segment, pMV10.2-Hi-7	6	L	Hilbert et al. (1991)
<i>D6CEP7</i>	DNA segment, pMV10.2-Hi-8	6	L	Hilbert et al. (1991)
<i>D6CEP8</i>	DNA segment, STMS (D3)	6	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>D7CEP1</i>	DNA segment, STMS (E5)	7	L, S	Serikawa et al. (1992b); Kondo et al. (1993)
<i>D7KYO1</i>	DNA segment, (mouse Myc)	7	L, S	Kondo et al. (1993)
<i>D7KYO2</i>	DNA segment, (mouse Wnt-1)	7	S	Kondo et al. (1993)
<i>D8CEP1</i>	DNA segment, pMV10.2-Ha-8	8	L	Hilbert et al. (1991)
<i>D8GOT1</i>	DNA segment	8	S	Levan et al. (1991)
<i>D9CEP1</i>	DNA segment, AW-Hi-10	9	L	Hilbert et al. (1991)
<i>D9KYO1</i>	DNA segment, RAPD	9	S	Serikawa et al. (1992a)
<i>D9KYO2</i>	DNA segment, STMS	9	S	Kuramoto et al. (1993b)
<i>D9S7h</i>	DNA segment	3	L	Kuramoto et al. (1993b)
<i>D10CEP1</i>	DNA segment, pASC-Hi-8	10	L	Hilbert et al. (1991)

Table 1. Continued.

Locus symbol	Locus name	Chr.	Mode	References
<i>D10KYO1</i>	DNA segment, (mouse Gfap)	10	L	Kondo et al. (1993)
<i>D10KYO2</i>	DNA segment, (mouse Sijje)	10	S	Kondo et al. (1993)
<i>D10MIT1</i>	DNA segment, STMS (RR24)	10	L	Jacob et al. (1991); Cash et al. (1993); Kuramoto et al. (1993a)
<i>D10MIT2</i>	DNA segment, STMS (RR92)	10	L	Jacob et al. (1991); Kuramoto et al. (1993a)
<i>D10MIT3</i>	DNA segment, STMS (RR1023)	10	L	Jacob et al. (1991); Cash et al. (1993)
<i>D10N1</i>	DNA segment, RAPD (F10F1)	10	L	Remmers et al. (1992); Cash et al. (1993)
<i>D10N2</i>	DNA segment, RAPD (F16F2)	10	L	Remmers et al. (1992)
<i>D11CEP1</i>	DNA segment, EFD-Ha-1	11	L	Hilbert et al. (1991)
<i>D12CEP1</i>	DNA segment, pMV10.2-Ha-3	12	L	Hilbert et al. (1991)
<i>D12CEP2</i>	DNA segment, YNZ2-Ha-4	12	L	Hilbert et al. (1991)
<i>D12CEP3</i>	DNA segment, YNZ22-Ha-2	12	L	Hilbert et al. (1991)
<i>D12CEP4</i>	DNA segment, STMS (H4)	12	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>D13KYO1</i>	DNA segment, RAPD	13	S	Serikawa et al. (1992a)
<i>D13KYO2</i>	DNA segment, RAPD	13	S	Serikawa et al. (1992a)
<i>D13KYO3</i>	DNA segment, STMS	13	L, S	Kuramoto et al. (1993b)
<i>D13KYO4</i>	DNA segment, (mouse Bcl-2)	13	L, S	Kondo et al. (1993)
<i>D14CEP1</i>	DNA segment, PER-Hi-1(4)	14	L	Hilbert et al. (1991)
<i>D14CEP2</i>	DNA segment, PER-Hi-4	14	L	Hilbert et al. (1991)
<i>D14CEP3</i>	DNA segment, YNZ2-Ha-7	14	L	Hilbert et al. (1991)
<i>D14CEP4</i>	DNA segment, YNZ2-Ha-14	14	L	Hilbert et al. (1991)
<i>D14CEP5</i>	DNA segment, YNZ2-Hi-1	14	L	Hilbert et al. (1991)
<i>D14CEP6</i>	DNA segment, YNZ2-Hi-5	14	L	Hilbert et al. (1991)
<i>D14CEP7</i>	DNA segment, YNZ2-Hi-13(5)	14	L	Hilbert et al. (1991)
<i>D14KYO1</i>	DNA segment, RAPD	14	S	Serikawa et al. (1992a)
<i>D14NS2</i>	DNA segment, STMS	14	L	Remmers et al. (1993a)
<i>D15KYO1</i>	DNA segment, STMS	15	S	Kuramoto et al. (1993b)
<i>D16CEP1</i>	DNA segment, pASC-Ha-6	16	L	Hilbert et al. (1991)
<i>D16FC1</i>	DNA segment	16	A	Yeung et al. (1993)
<i>D16KYO1</i>	DNA segment, STMS	16	L, S	Kuramoto et al. (1993b)
<i>D17CEP1</i>	DNA segment, YNH24-Ha-4	17	L	Hilbert et al. (1991)
<i>D17CEP2</i>	DNA segment, YNH24-Hi-7	17	L	Hilbert et al. (1991)
<i>D17CEP3</i>	DNA segment, STMS (F4)	17	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>D17TPL2</i>	DNA segment (Tpl2)	17	A	Yeung et al. (1993)
<i>D18CEP1</i>	DNA segment, AW-Ha-13	18	L	Hilbert et al. (1991)
<i>D18CEP2</i>	DNA segment, PER-Hi-5	18	L	Hilbert et al. (1991)
<i>D18CEP3</i>	DNA segment, pUCJ-Hi-6	18	L	Hilbert et al. (1991)
<i>D18CEP4</i>	DNA segment, YNZ2-Hi-14	18	L	Hilbert et al. (1991)
<i>D18CEP5</i>	DNA segment, YNZ2-Hi-19	18	L	Hilbert et al. (1991)
<i>D18MIT1</i>	DNA segment, STMS (RR1094)	18	S	Jacob et al. (1991)
<i>D18N1R</i>	DNA segment, STMS	18	L	Remmers et al. (1993b)
<i>D19CEP1</i>	DNA segment, AW-Ha-1	19	L	Hilbert et al. (1991)
<i>D19CEP2</i>	DNA segment, AW-Ha-3	19	L	Hilbert et al. (1991)
<i>D19CEP3</i>	DNA segment, AW-Hi-2	19	L	Hilbert et al. (1991)
<i>D19CEP4</i>	DNA segment, pASC-Hi-1	19	L	Hilbert et al. (1991)
<i>D19CEP5</i>	DNA segment, pASC-Hi-5(3)	19	L	Hilbert et al. (1991)
<i>D19CEP6</i>	DNA segment, pUCJ-Ha-5	19	L	Hilbert et al. (1991)
<i>D19SF1</i>	DNA segment, CAC5-1	19	L	Pravenec et al. (1992)
<i>D19SF2</i>	DNA segment, MS15-2	19	L	Pravenec et al. (1992)
<i>D20CEP1</i>	DNA segment, AW-Hi-6	20	L	Hilbert et al. (1991)
<i>D20CEP2</i>	DNA segment, AW-Hi-11	20	L	Hilbert et al. (1991)
<i>D20CEP3</i>	DNA segment, pASC-Ha-7	20	L	Hilbert et al. (1991)
<i>D20CEP4</i>	DNA segment, pASC-Hi-9	20	L	Hilbert et al. (1991)
<i>D20CEP5</i>	DNA segment, PER-Hi-13	20	L	Hilbert et al. (1991)
<i>D20CEP6</i>	DNA segment, pMV10.2-Hi-2	20	L	Hilbert et al. (1991)
<i>D20KYO1</i>	DNA segment, (mouse Tnfa)	20	L, S	Kondo et al. (1993)
<i>DBP</i>	D site of albumin promoter binding protein	1	S	Szpirer et al. (1992a)
<i>DDC</i>	DOPA-decarboxylase	14	S	Vassort et al. (1993)
<i>DHFR1</i>	dihydrofolate reductase 1	2	S	Hanson et al. (1990)
<i>DHFR2</i>	dihydrofolate reductase 2	4	S	Hanson et al. (1990)
<i>DI</i>	diabetes insipidus	3	L	Stolc (1984a)
<i>DIA4</i>	diaphorase 4 (NADA/NADPH)	19	S	Yasue et al. (1991)
<i>DPRP</i>	decidual prolactin-related protein	17	S	Roby et al. (1993)
<i>DRD1L</i>	dopamine receptor, D1-like-2	14	L	Remmers et al. (1993a)
<i>DSII</i>	a region of proviral insertions in Moloney MuLV-induced rat thymomas	5	S	Szpirer et al. (1989b, 1990)
<i>DW3</i>	dwarf-3	20	L	Gill, Kunz (1979)
<i>DXCEP1</i>	DNA segment, INS310-Hi-3(11)	X	L	Hilbert et al. (1991)
<i>DXCEP2</i>	DNA segment, INS310-Hi-9(4)	X	L	Hilbert et al. (1991)
<i>DXCEP3</i>	DNA segment, pASC-Hi-6(2)	X	L	Hilbert et al. (1991)
<i>DXCEP4</i>	DNA segment, PER-Ha-2(2)	X	L	Hilbert et al. (1991)
<i>DXCEP5</i>	DNA segment, PER-Ha-7	X	L	Hilbert et al. (1991)
<i>DXCEP6</i>	DNA segment, PER-Hi-12	X	L	Hilbert et al. (1991)
<i>EAG1</i>	endothelial antigen 1	13	L	Cramer et al. (1985)
<i>EGFR</i>	epidermal growth factor receptor, (ERBB1)	14	S	Szpirer et al. (1991b)
<i>ELA1</i>	elastase 1, (elail)	7	L, S	Serikawa et al. (1992b); Kunieda et al. (1992a)
<i>ENO1</i>	enolase 1	5	S	Yoshida (1978, 1982)
<i>ENO2</i>	enolase 2	4	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>EPO</i>	erythropoietin	4	S	Levan et al. (1991)

Table 1. Continued.

Locus symbol	Locus name	Chr.	Mode	References
<i>ERBB2</i>	avian erythroblastosis viral oncogene homolog B2, (neu)	10	L, S	Szpirer et al. (1991b), Remmers et al. (1992)
<i>ES1</i>	esterase 1	19	L	Augustinsson, Henricson (1966); Womack (1973); Osten et al. (1993)
<i>ES2</i>	esterase 2	19	L	Womack, Sharp (1976); Serikawa et al. (1992b); Pravenec et al. (1992); Osten et al. (1993)
<i>ES3</i>	esterase 3	19	L	Womack (1972); Pravenec et al. (1992)
<i>ES4</i>	esterase 4	19	L	Womack, Sharp (1976)
<i>ES6</i>	esterase 6	8	L	Pravenec et al. (1987); Serikawa et al. (1992b); Kobayashi et al. (1992b)
<i>ES7</i>	esterase 7	19	L	Matsumoto (1980)
<i>ES8</i>	esterase 8	19	L	Matsumoto (1980)
<i>ES9</i>	esterase 9	19	L	Hedrich, Deimling (1987a)
<i>ES10</i>	esterase 10	19	L, S	Hedrich, Deimling (1987a); Pravenec et al. (1992)
<i>ES14(SI)</i>	esterase 14	19	L	Yamada et al. (1980); Hedrich et al. (1987b); Pravenec et al. (1992)
<i>ES15</i>	esterase 15	19	L	Hedrich et al. (1987b)
<i>ES16</i>	esterase 16	19	L	Hedrich et al. (1987b)
<i>ES18</i>	esterase 18	19	L	Hedrich et al. (1987b)
<i>ESD</i>	esterase D	15	S	Yasue et al. (1991)
<i>F</i>	fawn	3	L	Robinson (1982)
<i>F5</i>	coagulation factor 5	13	S	Dahlbäck et al. (1988)
<i>FA</i>	fatty	5	L	Truett et al. (1991)
<i>FABP1</i>	fatty acid binding protein, liver, (fabplg)	4	L, S	Serikawa et al. (1992b); Kunieda et al. (1992a)
<i>FDP</i>	fructose-1,6-bisphosphatase	17	S	Fulchignoni-Lataud et al. (1992)
<i>FGA</i>	fibrinogen, alpha	2	A, S, L	Marino et al. (1986); Serikawa et al. (1992b)
<i>FGB</i>	fibrinogen, beta	2	A, S	Marino et al. (1986); Szpirer et al. (1987, 1988b)
<i>FGG</i>	fibrinogen, gamma, (fibg2)	2	A, S, L	Marino et al. (1986); Serikawa et al. (1992b); Kunieda et al. (1992a); Zha et al. (1993)
<i>FH</i>	fumarate hydratase	13	L	Carleer, Ansay (1975); Cramer et al. (1985); Kuramoto et al. (1993b)
<i>FOS</i>	murine FBI viral oncogene homolog	6	A	Li et al. (1989)
<i>FPGS</i>	folypolyglutaminase synthetase	3	S	Levan et al. (1986)
<i>FST</i>	folistatin	2	L, S	Serikawa et al. (1992b)
<i>FT</i>	fertility	20	L	Skow et al. (1985); Gill et al. (1979, 1982)
<i>FUCA</i>	alpha-L-fucosidase	5	S	Yoshida (1978)
<i>FZ</i>	fuzzy	1	L	Palm, Ferguson (1976)
<i>G6PD</i>	glucose-6-phosphate dehydrogenase	X	S	Yoshida (1978)
<i>GAD1</i>	glutamic acid decarboxylase 1	3	S	Vassort et al. (1993)
<i>GAD2</i>	glutamic acid decarboxylase 2	17	S	Vassort et al. (1993)
<i>GALK</i>	galactokinase	10	S	Levan et al. 1986)
<i>GANC</i>	alpha-glucosidase, neutral C	3	S	Yasue et al. (1991)
<i>GC</i>	group-specific component (GL1, VDBG)	14	L, S	Moutier et al. (1973b); Cooke et al. (1987)
<i>GCK</i>	glucokinase (GLUKA)	14	L, S	Serikawa et al. (1992b); Remmers et al. (1993a)
<i>GDC1</i>	alpha-glycerophosphate dehydrogenase	8	L	Eriksson et al. (1976); Serikawa et al. (1992b)
<i>GDH</i>	glucose dehydrogenase	5	S	Yoshida (1984b)
<i>GGTB2</i>	glycoprotein 3-beta-galactosyl transferase 2	5	S	Szpirer et al. (1989b)
<i>GH</i>	growth hormone (RD17)	10	L, S	Cooke et al. (1986); Hilbert et al. (1991); Jacob et al. (1991); Serikawa et al. (1992b); Remmers et al. (1992); Kuramoto et al. (1993a)
<i>GJA1</i>	gap junction protein, heart (connexin 43)	18	L, S	Serikawa et al. (1992b); Remmers et al. (1993b)
<i>GLA</i>	alpha-galactosidase	X	S	Levan et al. (1986)
<i>GLB1</i>	beta-galactosidase	8	S	Yasue et al. (1991)
<i>GLO1</i>	glyoxalase	20	L, S	Stolc et al. (1980); Gill et al. (1982); Yasue et al. (1991)
<i>GLS</i>	glutaminase (glut)	9	S	Mock et al. (1989); Kunieda et al. (1992a)
<i>GLUT1</i>	glucose transporter, brain, (GLUTB, gtg3)	5	L, S	Szpirer et al. (1990); Serikawa et al. (1992b); Kunieda et al. (1992a); Kuramoto et al. (1993b)
<i>GOT1</i>	glutamic oxaloacetic transaminase 1	1	S	Levan et al. (1986)
<i>GPD1</i>	glucose-6-phosphate dehydrogenase	(XIII)*	L	Kendall (1985)
<i>GPI</i>	glucosephosphate isomerase	1	S	Yoshida (1984a)
<i>GRL</i>	glucocorticoid receptor	18	L, S	Hilbert et al. (1991); Goldner-Sauvé et al. (1991); Serikawa et al. (1992b)
<i>GST</i>	glutathione-S-transferase, placental	1	A, S	Masuda et al. (1986); Yasue et al. (1992)
<i>GSTA1</i>	glutathione-S-transferase Ya	8	S	Yamada et al. (1992)
<i>GSTA2</i>	glutathione-S-transferase Yc	9	S	Yamada et al. (1992)
<i>GSTA3</i>	glutathione-S-transferase Yb1	2	S	Muramatsu et al. (1993)
<i>GSTA4</i>	glutathione-S-transferase Yb2	2	S	Muramatsu et al. (1993)
<i>GSTPL1</i>	glutathione-S-transferase like 1	3	S	Yasue et al. (1992)
<i>GSTPL2</i>	glutathione-S-transferase like 2	5	S	Yasue et al. (1992)
<i>GSTPL3</i>	glutathione-S-transferase like 3	8	S	Yasue et al. (1992)
<i>GSTPL4</i>	glutathione-S-transferase like 4	10	S	Yasue et al. (1992)
<i>GSTPL5</i>	glutathione-S-transferase like 5	16	S	Yasue et al. (1992)
<i>GSTPL6</i>	glutathione-S-transferase like 6	X	S	Yasue et al. (1992)
<i>GUSB</i>	beta-glucuronidase	12	S	Yasue et al. (1991)
<i>H</i>	hooded	14	L	Moutier et al. (1973b)
<i>HAGH</i>	hydroxyacyl glutathione hydrolase	2	S	Yasue et al. (1991)
<i>HAO1</i>	hydroxiacid oxidase, (GOX1)	3	L, S	Yamada et al. (1989); Serikawa et al. (1992b); Kondo et al. (1993); Kuramoto et al. (1993b)

Table 1. Continued.

Locus symbol	Locus name	Chr.	Mode	References
<i>HBB</i>	hemoglobin beta chain	1	L	Brdicka (1968); French et al. (1971); Lindpaintner et al. (1992); Goldmuntz et al. (1993)
<i>HC</i>	hemagglutinin capacity	20	L	Heslop, Jolly (1979)
<i>HD</i>	hypodactyly	5	L	Moutier et al. (1973c); Moutier (1980)
<i>HDC</i>	histidine carboxylase	3	S	Sullivan et al. (1991)
<i>HE</i>	hematoma	1	L	Dunning, Curtis (1939)
<i>HEOXG</i>	heme oxygenase	19	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>HEXA</i>	hexosaminidase A	8	S	Yasue et al. (1991)
<i>HGF</i>	hepatic growth factor	4	S	Szpirer et al. (1992a)
<i>HH1TTS</i>	testis-specific histone, H1t and H4t	17	S	Serikawa et al. (1992b)
<i>HM</i>	hooded modifier	14	L	Stolc (1984b)
<i>HNF1A</i>	hepatic nuclear factor 1, (TCF1)	12	S	Szpirer et al. (1992a)
<i>HP</i>	haptoglobin, (hpb)	19	L, S	Serikawa et al. (1992b); Kunieda et al. (1992a)
<i>HPRT</i>	hypoxanthine phosphoribosyl transferase	X	S	Yoshida (1978); Szpirer et al. (1984)
<i>HRAS</i>	Harvey rat sarcoma viral oncogene homolog	1	S	Szpirer et al. (1985); Fang et al. (1985)
<i>HRASP</i>	Harvey sarcoma proto-oncogene	X	S	Szpirer et al. (1985)
<i>HSD3B</i>	hydroxy-delta-5-steroid dehydrogenase	2	L	Zha et al. (1993)
<i>HSP70</i>	heat shock protein 70	20	L	Wurst et al. (1989)
<i>HTR1A</i>	5-hydroxytryptamine-1a receptor	2	S	Serikawa et al. (1992b)
<i>HX</i>	histocompatibility X	X	—	Mullen, Hilderman (1972)
<i>HY</i>	histocompatibility Y	Y	—	Mullen, Hilderman (1972)
<i>HYD</i>	hydrocephalus	X	—	Koto et al. (1987)
<i>IC</i>	ichthyosis	1	L	Knox, Lister-Rosenoer (1978)
<i>IA</i>	incisor absence	5	L	Greep (1941); Moutier (1980)
<i>IDH1</i>	isocitrate dehydrogenase 1	9	S	Yasue et al. (1991)
<i>IFNA</i>	interferon, alpha	5	S	Islam et al. (1989)
<i>IFNB1</i>	interferon, beta	5	S	Szpirer et al. (1989b, 1990)
<i>IGF1</i>	insulin-like growth factor I	7	L, S	Serikawa et al. (1992b)
<i>IGF2</i>	insulin-like growth factor II	1	L, S	Serikawa et al. (1992b); Lindpaintner et al. (1992); Goldmuntz et al. (1993)
<i>IGFBP</i>	insulin-like growth factor binding protein (IGF-BP3)	14	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>IGH1</i>	Ig heavy chain 1	6	L	Bazin et al. (1974)
<i>IGH2</i>	Ig heavy chain 2	6	CH, S	Schröder et al. (1980); Pear et al. (1986)
<i>IGH3</i>	Ig heavy chain 3	6	L	Beckers, Bazin (1975)
<i>IGHE</i>	Ig heavy chain, epsilon	6	L, S	Pear et al. (1986); Hilbert et al. (1991); Serikawa et al. (1992b)
<i>IGK</i>	immunoglobulin kappa chain 1, (D4MIT8)	4	L, S, W	Collard et al. (1982); Perlmann et al. (1985); Jacob et al. (1992)
<i>IGL</i>	immunoglobulin lambda chain	11	S	Szpirer et al. (1988a)
<i>IL3</i>	interleukin 3	10	L	Kunieda et al. (1992b)
<i>IL6</i>	interleukin 6, (il6g)	4	S	Szpirer et al. (1991b); Serikawa et al. (1992b); Kunieda et al. (1992a)
<i>IL6R1</i>	interleukin 6 receptor	2	S	Szpirer et al. (1991c)
<i>INHHA</i>	inhibin, alpha-subunit, (inhab1)	9	S	Serikawa et al. (1992b); Kunieda et al. (1992a)
<i>INS1</i>	insulin 1	1	A, L	Soares et al. (1985); Mori et al. (1992a)
<i>INS2</i>	insulin 2	1	A	Soares et al. (1985)
<i>IRJHM</i>	immune response to JHM	14	L	Watanabe et al. (1987); Hedrich et al. (1989)
<i>ITGA4</i>	integrin alpha-4	3	S	Szpirer et al. (1992b)
<i>ITGA5</i>	integrin alpha-5	7	S	Szpirer et al. (1992b)
<i>ITGB1</i>	integrin beta-1	19	S	Szpirer et al. (1992b)
<i>ITPA</i>	inosine triphosphatase 1	3	S	Yasue et al. (1991)
<i>IVD</i>	isovaleryl-CoA dehydrogenase	3	S	Szpirer et al. (1989a); Serikawa et al. (1992b)
<i>K</i>	kinky	(III)*	L	Castle, King (1944)
<i>KAL</i>	kallikrein, renal	1	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>KCPVD</i>	K <sup>+</sup> channel protein, voltage dependent	4	S	Serikawa et al. (1992b)
<i>KRAS2</i>	Kirsten rat viral oncogene homolog (v-Ki-ras 2)	4	S	Szpirer et al. (1985)
<i>LALBA</i>	alpha-lactalbumin	7	S	Serikawa et al. (1992b)
<i>LAP1</i>	leucin arylaminopeptidase	1	L	van Zutphen et al. (1981, 1985); Serikawa et al. (1992b)
<i>LCA</i>	leucocyte common antigen, (CD45)	13	S	Goldner-Sauvé et al. (1991); Serikawa et al. (1992b)
<i>LCK1</i>	lymphocyte tyrosine kinase 1	5	S	Szpirer et al. (1989b, 1990)
<i>LCK2</i>	lymphocyte tyrosine kinase 2	7	S	Szpirer et al. (1989b, 1990)
<i>LDHA</i>	lactate dehydrogenase A	1	S	Yoshida (1984a)
<i>LDHB</i>	lactate dehydrogenase B	4	S	Yasue et al. (1991)
<i>LDR1</i>	LDHA regulator 1	1	L	Stolc, Gill (1983)
<i>LG</i>	Grüneberg lethal	1	L	Grüneberg (1939)
<i>LSN</i>	leukosianin	1	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Lindpaintner et al. (1992)
<i>LSNR</i>	leukosianin-related	12	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>LX</i>	polydactyly-luxate	8	L	Kren (1975)
<i>LY2</i>	peripheral T-cell antigen	1	L	DeWitt, McCullough (1975); Butcher et al. (1979)
<i>LYP</i>	T-cell lymphopenia	4	L	Jacob et al. (1992)
<i>MANB</i>	mannosidase, alpha B, lysosomal	20	L	van de Berg et al. (1981)
<i>MBP</i>	myelin basic protein	18	L, S	Yasue et al. (1991); Goldner-Sauvé et al. (1991); Serikawa et al. (1992b)
<i>MBPA</i>	mannose-binding protein (serum) A	16	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Kuramoto et al. (1993b)
<i>MDH2</i>	malate dehydrogenase, mitochondrial	12	L, S	Serikawa et al. (1992b)
<i>MDHL</i>	malate dehydrogenase like enzyme	3	L	Matsumoto et al. (1982)
<i>ME1</i>	malic enzyme 1 (solubule)	8	S	Levan et al. (1986)

Table 1. Continued.

Locus symbol	Locus name	Chr.	Mode	References
<i>MLVI2</i>	Moloney MuLV integration site 2, ( <i>mlvi2e</i> )	2	S	Tsichlis et al. (1985); Kunieda et al. (1992a)
<i>MLVI3</i>	Moloney MuLV integration site 3	15	S	Tsichlis et al. (1985)
<i>MLVI4</i>	Moloney MuLV integration site 4	7	S	Hanson et al. (1988); Tsichlis et al. (1989)
<i>MOS</i>	Moloney sarcoma oncogene ( <i>v-mos</i> )	5	S	Szpirer et al. (1989b, 1990)
<i>MPI</i>	mannose phosphate isomerase	8	S	Yoshida (1978)
<i>MT1PA</i>	metallothionein-1 pseudogene a	1	L, S	Serikawa et al. (1992b)
<i>MT1PB</i>	metallothionein-1 pseudogene b	2	L, S	Serikawa et al. (1992b)
<i>MUP1</i>	major urinary protein 1	5	L	van Zutphen et al. (1981); Nikaido et al. (1982)
<i>MX1</i>	interferon-inducible protein 78KDa, homolog of murine myxovirus resistance 1	11	S	Levan et al. (1991, Haller et al.)
<i>MYB</i>	avian myeloblastosis viral oncogene homolog ( <i>v-myb</i> )	1	S	Yasue et al. (1992)
<i>MYC</i>	<i>c-myc</i> oncogene	7	A, CH, L, S	Wiener et al. (1982); Stümegi et al. (1983); Tsichlis et al. (1985); Serikawa et al. (1992b); Kunieda et al. (1992a); Kondo et al. (1993)
<i>MYCB</i>	MYC-like oncogene	3	S	Ingvarsson et al. (1988b)
<i>MYCL1</i>	MYC-like oncogene	5	S	Ingvarsson et al. (1987, 1988b)
<i>MYCN</i>	MYC-like oncogene	6	S	Ingvarsson et al. (1987, 1988b)
<i>MYCS</i>	s-myc protein	X	L, S	Serikawa et al. (1992b)
<i>MYHSE</i>	myosin heavy chain, embryonic skeletal muscle. (RD9), (MYH3)	10	L, S	Hilbert et al. (1991); Jacob et al. (1991); Serikawa et al. (1992b); Remmers et al. (1992); Cash et al. (1993); Kuramoto et al. (1993a)
<i>MYL2</i>	myosin light chain, muscle 2	1	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Lindpaintner et al. (1992); Goldmuntz et al. (1993)
<i>MYLC1V</i>	myosin light chain, alkali, cardiac ventricles	8	L, S	Serikawa et al. (1992b)
<i>NCAM</i>	neural cell adhesion molecule	8	L, S	Yasue et al. (1992); Kobayashi et al. (1992b)
<i>NEFM</i>	neurofilament protein middle polypeptide	15	S	Yasue et al. (1992)
<i>NEFML</i>	neurofilament protein-like	14	S	Yasue et al. (1992)
<i>NEU1</i>	neuraminidase-1	20	L	van de Berg et al. (1981)
<i>NGFB</i>	nerve growth factor, beta	2	S	Levan et al. (1991)
<i>NGFG</i>	nerve growth factor, gamma	1	S	Yasue et al. (1992)
<i>NGFI</i>	nerve growth factor-induced gene	18	S	Serikawa et al. (1992b)
<i>NGFR</i>	nerve growth factor receptor, fast	10	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Kondo et al. (1993)
<i>NP</i>	nucleoside phosphorylase 1	15	S	Yasue et al. (1991)
<i>NPY</i>	neuropeptide Y, (D4MIT7)	4	L, S	Serikawa et al. (1992b); Jacob et al. (1992)
<i>NRAS2</i>	neuroblastoma homolog 2 ( <i>v-ras</i> )	1	L	Kunieda et al. (1990)
<i>OLF</i>	olf-alpha (olfactory specific G) protein	18	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Remmers et al. (1993b)
<i>ORM</i>	orosomucoid	5	S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>P</i>	pink eyed dilution	1	L	Brdicka (1968)
<i>P9KA</i>	protein 9Ka	2	L, S	Serikawa et al. (1992b)
<i>PA</i>	placental antigen	20	L	Misra et al. (1989a, 1989b)
<i>PAH</i>	phenylalanine hydroxylase	7	S	Fulchignoni-Lataud et al. (1990)
<i>PBPC1</i>	prostatic binding protein 1	5	A	Zhang et al. (1988)
<i>PBPC2</i>	prostatic binding protein 2, C2	1	A, L, S	Serikawa et al. (1992b)
<i>PBPC3</i>	prostatic binding protein 3	5	A	Zhang et al. (1988)
<i>PCCB</i>	propionyl-CoA carboxylase, beta	8	S	Szpirer et al. (1989a)
<i>PCK</i>	phosphoenolpyruvate carboxykinase	3	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>PDGFB</i>	platelet-derived growth factor beta oncogene homolog ( <i>v-sis</i> )	7	S	Fang et al. (1985)
<i>PEPB</i>	peptidase 2	7	S	Yasue et al. (1991)
<i>PEPC</i>	peptidase 3	13	L	Womack, Cramer (1980); Cramer et al. (1986); Serikawa et al. (1992b); Kondo et al. (1993)
<i>PEPD</i>	peptidase 4	1	S	Yoshida (1984a)
<i>PEPS</i>	peptidase 7	14	S	Yasue et al. (1991)
<i>PERF</i>	peripherin	7	L, S	Serikawa et al. (1992b); Kondo et al. (1993)
<i>PF4</i>	platelet factor 4	14	L	Remmers et al. (1993a)
<i>PFK2</i>	phosphofructokinase 2	X	S	Darville et al. (1989)
<i>PFKFB1</i>	6-phosphofructo-2-kinase/fructose-2,6-bisphosphatase, liver and muscle	X	A, L, S	Hilliker et al. (1991); Hilbert et al. (1991); Serikawa et al. (1992b)
<i>PFKFB2</i>	6-phosphofructo-2-kinase/fructose-2,6-bisphosphatase, heart	13	S	Hilliker et al. (1991)
<i>PFLG</i>	profilagrin	2	S	Serikawa et al. (1992b)
<i>PG1</i>	pepsinogen 1	(XII)*	L	Cramer (1981); Hamada et al. (1987)
<i>PG2</i>	pepsinogen 2	(XII)*	L	Hamada et al. (1987)
<i>PGD</i>	phosphogluconate dehydrogenase	5	L, S	Koga et al. (1972); Carter, Parr (1969); Serikawa et al. (1992b)
<i>PGK</i>	phosphoglycerate kinase	X	S	Levan et al. (1986); Serikawa et al. (1992b)
<i>PGM1</i>	phosphoglucomutase 1	5	S	Koga et al. (1972); Yoshida (1979, 1982)
<i>PGY1</i>	P-glycoprotein 1/multi drug resistance 1	4	S	Hanson et al. (1988)
<i>PI</i>	alpha 1-antitrypsin	6	S	Fulchignoni-Lataud et al. (1992)
<i>PIM1</i>	proviral integration, MCF	20	S	Yasue et al. (1992)
<i>PKATA</i>	peroxisomal 3-ketoacyl-CoA thiolase	8	L, S	Serikawa et al. (1992b)
<i>PKC</i>	protein kinase C type 1	1	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>PKCS</i>	protein F1 (substrate of protein kinase C)	11	S	Serikawa et al. (1992b)
<i>PKL</i>	pyruvate kinase, L-type	2	L, S	Fulchignoni-Lataud et al. (1990); Serikawa et al. (1992b); Zha et al. (1993)
<i>PL2</i>	placental antigen 2	17	S	Levan et al. (1991)
<i>PLCD1</i>	phospholipase C-delta 1	8	S	Katsuya et al. (1992)

Table 1. Continued.

Locus symbol	Locus name	Chr.	Mode	References
<i>PLANH</i>	plasminogen activator inhibitor	12	L, S	Serikawa et al. (1992b)
<i>PLP</i>	parathyroid-like peptide	2 or 4	S	Hendy et al. (1988); Levan et al. (1990)
<i>PLPA</i>	prolactin-like protein A	17	S	Levan et al. (1991)
<i>PLPB</i>	prolactin-like protein B	17	S	Levan et al. (1991)
<i>PLPC</i>	prolactin-like protein C	17	S	Deb et al. (1991)
<i>PMCH</i>	pro-melanin-concentrating hormone	7	S	Nahon et al. (1992)
<i>PND</i>	pronatriodilatin (atrial natriuretic factor), (anf)	5	L, S	Szpirer et al. (1989b, 1990); Serikawa et al. (1992b); Kunieda et al. (1992a); Kuramoto et al. (1993b)
<i>PP</i>	pyrophosphatase, inorganic	20	S	Yasue et al. (1991)
<i>PP63</i>	insulin receptor tyrosine kinase inhibitor	11	S	Falquerho et al. (1991)
<i>PPY</i>	pancreatic polypeptide	10	L, S	Serikawa et al. (1992b); Remmers et al. (1992); Cash et al. (1993); Kuramoto et al. (1993a); Kondo et al. (1993)
<i>PRL</i>	prolactin	17	A, L, S	Cooke et al. (1986); Hilbert et al. (1991); Serikawa et al. (1992b)
<i>PRLR</i>	prolactin receptor	2	L, S	Serikawa et al. (1992b)
<i>PRM1</i>	protamine-1, spermatid specific	10	S	Adham et al. (1991)
<i>PRPS2</i>	phosphoribosylpyrophosphate synthetase subunit II	X	L, S	Serikawa et al. (1992b)
<i>PRR1</i>	ventral prostatic proline rich polypeptide	10	A	Zhang et al. (1989)
<i>PRT1</i>	protenase-1, submandibular gland	1	L	von Deimling, Günther (1982)
<i>PRT2</i>	protenase-2, submandibular gland	1	L	von Deimling, Günther (1982)
<i>PTH</i>	parathyroid hormone	1	S	Levan et al. (1986)
<i>PTHR</i>	parathyroid hormone related	1	L	Goldmuntz et al. (1993)
<i>PTH LH</i>	parathyroid hormone-like peptide	4	L, S	Hendy et al. (1988); Szpirer et al. (1991a); Serikawa et al. (1992b)
<i>PTP</i>	protein-tyrosine-phosphatase	3	L, S	Serikawa et al. (1992b)
<i>PVT1</i>	MYC activator, Moloney murine leukemia virus integration site 1, (MLV11, MIS1)	7	S	Tsichlis et al. (1985); Koehne et al. (1989)
<i>R</i>	red-eyed dilution	1	L	Castle, King (1949)
<i>RAF1</i>	3611-MSL viral oncogene	4	S	Ingvarsson et al. (1988a)
<i>RAFAS</i>	breakage region for RAF-rearrangement	13	S	Ingvarsson et al. (1988a)
<i>RARA</i>	retinoic acid receptor, alpha chain	10	S	Levan et al. (1991)
<i>RARB</i>	retinoic acid receptor, beta chain	15	S	Levan et al. (1991)
<i>RARG</i>	retinol acid receptor, gamma chain	7	S	Mattei et al. (1991)
<i>RB1</i>	retinoblastoma protein	15	S	Szpirer et al. (1991b)
<i>RBP2</i>	retinol binding protein II, cellular	8	L, S	Serikawa et al. (1992b)
<i>RDY</i>	retinal dystrophy	3	L	La Vail (1981)
<i>REN</i>	renin	13	A, L, S	Pravence et al. (1991); Mori et al. (1992b); Serikawa et al. (1992b); Kuramoto et al. (1993b)
<i>RN5S1</i>	ribosomal 5s RNA 1	12	A	Szabo et al. (1978)
<i>RN5S2</i>	ribosomal 5s RNA 2	19	A	Szabo et al. (1978)
<i>RNR1</i>	ribosomal 18s and 28s RNA	3	A, CH	Kano et al. (1976); Szabo et al. (1978); Sasaki et al. (1986)
<i>RNR2</i>	ribosomal 18s and 28s RNA	11	A, CH	Kano et al. (1976); Szabo et al. (1978); Sasaki et al. (1986)
<i>RNR3</i>	ribosomal 18s and 28s RNA	12	A, CH	Kano et al. (1976); Szabo et al. (1978); Sasaki et al. (1986)
<i>RNU1</i>	small nuclear RNA Ulb 3	2	A	Levan et al. (1991)
<i>RONU</i>	Rowett nude (RNU)	10	L	Cash et al. (1993); Kuramoto et al. (1993a)
<i>RPL35P</i>	ribosomal protein L35a related pseudogene	17	S	Serikawa et al. (1992b)
<i>RT1A</i>	MHC-A (class I)	20	L	Bogden, Aptekman (1960); Frenzl et al. (1960); Palm (1962, 1971)
<i>RT1B</i>	MHC-B (class II), D20RWH1	20	L, S	Stark et al. (1977); Lobel, Cramer (1981); Locker et al. (1990); Jacob et al. (1992)
<i>RT1C</i>	MHC-C	20	L	Kohoutova et al. (1980)
<i>RT1D</i>	MHC-D	20	L	Lobel, Cramer (1981)
<i>RT1E</i>	MHC-E	20	L	Kunz et al. (1982)
<i>RT2</i>	cell surface alloantigen	19	L	Owen (1962); Palm (1962); Pravenec et al. (1992)
<i>RT3</i>	cell surface alloantigen	13	L	Brdicka, Frenzl (1978)
<i>RT4</i>	cell surface alloantigen	1	L	Kren et al. (1973)
<i>RT5</i>	cell surface alloantigen	8	L	Kren et al. (1973); Kren (1975)
<i>RT6</i>	cell surface alloantigen	1	L	DeWitt, McCullough (1975)
<i>RT9</i>	cell surface alloantigen	19	L	Kunz et al. (1985)
<i>RT11</i>	cell surface alloantigen	20	L	Kunz et al. (1989)
<i>RTLH1</i>	cell surface alloantigen	20	L	Wonigeit (1979)
<i>RTP1</i>	rat tear protein 1	5	L	Kondo et al. (1987, 1988)
<i>RTP2</i>	rat tear protein 2	1	L	Kondo et al. (1987, 1989)
<i>RW</i>	warfarin resistance	1	L	Greaves, Ayres (1969, 1976, 1977)
<i>S</i>	silver	5	L	Castle (1953)
<i>SA</i>	SA gene	1	L	Lindpaintner et al. (1992)
<i>SAI1</i>	transformation suppressor	5	CH	Islam et al. (1989)
<i>SCN2A</i>	sodium channel II, alpha	3	L, S	Hilbert et al. (1991); Yasue et al. (1992); Serikawa et al. (1992b); Kuramoto et al. (1993b)
<i>SECR</i>	secretin	1	S	Serikawa et al. (1992b)
<i>SH</i>	shaggy	5	L	Castle, King (1947)
<i>SHBG</i>	sex hormone-binding globulin (ABP)	10	L, S	Sullivan et al. (1991); Hilbert et al. (1991); Serikawa et al. (1992b); Remmers et al. (1992); Cash et al. (1993); Kuramoto et al. (1993a)



Table 1. Continued.

Locus symbol	Locus name	Chr.	Mode	References
<i>SHDL</i>	steroid hydroxylase, hepatic	1	S	Serikawa et al. (1992b)
<i>SMST</i>	somatostatin	11	L, S	Yasue et al. (1992); Serikawa et al. (1992b)
<i>SORD</i>	sorbitol dehydrogenase	3	S	Yasue et al. (1991)
<i>SP</i>	serum protein	20	L	Cramer (1983)
<i>SP1</i>	Sp-1 transcription factor	7	S	Szpirer et al. (1991c)
<i>SPAT</i>	serine, pyruvate aminotransferase, (AGXT)	9	A, S	Mori et al. (1992d)
<i>SPIN1</i>	serine protease inhibitor 1	6	S	Pagés et al. (1990)
<i>SPIN2</i>	serine protease inhibitor 2	6	S	Pagés et al. (1990)
<i>SPIN3</i>	serine protease inhibitor 3	6	S	Pagés et al. (1990)
<i>ST</i>	stub	(III)*	L	Castle, King (1944)
<i>SVP1</i>	seminal vesicle protein 1	3	L	Gasser (1972); Moutier et al. (1973a)
<i>SVS2P</i>	seminal vesicle secretion II protein	3	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Kondo et al. (1993); Kuramoto et al. (1993b)
<i>SVS4</i>	seminal vesicle secretion IV	3	L	Kobayashi et al. (1992a)
<i>SYB2</i>	synaptobrevin 2 (vesicle associated membrane protein, VAMP-2)	10	L, S	Archer III et al. (1990); Hilbert et al. (1991); Serikawa et al. (1992b); Kuramoto et al. (1993a)
<i>TAC</i>	tachykinin (D4MIT1)	4	L	Jacob et al. (1992)
<i>TAC1R</i>	tachykinin 1 (substance P) receptor	4	S, A, L	Mori et al. (1992c); Hilbert et al. (1991); Serikawa et al. (1992b)
<i>TAC2R</i>	tachykinin 2 (substance K) receptor	20	S	Mori et al. (1992c)
<i>TAC3R</i>	tachykinin 3 (neuromedine K) receptor	2	S	Mori et al. (1992c)
<i>TAL2</i>	tail anomaly lethal 2	1	L	Morris-Kay, Hunt (1986)
<i>TAM1</i>	tamase (submaxillary gland)	1	L	Matsumoto et al. (1984)
<i>TAT</i>	tyrosine aminotransferase	19	L, S	Fulchignoni-Lataud et al. (1990); Serikawa et al. (1992b)
<i>TBM1</i>	tubular basement membrane 1	1	L	Matsumoto et al. (1984)
<i>TBM2</i>	tubular basement membrane 2	3	L	Matsumoto et al. (1984)
<i>TCP1</i>	t-complex protein 1	1	L, S	Yasue et al. (1992); Serikawa et al. (1992b); Goldmuntz et al. (1993)
<i>TCP1L</i>	t-complex protein 1-like	4	S	Yasue et al. (1992)
<i>TCRB</i>	T-lymphocyte receptor, beta chain, (D4MIT4)	4	L, S	Levan et al. (1991); Jacob et al. (1992); Dissen et al. (1993)
<i>TCRG</i>	T-lymphocyte receptor, gamma chain	17	S	Yasue et al. (1992)
<i>TF</i>	transferrin	8	S	Szpirer et al. (1987, 1988b)
<i>TG</i>	thyroglobulin	7	S	Brocas et al. (1985)
<i>TGFA</i>	transforming growth factor, alpha	4	L, S	Serikawa et al. (1992b)
<i>THRA1</i>	thyroid hormone receptor, alpha 1 (ERBA1)	10	S	Szpirer et al. (1991b)
<i>THRB</i>	thyroid hormone receptor, beta (ERBA2)	15	S	Szpirer et al. (1991b)
<i>THY1</i>	thymus cell antigen-1	8	L, S	Serikawa et al. (1992b); Kunieda et al. (1992a)
<i>TILP</i>	trypsin inhibitor-like protein, pancreatic	18	L, S	Serikawa et al. (1992b); Remmers et al. (1993b)
<i>TK</i>	thymidine kinase (soluble)	10	S	Yoshida (Levan et al. 1986)
<i>TKG</i>	T-kininogen	11	L, S	Serikawa et al. (1992b)
<i>TLS1</i>	thymic lymphoma susceptible 1	1	L	Shisa, Hiai (1985)
<i>TNF</i>	tumor necrosis factor	20	L, S	Serikawa et al. (1992b); Kondo et al. (1993)
<i>TNP1</i>	transition protein-1, spermatid specific	9	S	Adham et al. (1991)
<i>TNP2</i>	transition protein-2, spermatid specific	10	S	Adham et al. (1991)
<i>TNT</i>	troponin T, fast skeletal	1	L	Goldmuntz et al. (1993)
<i>TON</i>	tonin	1	L, S	Hilbert et al. (1991); Serikawa et al. (1992b)
<i>TP11</i>	triosephate isomerase 1	4	S	Levan et al. (1986)
<i>TPL1</i>	tumor progression	8	S	Bear et al. (1989)
<i>TPM</i>	alpha-tropomyosin	8	L, S	Serikawa et al. (1992b)
<i>TRAGGL</i>	Asp-, Gly-, Glu- and Leu-tRNAs cluster	13	S	Serikawa et al. (1992b)
<i>TRP53</i>	transformation related protein 53	10	S	Yasue et al. (1992)
<i>TRP53L1</i>	transformation related protein 53-like 1	9	S	Yasue et al. (1992)
<i>TRP53L2</i>	transformation related protein 53-like 2	14	S	Yasue et al. (1992)
<i>TRP53L3</i>	transformation related protein 53-like 3	18	S	Yasue et al. (1992)
<i>TRPM2</i>	testosterone-repressed prostate message 2	15	S	Goldner-Sauvé et al. (1991)
<i>TRY1</i>	trypsin I, pancreatic	4	L, S	Serikawa et al. (1992b)
<i>TTR</i>	transthyretin	18	L, S	Serikawa et al. (1992b); Remmers et al. (1993b)
<i>UCP</i>	uncoupling protein	19	L, S	Hilbert et al. (1991); Serikawa et al. (1992b); Osten et al. (1993)
<i>UGT2B2</i>	androsterone UDP-glucuronosyl-transferase	14	A	Satoh et al. (1993)
<i>UMPH2</i>	uridine monophosphatase	10	S	Yasue et al. (1991)
<i>VDR</i>	1,25-dehydroxy vitamin-D3 receptor	7	S	Szpirer et al. (1991d)
<i>VET</i>	vestigial testes	X	—	Bardin et al. (1973)
<i>W</i>	waltzing	1	L	King (1936); Castle, King (1949)
<i>YES1</i>	avian Y73 sarcoma virus	1	S	Levan et al. (1986)
<i>ZI</i>	zitter	3	L	Rehm et al. (1982); Yamada et al. (1989); Serikawa et al. (1992b)

An asterisk notes the linkage group in Hedrich's map (1990).

For method of gene localization (Mode), the following codes have been used: A, in situ hybridization; CH, cytogenetic rearrangement; L, linkage studies; S, somatic cell hybrids; W, flow-sorted chromosomes.



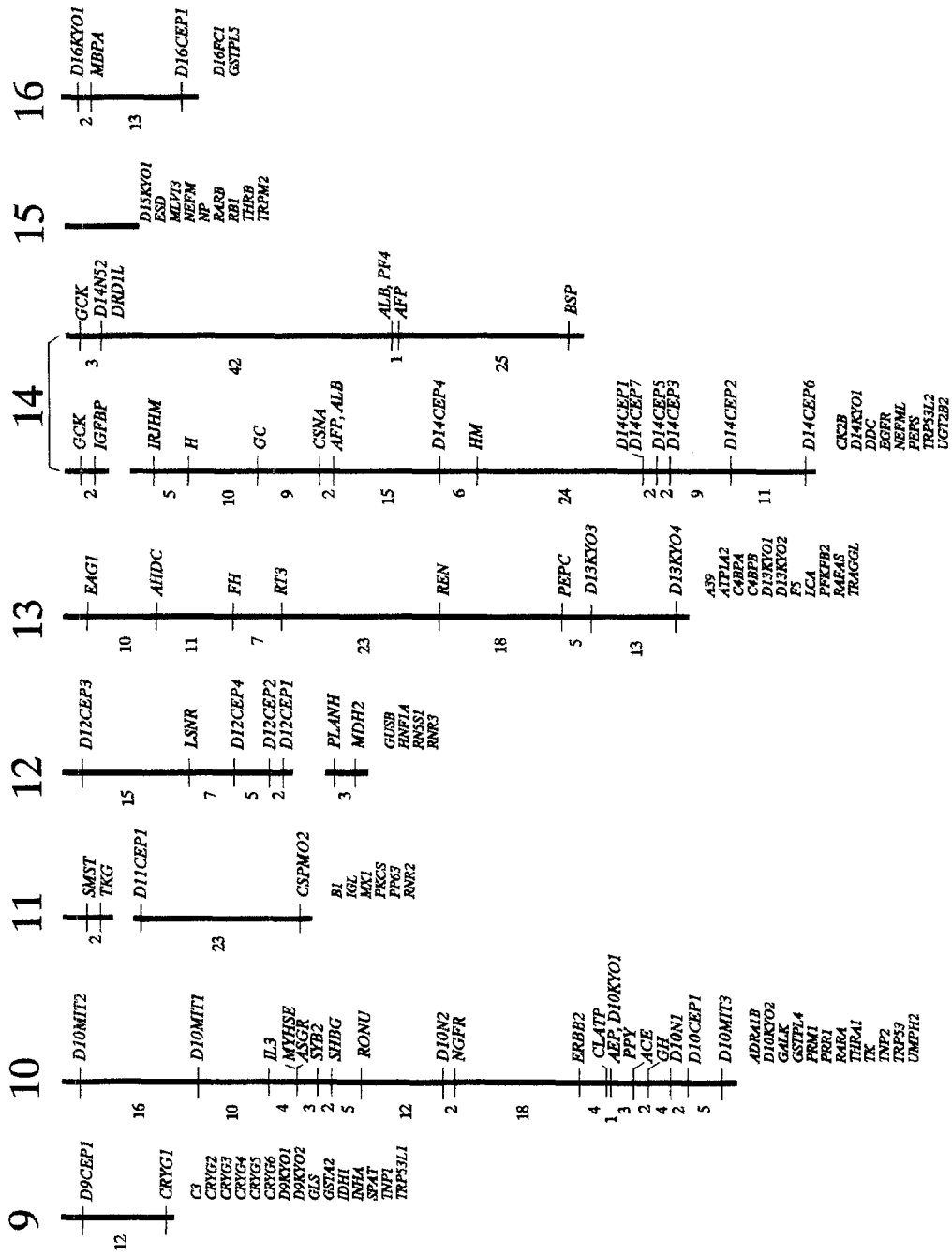


Fig. 1. Continued.

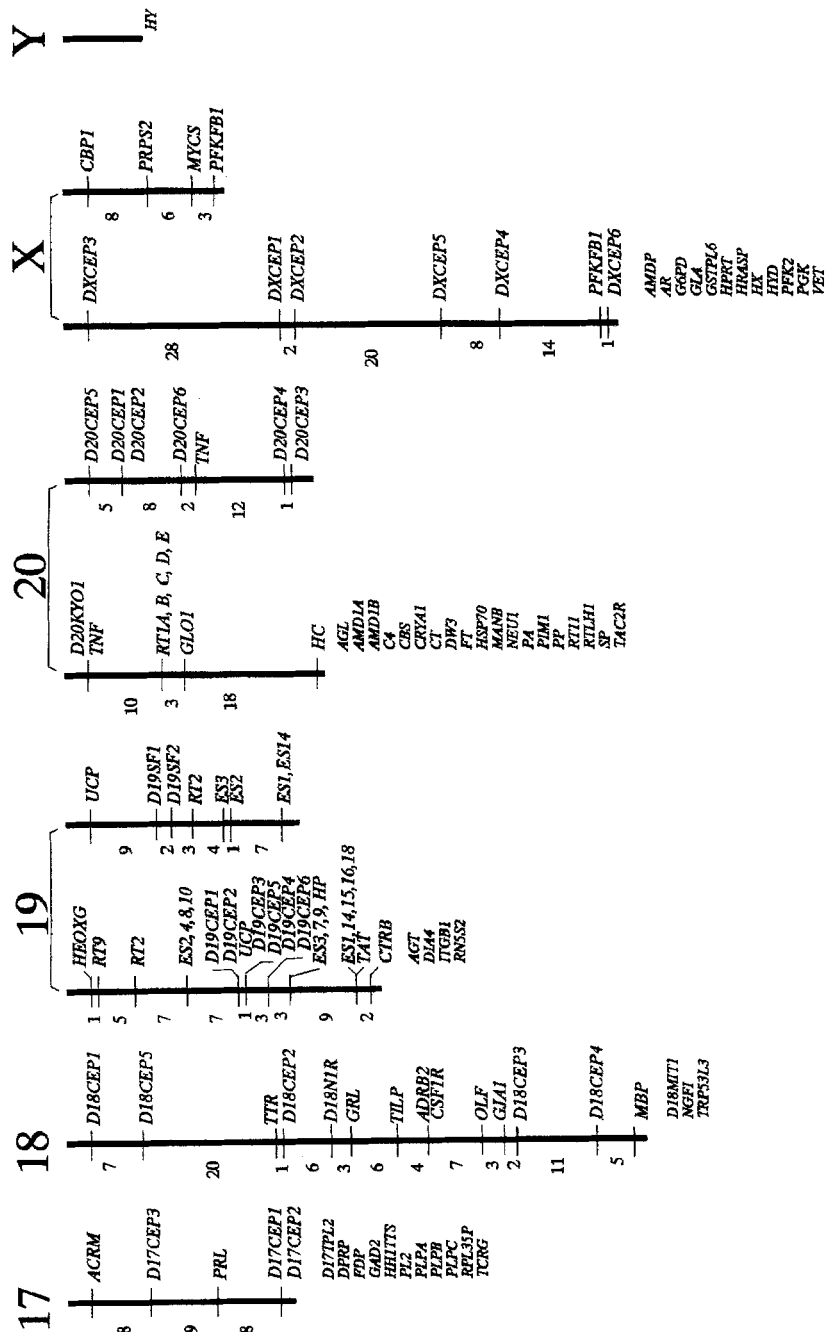
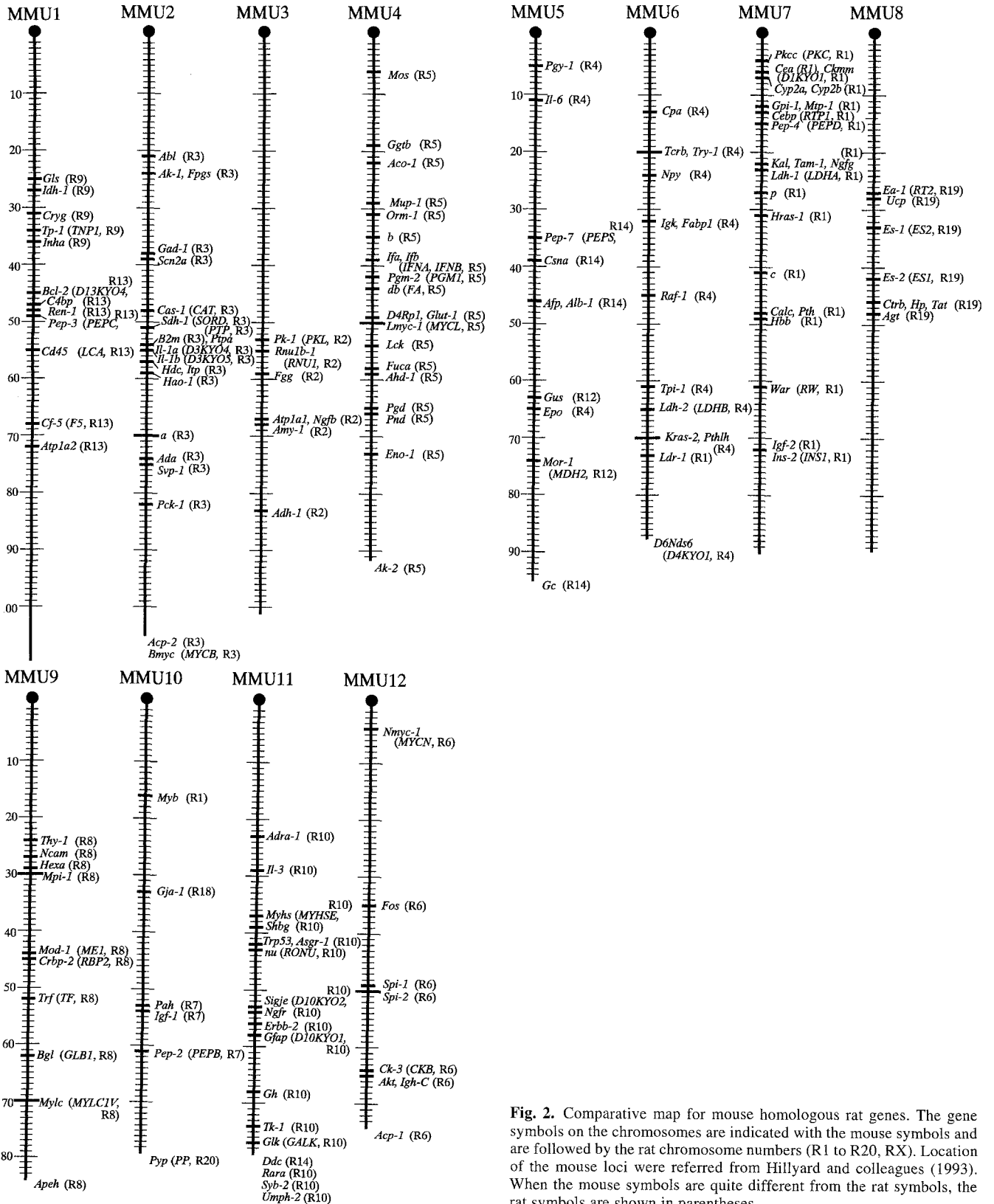


Fig. 1. Continued.



**Fig. 2.** Comparative map for mouse homologous rat genes. The gene symbols on the chromosomes are indicated with the mouse symbols and are followed by the rat chromosome numbers (R1 to R20, RX). Location of the mouse loci were referred from Hillyard and colleagues (1993). When the mouse symbols are quite different from the rat symbols, the rat symbols are shown in parentheses.

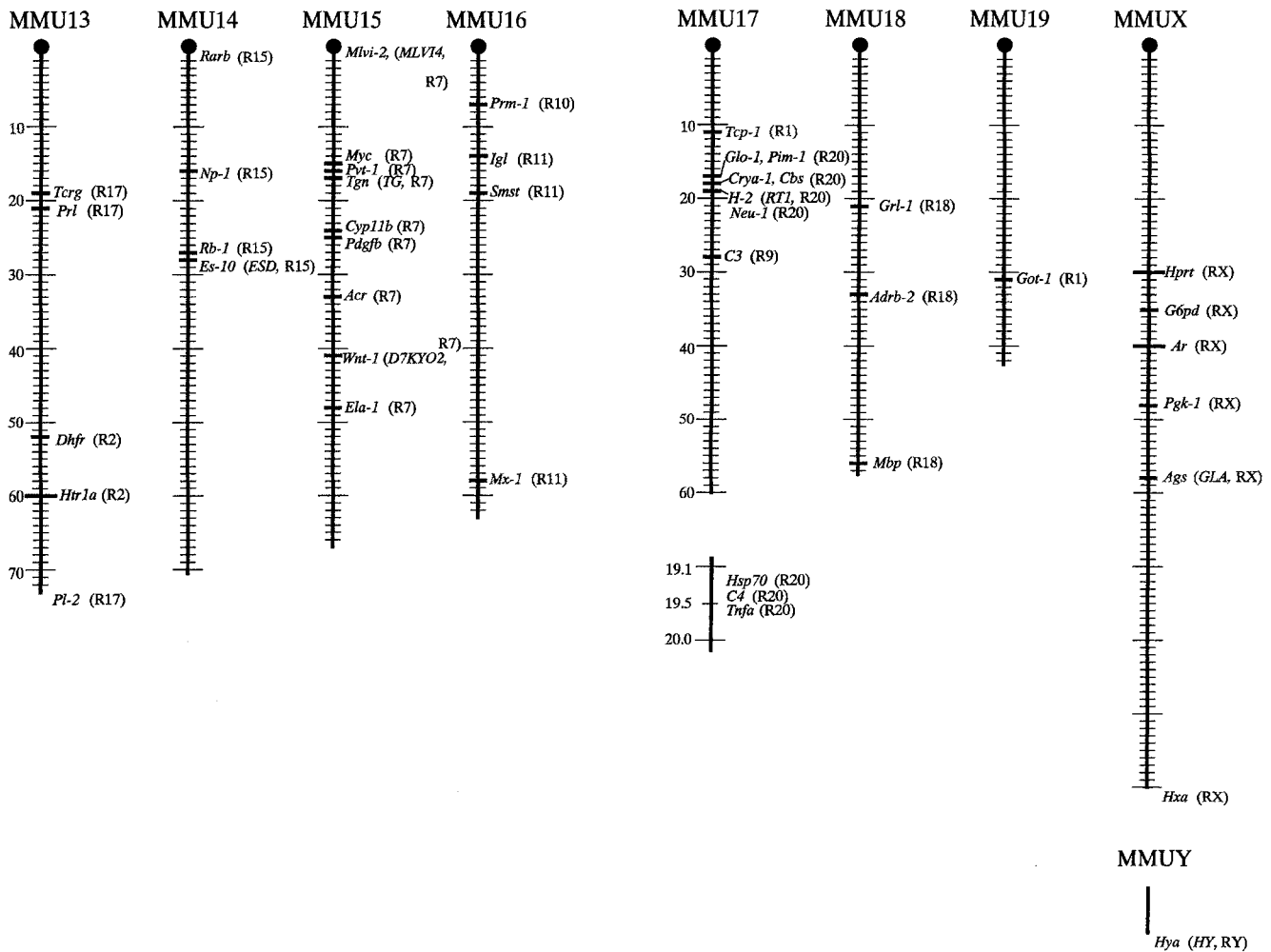


Fig. 2. Continued.

RNO3, 2, 5, 4, 1, 19, 8, 10, 6, 15, 7, 11, 18, and X, respectively. It seems that MMU1 consists of a homologous RNO9 (centromeric half) and RNO13 (telomeric half); this has already been deduced from the G-banding patterns by Levan and coworkers (1991). Conserved linkage of homologous genes between MMU7 and RNO1, and between MMU11 and RNO10, were confirmed. On MMU5, 10, 13, 16, and 17, the rat homologs belong to two or three different chromosomes.

Although the gene orders on homologous chromosomes or chromosomal segments between the two species are fairly well preserved, a few genes are ordered in the opposite direction in the two species, and only one rat homolog was assigned on MMU19 and MMUY. In order to compare more precisely the gene orders among the different species, we have to wait to obtain a more complete rat gene map. Resemblance between mouse and rat maps is considered to reflect the phylogenetically close relationships between the two species.

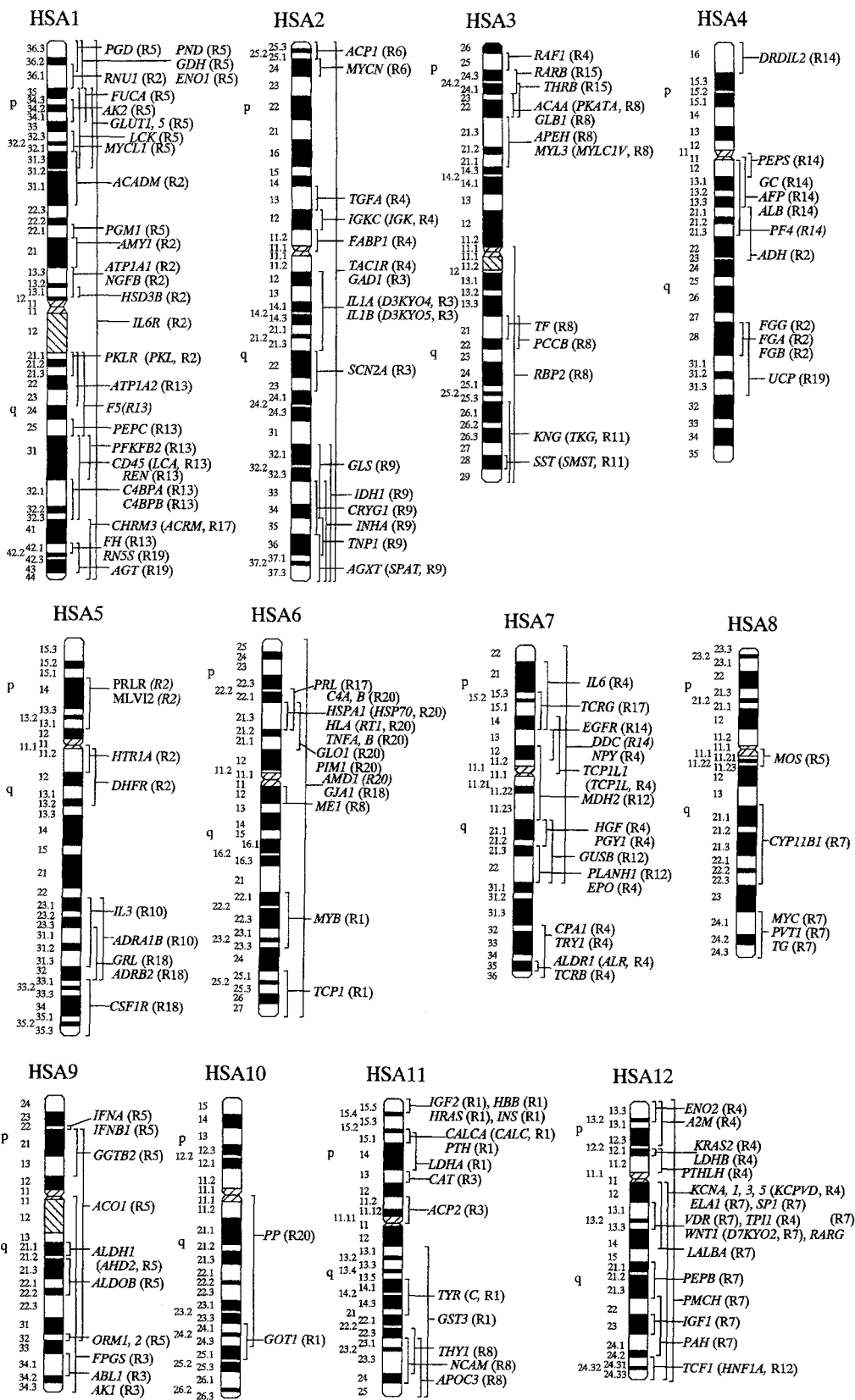
### Comparative human map

In Fig. 3, we assigned human homologous rat genes to the human chromosomes, shown by the human symbols. Lo-

cation of the human loci have been referred from the 1991 catalog of human mapped genes of McAlpine and associates (1991). All of the human homologous rat genes shown on HSA17 and HSAX locate on RNO10 and RNOX, respectively. In the other human chromosomes, human homologous rat genes are divided into two or more rat chromosomes. Out of 218 human homologous rat genes in this map, 169 genes (77.5%) are known also in the mouse. The remaining 49 human homologous rat genes (22.5%) have not been reported yet in the mouse. This suggests that the rat makes considerable contributions in the area of biomedical research, as well as the mouse. In fact, the rat provides a variety of models for human disease, including hypertension, diabetes, various cancers, and so on.

In order to make comparisons of the rat genes with those of mouse and human homologs, we have performed searches that were as precise as possible. There is a possibility, however, that there may be some misunderstandings or misreading of the homologs. If this is the case, we hope that they will be quickly corrected by new studies.

We can now use chromosome numbers instead of linkage groups in rat gene mapping, as in the mouse or human. We have no doubt that the rat genetic linkage map will be furnished with more newly assigned genes within the next couple of years, by currently available techniques and



**Fig. 3.** Comparative map for human homologous rat genes. The gene symbols on the chromosomes are indicated with the human symbols and are followed by the rat chromosome numbers (R1 to R20, RX). Location of the human loci were referred from McAlpine and coworkers (1991). When the human symbols are quite different from the rat symbols, the rat symbols are shown in parentheses.

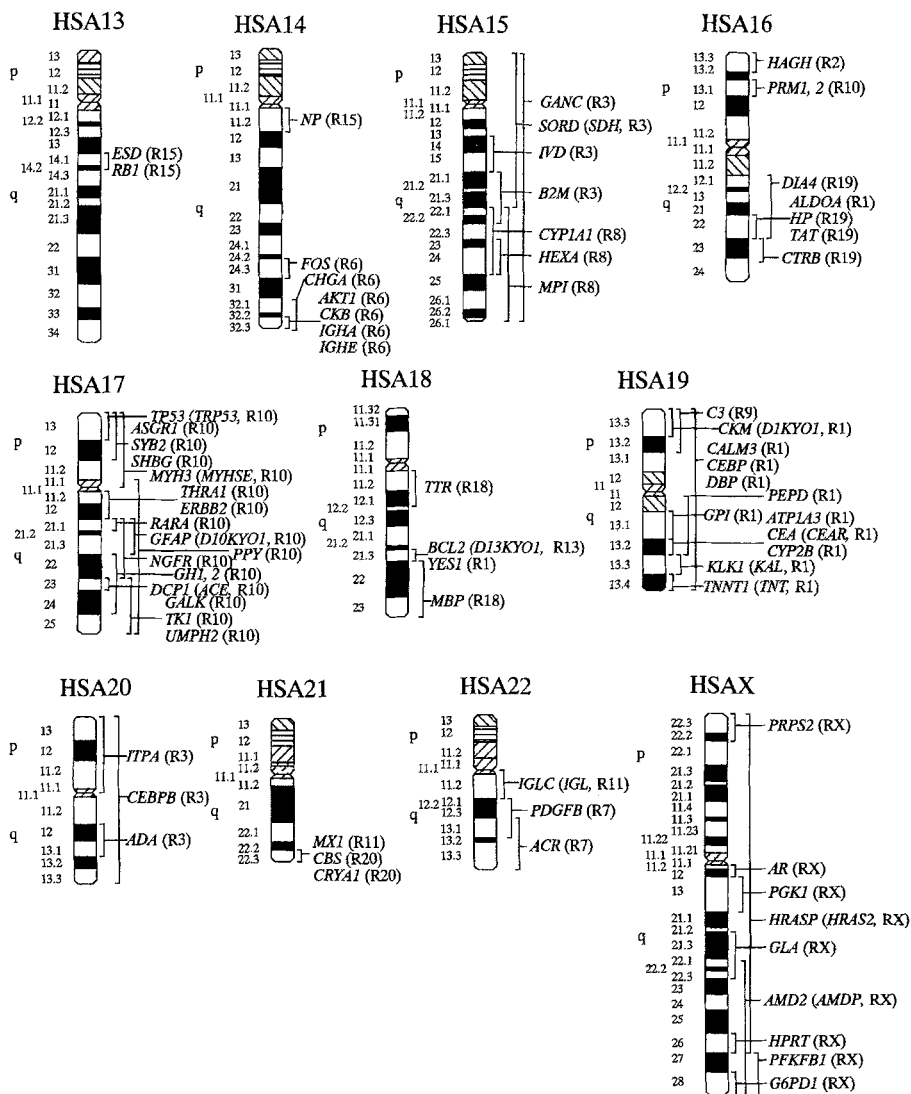


Fig. 3. Continued.

newly developed DNA technologies. In this way, comparisons of genes among rat–mouse–human will become easier and also more precise.

**Acknowledgments.** The authors thank Dr. Jean-Louis Guénet, Institut Pasteur de Paris, and Dr. Mark Lathrop, C.E.P.H., France, for their valuable comments. This study was supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture, in Japan.

## References

- Adams, M., Baverstock, P.A., Watts, C.H.S., Gutman, G.A. (1984). Enzyme markers in inbred rat strains: genetics of new markers and strain profiles. *Biochem. Genet.* 22, 611–629.
- Adham, I.M., Szpirer, C., Kremling, H., Keime, S., Szpirer, J., Levan, G., Engel, W. (1991). Chromosomal assignment of 4 rat genes coding for the spermatid-specific proteins proacrosin (*ACR*), transition protein-1 (*TNP1*) and transition protein-2 (*TNP2*), and protamine-1 (*PRM1*). *Cytogenet. Cell Genet.* 57, 47–50.
- Anderson, A., Dahlbäck, B., Hanson, C., Hillarp, A., Levan, G., Szpirer, J., Szpirer, C. (1990). The gene for the C4b-binding protein  $\beta$ -chain (*C4BPB*) is located on chromosome 1, band 1q32 in human and on chromosome 13 in the rat. *Somatic Cell Mol. Genet.* 16, 493–500.
- Archer III, B.T., Ozelik, T., Jahn, R., Francke, U., Südhof, T.C. (1990). Structures and chromosomal localizations of two human genes encoding synaptobrevins 1 and 2. *J. Biol. Chem.* 265, 17267–17273.
- Augustinsson, K.-B., Henricson, B. (1966). A genetically controlled esterase in rat plasma. *Biochim. Biophys. Acta* 124, 323–331.
- Bardin, C.W., Bullock, L.P., Sherins, R.J., Mowszowicz, I., Blackburn, W.R. (1973). Androgen metabolism and mechanism of action in male pseudohermaphroditism: a study of testicular feminization. *Recent Prog. Horm. Res.* 29, 65–109.
- Bazin, H., Beckers, A., Vaerman, J.-P., Heremans, J.F. (1974). Allotypes of rat immunoglobulins. I. An allotype at the alpha-chain locus. *J. Immunol.* 112, 1035–1041.
- Bear, S.E., Bellacosa, A., Lazo, P.A., Jenkins, N.A., Copeland, N.G., Hanson, C., Levan, G., Tschlis, P.N. (1989). Provirus insertion in *Tpl-1*, and *Ets-1* related oncogene, is associated with tumor progression in Mo-MuLV induced rat thymic lymphomas. *Proc. Natl. Acad. Sci. USA.* 86, 7495–7499.
- Beckers, A., Bazin, H. (1975). Allotypes of rat immunoglobulins III: an allotype of the  $\gamma 2\beta$ -chain locus. *Immunochemistry* 12, 671–675.
- Bellacosa, A., Franke, T.F., Gozalez-Portal, M.E., Datta, K., Taguchi, T., Gardner, J., Cheng, J.Q., Testa, J.R., Tschlis, P.N. (1993). Structure, expression and chromosomal mapping of *c-akt*: relationship to *v-akt* and its implications. *Oncogene* 8, 745–754.
- Bender, K., Bissbort, S., Kuhn, A., Nagel, M., Günther, E. (1986). Ge-



- netic variation of an acid phosphatase (*Acp-2*) in the laboratory rat: possible homology with mouse *AP-1* and human *ACP2*. *Biochem. Genet.* 24, 1–11.
- Bogden, A.E., Aptekman, P.M. (1960). The R-1 factor, a histocompatibility antigen in the rat. *Cancer Res.* 20, 1372–1382.
- Brdicka, R. (1968). The chromosome I of the laboratory rat (*Rattus norvegicus*). Linkage studies of the hemoglobin locus. *Acta Univ. Carolinae Med.* 14, 93–98.
- Brdicka, R., Frenzl, F. (1978). Linkage of alloantigenic locus *H-3* and plasma esterase locus *Es-2* in the Norway rat. *Folia Biol.* 24, 381–382.
- Brocas, H., Szpirer, J., Lebo, R.V., Levan, G., Szpirer, C., Cheung, M.C., Vassart, G. (1985). The thyroglobulin gene resides on chromosome 8 in man and on chromosome 7 in the rat. *Cytogenet. Cell Genet.* 39, 150–153.
- Butcher, G.W., Clarke, S., Tucker, E.M. (1979). Close linkage of peripheral T-lymphocyte antigen A (*PtaA*) to the hemoglobin variant *Hbb* on linkage group I of the rat. *Transplant. Proc.* 11, 1629–1630.
- Carlee, J., Ansay, M. (1975). Allelic and tissue variation of rat fumarate hydratase (E.C. 4.2.1.2.). *Int. J. Biochem.* 7, 565–566.
- Carter, N.D., Parr, C.W. (1969). Phosphogluconate dehydrogenase polymorphism in British wild rats. *Nature* 224, 1214.
- Cash, J.M., Remmers, E.F., Goldmuntz, E.A., Crofford, L.J., Zha, H., Hansen, C.T., Wilder, R.L. (1993). Genetic mapping of the athymic nude (*RNU*) locus in the rat to a region on chromosome 10. *Mammalian Genome* 4, 37–42.
- Castle, W.E. (1953). Silver, a mutation of the rat. *J. Hered.* 44, 205–206.
- Castle, W.E., King, H.D. (1941). Linkage studies of the rat (*Rattus norvegicus*) V. *Proc. Natl. Acad. Sci. USA* 27, 394–399.
- Castle, W.E., King, H.D. (1944). Linkage studies of the rat (*Rattus norvegicus*) VI. *Proc. Natl. Acad. Sci. USA* 30, 79–82.
- Castle, W.E., King, H.D. (1947). Linkage studies of the rat (*Rattus norvegicus*) VII. Shaggy, a new dominant. *J. Hered.* 38, 341–344.
- Castle, W.E., King, H.D. (1949). Linkage studies of the rat X. *Proc. Natl. Acad. Sci. USA* 35, 545–546.
- Cicila, G.T., Rapp, J.P., Wang, J.-M., St. Lezin, E., Ng, S.C., Kurtz, T.W. (1993). Linkage of 11 $\beta$ -hydroxylase mutations with altered steroid biosynthesis and blood pressure in the Dahl rat. *Nature Genet.* 3:346–353.
- Collard, J.G., Schijven, J.F., Tulp, A. (1982). Localization of rat genes on fractionated chromosomes by molecular hybridization. *Cytogenet. Cell Genet.* 32, 257–258.
- Cooke, N., Szpirer, C., Levan, G. (1986). The related genes encoding growth hormone and prolactin have been dispersed to chromosome 10 and 17 in the rat. *Endocrinology* 119, 2451–2454.
- Cooke, N., Levan, G., Szpirer, J. (1987). The rat vitamin D binding protein (Gc-globulin) gene is syntenic with the rat albumin and alpha-fetoprotein genes on chromosome 14. *Cytogenet. Cell Genet.* 44, 98–100.
- Cramer, D.V. (1981). Genetic variation of urinary pepsinogen and its probable linkage to albinism in the rat. *Immunogenetics* 13, 555–558.
- Cramer, D.V. (1983). Linkage of quantitative variation of a serum protein (*Sp*) to the major histocompatibility complex of the rat. *Immunogenetics* 18, 593–598.
- Cramer, D.V., Blankert J.J., Leendert, C.P. (1985). Linkage of loci encoding a kidney endothelial antigen and fumarate hydratase (*Fh-1*) in the rat. *Biochem. Genet.* 23, 623–629.
- Cramer, D.V., Mowery, P.A., Adams, M. (1986). Biochemical markers in rats: linkage relationships of aconitase (*Acon-1*), aldehyde dehydrogenases (*Adh-2* and *Adh-c*), alkaline phosphatase (*Akp-1*), and hydroxyacid oxidase (*Hao-1*). *Biochem. Genet.* 24, 217–227.
- Dahlbäck, B., Hanson, C., Islam, M.Q., Szpirer, C., Landwall, A., Levan, G. (1988). Assignment of a gene for coagulation factor V to chromosome 1 in man and to chromosome 13 in the rat. *Somatic Cell Mol. Genet.* 14, 509–514.
- Darville, M.L., Crepin, K.M., Szpirer, J., Levan, G., Hue, L., Rosseau, G.G. (1989). Characterization and chromosomal assignment of a gene for rat 6-phosphofructo-2-kinase. *Arch. Int. Physiol. Biochem.* 97, B19.
- Deb, S., Roby, K.F., Faria, T.N., Szpirer, C., Levan, G., Kwok, S.C.M., Soares, M.J. (1991). Molecular cloning and characterization of prolactin-like protein C complementary deoxyribonucleic acid. *J. Biol. Chem.* 266, 23027–23032.
- Den Dunnen, J.T., Szpirer, J., Levan, G., Islam, M.Q., Schoenmakers, J.G.G. (1987). All six rat gamma-crystallin genes are located on chromosome 9. *Exp. Eye Res.* 45, 747–750.
- De Witt, C.W., McCullough, M. (1975). Ag-F: serological and genetic identification of a new locus in the rat governing lymphocyte membrane antigens. *Transplantation* 19, 310–317.
- Dissen, E., Hunt, S.V., Rolstad, B., Fossum, S. (1993). Localization of the rat T-cell receptor  $\beta$ -chain and carboxypeptidase A1 loci to chromosome 4. *Immunogenetics* 37, 153–156.
- Donner, M.E., Skow, L.C., Kunz, H.W., Gill III, T.J. (1985). Electrophoretic variation in low molecular weight lens crystallins from inbred strains of rats. *Biochem. Genet.* 23, 787–800.
- Dunning, W.F., Curtis, M.R. (1939). Linkage in rats between factors determining a pathological condition and a coat color. *Genetics* 24, 70.
- Eriksson, K., Halkka, O., Lokki J., Saura, A. (1976). Enzyme polymorphism in feral, outbred and inbred rats (*Rattus norvegicus*). *Heredity* 37, 341–349.
- Erlandsson, R., Szpirer, J., Islam, M.Q., Boldog, F., Klein, G., Ingvarsson, S. (1991). The most frequently lost allelic site in human renal cell carcinoma (D3F15S2) on the short arm of chromosome 3 has homologous sequences on rat chromosome 8. *Cytogenet. Cell Genet.* 57, 149–150.
- Falquerho, L., Patey, G., Paquereau, L., Rossi, V., Lahuna, O., Szpirer, J., Szpirer, C., Levan, G., Cam, A.L. (1991). Primary structure of the rat gene encoding an inhibitor of the insulin receptor tyrosine kinase. *Gene* 98, 209–216.
- Fang, X.-E., Yoshida, M.C., Naylor S.L., Sakaguchi, A.Y. (1985). Chromosomal mapping of rat cellular oncogenes and growth factor genes. *Cytogenet. Cell Genet.* 40, 627.
- French, E.A., Roberts, K.B., Searle, A.G. (1971). Linkage between a hemoglobin locus and albinism in the Norway rat. *Bochem. Genet.* 5, 397–404.
- Frenzl, B., Kren, V., Stark, O. (1960). Attempt to determine blood groups in rats. *Folia Biol.* 6, 121–126.
- Fulchignoni-Lataud, M.C., Weiss, M., Szpirer, C., Levan, G. (1990). Assignment of the rat genes coding for phenylalanine hydroxylase, tyrosine aminotransferase and pyruvate kinase to chromosomes, 6, 19 and 2 respectively. *Cytogenet. Cell Genet.* 53, 172–174.
- Fulchignoni-Lataud, M.C., Szpirer, J., Levan, G., Weiss, M.C. (1992). Assignment of the rat genes coding for  $\alpha$ 1-antitrypsin (*PI*), phosphoenolpyruvate carboxykinase (*PEPCK*), alcohol dehydrogenase (*ADH*), and fructose-1, 6-bisphosphatase (*FDP*). *Mammalian Genome* 3, 42–45.
- Gal, A., Nahon, J.L., Lucotte, G., Sala-Trepast, J.M. (1984). Structural variants of the  $\alpha$ -fetoprotein gene in different inbred strains of rat. *Mol. Gen. Genet.* 195, 153–158.
- Gasser, D.L. (1972). Seminal vesicle protein in rats: a gene in the fourth linkage group determining electrophoretic variants. *Biochem. Genet.* 6, 61–63.
- Gill III, T.J., Kunz, H.W. (1979). Gene complex controlling growth and fertility linked to the major histocompatibility complex in the rat. *Am. J. Pathol.* 96, 185–202.
- Gill III, T.J., Kunz, H.W., Schaid, D.J., Van de Berg, J.L., Stolc, V. (1982). Orientation of loci in the major histocompatibility complex of the rat and its comparison to man and the mouse. *J. Immunogenet.* 9, 281–293.
- Goldmuntz, E.A., Remmers, E.F., Zha, H., Cash, J.M., Mathern, P., Crofford, L.J., Wilder, R.L. (1993). Genetic map of 12 polymorphic loci on rat chromosome 1. *Genomics* 16, 761–764.
- Goldner-Sauvé, A., Szpirer, C., Szpirer, J., Levan, G., Gasser, D.L. (1991). Chromosomal assignments of the genes for glucocorticoid receptor, myelin basic protein, leucocyte common antigen, and TRPM2 in the rat. *Biochem. Genet.* 29, 275–286.
- Graham, C., Szpirer, C., Levan, G., Carper, D. (1991). Characterization of the aldose reductase-encoding gene family in rat. *Gene* 107, 259–267.
- Granados, J., Cramer, D.V., Caputo, J.B., Marcus, D., Alper, C.A. (1984). Genetic polymorphism of the sixth component (C6) of rat complement. *J. Immunol.* 133, 405–407.
- Greaves, J.H., Ayres, P.B. (1969). Linkages between genes for coat colour and resistance to warfarin in *Rattus norvegicus*. *Nature* 224, 284–285.
- Greaves, J.H., Ayers, P.B. (1976). Inheritance of Scottish-type resistance to warfarin in the Norway rat. *Genet. Res.* 28, 231–239.
- Greaves, J.H., Ayers, P.B. (1977). Unifactorial inheritance of warfarin resistance in *Rattus norvegicus* from Denmark. *Genet. Res.* 29, 215–222.
- Greep, R.O. (1941). An hereditary absence of the incisor teeth. *J. Hered.* 32, 397–398.
- Grünberg, H. (1939). The linkage relations of a new lethal gene in rat (*Rattus norvegicus*). *Genetics* 24, 732–741.

- Gumbreck, L.G. (1964). New genetic factors that affect fertility in the male rat. Proc. Vth International Congress on Animal Reproduction and Artificial Insemination, pp. 319–325.
- Hamada, S., Yamada, J., Bender, K., Adams, M. (1987). A new polymorphic pepsinogen locus (*Pg-2*) in the rat (*Rattus norvegicus*). Exp. Anim. 36, 267–272.
- Hanson, C., Islam, M.Q., Szpirer, J., Szpirer, C., Tschlis, P.N., Levan, G. (1988). Localization of the MDR 170kDa P-glycoprotein locus to chromosome 4 and the *Mlvi-4* locus to chromosome 7 in the rat. Abstr., BioScience, Malmö, Sweden.
- Hanson, C., Anderson, A., Islam, M.Q., Szpirer, J., Szpirer, C., Levan, G. (1990). Assignment of two rat dihydrofolate reductase (*DHFR*) genes to chromosome 2 and 4. Cytogenet. Cell Genet. 53, 23–25.
- Hedrich, H.J. (1990). *Genetic Monitoring of Inbred Strains of Rats*. (Stuttgart: Gustav Fischer Verlag).
- Hedrich, H.J., von Deimling, O. (1987a). Re-evaluation of LGV of the rat and assignment of 12 carboxylesterases to two gene clusters. J. Hered. 78, 92–96.
- Hedrich, H.J., von Deimling, O., Kluge, R. (1987b). Biochemical genetics of *Es-14* (formerly *Es-Si*) and a new esterase variation, *Es-15*, of the laboratory rat (*Rattus norvegicus*): biochemistry, tissue expression, and linkage to *Es-1* in linkage group V. Biochem. Genet. 25, 79–83.
- Hedrich, H.J., Wege, H., Reetz, I.C. (1989). Genetic analysis of coronavirus induced demyelination encephalomyelitis. Immunobiol. Suppl. 4, 200–201.
- Hendy, G.N., Sakaguchi, A., Yasuda, T., Weber, D.K., Wang, L.M., Yoshida, M.C., Banville, D., Goltzman, D. (1988). Gene for parathyroid hormone-like peptide is on rat chromosome 2. Biochem. Biophys. Res. Commun. 157, 558–562.
- Heslop, B.F., Jolly, K.D. (1979). Genetic control of haemagglutinin production against an MHC determined alloantigen in rats. Immunogenetics. 8, 567–570.
- Hilbert, P., Lindpaintner, K., Beckmann, J.S., Serikawa, T., Soubrier, F., Dubay, C., Cartwright, P., De Gouyon, B., Julier, C., Takahasi, S., Vincent, M., Ganten, D., Georges, M., Lathrop, G.M. (1991). Chromosomal mapping of two genetic loci associated with blood-pressure regulation in hereditary hypertensive rats. Nature 353, 521–529.
- Hilliker, C.E., Darville, M.I., Aly, M.S., Chikri, M., Szpirer, C., Marynen, P., Rousseau, G.G., Cassiman, J.J. (1991). Human and rat chromosomal localization of two genes for 6-phosphofructo-2-kinase/fructose-2,6-bisphosphatase by analysis of somatic cell hybrids and in situ hybridization. Genomics 10, 867–873.
- Hillyard, A.L., Doolittle, D.P., Davisson, M.T., Roderick, T.H. (1993). Locus map of mouse with comparative points of human on mouse. Mouse Genome 91, 15–39.
- Ingvarsson, S., Asker, C., Wirschubsky, Z., Szpirer, J., Levan, G., Klein, G., Sümegi, J. (1987). Mapping of *Lmyc* and *Nmyc* to rat chromosome 5 and 6. Somatic Cell Mol. Genet. 13, 335–339.
- Ingvarsson, S., Asker, C., Szpirer, J., Levan, G., Klein, G. (1988a). Rat *c-ras* oncogene is located on chromosome 4 and may be activated by sequences from chromosome 13. Somatic Cell Mol. Genet. 14, 401–405.
- Ingvarsson, S., Asker, C., Axelson, H., Klein, G., Sümegi, J. (1988b). Structure and expression of B-myc, a new member of the myc gene family. Mol. Cell. Biol. 8, 3168–3174.
- ISCN (1978). An International System for Human Cytogenetic Nomenclature. *Birth Defects: Orig. Artic Ser.* Vol XIV, No. 8 (The National Foundation, New York 1978); also in Cytogenet. Cell Genet. 21, 309–404.
- Islam, M.Q., Szpirer, J., Szpirer, C., Islam, K., Dasnoy, J.F., Levan, G. (1989). A gene for the suppression of anchorage independence is located in rat chromosome 5 bands q22-23, and rat alpha interferon locus maps at the same region. J. Cell Sci. 92, 147–162.
- Jacob, H.J., Lindpaintner, K., Lincoln, S.E., Kusumi, K., Bunker, R.K., Mao, Y.-P., Ganten, D., Dzau, V.J., Lander, E.S. (1991). Genetic mapping of a gene causing hypertension in the stroke-prone spontaneously hypertensive rat. Cell 67, 213–224.
- Jacob, H., Pettersson, A., Wilson, D., Mao, Y., Lernmark, Å., Lander, E.S. (1992). Genetic dissection of autoimmune type I diabetes in the BB rat. Nature Genet. 2, 56–60.
- Kano, Y., Maeda, S., Sugiyama, T. (1976). The location of ribosomal cistrons (rDNA) in chromosomes of the rat. Chromosoma 55, 37–42.
- Katsuya, T., Higai, J., Mikki, T., Kohara, K., Yagisawa, H., Tanase, H., Mikami, H., Serikawa, T., Nojima, H., Ogihara, T. (1992). Hypotensive effect associated with a phospholipase C- $\delta$ 1 gene mutation in the spontaneously hypertensive rat. Biochem. Biophys. Res. Commun. 187, 1359–1366.
- Kendall, P.B. (1985). Glucose phosphate dehydrogenase polymorphism and the genetics of linkage group I in the Norway rat (*Rattus norvegicus*). Lab. Anim. 19, 169–172.
- King, H.D. (1936). A waltzing mutation in the white rat. J. Mammalogy 17, 157–163.
- Klinga, K., Fang, G., Levan, G. (1990). Analysis of a mini library of DNA fragments from microdissected chromosome pieces of RNO5, band q22-23. Hereditas 112, 5–6.
- Knox, W.E., Lister-Rosenoer, L.M. (1978). Infantile ichthyosis in rats: a new model of hyperkeratotic skin disease. J. Hered. 69, 391–394.
- Kobayashi, E., Ikadai, H., Imamichi, T., Kunieda, T. (1992a). Polymorphism detected in variable number of tandem repeats (VNTR) of the seminal vesicle secretion (SVS) IV gene in inbred rats. Biochem. Genet. 30, 339–346.
- Kobayashi, E., Tachibana, M., Ikadai, H., Imamichi, T., Kunieda, T. (1992b). Linkage among esterase-6 (*Es-6*), neural cell adhesion molecule (*NCAM*), and apolipoprotein C-III (*apoc-3*) genes on rat chromosome 8. Mammalian Genome 3, 656–658.
- Koehne, C.E., Lazo, P.A., Alves, K., Lee, J.S., Tschlis, P.N., O'Donnel, P.V. (1989). The *Mlvi-1* locus involved in the induction of rat T-cell lymphomas and the *pvt-1/Mis-1* locus are identical. J. Virol. 63, 2366–2369.
- Koga, A., Harada, S., Omoto, K. (1972). Polymorphisms of erythrocyte 6-phosphogluconate dehydrogenase and phosphoglucomutase in *Rattus norvegicus* in Japan. Jpn. J. Genet. 46, 335–338.
- Kohoutova, M., Günther, E., Stark, O. (1980). Genetic definition of a further gene region and identification of at least three different histocompatibility genes in the rat major histocompatibility system. Immunogenetics 11, 483–490.
- Kondo, Y., Yamada, J. (1983). Male urinary protein (*Mup-1*) expression in the female rat. J. Hered. 74, 280–282.
- Kondo, Y., Hamada, S., Serikawa, T., Yamada, J. (1987). Two polymorphic genetic loci of rat tear proteins. Transplant Proc. 19, 3146–3147.
- Kondo, Y., Hamada, S., Serikawa, T., Yamada, J. (1988). Genetic polymorphism of tear proteins in the rat. Biochem. Genet. 26, 683–691.
- Kondo, Y., Hamada, S., Serikawa, T., Yamada, J. (1989). Second genetic polymorphism of tear proteins in the rat (*Rtp-2*). Exp. Anim. 38, 327–331.
- Kondo, Y., Mori, M., Kuramoto, T., Yamada, J., Beckmann, J.S., Simon-Chazottes, D., Montagutelli, X., Guénet, J.-L., Serikawa, T. (1993). DNA segments mapped by reciprocal use of microsatellite primers between mouse and rat. Mammalian Genome 4, 571–576.
- Koto, M., Adachi, J., Shimizu, A. (1987). A new mutation of primary ciliary dyskinesia (PCD) with visceral inversion (Karthagen's syndrome) and hydrocephalus. Rat News Lett. 18, 14–15.
- Kren, V. (1975). Genetics of the polydactyl-luxuate syndrome in the Norway rat, *Rattus norvegicus*. Acta Univ. Carolinae Med. 1–103.
- Kren, V., Stakr, O., Bila, V., Frenzl, B., Krenova, D., Krsiakova, M. (1973). Rat alloantigenic systems defined through congenic strain production. Transplant. Proc. 5, 1463–1466.
- Kunieda, T., Kobayashi, E., Ikadai, H., Imamichi, T., Nomura, N., Ishizaki, R. (1990). Restriction fragment length polymorphisms detected in N-ras-related sequences of rats and their linkage analysis. Biochem. Genet. 28, 631–642.
- Kunieda, T., Kogbayashi, E., Tachibana, M., Ikadai, H., Imamichi, T. (1992a). Localization of the interleukin-3 gene to rat chromosome 10 by linkage analyses with a variable number of tandem repeats (VNTR). Mammalian Genome 3, 464–466.
- Kunieda, T., Kobayashi, E., Tachibana, M., Ikadai, H., Imamichi, T. (1992b). Polymorphic microsatellite loci of the rat (*Rattus norvegicus*). Mammalian Genome 3, 564–567.
- Kunz, H.W., Gill III, T.J., Dhirendra, N.M. (1982). The identification and mapping of a second class I locus in the major histocompatibility complex of the rat. J. Immunol. 12, 75–78.
- Kunz, H.W., Misra, D.N., Gill III, T.J. (1985). Production of monoclonal antibodies against RT2 antigens of the rat and definition of a new locus, RT9, linked to RT2. J. Immunogenet. 12, 75–78.
- Kunz, H.W., Ho, H.-N., Misra, D.N., Gill III, T.J. (1989). A unique placental antigen controlled by an MHC-linked locus RT11. Transplant. Proc. 21, 559–560.
- Kuramoto, T., Serikawa, T., Hayasaka, N., Mori, M., Yamada, J. (1993a).

- Regional mapping of the Rowett nude gene (RONU) to rat chromosome 10q24 → q32 by localizing linked SYB2 and GH loci. *Cytogenet. Cell Genet.* 63, 107–110.
- Kuramoto, T., Mori, M., Hirayama, N., Saburi, S., Yamada, J., Serikawa, T. (1993b). A strategy for rapid construction of genetic and physical maps in the rat. *Acta Histochem. Cytochem.* 26, 325–332.
- La Vail, M.M. (1981). Assignment of retinal dystrophy (*rdy*) to linkage group IV of the rat. *J. Hered.* 72, 294–296.
- Levan, G., Szpirer, J., Szpirer, C., Yoshida, M.C. (1986). Recent status of chromosome localization of rat genes. *Rat News Lett.* 17, 3–8.
- Levan, G., Hanson, C., Klinga, K., Szpirer, C., Szpirer, J. (1990). The rat gene map 1989. *Rat News Lett.* 23, 12–24.
- Levan, G., Szpirer, J., Szpirer, C., Klinga, K., Hanson, C., Islam M.Q. (1991). The gene map of the Norway rat (*Rattus norvegicus*) and comparative mapping with mouse and man. *Genomics* 10, 699–718.
- Levan, G., Klinga-Levan, K., Hanson, C., Szpirer, C., Szpirer, J. (1992). Rat gene map 1992. *Rat News Lett.* 27, 10–34.
- Li, S.Z., Oikawa, T., Yoshida, M.C., Naito, H., Kuzumaki, N. (1989). Regional mapping of the *c-fos* oncogene to rat chromosome 6q21-q23. *Cytogenet. Cell Genet.* 52, 42–44.
- Lindpaintner, K., Hilbert, P., Ganten, D., Nadal-Ginard, B., Inagami T., Iwai, N. (1992). Molecular genetics of the  $S_A$ -gene: cosegregation with hypertension and mapping to rat chromosome 1. *J. Hypertension* 11, 19–23.
- Lobel, S.A., Cramer, D.V. (1981). Demonstration of a new genetic locus in the major histocompatibility system of the rat. *Immunogenetics* 13, 465–473.
- Locker, J., Kraus, J.P., Ohura, T., Riviere, M., Islam, M.Q., Levan, G., Szpirer, J., Szpirer, C. (1990). The rat major histocompatibility complex and the cystathionine beta-synthase gene are syntenic and map to chromosome 20. *Immunogenetics* 31, 271–274.
- Lynch, D.H., De Witt, C.W. (1978). Genetic identification of a locus linked to the rat MHC that codes for a membrane antigen detectable with cytotoxic lymphocytes. *J. Immunol.* 121, 2367–2375.
- Lynch, D.H., De Witt, C.W. (1980). The LEW.BN (2R) strain: a recombinant in the rat MHC. *J. Immunol.* 124, 2247–2253.
- Marino, N.W., Fuller, G.M., Elder, F.F.B. (1986). Chromosomal localization of human and rat  $\alpha_2$ ,  $\beta_2$ , and  $\gamma$  fibrinogen genes by in situ hybridization. *Cytogenet. Cell Genet.* 42, 36–41.
- Marshak, A., Doherty, P.C., Wilson, D.B. (1977). The control of specificity of cytotoxic T lymphocytes by the major histocompatibility complex (AG-B) in rats and identification of a new alloantigen system showing no Ag-B restriction. *J. Exp. Med.* 146, 1773–1790.
- Masuda, R., Yoshida, M.C., Sasaki, M., Okuda, A., Muramatsu, M. (1986). Localization of the gene for glutathione S-transferase P on rat chromosome 1 at band q43. *Jpn. J. Cancer Res.* 77, 1055–1058.
- Matsumoto, K. (1980). New polymorphism of esterase 7 and esterase 8 in inbred strains of rats: tissue expression and linkage studies. *Biochem. Genet.* 18, 879–885.
- Matsumoto, K., Matsuhashi, A., Aizawa, M. (1982). A new genetic variation of the malate dehydrogenase-like enzyme (*MDL-1*) in inbred rats and its possible linkage. *Biochem. Genet.* 20, 443–448.
- Matsumoto, K., McCafferty, E., Neilson, E.G., Gasser, D.L. (1984). Mapping of the genes for tubular basement membrane antigen and submaxillary gland protease in the rat. *Immunogenetics* 20, 117–123.
- Mattei, M.-G., Rivière, M., Krust, A., Ingvarsson, S., Vennström, B., Islam, M.Q., Levan, G., Kautner, P., Zelent, A., Chambon, P., Szpirer, J., Szpirer, C. (1991). Chromosomal assignment of retinoic acid receptor (RAR) genes in the humans, mouse, and rat genomes. *Genomics* 10, 1061–1069.
- McAlpine, P.J., Shows, T.B., Boucheix, C., Huebner, M., Anderson, W.A. (1991). The 1991 catalog of mapped genes and report of the nomenclature committee. *Cytogenet. Cell Genet.* 58, 5–102.
- Misra, D.N., Kunz, H.W., Gill III, T.J. (1989a). MHC class I antigens in rat pregnancy: biochemical comparison between the pregnancy-associated (Pa) antigen and the class I MHC antigen RT1. A\*<sub>a</sub> in the rat. *Transplant. Proc.* 21, 3271.
- Misra, D.N., Kunz, H.W., Kanbour, A., Gill III, T.J. (1989b). Characterization of pregnancy-associated rat MHC class I antigen Pa by mating studies and by peptide mapping. *Transplant. Proc.* 21, 561–562.
- Mizuno, M., Suzuki, K. (1978). Genetic variation of pancreatic  $\alpha$ -amylase in the rat, *Rattus norvegicus*. *Jpn. J. Genet.* 53, 137–142.
- Mock, B., Kozak, C., Seldin, M.F., Ruff, N., D'Hoostelaere, L., Szpirer, C., Senanez, H., O'Brien, S., Banner, C. (1989). A glutaminase (*Gls*) gene maps to mouse chromosome 1, rat chromosome 9, and human chromosome 2. *Genomics* 5, 291–297.
- Mori, M., Ishizaki, K., Yamada, T., Chen, H., Sugiyama, T., Serikawa, T., Yamada, J. (1989). Restriction fragment length polymorphism of the angiotensinogen gene in inbred rat strains and mapping of the gene on chromosome 19q. *Cytogenet. Cell Genet.* 50, 42–45.
- Mori, M., Ishizaki, K., Serikawa, T., Yamada, J. (1992a). Localization of the rat insulin I gene (*INS1*) to chromosome 1q55 by fluorescence in situ hybridization. *Cytogenet. Cell Genet.* 59, 31–33.
- Mori, M., Ishizaki, K., Serikawa, T., Yamada, J. (1992b). Instability of the minisatellite sequence in the first intron of the rat renin gene. *J. Hered.* 83, 204–207.
- Mori, M., Yokota, Y., Yasue, M., Serikawa, T., Yamada, J. (1992c). Assignment of the rat genes coding for substance P receptor, substance K receptor and neuromedin K receptor to chromosome 4, 20 and 2, respectively. *Cytogenet. Cell Genet.* 60, 222–223.
- Mori, M., Oda, T., Nishiyama, K., Serikawa, T., Yamada, J., Ichiyama, A. (1992d). A single serine: pyruvate aminotransferase gene on rat chromosome 9q34-q36. *Genomics* 13, 686–689.
- Morris-Kay, G.M., Hunt, S.V. (1986). Preliminary characterization of a skeletal mutant, *Tal-2*, and a comment on linkage group I to which it maps. *Rat News Lett.* 16, 6–7.
- Moutier, R. (1980). Linkage of the hypodactyly and incisorless genes in the Norway rat. *J. Hered.* 71, 129–130.
- Moutier, R., Toyama, K., Charrier, M.-F. (1973a). Biochemical polymorphism in the rat (*Rattus norvegicus*): genetic study of four markers. *Biochem. Genet.* 8, 321–328.
- Moutier, R., Toyama, K., Charrier, M.-F. (1973b). Linkage of a plasma protein marker (*Gl-1*) and the hooded locus in the rat (*Rattus norvegicus*). *Biochem. Genet.* 10, 395–398.
- Moutier, R., Toyama, K., Charrier, M.-F. (1973c). Hypodactyly, a new recessive mutation in the Norway rat. *J. Hered.* 64, 99–100.
- Mullen, Y., Hilderman, W.H. (1972). X- and Y-linked transplantation antigens in rats. *Transplantation* 13, 521–529.
- Muramatsu, Y., Yamada, T., Agui, T., Yamada, J., Serikawa, T., Matsumoto, K. (1993). Chromosomal assignments of genes for rat glutathione S-transferase Yb1 (GSTA3) and Yb2 (GSTA4) subunits. *Cytogenet. Cell Genet.* 63, 141–143.
- Nahon, J.-L., Joly, C., Levan, G., Szpirer, J., Szpirer, C. (1992). Pro-melanin-concentrating hormone gene (PMCH) is localized on human chromosome 12q and rat chromosome 7. *Genomics* 12, 846–848.
- Nikaido, H., Yamada, J., Kondo, Y. (1982). Male urinary protein-1 (*MUP-1*) in the rat. *J. Hered.* 73, 119–122.
- Osten, M., Den Bieman, M., Van Zutphen, L.F.M. (1993). Linkage of the gene for uncoupling protein to esterase-1,2 and haptoglobin in the rat. *J. Hered.* 84, 149–151.
- Owen, R.D. (1962). Earlier studies of blood groups in the rat. *Ann. N.Y. Acad. Sci.* 97, 37–42.
- Pagés, G., Rouayrenc J.F., Rossi, V., LeCam, G., Mariller, M., Szpirer, J., Szpirer, C., Levan, G., LeCam, A. (1990). Primary structure and assignment to chromosome 6 of three closely related rat genes which encode serine protease inhibitors expressed in liver. *Gene* 94, 273–282.
- Palm J. (1962). Current status of blood groups in rats. *Ann. N.Y. Acad. Sci.* 97, 57–68.
- Palm, J. (1971). Immunogenetic analysis of Ag-B histocompatibility antigens in rats. *Transplantation* 11, 175–183.
- Palm, J., Ferguson, G. (1976). Fuzzy, a hypotrichotic mutant in linkage group I of the Norway rat. *J. Hered.* 67, 284–288.
- Pear, W., Wahlström, G., Szpirer, J., Levan, G., Klein, G., Sümegi, J. (1986). Localization of the rat immunoglobulin heavy chain locus to chromosome 6. *Immunogenetics* 23, 293–295.
- Perlmann, C., Sümegi, J., Szpirer, C., Levan, G., Klein, G. (1985). The rat immunoglobulin kappa light chain locus is on chromosome 4. *Immunogenetics* 22, 97–100.
- Perrotez, C., Maurice, M., Feldman, G., Szpirer, C., Szpirer, J., Parent, I., Cassio, D., Levan, G. (1989). Expression of rat hepatocyte plasma membrane antigens in hybrid clones: assignment of genes coding for two antigens of the basolateral domain to chromosome 11 and 13. *Cytogenet. Cell Genet.* 52, 154–156.
- Pravenec, M., Kren, V., Klir, P. (1987). Assignment of *Es-6* locus to linkage group VII of the rat (*Rattus norvegicus*) by the use of HXB recombinant inbred rat strains. *J. Immunogenet.* 14, 313–316.
- Pravenec, M., Simonet, L., Kren, V., Kunes, J., Levan, G., Szpirer, J., Szpirer, C., Kuntz, T. (1991). The rat renin gene: assignment to chro-

- mosome 13 and linkage to the regulation of blood pressure. *Genomics* 9, 466–472.
- Pravenec, M., Simonet, L., Kren, V., Lezin, E.S., Levan, G., Szpirer, J., Szpirer, C., Kurtz, T. (1992). Assignment of rat linkage group V to chromosome 19 by single-strand conformation polymorphism analysis of somatic cell hybrids. *Genomics* 12, 350–356.
- Pulkka, A., Ihalainen, R., Suorsa, A., Rivière, M., Szpirer, J., Pajunen, A. (1993). Structures and chromosomal localizations of two rat genes encoding s-adenosylmethionine decarboxylase. *Genomics* 16, 342–349.
- Rampersaud, A., Waltz Jr., F.G. (1987). Mapping of genes for cytochromes P-450b, P450e, and P-450h in the rat. *J. Biol. Chem.* 262, 5649–5653.
- Rehm, S., Mehraein, P., Anzil, A.P., Deerbeg, F. (1982). A new rat mutant with defective overhairs and spongy degeneration of the central nervous system: clinical and pathological studies. *Lab. Anim. Sci.* 32, 70–73.
- Remmers, E.F., Goldmuntz, E.A., Cash, J.M., Crofford, L.J., Misiewicz-Poltorak, B., Zha, H., Wilder, R.L. (1992). Genetic map of nine polymorphic loci comprising a single linkage group on rat chromosome 10: evidence for linkage conservation with human chromosome 17 and mouse chromosome 11. *Genomics* 14, 618–623.
- Remmers, E.F., Goldmuntz, E.A., Cash, J.M., Zha, H., Crofford, L.J., Misiewicz-Poltorak, B., Mathern, P., Wilder, R.L. (1993a). Map of seven polymorphic markers on rat chromosome 14: linkage conservation with human chromosome 4. *Mammalian Genome* 4, 90–94.
- Remmers, E.F., Goldmuntz, E.A., Zha, H., Crofford, L.J., Cash, J.M., Mathern, P., Du, Y., Wilder, R.L. (1993b). Linkage map of seven polymorphic markers on rat chromosome 18. *Mammalian Genome* 4, 265–270.
- Robinson, R. (1982). Linkage in the Norway rat (*Rattus norvegicus*). In *Genetic Maps*, S.J. O'Brien, ed. (Frederick Md.: National Cancer Institute), pp. 209–301.
- Roby, K.F., Deb, S., Gibori, G., Szpirer, C., Levan, G., Kwok, S.C.M., Soares, M.J. (1993). Decidual prolactin-related protein. *J. Biol. Chem.* 268, 3136–3142.
- Sasaki, M., Nishida, C., Kodama, Y. (1986). Characterization of silver stained nucleolus organizer regions (Ag-NORs) in 16 inbred strains of the Norway rat. *Cytogenet. Cell Genet.* 41, 83–88.
- Satoh, H., Nagai, F., Homma, H., Mori, S., Matsui, M. (1993). Regional assignment of rat androsterone UDP-glucuronosyltransferase gene (UGT2B2) to chromosome 14p21.2-p22. *Cytogenet. Cell Genet.* 62, 49–51.
- Schröder, J., Autio, K., Jarvis, J.M., Milstein, C. (1980). Chromosome segregation and expression of rat immunoglobulins in rat/mouse hybrid myelomas. *Immunogenetics* 10, 125–131.
- Serikawa, T., Montagutelli, X., Simon-Chazottes, D., Guénet, J.-L. (1992a). Polymorphisms revealed by PCR with single, short-sized, arbitrary primers are reliable markers for mouse and rat gene mapping. *Mammalian Genome* 3, 65–72.
- Serikawa, T., Kuramoto, T., Hilbert, P., Mori, M., Yamada, J., Dubay, C.J., Lindpainter, K., Ganten, D., Guénet, J.-L., Lathrop, M., Beckmann, J.S. (1992b). Rat gene mapping using PCR-analyzed microsatellites. *Genetics* 131, 703–723.
- Shisa, H., Hiai, H. (1985). Genetically determined susceptibility of Fischer 344 rats to propylnitrosourea-induced thymic lymphomas. *Cancer Res.* 45, 1483–1487.
- Shumiya, K., Nagase, S. (1982). Linkage of the analbuminemia locus (*alb*) and the hooded locus in the rat, *Rattus norvegicus*. *Exp. Anim.* 31, 199–202.
- Shumiya, K., Nagase, S. (1988). Mapping of hooded, Gc protein, and albumin gene loci in linkage group VI of the laboratory rat. *Biochem. Genet.* 26, 585–593.
- Simon-Chazottes, D., Wu, H., Parmer, R.J., Rozansky, D.J., Szpirer, J., Levan, G., Kurtz, T.W., Szpirer, C., Guénet, J.-L., O'Connor, D.T. (1993). Assignment of the chromogranin A (*Chga*) locus to homologous regions on mouse chromosome 12 and rat chromosome 6. *Genomics* 17, 252–255.
- Skow, L.C., Heinz, W., Gill III, T.J. (1985). Linkage of the locus encoding the A chain of  $\alpha$ -crystallin (*Acry-1*) to the major histocompatibility complex in the rat. *Immunogenetics* 22, 291–293.
- Soares, M.B., Schon, E., Henderson, A., Karathanasis, K., Cate, R., Zeitlin, S., Chirgwin, J., Efstratiadis, A. (1985). RNA-mediated gene duplication: the rat preproinsulin I gene is a functional retroposon. *Mol. Cell Biol.* 5, 2090–2103.
- Stark, O., Günther, E., Kohoutova, M., Vojcik, L. (1977). Genetic recombination in the major histocompatibility complex (H-1, Ag-B) of the rat. *Immunogenetics* 5, 183–187.
- Stolc, V. (1984a). Linkage of diabetes insipidus and agouti genes in the rat. *Biochem. Genet.* 22, 893–899.
- Stolc, V. (1984b). Linkage of hooded and hooded modifier genes in the rat. *J. Hered.* 75, 81.
- Stolc, V., Gill III, T.J. (1983). Linkage and polymorphism of gene controlling lactate dehydrogenase in the rat. *Biochem. Genet.* 21, 933–941.
- Stolc, V., Kunz, H.W., Gill III, T.J. (1980). The linkage of glyoxylase-1 to the major histocompatibility complex in the rat. *Immunology* 125, 1167–1170.
- Sullivan, P.M., Petrusz, P., Szpirer, C., Joseph, D.R. (1991). Alternative processing of androgen-binding protein RNA transcripts in fetal rat liver: identification of a transcript formed by trans splicing. *J. Biol. Chem.* 266, 143–154.
- Sümeği, J., Spira, J., Bazin, H., Szpirer, J., Levan, G., Klein, G. (1983). Rat c-myc oncogene is located on chromosome 7 and rearranges in immunocytomas with t(6;7) chromosomal translocation. *Nature* 306, 497–498.
- Szabo, P., Lee, M.R., Elder, F.B., Prenskey, W. (1978). Localization of 5S RNA and rRNA genes in the Norway rat. *Chromosoma* 65, 161–172.
- Szpirer, C., Szpirer, J., Islam, M.Q., Levan, G. (1988a). The rat gene map. *Curr. Top. Microbiol. Immunol.* 137, 33–38.
- Szpirer, C., Kraus, J.P., Rivière, M., Swaroop, M., Ohura, T., Matsubara, Y., Szpirer, J., Islam, M.Q., and Levan, G. (1989a). Assignment of the rat genes coding for medium-chain acyl-Co-A carboxylase, isovaleryl-CoA dehydrogenase, and the  $\beta$  subunit of propionyl-Co-A carboxylase to chromosome 2,3, and 8, respectively. *Cytogenet. Cell Genet.* 50, 23–26.
- Szpirer, C., Rivière, M., Szpirer, J., Genet, M., Dreze, P., Levan, G. (1989b). The rat gene map: assignment of 10 loci to chromosome 5, and homology of rat chromosome 5 with mouse chromosome 4, human chromosome 9, and human chromosome arm 1p. *Cytogenet. Cell Genet.* 51, 1087.
- Szpirer, C., Rivière, M., Szpirer, J., Genet, M., Dreze, P., Islam, M.Q., Levan, G. (1990). Assignment of 12 loci to rat chromosome 5: evidence that this chromosome is homologous to mouse chromosome 4 and to human chromosome 9 and 1 (1p arm). *Genomics* 6, 679–684.
- Szpirer, C., Rivière, M., Szpirer, J., Hanson, C., Levan, G., Hendy, G.N. (1991a). Assignment of the rat parathyroid hormone-like peptide gene (*PTHLH*) to chromosome 4: evidence for conserved synteny between human chromosome 12, mouse chromosome 6 and rat chromosome 4. *Cytogenet. Cell Genet.* 56, 193–195.
- Szpirer, C., Szpirer, J., Rivière, M., Ingvarsson, S., Vennström, B., Islam, M.Q., Levan, G. (1991b). Chromosomal assignment of five cancer-associated rat genes: two thyroid hormone receptor (*ERBA*) genes, two *ERBB* genes and the retinoblastoma gene. *Oncogene* 6, 1319–1324.
- Szpirer, C., Rivière, M., Cortese, R., Nakamura, T., Islam, M.Q., Levan, G., Szpirer, J. (1992a). Chromosomal localization in man and rat of the genes encoding the liver-enriched transcription factors *C/EBP*, *DBP*, and *HNF1/LFB-1 (CEBP, DBP and transcription factor 1, TCF1, respectively)* and of the hepatic growth factor/scatter factor gene (*HGF*). *Genomics* 13, 293–330.
- Szpirer, C., Reivière, M., Szpirer, J., Levan, G., Jaspers, M., Vekemans, S., Cassiman, J.-J. (1992b). Assignment of three rat integrin genes to chromosome 19 (*ITGB1*), chromosome 3 (*ITGA4*), and chromosome 7 (*ITGA5*). *Mammalian Genome* 3, 685–688.
- Szpirer, J., Levan, G., Thörn, M., Szpirer, C. (1984). Gene mapping in the rat by mouse-rat somatic cell hybridization: synteny of the albumin and  $\alpha$ -fetoprotein genes and assignment to chromosome 14. *Cytogenet. Cell Genet.* 38, 142–149.
- Szpirer, J., Efeo-Jones, D., Ellis, R.W., Levan, G., Szpirer, C. (1985). Assignment of three rat cellular RAS oncogenes to chromosomes 1, 4, and X. *Somatic Cell Mol. Genet.* 11, 93–97.
- Szpirer, J., Islam, Q., Rivière, M., Cooke, N.E., Koenig, M.A., Szpirer, C., Levan, G. (1987). Recent chromosomal assignments of rat genes fibrinogen ( $\beta$ -chain), aldolase B, transferrin, C3, ERBA and ERBB. *Cytogenet. Cell Genet.* 46, 701.
- Szpirer, J., Islam, M.Q., Cooke, N.E., Szpirer, C., Levan, G. (1988b). Assignment of three rat genes coding for plasma proteins: transferrin, third component of complement and beta-fibrinogen to chromosome 8, 9, and 2. *Cytogenet. Cell Genet.* 47, 42–45.
- Szpirer, J., Szpirer, C., Rivière, M., Houat, C., Baumann, M., Fey, G.H., Poli, V., Cortese, R., Islam, M.Q., Levan, G. (1991c). The interleukin-6-dependent DNA binding protein gene (transcription factor-5-TCF5)

- maps to human chromosome 20 and rat chromosome 3, the IL-6 receptor locus (*IL6R*) to human chromosome 1 and rat chromosome 2, and the rat *IL6* gene to rat chromosome 4. *Genomics* 10, 539–546.
- Szpirer, J., Szpirer, C., Rivière, M., Levan, G., Marynen, P., Cassiman, J.J., Wiese, R., Deluca, H.F. (1991d). The Sp1 transcription factor gene (*SP1*) and the 1,25-dihydroxy vitamin-D3 receptor gene (*VDR*) are localized on human chromosome arm 12q and rat chromosome 7q. *Genomics* 11, 168–173.
- Takahashi, R., Mihara, K., Maeda, S., Yamaguchi, T., Chen, H.-L., Aoyama, N., Murano, S.-H., Hatanaka, M., Sugiyama, T. (1986). Secondary activation of *c-abl* may be related to translocation to the nucleolar organizer region in an in vitro cultured rat leukemia cell line (K3D). *Proc. Natl. Acad. Sci. USA* 83, 1079–1083.
- Truett, G.E., Baharry, N., Friedman, J.M., Leibel, R.L. (1991). Rat obesity gene fatty (*fa*) maps to chromosome 5: evidence for homology with mouse gene diabetes. *Proc. Natl. Acad. Sci. USA* 88, 7806–7809.
- Tsichlis, P.N., Lohse, M.A., Szpirer, C., Szpirer, J., Levan, G. (1985). Cellular DNA regions involved in the induction of rat thymic lymphomas (*Mlvi-1*, *Mlvi-2*, *Mlvi-3*, and *c-Myc*) represent independent loci as determined by their chromosomal map location in the rat. *J. Virol.* 56, 938–942.
- Tsichlis P.N., Lee, J.S., Bear, S.E., Lazo, P.A., Patriotis, C., Gustafson, E., Shinton, S., Jenkins, N.A., Copeland, N.G., Huebner, K., Croce, C., Levan, G., Hanson, C. (1989). Activation of multiple genes by provirus integration in the *Mlvi-4* locus in T cell lymphomas induced by Moloney murine leukemia virus. *J. Virol.* 64, 2236–2244.
- van de Berg, J.L., Bittener, G.N., Meyer, G.S., Kunz, H.W., Gill III, T.J. (1981). Linkage of neuroaminidase and  $\alpha$ -mannosidase to the major histocompatibility complex in the rat. *J. Immunol.* 8, 239–242.
- van Zutphen, L.F.M., Lagerwerf, A., Bouw, J., den Biemann, M.G.C.W. (1981). Biochemical polymorphism in the rat: genetics of three electrophoretic variants and characterization of inbred strains. *Biochem. Genet.* 19, 173–186.
- van Zutphen, L.F.M., den Biemann, M., Hedrich, H.J., Kluge, R. (1985). Assignment of *Lap-1* to linkage group I of the rat (*Rattus norvegicus*). *Biochem. Genet.* 23, 599–606.
- Vassort, C., Rivière, M., Bruneau, G., Gros, F., Thibault, J., Levan, G., Szpirer, J., Szpirer, C. (1993). Assignment of the rat genes coding for DOPA decarboxylase (DDC) and glutamic acid decarboxylases (GAD1 and GAD2). *Mammalian Genome* 4, 202–206.
- von Deimling, O., Günther, E. (1982). *Rat News Lett.* 9, 43.
- Watanabe, R., Wege, R.H., terMeurlen, V. (1987). Comparative analysis of coronavirus JHM-induced demyelinating encephalomyelitis in Lewis and Brown Norway rats. *Lab. Invest.* 57, 375–384.
- Watters, J.W.F., Locker, J.D., Kunz, H.W., Gill III, T.J. (1987). Polymorphism and mapping of the component gene C4 in the rat. *Immunogenetics* 25, 204–206.
- Wiener, F., Babonitis, M., Spira, J., Klein, G., Bazin, H. (1982). Non-random chromosomal changes involving chromosomes 6 and 7 in spontaneous rat immunocytomas. *Int. J. Cancer* 29, 413–437.
- Womack, J.E. (1972). Generic control of an esterase of digestive tract tissues in *Rattus norvegicus*. *Experimentia* 28, 1372.
- Womack, J.E. (1973). Biochemical genetics of rat esterases: polymorphism, tissue expression and linkage of four loci. *Biochem. Genet.* 9, 13–24.
- Womack, J.E., Cramer, D.V. (1980). Peptidase-3 (*Pep-3*), dipeptidase variant in the rat homologous to mouse *Pep-3* (*Dip-3*) and human *PEP-C*. *Biochem. Genet.* 18, 1019–1026.
- Womack, J.E., Sharp, M. (1976). Comparative autosomal linkage in mammals: genetics of esterases in *Mus musculus* and *Rattus norvegicus*. *Genetics* 82, 665–675.
- Wonigeit, K. (1979). Definition lymphocyte antigens in rats: *RT-Ly-1*, *RT-Ly-2*, and a new MHC-linked antigen system. *Transplant. Proc.* 11, 1334–1336.
- Wurst, W., Benesch, C., Drabent, B., Rothermal, E., Benecke, B.J., Günther, E. (1989). Localization of heat shock protein 70 genes inside the rat major histocompatibility complex close to class III gene. *Immunogenetics* 30, 46–49.
- Yamada, J., Nikaido, H., Matsumoto, S. (1980). Linkage analyses among five esterase loci in the laboratory rat (*Rattus norvegicus*). *Biochem. Genet.* 18, 433–438.
- Yamada, J., Nikaido, H., Kondo, Y. (1981). Genetic studies of RBC catalase in the rat (*Rattus norvegicus*). *Jpn. J. Genet.* 56, 447–455.
- Yamada, T., Mori, M., Serikawa, T., Yamada, J. (1989). Assignment of body tremulous mutant gene zitter (*zi*) to linkage group IV of the rat (*Rattus norvegicus*). *J. Hered.* 80, 383–386.
- Yamada, T., Muramatsu, Y., Yasue, M., Agui, T., Yamada, J., Matsumoto, K. (1992). Chromosomal assignments of genes for rat glutathione s-transferase Ya (GSTA1) and Yc subunits (GSTA2). *Cytogenet. Cell Genet.* 61, 125–127.
- Yasue, M., Serikawa, T., Yamada, J. (1991). Chromosomal assignments of 23 biochemical loci of the rat by using rat  $\times$  mouse somatic cell hybrids. *Cytogenet. Cell Genet.* 57, 142–148.
- Yause, M., Serikawa, T., Kuramoto, T., Mori, M., Higashiguchi, T., Ishizaki, K., Yamada, J. (1992). Chromosomal assignments of 17 structural genes and 11 related DNA fragments in rats (*Rattus norvegicus*) by Southern blot analysis of rat  $\times$  mouse somatic cell hybrid clones. *Genomics* 12, 659–664.
- Yeung, R.S., Taguchi, T., Patriotis, C., Makris, A., Tsichlis, P.N., Levan, K.K., Levan, G., Tartof, K., Hino, O., Kundson, A.G., Testa, J.R. (1993). New markers, D16FC1 and Tpl2, differentiate between rat chromosomes 16 and 17. *Cytogenet. Cell Genet.* 62, 149–152.
- Yoshida, M.C. (1978). Rat gene mapping by rat-mouse somatic cell hybridization and a comparative Q banding analysis between rat and mouse chromosomes. *Cytogenet. Cell Genet.* 22, 606–609.
- Yoshida, M.C. (1979). Synteny of the genes for adenylate kinase and phosphoglucomutase in the rat and their assignment to rat chromosome 5. *Proc. Jpn. Acad.* 55, 403–406.
- Yoshida, M.C. (1982). Assignment of the syntenic genes *AK2*, *ENO1*, *PGD*, and *PGM2* to rat chromosome 5. *Cytogenet. Cell Genet.* 32, 330.
- Yoshida, M.C. (1984a). *GPI*, *LDHA*, and *PEPD* are syntenic and assigned to rat chromosome 7. *Cytogenet. Cell. Genet.* 37, 613.
- Yoshida, M.C. (1984b). Assignment of GDH and FUCA to rat chromosome 5: evidence for homologous linkage groups in rat, mouse, and man. *Cytogenet. Cell Genet.* 37, 613.
- Zha, H., Wilder, R.L., Goldmuntz, E.A., Cash, J.M., Crofford, L.J., Mathern, P., Remmers, E.F. (1993). Linkage map of 10 polymorphic markers on rat chromosome 2. *Cytogenetic. Cell Genet.* 63, 117–122.
- Zhang, J., Dirckz, L., Marynen, P., Rombauts, W., Delaey, B., van Den Berghe, H., Cassiman, J.-J., (1988). Mapping of rat prostatic binding protein genes C1, C2 and C3 to rat chromosome 5 by in situ hybridization. *Cytogenet. Cell Genet.* 48, 121–123.
- Zhang, J., Hemschoote, K., Peeters, B., De Clercq, N., Rombatus, W., Cassiman, J.J. (1989). Localization of the *PRRI* gene coding for rat prostatic proline-rich polypeptides to chromosome 10 by in situ hybridization. *Cytogenet. Cell Genet.* 52, 197–198.