

Supplementary Information

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Supplementary Figure Legends

Supplementary Figure 1

Alignment of TEX11 protein sequences. Multiple sequence alignment was performed using CLUSTAL 2.0.9. Red font marks residues affected by the five *TEX11* missense mutations identified in infertile men.

Supplementary Figure 2

Analysis of chromosomal synapsis in spermatocytes from 25-day-old wild type and *Tex11* KI(WT);-Y mice. Surface spread nuclei from spermatocytes were immunostained with anti-SYCP1 and anti-SYCP2 antibodies. Representative images of spermatocytes at the pachytene stage are shown. XY chromosomes are indicated. This supplementary figure is related to Figure 3B.

Supplementary Figure 3

Number of MLH1 foci in spermatocytes from 3-month-old males. Representative images are shown for the following *Tex11* genotypes: A) -/Y, 17 MLH1 foci; B) KI;-/Y, 21 MLH1 foci; C) +/Y, 22 MLH1 foci; D) KI;+/Y, 26 MLH1 foci. This supplementary figure is related to Figure 4A.

Supplementary Figure 4

Analysis of chromosomal synapsis in spermatocytes from 3-month-old male mice. Surface spread nuclei from spermatocytes were immunostained with anti-SYCP1 and anti-SYCP2 antibodies. XY chromosomes are indicated (A-C). Representative images are shown for the following *Tex11* KI/KO (KI;-/Y) genotypes: A) wt; B) W118R; C) Q173R; D) KIV749A. The spermatocyte (D) displayed extensive chromosomal asynapsis. This supplementary figure is related to Figure 6E.

Supplementary Figure 5

Testicular maturation arrest in an infertile male patient with V748A mutation in *TEX11* (WHT2499). Testicular tissue was obtained by biopsy, sectioned, and stained with hematoxylin/eosin. The biopsy sample shows absence of post-meiotic germ cells such as round spermatids in the seminiferous tubule, whereas meiotic stage spermatocytes such as at the pachytene stage (arrows) are present. The boxed tubule in panel A is enlarged in panel B. Scale bar, 50 μ m.

Supplementary Table 1 Common sequence variants in human *TEX11* gene.

Position	Nucleotide change	Resultant change	Infertile males		Normal males	
			AZ 246*	Fertile 93*	NIH diversity 82*	
Exon 6	344A→G	Missense mutation, K115R; SNP: rs6525433	14 [#]	5	20	
Exon 16	1306G→A	Missense mutation, E436K; SNP: rs4844247	11	4	10	
Exon 26	2274A→T	Silent mutation	1		1	
Exon 28	2496T→G	Missense mutation, D832E			2	
Exon 28	2496T→C	Silent mutation; SNP: rs16991177	13	4	9	
Exon 30	123T→C 3'UTR	Alteration in the first AATAAA signal	2	1	0	
Intron 4	+35G→A	Intronic alteration; SNP: rs5937008	118	34	29	
Intron 4	-22T→C	Intronic alteration	7	1	9	
Intron 4	-24C→T	Intronic alteration	1	1	3	
Intron 7	-26T→C	Intronic alteration; SNP: rs17301944	25	9	2	
Intron 8	+11T→A	Intronic alteration	1	1	1	
Intron 11	-27T→C	Intronic SNP: rs6653304	12	5	2	
Intron 16	+48A→T	Intronic SNP: rs5980996	38	23	13	
Intron 18	-25A→G	Intronic SNP: rs1325094	40	24	14	
Intron 18	-23T→C	Intronic SNP: rs1325094	88	39	21	
Intron 21	-10T→A**	Intronic alteration	2			
Intron 24	+89T→C	Intronic alteration			2	
Intron 28	+58T→C	Intronic SNP	8	3	12	
Intron 28	-3, -4 TC→AT	Intronic SNP: rs1536250, rs1536251	15	4	2	

Notes: *Number of individuals screened; AZ, azoospermic males. **+1 refers to the first base of a given intron, and -1 the last base.

[#]Number of males with the given variant.

Supplementary Figure 1 Alignment of TEX11 protein sequences

Species	Accession No.
Human	NM_031276
Mouse	NM_031384
Macaq	AB074448
Dog	XM_844423
Horse	XM_001490344
Cow	XM_593293
Rat	XM_576992
Oposs	XP_001368341
Chick	XM_420206
Danio	XM_001922537
Tetra	CAG09799
Branch	XM_002210899
Coral	EZ003728
Nemat	XM_001630824

Multiple sequence alignment was performed using CLUSTAL 2.0.9.

Human	-----MDNDDFFSMDFKEVVENLVTNDNS	24
Mouse	-----MDRITDFYFLDFRESVKTLIITGNS	25
Macaq	-----	1
Dog	-----MTSLWEEVPSARRPALWIEFVERRLWLSWSCGEIVENLIVKDNS	44
Horse	-----MKI IENLIVKGNS	13
Cow	-----MSLLSFVISETIENLIATDIS	21
Rat	-----MIITGNS	7
Oposs	-----	1
Chick	-----	1
Danio	-----MEQFAVEVKDLSEKLLHRQSH	21
Tetra	-----	1
Branch	MHVFLLVFSTDLLRLLFKFNFKNLYLFFCRLKALEKETLPKCQATMIKALEKDKDEDKVA	60
Coral	-----	1
Nemat	-----	1

Human	PNIPEAIDRLFSDIANINRESMAEITDIQIEEMAVNLWNWALTIGGGWLVNEEQKIRLHY	84
Mouse	WRLQEMIDRFFFTNISNFNRESLTEIQNIQIEEIAVNLWNWAVTKRVELSVRKNQAACLKY	85
Macaq	-----MIFFPWT-----LKIEEMAVNLWNWALTIGGGWHVNEERKIKLHY	40
Dog	PSIPEAINRLFTDIANINRESIAEQDAQVEEMAVNLWNWAVTKRVDLVINEEQKAKLWY	104
Horse	PSIHEAIDRLFMIDIANINRESMAEMQDAQVEEMAVNLWNWAVTRRVGLVISEEQKAKLQH	73
Cow	PTTPAAIDRLFMIDIGNINRESMAEQDSQIEEMAVNLWNWIITNNIGLVINEEQKAKVRH	81
Rat	WRLHEMIDKFFMNISNFNRSKSLTEVQNIQIEEIAVNLWNWATAKRLELSVRKSQAACLKY	67
Oposs	-----	1
Chick	-----	1
Danio	SDLDEVIDSLFKEILTLD--EAAKLQDSQLEEIAIQLWNWAVTKRVGTSITEEQKAKVRH	79
Tetra	-----	1
Branch	QRAETLSELLDKVSGLHGSDKNRTSSGELQNCVNLWNI AVAKRAGGHLSTGLNARLRH	120
Coral	-----	1
Nemat	-----	1

W117R

V142I

Human	VACKLLSMCEASFASEQSIQRLIMMNRIGKEWLDAGNFLIADECFQAAVASLEQLYVKL	144
Mouse	IACKLVYMHGISVSSEEAIQRQILMNIKTGKEWLYTGNAQIADEFFQAAMTDLERLYVRL	145
Macaq	VACKLLSMCEASFASEQGIQRLIMMNI RIGREWLDVGNFLIADECFQAAVASLEQLYIKL	100
Dog	VACKLVCMCGGSAASEEAI RRQILMNMKTGKGWVDVGNVIADEFFQAAMAGLEQLYVKL	164
Horse	VACKLVCMCEDSAVSEEAIQKQILMNMKTGKGWLDVGNVIADEFFQVAIAGLEQLYVRL	133
Cow	VACKLIRMCEHPDASEEAIHRQILMNMKTGKGWVNVGNVVLADDFQSAITSLEKLYSKI	141
Rat	IACKLVCMHGVSVSSEEAIQRQILMNMKTGKQWLDTGNAQIADEFFQAAMANLEKLYSRL	127
Oposs	-----	1
Chick	-----MQCGVARRETSMRSVAVPARSPEQAARM RPAVLSLS SGRAVLRDGLGHELLRELL	54
Danio	VACRLLYSCGPENPSESIVRKQILMNAKTGRTWLDCKNSKSADAFLSMAVNSLETLYSRL	139
Tetra	-----FSSYLQSLETLYSKL	15
Branch	LACQLAFKVS PLEGSEVVLKRRVMMASKTGRAWLDGGNPSMADNSLSLASECLEKLT KSV	180
Coral	-----	1
Nemat	-----	1

Q172R

Human	IQRS----SPEADLTMEKITVESDHFVLSYQAESAVAQGDFQRASMCV LQCKDMLMRLP	200
Mouse	MQSC----YTEANVCVYKMIVEKGFHVLSYQAESAVAQGDFKKASLCVLRCKDMLMRLP	201
Macaq	IQRS----SPEADLIMEKITVERDHFVLSYQAESAVAQGDFQRASMCV LQCKDMLMRLP	156
Dog	MQRS----STEIHMALHKIAMERDLFKVLSYQAEA AVAQGDFHFRAYTCTLRCKDMLMRFP	220
Horse	MQRS----STEAHVAMQKIAVERDLFKVLSYQAESAVAQGDFQRASACVLRCKDVL MRVP	189
Cow	TQRS----PTEEHVMVQKNTVERDLLKVLSYQAEA AVAGGNFQKASRCILRCKDMLVRLP	197
Rat	MQSC----HTETNLSLYKNTVERLHCRYVNW E IETAVAQGDFKKASICVLRCKDMLIRIP	183
Oposs	-----	1
Chick	REEA----PPRIAALTEELFQAAGALCEADGSAAEAVAQGDFQKAMQCVQRCKDMLVRLP	110
Danio	TSHG----DGE-DMNTPKGDIEKDLLRILSYQAESAVSQEQHQVAVSCIQRCKEILLRLP	194
Tetra	TSRT----DGSYDSTLSKEDVEKDLLRVLSFQAESALCQGNNAEALTCIQRCKDMLLRLP	71
Branch	LSAAAEGKLS EDDKERQKTEIEKDMFKVFCYQAESAVAQEQHDVAMRLAQRCKEMLARLP	240
Coral	-----	1
Nemat	-----AMSLGNNSALECIEKAKAFLVKLP	25

T244I

Human	QMTSSLHHLHCYNFGVETQKNNKYEESFFWLSQSYDIGKMDKK-S	TGPEMLAKVLRLLLATN	259
Mouse	NMTKYLHVLCYNLGI EASKRNKYKESFFWLGQSYEIGKMDRR-S	VEPQMLAKTLRLLLATI	260
Macaq	QMTSSLHHLHCYNFGVGTQKNNKYEESFFWLSQSYDIGKMDKK-S	TRPETLAKVLRLLLATN	215
Dog	KMTGYLHILHCYNFGVETHKQNKYEESFFWLSQSYDIGKMDKN-S	VGPEMLAKVLRLLLATA	279
Horse	KKTRYLHILHCYNFGVETYKQNKYEESFFWLSQSYDIGKMEKN-S	IGPEMLAKVLRLLLATA	248
Cow	QMVCYLHTVCYNFGLQTYRENKYEESCFWLSQSF DIGKTDGN-S	VEPEMLAKVLRLLLATA	256
Rat	EMTKYLHVLCYNFGV ESKQNKYRESSFFWLSQSYDIGKMGKD-S	VEPEMLAKGLRLLLATI	242
Oposs	-----		1
Chick	RETRYLAILHCYNFGVETYDCKKYEQSSFFWLSQSYDIGKMDMKYS	IGKEMQAKVLRLLLATA	170
Danio	KETGYLSLICYNFGVDTYSQ GKHEESTFWLSQSYDIGKMNMKYS	PGSEMQAKVLRLLLATV	254
Tetra	KDTAYLSLMCYNFGVDTYNMRKFEDSAI WLSQSYDIGKINVKYA	PGSEIQAKILRLLLATV	131
Branch	KETTF LAMLCYNFGVETYQKQKYEEAVAWLR-----		271
Coral	-----		1
Nemat	KENATLSRLCYNFGVTTYNRREYEDCIEWLRESLELGK GKAP--	VGHKKQATTLRLIANA	83
Human	YLDWDDTKYYDKALNAVNL ANKEHLSSPGLFLKMKILLKGETSNEE--	LLEAVMEILHLD	317
Mouse	YLNCGGEAYYTKAFIAILIANKEHLHPAGLFLKMRILMKGNSCNEE--	LLEAAKEILYLA	318
Macaq	YLDWDNTKYYDKALNAVNL ANKEHLNSTGLFLKMKILLKGETSNEE--	LLEAVMEILHLD	273
Dog	YVDWDDQEYYDKALSAINLANKEHLNPSGLFFKMKILLKSERANEE--	LLEAVMEILHLD	337
Horse	YLDWDDREYYDKALSAINLANKEHSHPAGLFLKMKILLKGEIANEE--	LLEAVMETLHLD	306
Cow	YLDWDSSEYRDKALNI INLANKEHLDPVGLFLKVKILLKGEIGNEE--	LFQNVMEILHLG	314
Rat	YLNCDDEAYYNKALIAVIVANKEHLDPAGLFLKMRILIKGKAFNEE--	LLEAAKEVLYLA	300
Oposs	-----		1
Chick	YFEWDCSLYLDKALKAINLANEENLHPAGFFLKVKILLKSGASDEG--	ISSAVAEFQHHE	228
Danio	YLEWDHQKYLEKALQAVSLANKEHMQLSGLYLKIRILVKGCSPDEA--	VKSGLSELLDCE	312
Tetra	YLEWDCQRFQEKALNAVNL ANKECMSTSGLYLKIRILQTCGASDDD--	IRAGLNEILEAE	189
Branch	-----LTANLIFTGLANSEHSHPAGLHLKVHILLVSDTVEDNRLVSAVTDC	LHHPE	322
Coral	-----		1
Nemat	YLKWDS-----LANAEHPHAGHYLKI ELLLLSDNTPMARLQSAFEEALS	SLPD	131
Human	MPLDFCLNIAKLLMDHERESVGFHFLTIIHERFKSSENIGKVLILHTDMLL	QORKEELLA	377
Mouse	MPLDFYLSIIQFLIDNKRESVGF RFLRIISDNFKSPEDRKRIILFYIDTLL	QKDQDMIAE	378
Macaq	MPLDFCLNIAKLLMDHEGESVGFHFLTIIHERFKSENTGKVL LLYIDMLL	QORKEELLA	333
Dog	MSLDFCLNVAKLLMDHERESVGFYFMKICEHFKSSENIGKALLLYIDMLL	QORKEELLA	397
Horse	ASLDVCLNIAKLLMDHDRESVGFYFLKICEHFKSSENIGKALLLHIDMLL	LERKEELLA	366
Cow	MTMNFCLNIVKLLMDHERDSVGFYFLKICEHFQSS EDTSKAQLLHIDMLL	QRKEDLFAK	374
Rat	MPLDFCLSIIQFLIDNKRD SVGFCFLKIADHFKLPEHRKRILFYIDMLL	QVDQDVIAE	360
Oposs	----MCL-----LARD SVGFDFLKTVC DRFESSADVGKGFLLHVKLL	LQRKEDQLAK	48
Chick	MSLDFCLNTAKLLLEHGRESVGFDFLKSVAERFEASPDFGKVTLLYIEFLL	QNKRELLAK	288
Danio	VPLEVCLSTVKLLVEENREALAFDFLKRVCQHFESSPELGSALLMHIE	LLQDKELLA	372
Tetra	AALEECLSTVNLLMSEDREVLA FEFLKRVCQHFESPD LGTALV LHAELL	LQRGKELLA	249
Branch	LTVELALNTIKLLIEHKRAQLALDGVKQLTQQFQASPELGKVYLLHLR	ILLDNROMQAAK	382
Coral	-----		1
Nemat	LTAQIGLSLAQLATRYKRTDLALNCLQTLATRFKNSPDLAKIQLOHV	ELLQNNQDQEA	191

Human	EKIEEIFLAHQ TGRQLTAESMNWLHNILWRQAASSFEVQNYTDALQWYYSLSRFYST-DE	436
Mouse	EKIKDVLKGYQTRSRLSRDLVNWLNILWGKASRSVKVQKYADALHWYSYSLKLYEY-DK	437
Macaq	EKIEEII LAHQ TGRQLTAELKNWLHNILWRKATSSFEVQNYADALQWYYSLSRFYSP-DE	392
Dog	EKIDEEIIIGQRTGRQLTTEL VVCLHNILWKKAARSFEVQNYADALNWYYSLSRFYAT-DR	456
Horse	EKIEEIIIVGHQ TGRQLTTEL VGCLHDILWKKAARSFEVQNYPDALQWYCYSLRLYAS-DQ	425
Cow	EKVEEII IGHQ TGRQLTTEL VVCLHNILWKKAARSFEVQNYPDALQWYCYSLRFYAA-DQ	433
Rat	EKIKEILIDHQ TRSRLTRALVNWLNILWGKATRCVKVQNYADALRWYSYSLKLYEC-DQ	419
Oposs	KKVEDILTAHHAGKELPPQILSWLHTILWDRAAQNFEAQNYFEALQWYNYSLNFYPS-GQ	107
Chick	QKVEEII IGHYTGKQLLPETLNRHLIILWDTAAKHYEAKSYSEALHWYNYSVSFYTP-GQ	347
Danio	QKIEDAITGHYTGKQLASQTLSSLHLLLWDRASKNFSEALQWYNYSLSFYKA-GE	431
Tetra	QKIEDIITDHYTGKQLSPQALTCLHVMLWDKACKYFEARNYPEALQWYNYSLSFFKA-GQ	308
Branch	ALVEDCITGHNTTQPLD TTRKRFHLLLWEQAAQAYEANEYEEALRWYDYSRNLFSSNDR	442
Coral	-----	1
Nemat	DLVEDCITGHNTGQQLSPDICKMFHLLLWEKAAN-----	225

Human	MDLDFTKLQRNMACCYLNLQQLDKAKEAVAEAEERHDPRNVFTQFYIFKIAVIEGNSERAL	496
Mouse	ADLDL IKLKRNMVSCYLSLKQLDKAKEAIAEVEQKDP THVFTRYIIFKIAIMEGDAFRAL	497
Macaq	MDLDFAKLQRNMACCYLNLQQLDKAKEAVAEAEERHDPRNVFTQFYIFKIAVIEGNSERAL	452
Dog	TDLDLAKLRRNMASCYLHLKQLDKAKEAVIEAEQRDP TNI FTQFYVFKIAVLEGNSGRAL	516
Horse	MDL DLAKLQRNMAACYLHLKQLDKAKVAVAEAEQRDP TNI FTQFYVFKIAVLEGNSDRAL	485
Cow	SDL DLAKLQRNMACCYLHLGQFDKAKDAVIKAAQRDP RNI FTQFYIFKISIVEGNSGRAL	493
Rat	ADMDLVKLRNMVSCYLSLKQLDKAKEALAEAEQDP TNI FTQYYIIFKIAILDGEAYRAL	479
Oposs	MDADFAKLQRNRASCYIHLKQLEKANA AVKEAERFDANIFTQFIIFKIAVLRDNT EEAL	167
Chick	IDQNLAKLQRNMACCYLHLKQIDKAKEAVKEAERC DLNSIFTQFSVYKIAVMENDTDKAV	407
Danio	LDPNLAKLQRNRSSCFLHLQQLDKAKEAVEEAARIDSANI FTQFNIYKIAILENNAEKAA	491
Tetra	LDPNLAKLQRNRVSCFLQLKQLEKAKDAVKEAQRSDPDSIF THFSVYKVAVLENNVERAA	368
Branch	HDNNMAKLERNRSACYLHLKQYDKALEAARQAETCDPTSAHTQYALFKIGLLQGN SDAAI	502
Coral	-----	1
Nemat	-----LYERNKCSCYTMLQDLKNASEAAAEAQRIEPNSPIVHFFQFKIALMKGDDNKAM	279

Human	QAIITLENILTDEESEDNDLVAERGSPTMLLSLAAQFALENGQQIVAEKALEYLAQHSED	556
Mouse	QVVSALKKSLMDGESEDRGLIEAGVSTLTILSLSIDFALENGQQFVAERALEYLCQLSKD	557
Macaq	QAIITLENVLTDEESEDNDLVAERGSPTMLLSLAAQFALENGQQIVAEKALEYLAQHSED	512
Dog	QAIT TLEKLE-EDPKENELLTDRDSPVMLLSIAAHFALENGQQIVAGKALEYLAQYSED	575
Horse	QAITSLEHLLTAEPEENNLLTDRGSTVMLLSLAAQFALEHGQQIVAGKALEYLAQYSED	545
Cow	QAIFSLEYLLTTEEQNENNVSTKRTSGVMLFCLAAQFALENGQQVAVKALENLAKYSEE	553
Rat	QIVSALKISMEE-DSEDCGLIENGVSTLRILSLCVEFALENEQQFVAQKALEYLIQLSKD	538
Oposs	TAVDALEKSVGNSAAQEKEMVKEENSSTAF LTFAAQFALENGQQDVARRALEYLSQHSQD	227
Chick	EAI IEMGKLAEKQSQHEDKLI VDESTSTNLLSLAAHIALENDQQVAVRALEHLSEHSQD	467
Danio	AALRGIGILAKAPVSSedrLLVTENAAANLLSLAAQIALEHEQQETA IKALETLCHESED	551
Tetra	EALDAIGLLCKAPVSSedrLLVSEDAASHLLKLAAQMALENEQQETAMKALES LCESSKD	428
Branch	EAIEKMGTVDEKGEENS-----TIEGLVCLAAQLAFEESNRDVAIRALERLVQHSHN	554
Coral	-----	1
Nemat	EAIKQISQSQAN-DHDNNDVTTDEDDAHGLICLAAQLSLEQNNRSVAVKALDGI LETSAS	338

Human	QEQLTAVKCLLRFLLPKIAEMPES-----EDKKKEMDRLL	592
Mouse	PKEVLGGLKCLMRIILPQAFHMPES-----EYKKKEMGRLW	593
Macaq	QEQLTAIKCLLRVLPKIAEMPES-----EDKKKEMDRLL	548
Dog	PQQVLTALKCLFCLVFPVRSQMPES-----ENKKKEMDRLL	611
Horse	PQQVLTALKCLFRLVLPKVSQMPES-----ENKKKEMDRLL	581
Cow	PPQVLTALKCLFRLCLPRISQMPES-----ENKRQEMDRIL	589
Rat	PREVLEALKCLVRIILPQAFYLPES-----EIKKKEMNRLL	574
Oposs	LQQVLTALKCLIRLTVPQISQTTECEGNRSDLFLETLFASPFILRVVPLKRRRVKFSMS	287
Chick	CQQVFAALKCLVRLTLSKVEKE-----EKRDNDIKSML	500
Danio	VPQTLTALRCLVRLALSTLENISE-----ENRNASLDILL	586
Tetra	AGLVLSALRCLVRLVLSATEQLTE-----GMRARGLVQED	463
Branch	IQQVLTAIRSSNDIILS-----	571
Coral	-----	1
Nemat	NKQVITALRCLIRLKLTISETDVKG-----DVNGIMPYLKAL	376

Exon 22-encoded aa sequence

Human	TCLNRAFVKLSQPFGEALSLESRANEAQWFRKTAWNLA VQCDKDPVMMREFFILSYK--	650
Mouse	NYLNTALLKFSEYFNEAPSTLDYMVNDANWFRKIAWNLA VQSEKDLEAMKNFFMVSYK--	651
Macaq	TCLNRAFVKLSQPFGEEDLSLESRVNEAQWFRKIAWNLA VQCDKDPVIMREFFILSYK--	606
Dog	TCLNTALQKLGQSLNGEALNSDSRAKEAHWFRKIAWNLA VQCGKDLVTMREFFILSYK--	669
Horse	TCLNIALLKLAQFFDGKASTSDSRTNEAHWFRKIAWNLA VQCDKDPVTMREFFMLSYK--	639
Cow	AYFNTALLNLTQLFEGETWTLASKINEAHWFRKTAWNLA VQCEKDPLSMREFFVLSYK--	647
Rat	SYLDTALLKFSQHFDTSSTLDPMVNDANWFRKIAWNLA LQSEKDLEKMKNFMI SYE--	632
Oposs	NKLEIAHQRLAEPVAKENLTLDVWTNEAHWFRKIAWNLA MQCEKCPGTM RDFVLSYE--	345
Chick	TYLTLAHQRLAEPFTEENLTRDIRTSEAHWFRKVAVNLA VQLKDCPEKMRDFVLSFK--	558
Danio	SYLKTALQKLSQVCHIPGQRAEQRSEDANWFRRIAWNLA LQCEHSPVRMKDFVLSFQ--	644
Tetra	RYQR-ALPRLSLNSLLHSDKPS-----FCAPAWNSALYCEKCPDRMRDFVLSYQAS	514
Branch	-----YLETAWNGLKCGEDTNMMHQFFNMCFK--	599
Coral	-----	1
Nemat	ECV NKMAALGPLADVQAEATWFMKIGNTILQKLAPWNMALDSSSESSDLREFFLIC YK--	434

Human	MSQFCPSDQVILIAKRTCLLMAVAVDLEQGRKASTAFEQTMFLSRALEEIQTCNDIHNFL	710
Mouse	LSLFCPLDQGLLIAQKTCLLVAAAVDLDRGRKAPTICEQNMLLRTALEQIKKCKKVWNLL	711
Macaq	MSQFCPSDQVILIAKRTCLLMAAAVDLEQGRKASTAFEQTMFLSRALEEIQTCNDIQNFL	666
Dog	LSQFCPSDQVILIAQKTCLLMAAAVDLEQGRKASTAFEQTRLLNRALEQIHKCRHTWNLL	729
Horse	LSQFCPSDQVILIAQKTCLLMAAAVDLEQGRKASTTFQOVMLLNRALEQIHKCRDIWNLL	699
Cow	MSLFCPSDQVILIAQKTCLLMAAAVDLQQRRASTAFEQNCFLNRALDLIRKCRDIWNVL	707
Rat	LSLFCPSDQGLLIAQKTCLLVAAAVDLQGRKATTTYEQNKLLRMALEQIQKCKNVWNLL	692
Oposs	LSQLCPSEKTVLTSQKACLLMVAADLELGRSASEASQO TELLSRALEHIQGCKEIS NVL	405
Chick	LSQFCPSDKAVLIAQKTCLLMAAAIDLELGRQEVTPSEQVEFWNQALQHLQACKEIWKVL	618
Danio	LSQLCAPDRAVL MGQKTCLLMSAAA SLEICRSSDHTEQQTELLTQTLENIQLCKEIWTTI	704
Tetra	LSQLCPPDRGLLTGQKTCLLMAAAA SLELCRKS-PLSDQTEELTRVLEQIQTCWEVWKT L	573
Branch	FSSLCPMDMANLVRKKTALMAAAA CLQSARNVSDPGEKMEMLKTIVILHVDACRETCREI	659
Coral	-----	1
Nemat	-----KEALSETLTHVQNCRDLCRI	455

V748A

Human	KQTGTFNSDSCEK-----LLLLYEFVRAKLN--DPLLESFLESVWELPHLETKTFETIA	763
Mouse	KKTGDFSGDDCGV-----LLLLYEFVKTCTN--DPSLSRFVDSVWKMPDLECRTLETMA	764
Macaq	KQTGTFNSDSCEK-----LLLLYEFVRAKLN--DPLLESFLESVWELPHLETKTFETIA	719
Dog	KETGDFSSPCET-----LLLLYEFVKAKMN--DPLLDSFLESVWELPHLESKTFETIA	782
Horse	KETGDFSNPCET-----LLLLYEFVKAKMN--DPFLDSFLESVWELPHLESKTFETIA	752
Cow	KTTGDFSRPCET-----LLILYEFVRAKLN--DPLLDHFLEP VWELPTLESKAFETMA	760
Rat	KQTGDFSGDDCGV-----MLLLYEFVKTCTN--DPSLHSFLQS VWKMPGLESRTLEIMA	745
Oposs	KLADGSKDPTEN-----LLLLYEI E ARAKLN--DAGLTSLLES VWELPQLETKILETIA	458
Chick	KLTGDFSKDPTDT-----LLLLYEF E ARAKLN--DPTLNNFMES VWEQP-HEIKTLEIVA	670
Danio	KTSGISSQDKTDS-----LLLLYEF E ARAKLN--DPKLETVLES VLELDNIETKLEIVIA	757
Tetra	KASGNLSVDPTDTL----LLLLYEF E ARAKLN--DPKVETVLEA VLELQNV E PKVLETIA	627
Branch	CNSKITDTDCSGDST-PILLCLYEF E AKAKLG--EPDLTQLVDR VMAMPQADAKTLETMA	716
Coral	-----HLG--DNNLSECLDM VEAMPHTDPNTFETLA	29
Nemat	NGTHSIQGNKDKKDDSI ILLILYEF E AKAKLGEGDVSLESCLHKLIALPFCEAKTFETVA	515

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Human	IIAMEKPAH-----YPLIALKALKKALLLYKKEEPIDISQ-----	798
Mouse	LLAMDKPAY-----YPTIAHKAMKLLLMYRKQEPVDVLK-----	799
Macaq	IIAMEKPAH-----YPFIALKALKKALLLYKKEESIDVSQ-----	754
Dog	SLAVEMPAH-----YPSIALKALKEALLLYKKKESIDVLK-----	817
Horse	SLAMEMPAC-----YPSIALKALKRALLHKKR KESIDVLK-----	787
Cow	ALAMEMPAC-----YPSIALKALKKALFFYKR KESIDVVR-----	795
Rat	SLAMDKPAH-----YPTIAQKALKKLLLIYRRKVPINVLK-----	780
Oposs	SVAMEHPAH-----YPDIAKKALRKALS LYLQGESIDVAK-----	493
Chick	SLAMEPPAR-----YPVLCKKALKSALNLYRKETT TDAVK-----	705
Danio	VLAMEPPAH-----YPVLCKKALKIALSLHRKQPQVDLMR-----	792
Tetra	ALAMEPPAH-----FPRLCKKALRVALALHRKQPQADLTR-----	662
Branch	AVCC-----	720
Coral	ALAVESPVY-----HRDLSMRSLRIA I KKCLAMDVIDFTK-----	64
Nemat	GITNNEPFFPVIVWIALFAGPPRGVSMLIQDLL E EGKLALHKIIFTRNNYFALPVHTFDF	575

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Human	-YSKCMHNLVNLSVPD GASNVELCPLEEVWGYFEDALSHISRT-KDYPEMEILWLMVKSW	856
Mouse	-YSVCMHNLIKLLVADEVWNISLYPLKEVQSHFKNTLSI IRQN-EGYPEEEIVWLMIKSW	857
Macaq	-YSKCMHNLINLSVPD GASNVELCPLEEVWGYFEDALSHISHT-KDYPEMEILWLMVKSW	812
Dog	-YSKCMHNLINLLVDPDGV PSTELCPLEEVWGYFEDALSLISHT-KGYPETEILWLMIKSW	875
Horse	-YSKCMHNLINLLVPERVLSAELCPLEEVWGYFEDALHLISHT-EGYPETEILWLMVKSW	845
Cow	-YSQCMHSLVNLLVDPDGV PNTLCPMEEIWGNFEDALIFISQT-EGYPEMEVLCLMIKSW	853
Rat	-YSVCMHNLIDLLVSDRRWNMALYPLKEVWGHLKSALS LI RQT-KGYPEEEIVWLMIKAW	838
Oposs	-FSKCLHSFINLSLPDEALSTDVCSLQDIWSTFEVALRVISHS-EEYPQVEILWLMTKAW	551
Chick	-FSKCLHSLINLSLPTGVTDLDACVLQEVWGYFEDALS VVSST-DSYPEMEILWLMTRAW	763
Danio	-CSNCLHSLIQLSLPNGVSEVQPCVLEE V WGYEEALS LI ATT-EDFPELEILWLLTRAW	850
Tetra	-CSKCVHSLIKLSLPSGVSEVEARVLEE V WEYEEALS MIAASPDDFPEMETLWLLTRAW	721
Branch	-----	720
Coral	-LSKAFHSL-----	72
Nemat	MFSKVFHSLAELALGRGSSRDAESKEEAWTLYQE I IEFVESTDKG SYP E MELIWLMTKAW	635

Human	NTGVLMFSRSKYASAEKWCGLALRFLNHLTSFKESYETQ-----MNMLYSQ-----	902
Mouse	NIGILMSSKNKYISAERWAAMALDFLGHSTLKTSEYAK-----VNLLYAN-----	903
Macaq	NTGILMFSRSKYVSTEKWCGLALRFLDHLTSFKESYETQ-----MNMLYSQ-----	858
Dog	NTGIFMYGRNKYVSAEKWCGLALRFLDRLGSLKRSYETQ-----MNILYSE-----	921
Horse	NIGIFMYGSSKYVSAEKWCGLALRFLDHLGSLRRSYEIQ-----MNVLYSQ-----	891
Cow	NIGIFLYSERMYVSTEKWCGLALRLLDYLGLSLKSTYETQ-----VNILYGE-----	899
Rat	NIGILMYSRNKYISAERWARMTLEFLDHLGSLKTNYEAKHPFRLLPTSCLHAVSHSQKYL	898
Oposs	NTGVSQYKEGMYATAEKWCHLGIRFLDHLGSLKKCYEQ-----MADLYGE-----	597
Chick	NTGIFQYTVGKYQEAEQWCGLGMRFLNHLGSLKRSYEGH-----VSQMPES-----	809
Danio	NTGILLYSLAQYPEAERWCGLGMSFLRYLGLSLQDSYQOTQ-----MAGLYSE-----	896
Tetra	NTGILLYSLAPYPAAERWCGLAMSFVRHLGSLQOSYGTQ-----VNS-----	763
Branch	-----	720
Coral	-----	72
Nemat	NCGINLFSSGRFDASEKWCATAMRLLQRLVGFKTNYESK-----MTSVYSD-----	681

Human	LVEALSNNKGPVFHEHGYWSKSD-----	925
Mouse	LMEILDKKT-----LRSTEMTEQ-----LRALIV	928
Macaq	LVEALSNNKGPVFHEHGYWSKSD-----	881
Dog	LVEALDRKKGSLFNEE-----	937
Horse	LVEALDKNKGSLFNKECPLETEDRSQAPPCPLGFFFFRLNLLRPHTCSSQDVVTSPSKSE	951
Cow	LMEALEKNKRSAFNEE-----	915
Rat	LQALLKGHKDDWTSPGWTHPTFTVGVKVGMAALQGQQLLSVKSPSSSSQPKPLLLRCRLA	958
Oposs	VLTKVERDKSLPPNEE-----	613
Chick	-----	809
Danio	VLDRLDKAKKNLIIEE-----	912
Tetra	-----	763
Branch	-----	720
Coral	-----	72
Nemat	ILDRISSRAAAQATVEE-----	697

Human	-----	925
Mouse	PP-----EDQGSVSSTNVAAQN-----HL-----	947
Macaq	-----	881
Dog	-----	937
Horse	CRWQKRDRTSRWF IQSNVKTTSGYPMAPTGTALQIKSSWGFTAEEARLFSGKAHGIETLF	
1011		
Cow	-----	915
Rat	PPGANLSSEENDQIQSCKPAVOGRNAOGHLITWAVSLTSQAVQLSRVCLSVSPRLFSALL	
1018		
Oposs	-----	613
Chick	-----	809
Danio	-----	912
Tetra	-----	763
Branch	-----	720
Coral	-----	72

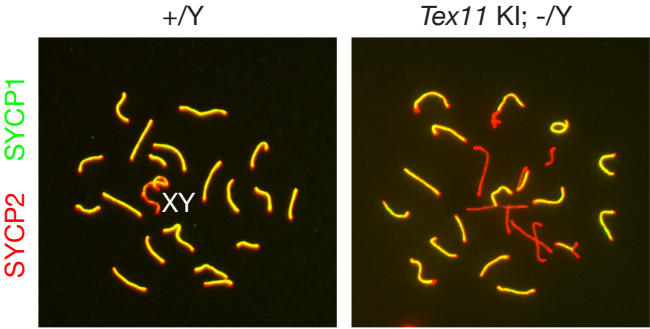
Nemat

697

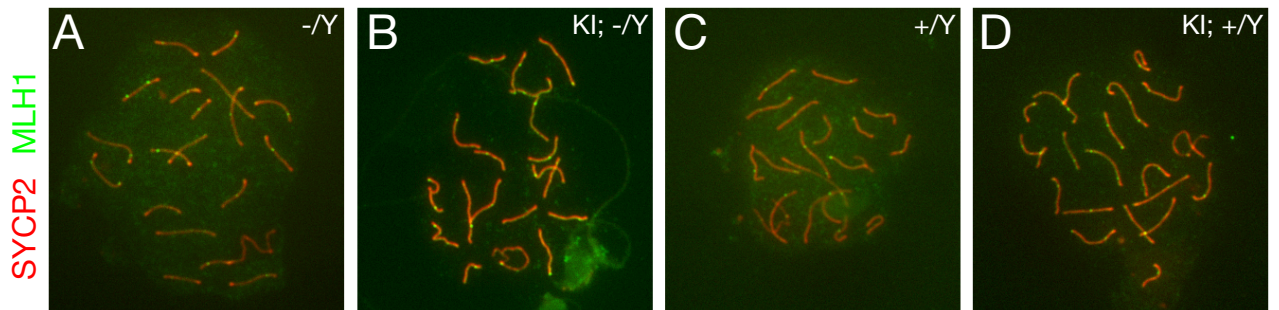
Human	-----	925
Mouse	-----	947
Macaq	-----	881
Dog	-----	937
Horse	AEGGTRCAGASSAISCK-----	1028
Cow	-----	915
Rat	LGVYENNNSDGFAPVLARERSMQEWARSHDE	1049
Oposs	-----	613
Chick	-----	809
Danio	-----	912
Tetra	-----	763
Branch	-----	720
Coral	-----	72
Nemat	-----	697

Supplementary Figure 2

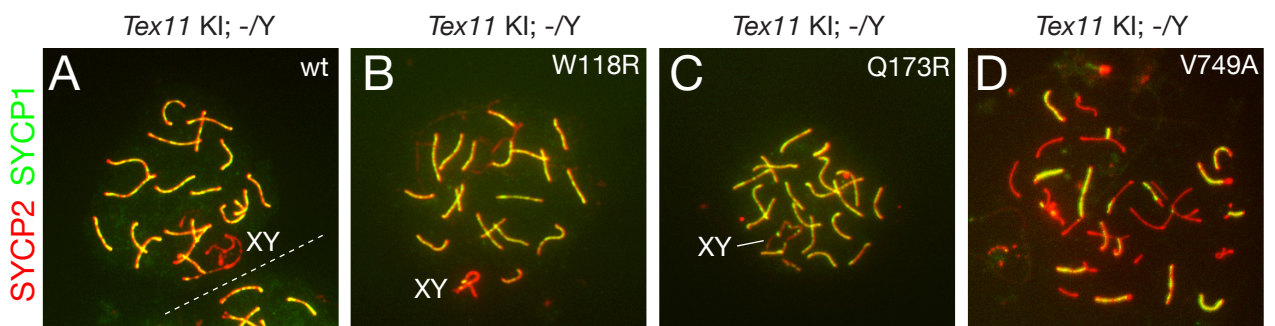
Spermatocytes from 25-day-old males



Supplementary Figure 3



Supplementary Figure 4



Supplementary Figure 5

