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## **Ipl1/Aurora B kinase coordinates synaptonemal complex disassembly with cell cycle progression and crossover formation in budding yeast meiosis**

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## Ipl1/Aurora B kinase coordinates synaptonemal complex disassembly with cell cycle progression and crossover formation in budding yeast meiosis

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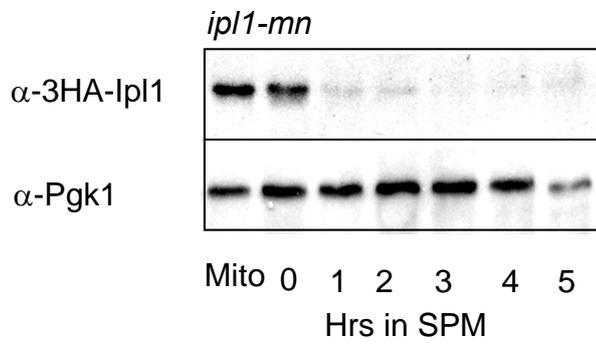
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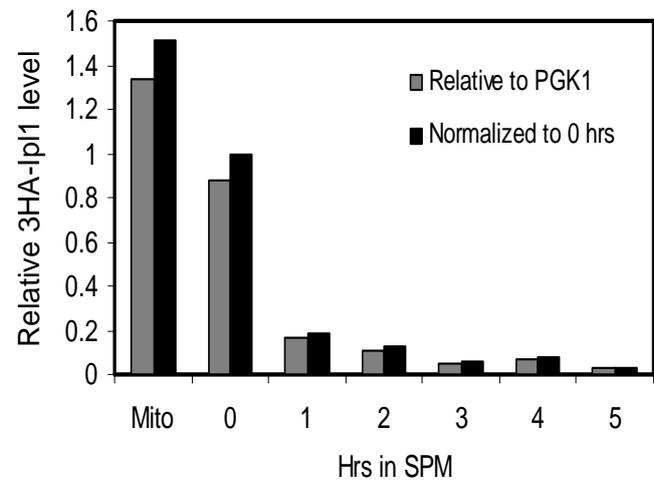
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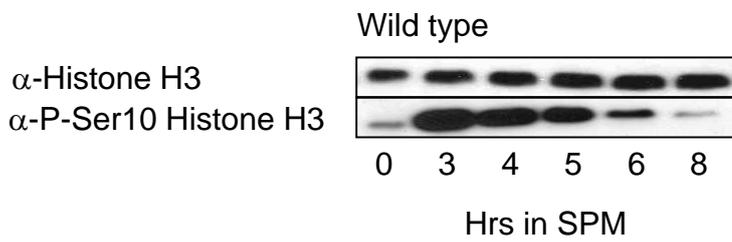
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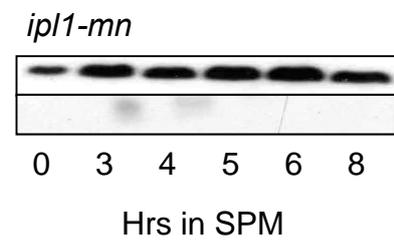
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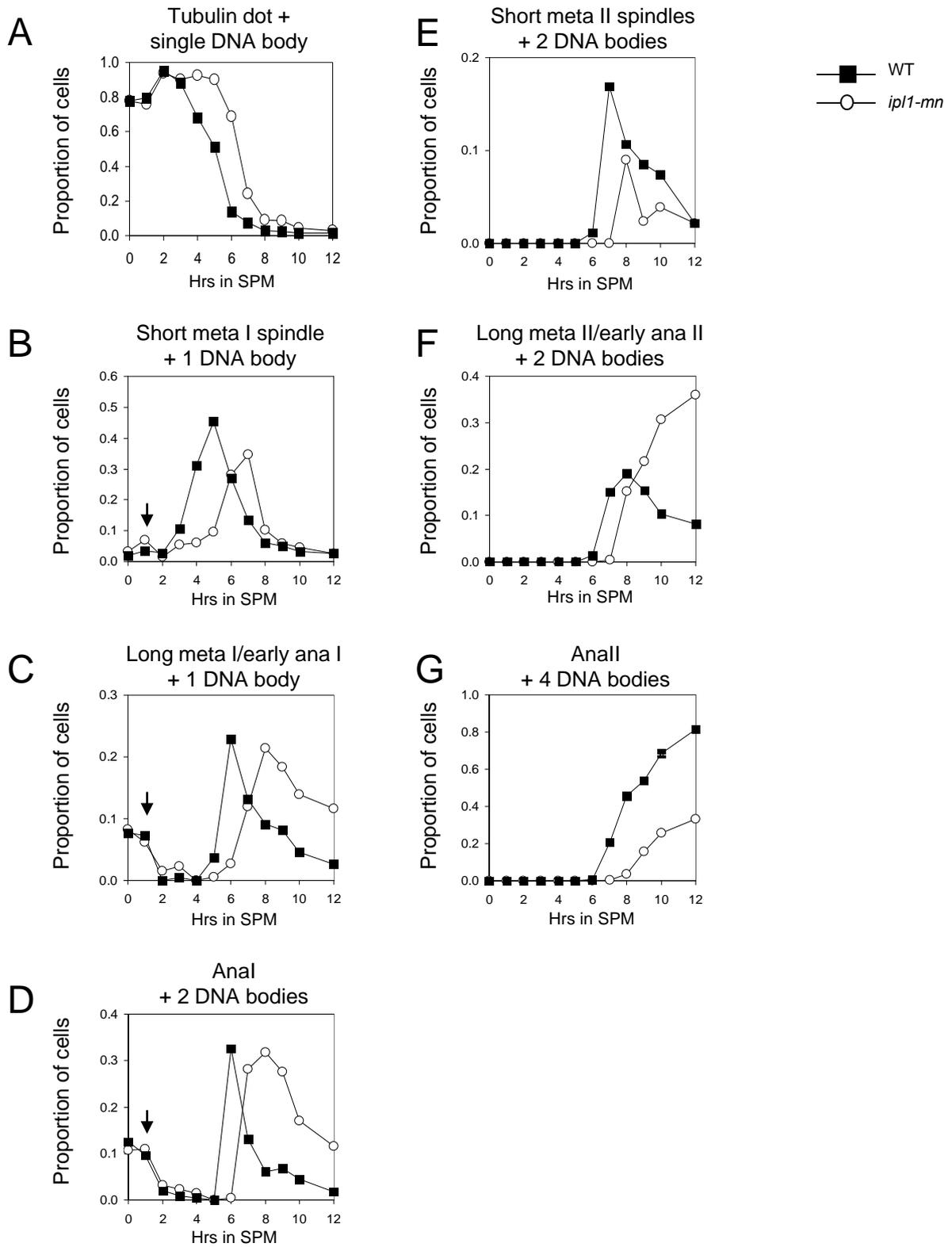


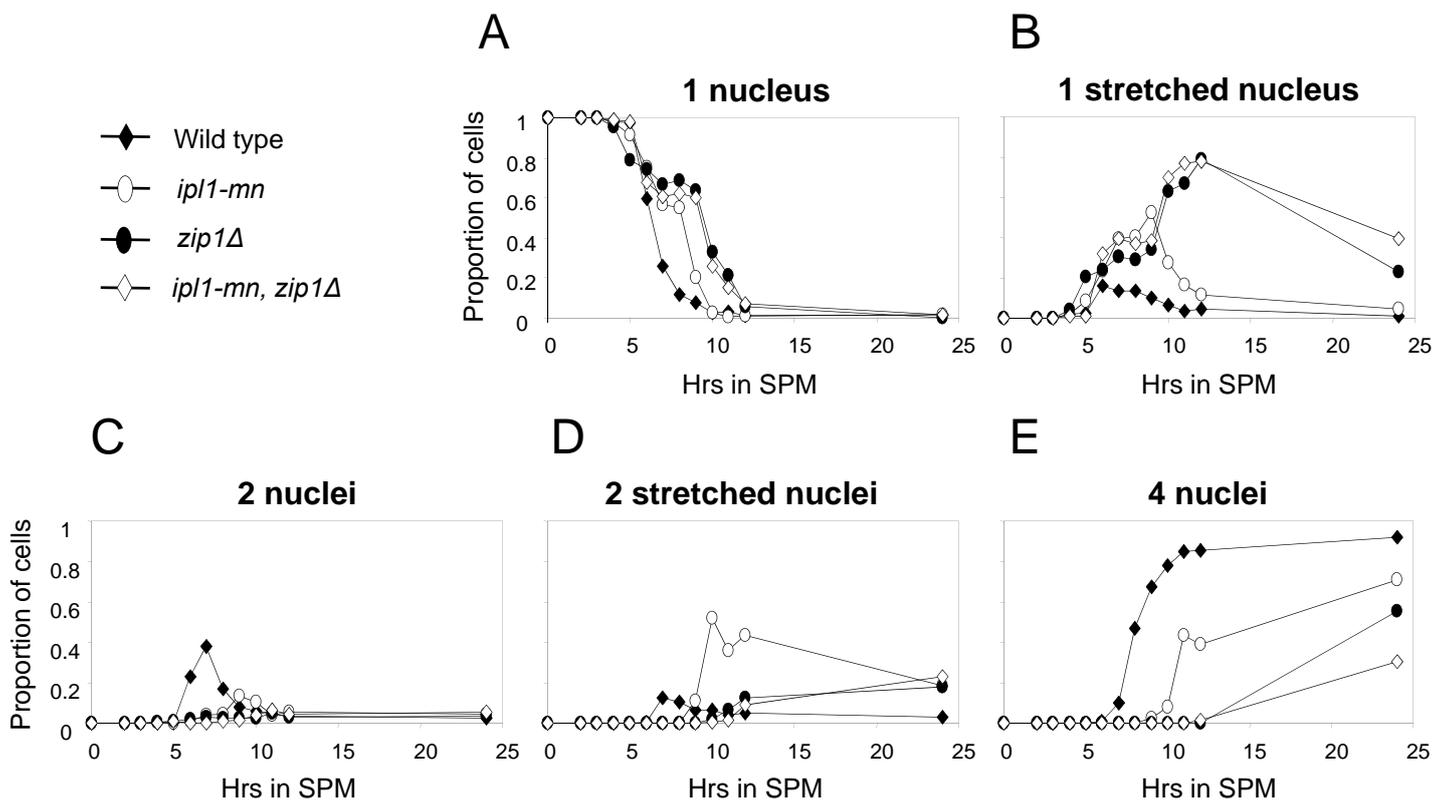
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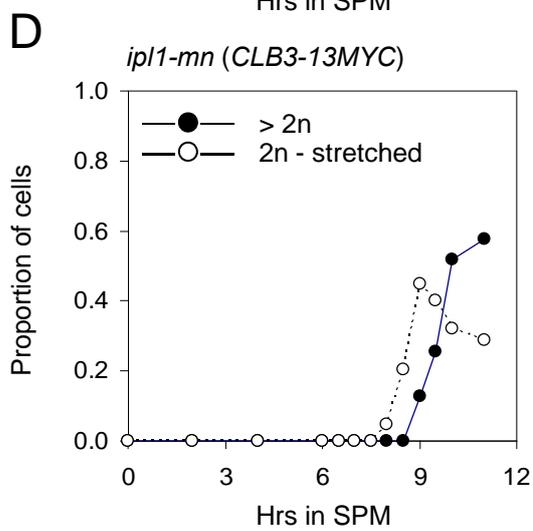
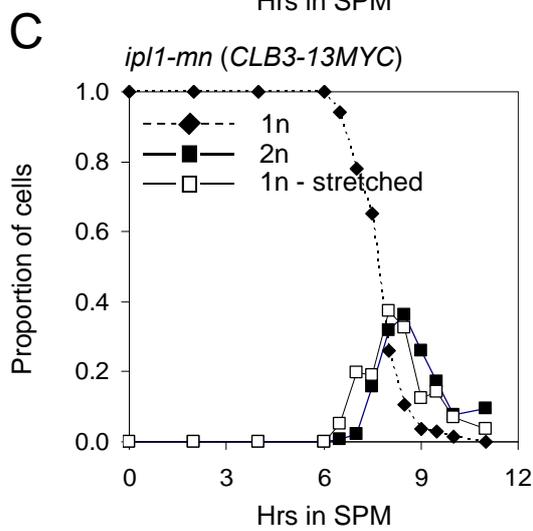
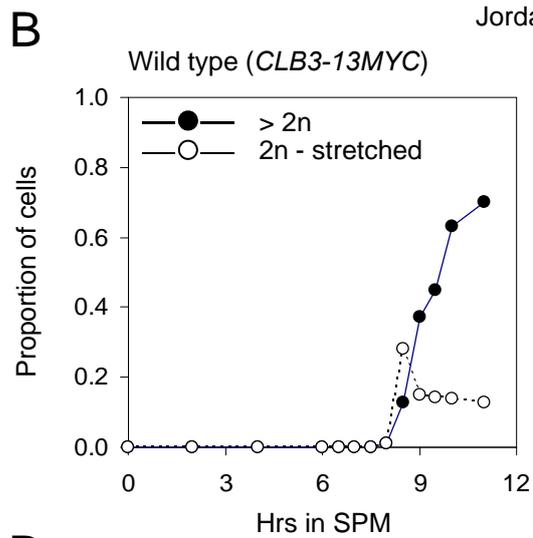
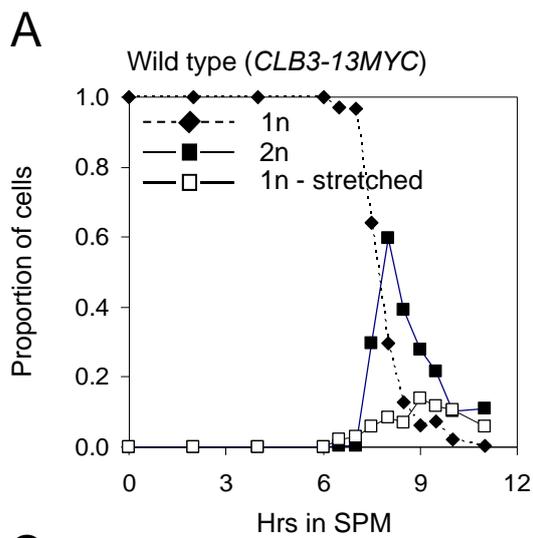


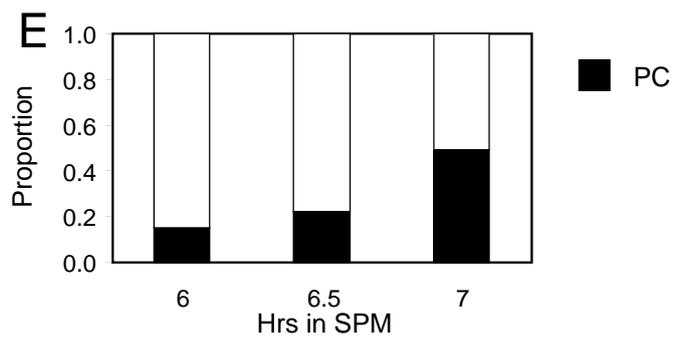
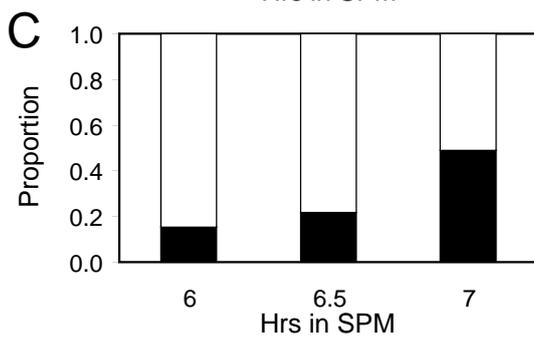
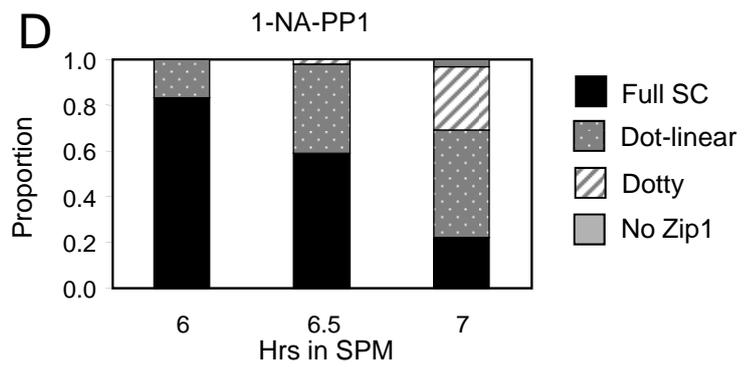
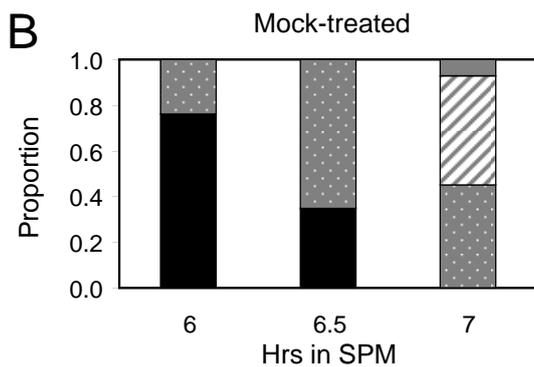
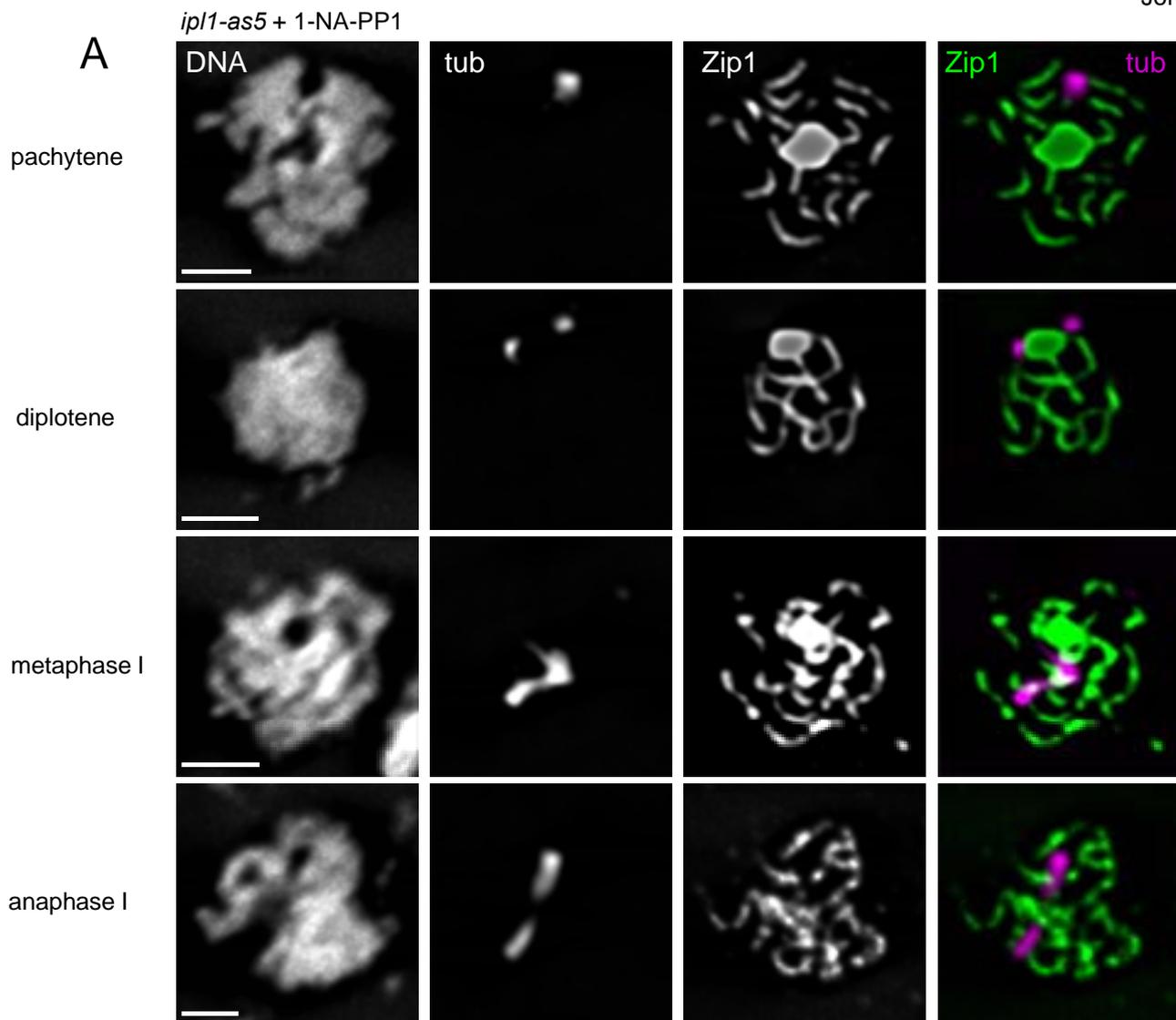
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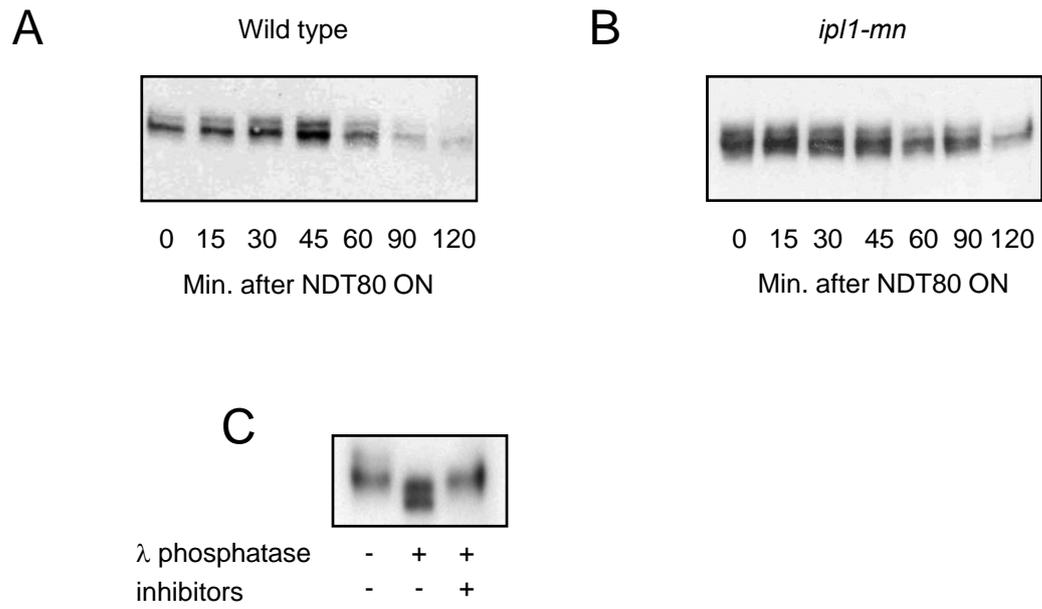


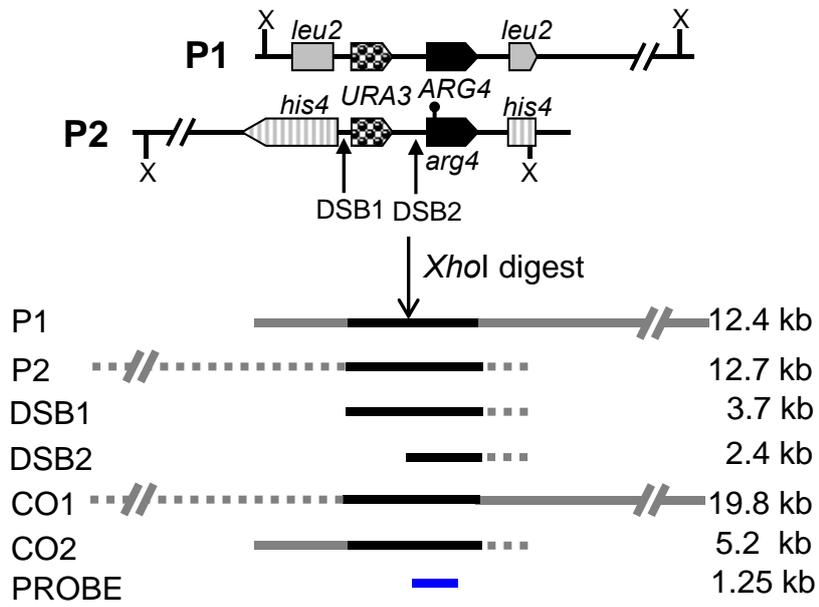


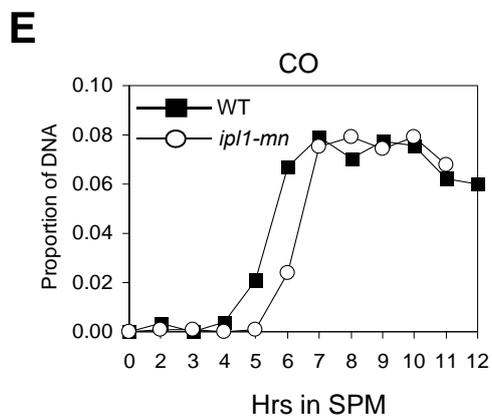
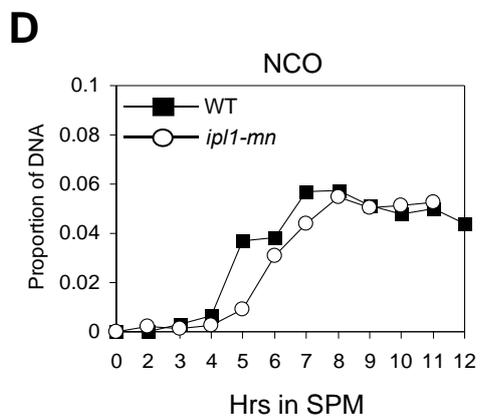
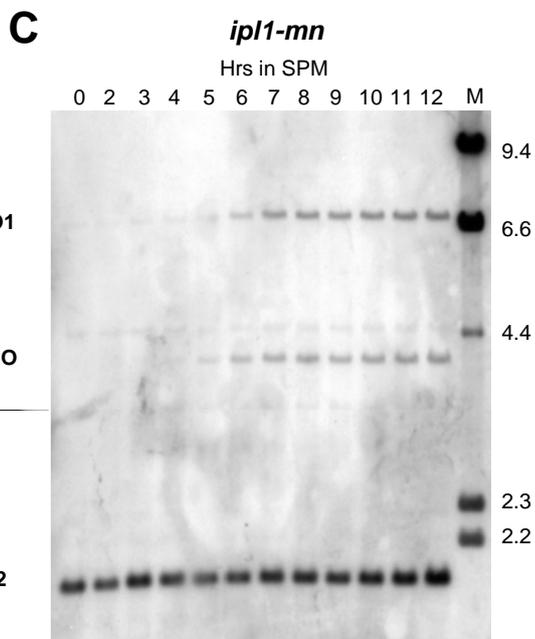
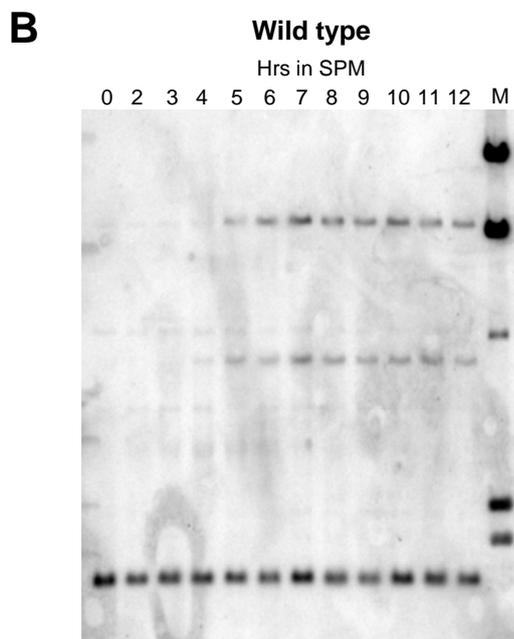
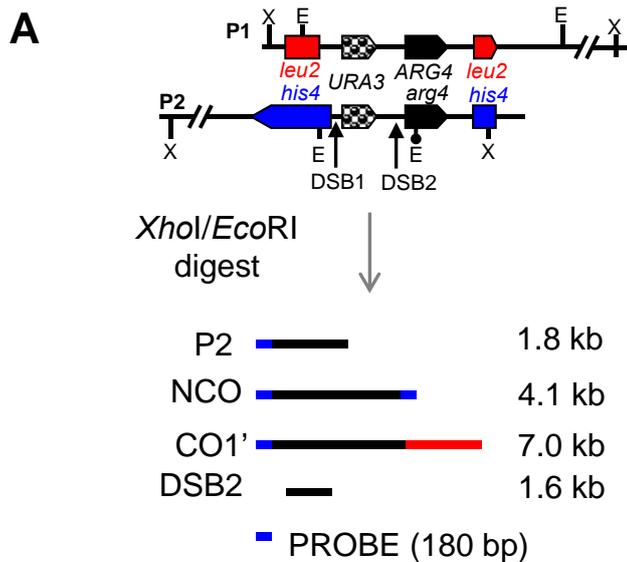






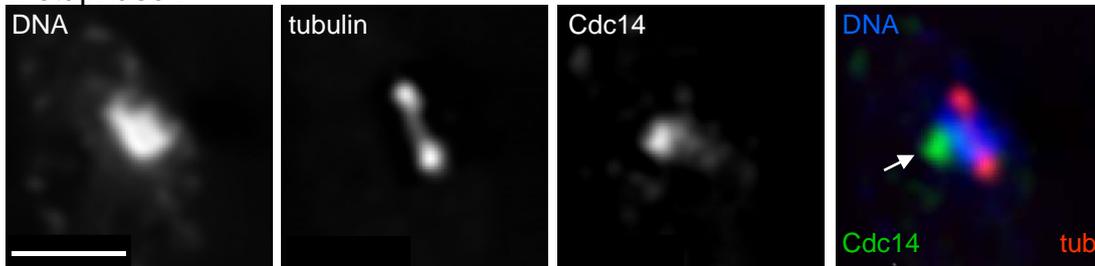






**A**

metaphase I

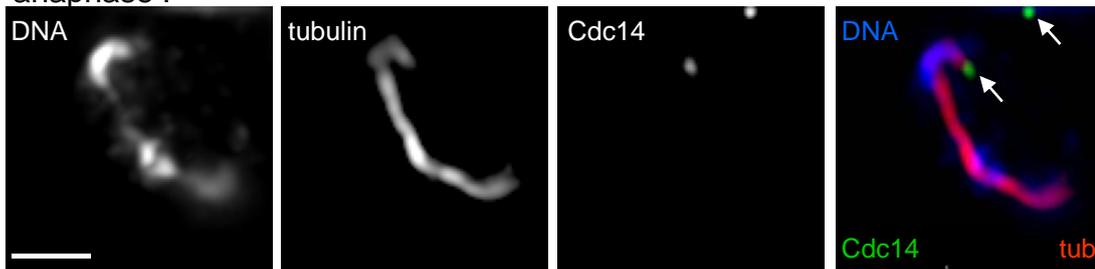


WT *ipl1-mn*  
Nucleolar Cdc14-13Myc

19/20 16/16

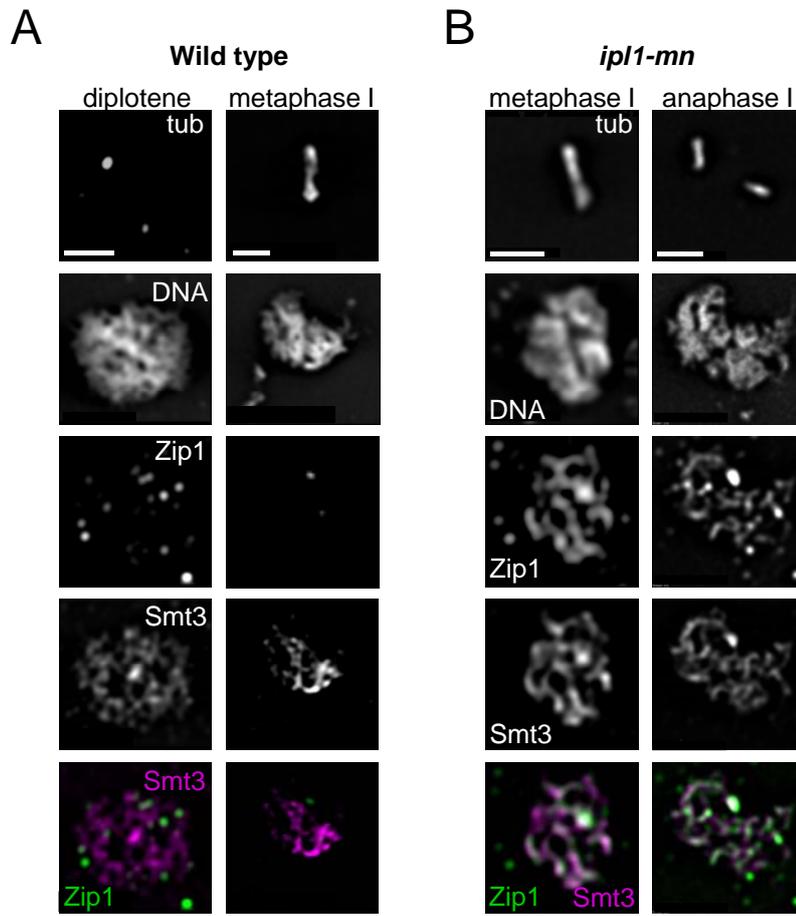
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anaphase I

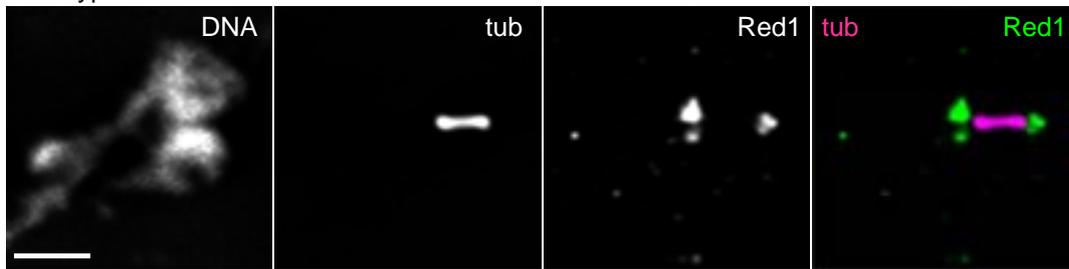


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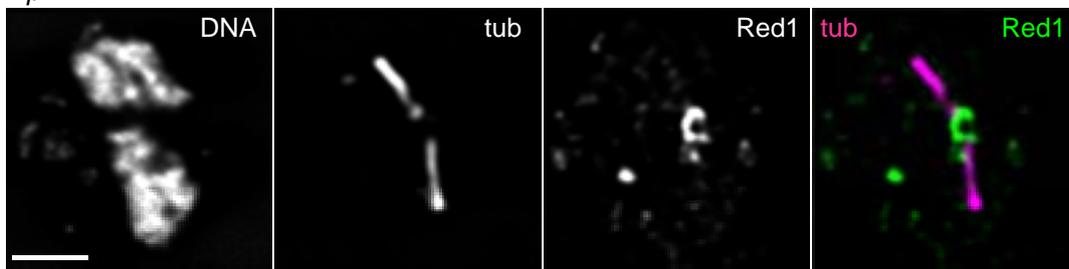
0/9 0/25

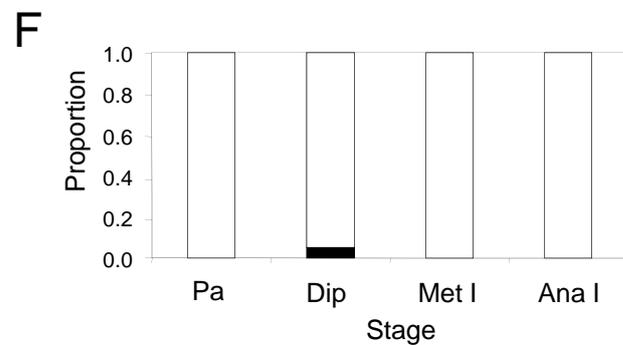
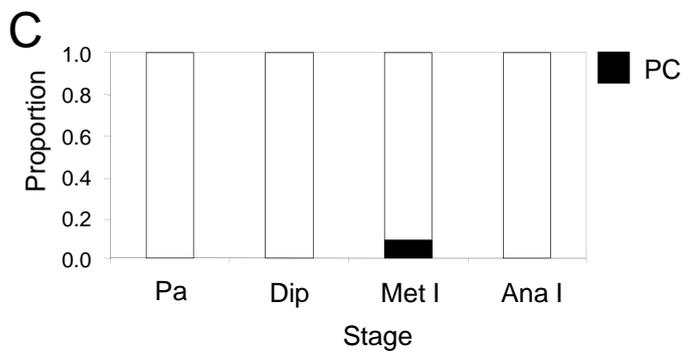
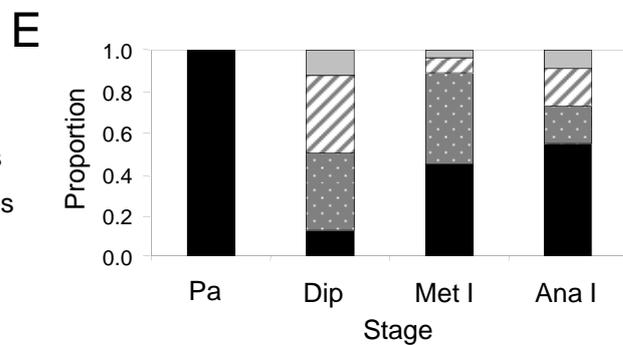
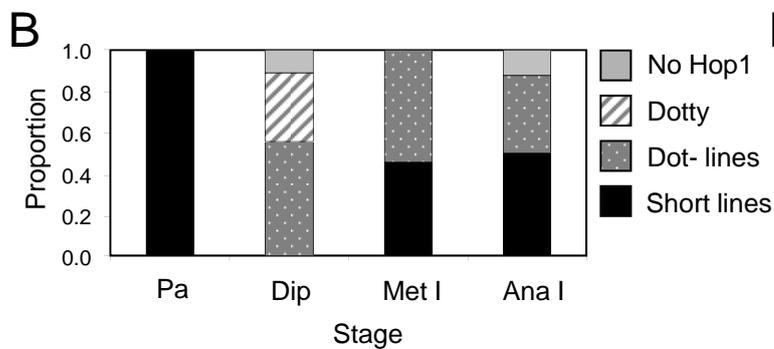
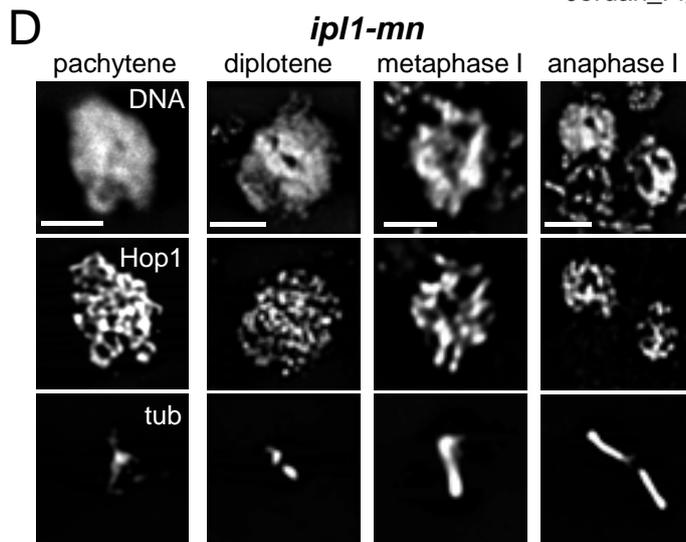
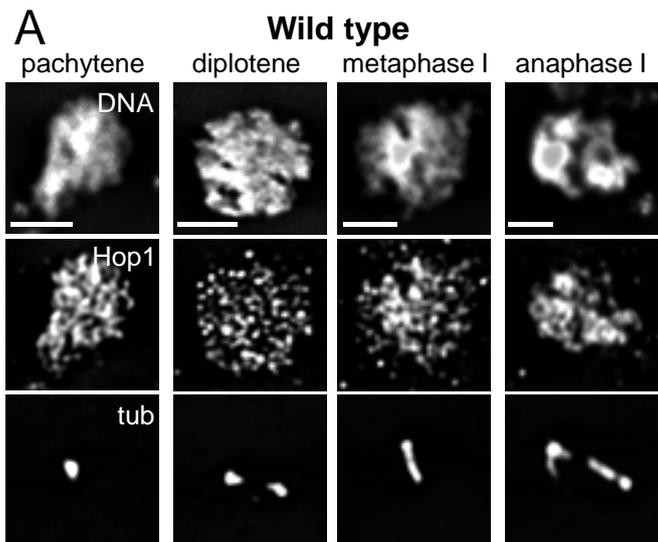


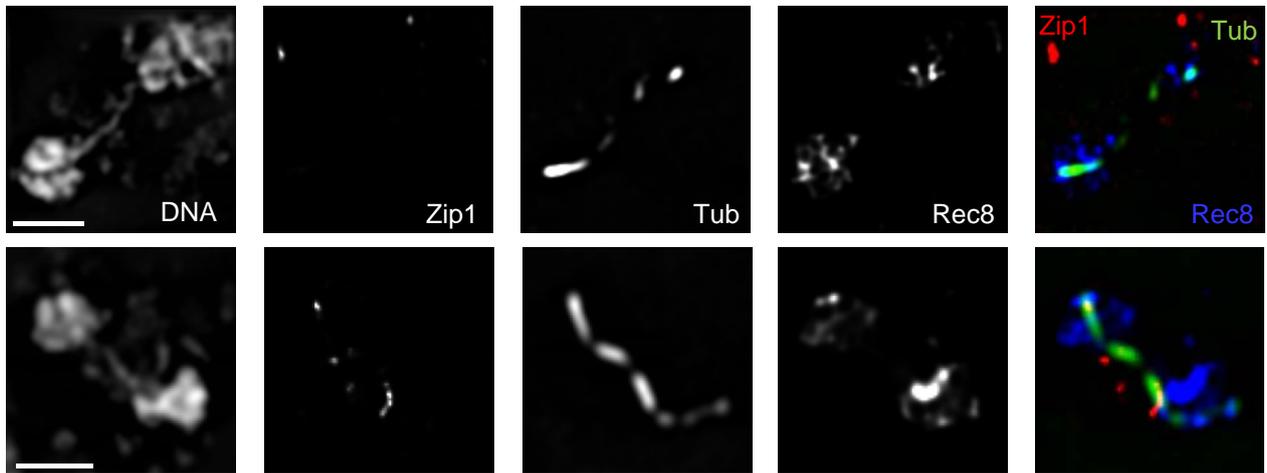
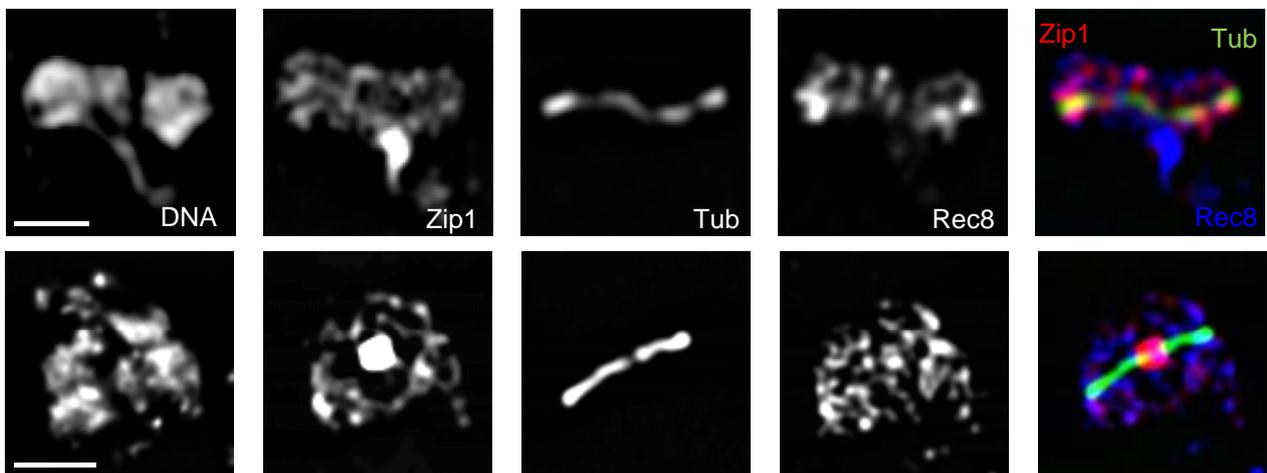
Wild type



*ipl1-mn*

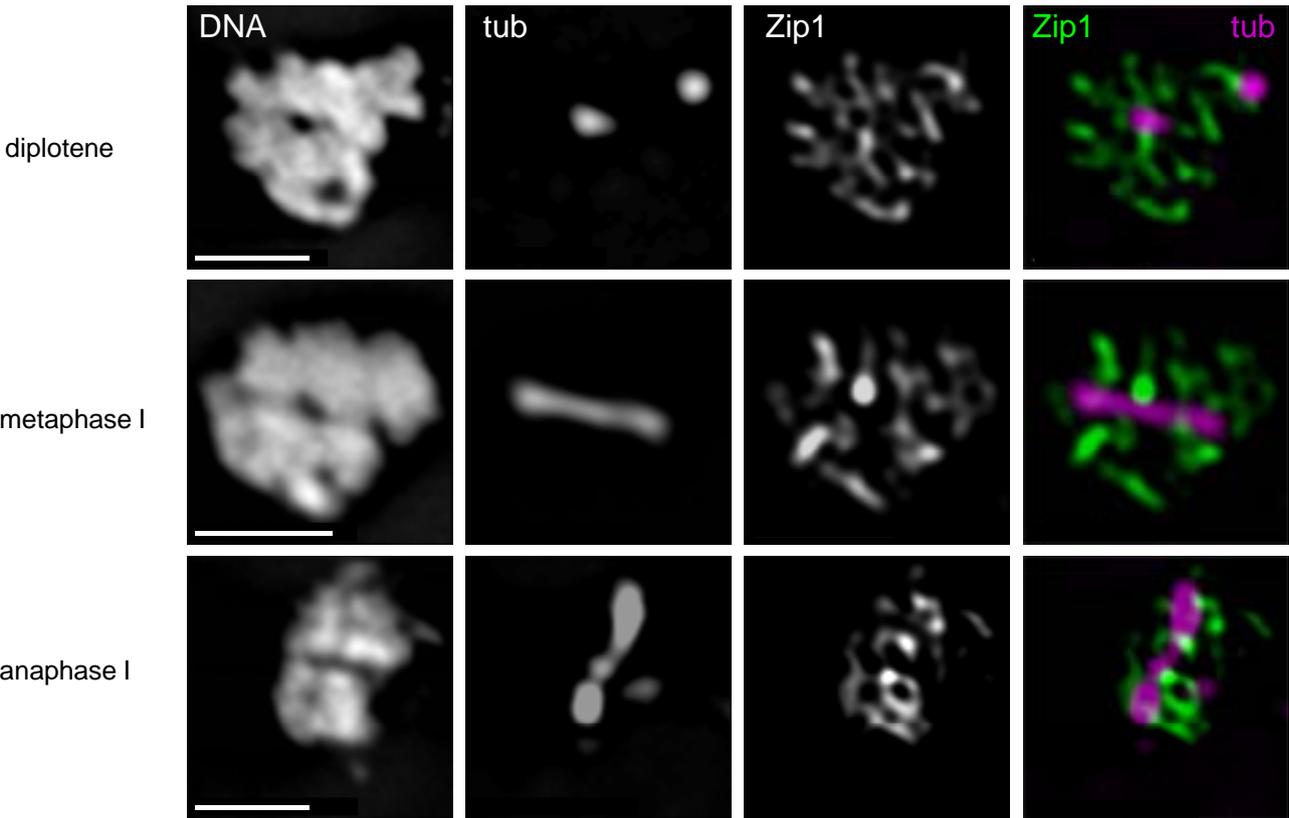




**A Wild type****B *ipl1-mn***

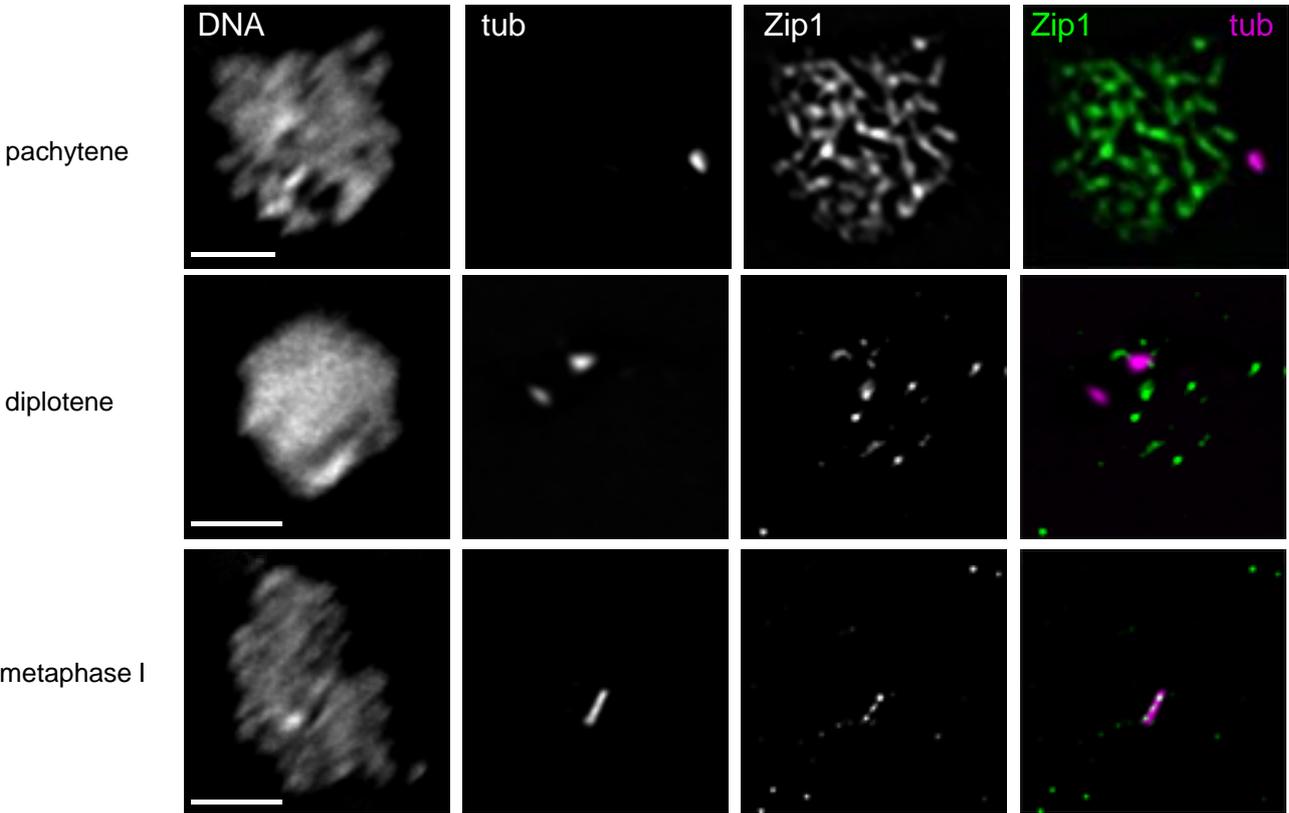
*ipl1-mn*

A



B

H3-Ser10 →Ala



## Supplementary Material.

### Supplementary Figure legends.

**Supplementary Figure S1.** 3HA-Ipl1 protein levels and kinase activity during meiotic prophase. (A) Western blot analysis of 3HA-Ipl1 expressed from the *CLB2* promoter. (B) 3HA-Ipl1 levels were quantified relative to Pgk1 (gray bars) and then normalized to the 0 hour time point (black bars). Ipl1 activity was measured by determining the phosphorylation of Ser10 Histone H3 compared to total cellular levels of histone H3 in wild type (C, Y1381) and *ipl1-mn* (D, Y1669).

**Supplementary Figure S2.** Nuclear divisions and spindle behaviour in *ipl1-mn* mutants suggest a metaphase-anaphase delay. Cells were assessed for nuclear as well as spindle morphology simultaneously to determine whether nuclear divisions had been decoupled from spindle morphology. Cells were divided into six categories, described as follows. Proportion of cells with a single DNA mass and a single focus of tubulin (A), representative of meiotic prophase cells, with a metaphase I spindle and a single DNA mass (B), representative of metaphase I, or a long metaphase I/early anaphase I spindle and a single DNA mass (C), representative of late metaphase I. In the wild type (Y940), < 5 % of such DNA masses were 'stretched' at late metaphase I, whereas in *ipl1-mn* (Y1206), the majority displayed a 'stretched' phenotype. (D) Proportion of cells with two clearly separated DNA bodies and an anaphase I spindle, representative of cells having completed the metaphase I-anaphase I transition. (E) Cells with two, short metaphase I spindles, each

with a single body of DNA, representative of cells in metaphase II. (F) Proportion of cells with long metaphase II/early anaphase II spindles, each with a single body of DNA (late metaphase II). In the *ipl1-mn* mutant, the majority of these nuclei were stretched, as in (C). (G) Cells with two anaphase II spindles and four separate DNA bodies represented cells that had successfully completed both meiotic nuclear divisions. Arrows indicate spindles formed prior to meiotic entry. At least 200 cells were counted for each time point.

**Supplementary Figure S3.** Stretched nuclei are observed in *zip1* and *ipl1-mn zip1*. Time course experiments of nuclear divisions and stretched nuclear phenotypes in wild-type (Y940), *ipl1-mn* (1206), *zip1* (Y1530), and *ipl1-mn zip1* (Y1658) mutants. At least 200 cells were counted for each time point.

**Supplementary Figure S4.** Meiotic nuclear divisions are delayed despite normal expression of Clb3-13Myc in *ipl1-mn* cells. (A and C) Proportion of ethanol-fixed cells containing a single nuclear body (1n), a stretched nuclear body (1n - stretched), or two distinct nuclear bodies (2n). (B and D) Proportion of cells with more than two nuclear bodies or containing two nuclear bodies of which at least one was stretched (2n – stretched).  $\beta$ -estradiol was added 6 hours after cells were transferred to SPM. Strains: wild type (Y1581), *ipl1-mn* (Y1582).

**Supplementary Figure S5.** Delayed SC disassembly in the *ipl1-as5* mutant (Y1583) treated with 1-NA-PP1. (A) Examples of surface-spread nuclei at

various stages. Zip1 is given in green and tubulin (tub) in magenta. (B) SC disassembly and PC occurrence (C) in mock-treated cells and 1-NA-PP1 treated cells (D and E). Bars: 2  $\mu$ m. More than 100 nuclei were inspected for each time point.

**Supplementary Figure S6.** Zip1 is a phosphoprotein. Western blot analysis of Zip1 shows two bands in both wild-type (A, Y1602) and *ipl1-mn* (B, Y1538). Both bands are present prior to Ndt80 expression (0 minutes) and after Ndt80 expression. (C) Zip1 protein mock-treated (lane 1) treated with  $\lambda$  phosphatase (lane 2), or treated with both  $\lambda$  phosphatase and inhibitor.

**Supplementary Figure S7.** Schematic representation of the *URA3-ARG4* ectopic recombination interval on Chromosome III (Allers and Lichten, 2001). *Xho*I digest of DNA yields the indicated sizes of parental molecules (P1 and P2), DSBs (DSB1 and DSB2) as well as crossovers (CO1 and CO2). Sequences flanking the insert at *LEU2* and the insert at *HIS4* are denoted by solid grey and dashed grey lines, respectively. The region recognized by the probe is shown in blue.

**Supplementary Figure S8.** Detection of crossover and noncrossover products at the *URA3-ARG4* interval on Chromosome III (Allers and Lichten, 2001). (A) *Xho*I and *Eco*RI digest of DNA, probed with *HIS4*-specific sequences, yields the indicated sizes of parental (P2), double-strand break (DSB2), crossover (CO1) as well as noncrossover recombinants (NCO). The region recognized by the probe, which is specific to *HIS4* sequences, is

shown in blue. M- marker. The sizes, in kilobases, are given adjacent to the *ipl1-mn* blot. (B and C) Autoradiograms of typical wild-type (Y940) and *ipl1-mn* (Y1206) meiotic time courses. (D and E) Quantification of NCO products (D) and CO products (E).

**Supplementary Figure S9.** Cdc14-13Myc release from the nucleolus in nuclei containing metaphase I or anaphase I spindles. Examples of nuclei at metaphase I (A) and anaphase I (B). DNA is shown in blue, Cdc14-13Myc in green, and tubulin (tub) in red. The proportion of nuclei with metaphase I (A) spindle and nucleolar Cdc14-13Myc focus is shown to the right of the image for wild type (Y1662) and *ipl1-mn* (Y1664). When nuclei were selected for anaphase I spindles (B), virtually all showed absent Cdc14-13Myc staining of the DNA, as expected. Arrows indicate Cdc14-13Myc staining in the merged images. Bars: 2  $\mu$ m.

**Supplementary Figure S10.** Surface-spread nuclei stained for Zip1 and Smt3 simultaneously. Individual channels obtained for the merged images shown in Figure 6G and H. Bars: 2  $\mu$ m. Strains: wild type (Y940), *ipl1-mn* (Y1206).

**Supplementary Figure S11.** Red1 accumulation on spindles. (A) Accumulation of Red1 at the poles of metaphase I spindles in wild type ( $\sim 1/3$ , Y940) and on anaphase I spindles in *ipl1-mn* ( $\sim 1/3$ , Y1206). Bars: 2  $\mu$ m.

**Supplementary Figure S12.** Hop1 dissociation from meiotic chromosomes in wild type and *ipl1-mn*. Examples of Hop1 staining in nuclei at various stages

of meiosis I in wild type (Y940) and *ipl1-mn* (Y1206) (A and D). tub = tubulin. Bars: 2  $\mu$ m. Quantification of Hop1 staining of meiotic chromosomes and aggregate formation in wild type (B and C) and *ipl1-mn* (E and F). > 50 nuclei were assessed for each stage.

**Supplementary Figure S13.** Rec8 is retained in anaphase I/telophase I nuclei of *ipl1-mn* that contain Zip1 staining. (A) Examples of wild-type (Y1485) nuclei stained for DNA (DAPI), Zip1 (red), tubulin (green), and Rec8-3HA (Rec8, blue). 30/30 spreads with clearly separated nuclei showed Rec8 staining at the spindle poles only. In contrast, 30/30 spreads that contained Zip1 staining in the *ipl1-mn* mutant (Y1551) also displayed significant non-polar Rec8 staining (B). Bars: 2  $\mu$ m.

**Supplementary Figure S14.** Decoupling of cell cycle progression and SC disassembly in the *ipl1-mn*, but not the histone H3 Ser10→Ala mutant. (A) *ipl1-mn* (Y1175, S288c) shows delayed SC disassembly at diplotene, metaphase I and anaphase I. (B) SC disassembly occurs normally a mutant (and isogenic wild-type strain, Y1127) expressing histone H3 Ser10→Ala (Y1728, S288c). Zip1 is shown in green and tubulin (tub) in magenta. Bars: 2  $\mu$ m.

## Supplementary Tables.

Supplementary Table S1: Strains used in this study.		
Strain <sup>1</sup>	Genotype	Reference
Y940	<u>MAT<math>\alpha</math> his4::URA3-arg4-EcPal(1691) LEU2</u> MAT $\alpha$ HIS4 leu2::URA3-ARG4  <u>ura3<math>\Delta</math> arg4<math>\Delta</math> lys2 ho::LYS2</u> <u>ura3<math>\Delta</math> arg4<math>\Delta</math> lys2 ho::LYS2</u>	(Allers and Lichten, 2001)
Y1175 (S288c)	<u>MAT<math>\alpha</math> leu2-3,112 his3<math>\Delta</math> lys2<math>\Delta</math>BglII</u> <u>MAT<math>\alpha</math> leu2-3,112 his3<math>\Delta</math> lys2<math>\Delta</math>BglII</u>  <u>arg4 ilv1-Kpn, PAC2::[pD174::LEU2 lacO array]</u> <u>arg4 ilv1-Kpn, PAC2::[pD174::LEU2 lacO array]</u>  <u>rad3 trp2 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u> <u>rad3 trp2 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u>	This work
Y1206	<u>MAT<math>\alpha</math> his4::URA3-arg4-EcPal(1691) LEU2</u> MAT $\alpha$ HIS4 leu2::URA3-ARG4  <u>ura3<math>\Delta</math> arg4<math>\Delta</math> lys2 ho::LYS2</u> <u>ura3<math>\Delta</math> arg4<math>\Delta</math> lys2 ho::LYS2</u>  <u>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u> <u>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u>	This work
Y1381	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u>  <u>ho::LYS2</u> <u>ho::LYS2</u>	This work
Y1485	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u>  <u>ho::LYS2 PDS1-18MYC::TRP1</u> <u>ho::LYS2 PDS1-18MYC::TRP1</u>  <u>REC8-3HA::URA3</u> <u>REC8-3HA::URA3</u>	(Clyne et al., 2003)
Y1486	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u>	(Clyne et al., 2003)

	<u>ho::LYS2 PDS1-18MYC::TRP1</u> <u>ho::LYS2 PDS1-18MYC::TRP1</u>  <u>REC8-3HA::URA3 KANMX6-P<sub>SCC1</sub>-3HA-CDC5</u> <u>REC8-3HA::URA3 KANMX6-P<sub>SCC1</sub>-3HA-CDC5</u>	
Y1530	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u>  <u>ho::LYS2 zip1<math>\Delta</math></u> <u>ho::LYS2 zip1<math>\Delta</math></u>	This work
Y1538	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>P<sub>GAL1</sub>-NDT80::TRP1 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u> <u>P<sub>GAL1</sub>-NDT80::TRP1 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u>	This work
Y1551	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u>  <u>ho::LYS2 PDS1-18MYC::TRP1</u> <u>ho::LYS2 PDS1-18MYC::TRP1</u>  <u>REC8-3HA::URA3 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u> <u>REC8-3HA::URA3 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u>	This work
Y1553	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>P<sub>GAL1</sub>-NDT80::TRP1 pdr5<math>\Delta</math>::TRP1</u> <u>P<sub>GAL1</sub>-NDT80::TRP1 pdr5<math>\Delta</math>::TRP1</u>	This work
Y1581	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>P<sub>GAL1</sub>-NDT80::TRP1 CLB3-13MYC::TRP1</u> <u>P<sub>GAL1</sub>-NDT80::TRP1 CLB3-13MYC::TRP1</u>	This work
Y1582	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u>	This work

	<p><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></p> <p><u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u>  <u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u></p> <p><u><i>P<sub>GAL1</sub>-NDT80::TRP1 CLB3-13MYC::TRP1</i></u>  <i>P<sub>GAL1</sub>-NDT80::TRP1 CLB3-13MYC::TRP1</i></p> <p><u><i>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u>  <i>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></p>	
Y1583	<p><u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u>  <i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></p> <p><u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u>  <u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u></p> <p><u><i>P<sub>GAL1</sub>-NDT80::TRP1</i></u>  <i>P<sub>GAL1</sub>-NDT80::TRP1</i></p> <p><u><i>ipl1-M181G, T244A::LEU2 (ipl1-as5)</i></u>  <i>ipl1-M181G, T244A::LEU2 (ipl1-as5)</i></p>	This work
Y1602	<p><u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u>  <i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></p> <p><u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u>  <u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u></p> <p><u><i>P<sub>GAL1</sub>-NDT80::TRP1</i></u>  <i>P<sub>GAL1</sub>-NDT80::TRP1</i></p>	(Carlile and Amon, 2008)
Y1627	<p><u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u>  <i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></p> <p><u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u>  <u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u></p> <p><u><i>P<sub>GAL1</sub>-NDT80::TRP1 KANMX6-P<sub>CLB2</sub>-3HA-CDC20</i></u>  <i>P<sub>GAL1</sub>-NDT80::TRP1 KANMX6-P<sub>CLB2</sub>-3HA-CDC20</i></p> <p><u><i>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u>  <i>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></p>	This work
Y1656	<p><u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u>  <i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></p> <p><u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u>  <u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u></p>	This work

	<u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>KANMX6-P<sub>CLB2</sub>-3HA-CDC20</u> <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>KANMX6-P<sub>CLB2</sub>-3HA-CDC20</u>	
Y1657	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MATa leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>KANMX6-P<sub>SCC1</sub>-3HA-CDC5</u> <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>KANMX6-P<sub>SCC1</sub>-3HA-CDC5</u>	This work
Y1658	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</u> <u>MATa leu2::hisG his3::hisG trp1::hisG ura3 lys2</u>  <u>ho::LYS2 zip1<math>\Delta</math> KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u> <u>ho::LYS2 zip1<math>\Delta</math> KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u>	This work
Y1661	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MATa leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>CLB1-13MYC::TRP1</u> <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>CLB1-13MYC::TRP1</u>	This work
Y1662	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MATa leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>CDC14-13MYC::TRP1</u> <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>CDC14-13MYC::TRP1</u>	This work
Y1663	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MATa leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>CLB1-13MYC::TRP1</u> <u>P<sub>GAL1</sub>-NDT80::TRP1</u> <u>CLB1-13MYC::TRP1</u>  <u>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u> <u>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u>	This work
Y1664	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u>	This work

	<p><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></p> <p><u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u>  <u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u></p> <p><u><i>P<sub>GAL1</sub>-NDT80::TRP1 CDC14-13MYC::TRP1</i></u>  <u><i>P<sub>GAL1</sub>-NDT80::TRP1 CDC14-13MYC::TRP1</i></u></p> <p><u><i>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u>  <u><i>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u></p>	
Y1669	<p><u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</i></u>  <u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG ura3 lys2</i></u></p> <p><u><i>ho::LYS2 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u>  <u><i>ho::LYS2 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u></p>	This work
Y1727 (S288c)	<p><u><i>MAT<math>\alpha</math> leu2 hht1-hhf1<math>\Delta</math>::KAN hhf2-hht2<math>\Delta</math>::NAT</i></u>  <u><i>MAT<math>\alpha</math> leu2 hht1-hhf1<math>\Delta</math>::KAN hhf2-hht2<math>\Delta</math>::NAT</i></u></p> <p><u><i>hta1-htb1<math>\Delta</math>::HPH hta2-htb2<math>\Delta</math>::NAT</i></u>  <u><i>hta1-htb1<math>\Delta</math>::HPH hta2-htb2<math>\Delta</math>::NAT</i></u></p> <p><i>p(HTA1-HTB1-HHT2-HHF2)-LEU2</i></p>	(Liu et al., 2005)
Y1728 (S288c)	<p><u><i>MAT<math>\alpha</math> leu2 hht1-hhf1<math>\Delta</math>::KAN hhf2-hht2<math>\Delta</math>::NAT</i></u>  <u><i>MAT<math>\alpha</math> leu2 hht1-hhf1<math>\Delta</math>::KAN hhf2-hht2<math>\Delta</math>::NAT</i></u></p> <p><u><i>hta1-htb1<math>\Delta</math>::HPH hta2-htb2<math>\Delta</math>::NAT</i></u>  <u><i>hta1-htb1<math>\Delta</math>::HPH hta2-htb2<math>\Delta</math>::NAT</i></u></p> <p><i>p(HTA1-HTB1-HHT2-HHF2 with H3 S10/28A)-LEU2</i></p>	(Liu et al., 2005)
Y2030	<p><u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u>  <u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u></p> <p><u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u>  <u><i>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</i></u></p> <p><u><i>P<sub>GAL1</sub>-NDT80::TRP1 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u>  <u><i>P<sub>GAL1</sub>-NDT80::TRP1 KANMX6-P<sub>CLB2</sub>-3HA-IPL1</i></u></p> <p><u><i>KANMX6-P<sub>SCC1</sub>-3HA-CDC5</i></u>  <u><i>KANMX6-P<sub>SCC1</sub>-3HA-CDC5</i></u></p>	This work
Y2262	<p><u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u>  <u><i>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</i></u></p>	This work

	<u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>ndt80::HPHMX6 P<sub>GAL1</sub>-CDC5::TRP1</u> <u>ndt80::HPHMX6 CDC5</u>	
Y2263	<u>MAT<math>\alpha</math> leu2::hisG his3::hisG trp1::hisG lys2</u> <u>MAT<math>a</math> leu2::hisG his3::hisG trp1::hisG lys2</u>  <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u> <u>ho::LYS2 ura3::pGPD1-GAL4(848).ER::URA3</u>  <u>ndt80::HPHMX6 P<sub>GAL1</sub>-CDC5::TRP1</u> <u>ndt80::HPHMX6 CDC5</u>  <u>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u> <u>KANMX6-P<sub>CLB2</sub>-3HA-IPL1</u>	This work

<sup>1</sup>Strains were SK1 or, when indicated, S288c.

### Supplementary References.

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