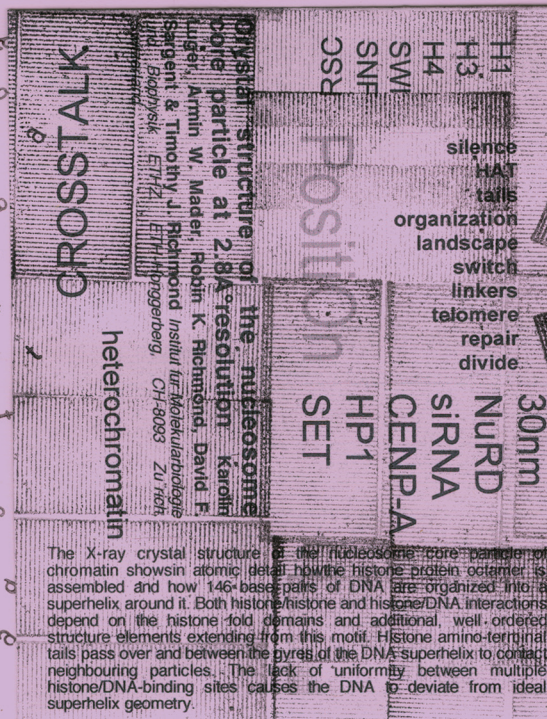


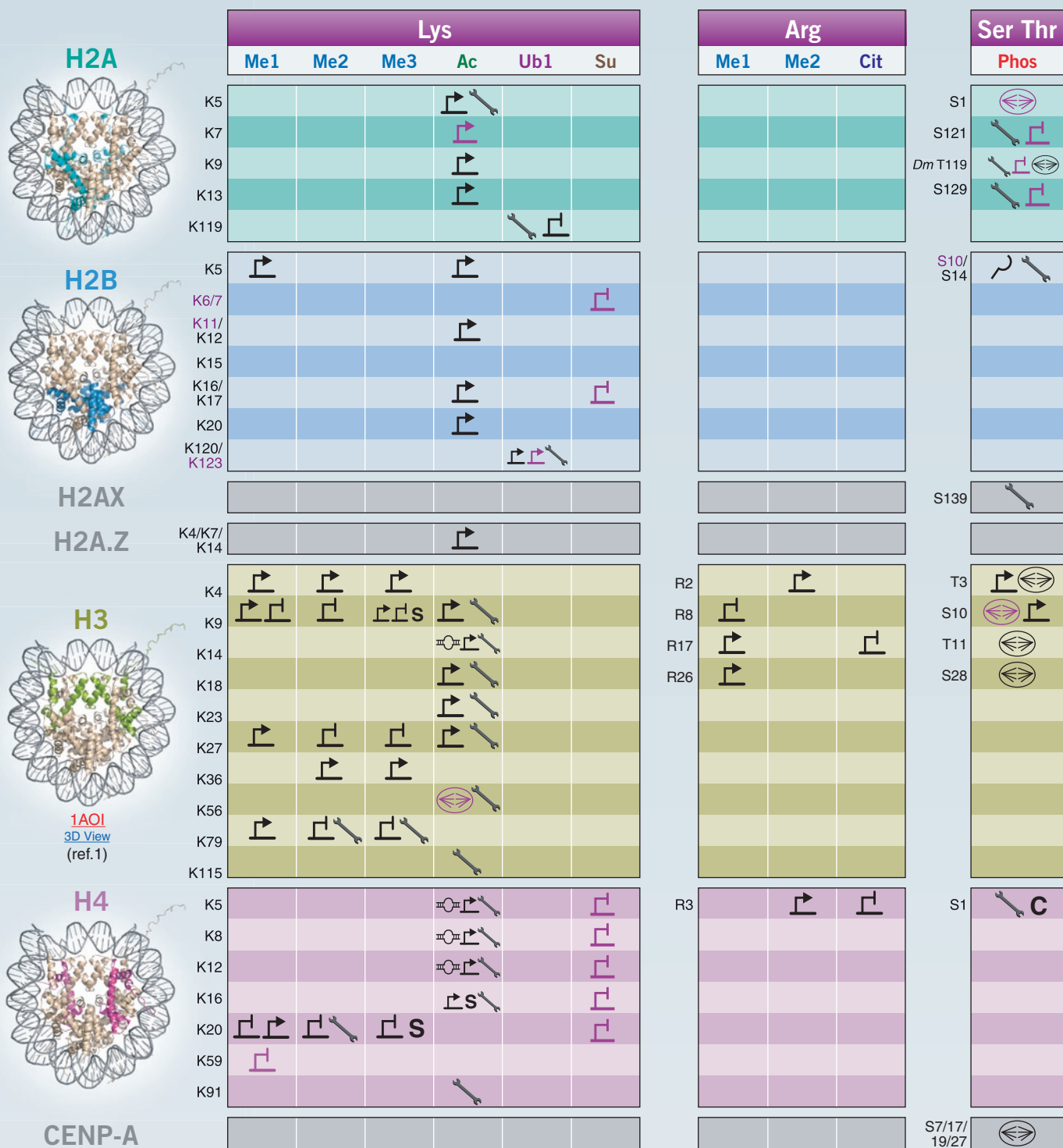
PRIMERS ON CHROMATIN

SABBI LALL. DESIGN BY KATIE RIS-VICARI.



To accompany the Focus on Chromatin appearing in this issue of *Nature Structural & Molecular Biology*, a series of primers has been specially prepared that covers the wealth of knowledge in four areas of chromatin research. These areas include functions associated with covalent histone modifications, the enzymes that mediate these modifications, modules that recognize chromatin, and the ATP-dependent chromatin-remodeling complexes. In such a complex field, the information has inevitably been somewhat simplified. As an example, the correlation between modifications and functions are often context dependent. For instance, H3K9 methylation has been associated with transcriptional activation when present in the coding region of the gene, but has also been associated with repression. The reference list provides further reading and details, as do the Reviews and Perspective in this issue. Although there are many informative structures in this field, space constraints allowed only representative structures to be shown, followed by reference citations for related structures ('3D REF' column). The primers can be used as a stand-alone resource — feel free to tear them out of the issue or print out the PDF versions and modify or add to them yourself as new data emerge. The online versions of the primers contain hyperlinks to the Protein Data Bank as well as 3D view links that allow structural visualization.

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Symbols indicate processes associated or correlated with modification (effects will be context dependent)

C Chromatin condensation **S** Domain-limited functional chromatin changes ↗ DNA repair ↔ Cell division ↗ Replication/histone deposition
 ↗ Active transcription ↗ Repressed transcription/ silent regions ↗ Apoptosis ↗ Symbols in purple indicate data from yeast

Other modifications include ADP ribosylation, such as that at H2BE2, proline isomerization, such as that at H3P38 and biotinylation.

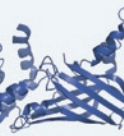



'3D ref' columns list structure citations (in some cases including homologs from other species). Further reading can be found in refs. 106–139 and references cited therein.

Additional histone variants have been identified and are modified. These include macroH2A and histone H3.3 (ref. 106). Residues not shown are also modified¹⁰⁶, and the Reviews in this issue cover in detail the functions associated with modifications and cross-talk between modifications^{107–112}

Structure figures used PyMOL (<http://pymol.sourceforge.net/>), domain assignments used PubMed and/or SMART (<http://smart.embl-heidelberg.de/>).

Me, methylation; Ub1, monoubiquitination; Ac, acetylation; Cit, citrullination; Phos, phosphorylation; Su, sumoylation.

HISTONE-MODIFYING ENZYMES

REPRESENTATIVE STRUCTURE		PROTEIN	TARGET	DOMAIN	3D REF	PROTEIN	TARGET	DOMAIN	3D REF																																																																																																
Histone acetyltransferases (HATs)																																																																																																									
<i>Tt</i> Gcn5  5GCN 3D View	GNAT family																																																																																																								
	Gcn5	H3K9/14/18/23/27, H2B		2-9	<i>Sc</i> Hpa2	H3K14		12																																																																																																	
	PCAF & GCN5L	H3K9/14/18		10, 11	<i>Sc</i> Hat1	H2AK5/7, H4K5/12		13																																																																																																	
<i>Sc</i> Esa1  1FY7 3D View	MYST family																																																																																																								
	<i>Sc</i> Esa1 (TIP60)	H2A, H4		14, 15	HBO1	H4K5/8/12		17																																																																																																	
	MOZ & MORF/ <i>Sc</i> Sas3	H3K14/23	 (Sas3)	16	MOF/ <i>Dm</i> Mof/ <i>Sc</i> Sas2	H4K16		17																																																																																																	
Other																																																																																																									
	<i>Sc</i> Rtt109	H3K56			CBP/p300	H2AK5, H2BK12/15 H3K14/18, H4K5/8/12		See note																																																																																																	
Histone deacetylases (HDACs)																																																																																																									
HDAC8  1W22 3D View	<i>Sc</i> Rpd3	H2A, H2B, H3, H4K5/8/12ac			Hst3 & 4	H3K56ac																																																																																																			
	HDAC8 ^b	H3ac, H4ac		19-21	SIRT1 ^b	H3K9ac, H4K16ac, H1ac		23																																																																																																	
	<i>Sc</i> Hos1 & Hos2	H3ac, H4ac			<i>Sc</i> SIRT2	H3K9ac, H4K16ac		27																																																																																																	
	<i>Sc</i> Hos3	H2BK11/16ac, H4K12ac			<i>Sc</i> Hst2	H4K16ac		22-26																																																																																																	
	<i>Sc</i> Hda1	H3, H2BK11/16ac			<i>Sc</i> Sir2	H3K56ac, H4K16ac		28																																																																																																	
Histone methyltransferases (HMTs)																																																																																																									
SET7/9  1O9S 3D View	SET domain lysine HMTs																																																																																																								
	<i>Sc</i> Set1 ^a , SET1A & 1B	H3K4		29	<i>Sp</i> Clr4	H3K9		33,34																																																																																																	
	MLL1-4 ^a	H3K4		30	<i>Dm</i> E(z) & EZH2	H3K27(EZH2, H1bK26) ^a																																																																																																			
	Ash1 ^a	H3K4			SET2	H3K36		35,36																																																																																																	
	SUV39H1 & H2	H3K9			NSD1	H3K36																																																																																																			
	ESET/SETDB1	H3K9			SMYD2	H3K36																																																																																																			
	<i>Nc</i> DIM-5	H3K9		31,32	SUV420H1 & H2	H4K20																																																																																																			
	RIZ1	H3K9		(x8)	SET7/9	H3K4		37-41																																																																																																	
	G9a	H3K9		(x6)	SET8/PR-SET7	H4K20		42,43																																																																																																	
	EuHMTase1	H3K9		(x7)																																																																																																					
PRMT1  1ORI 3D View	Non-SET domain lysine HMTs																																																																																																								
	<i>Sc</i> Dot-1 & DOT1L	H3K79		44,45																																																																																																					
Arginine HMTs																																																																																																									
	CARM1	H3R2/17/26		46,47	PRMT5	H3R8/H4R3																																																																																																			
	PRMT1/ <i>Sc</i> Hmt1	H4R3		48,49	PRMT6	H3R2																																																																																																			
Histone demethylases																																																																																																									
LSD1  2H94 3D View	LSD1/BHC110																																																																																																								
	LSD1/BHC110	H3K4me1/2, H3K9me1/2		50-54																																																																																																					
JMJD2A  2Q8E 3D View	JmjC family demethylases																																																																																																								
	<i>Dm</i> Lid/JARID1A,B,C,D	H3K4me2/3			UTX	H3K27me2/3		(x6)																																																																																																	
	JHDM2a & b	H3K9me1/2			JMJD2A & C	H3K9/36me2/3		55-59																																																																																																	
	JMJD2D	H3K9me2/3			JHDM1a & b	H3K36me1/2																																																																																																			
	JMJD2B	H3K9me3			JMJD6	H3R2me2, H4R3me2																																																																																																			
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PROTEIN	TARGET	3D REF	PROTEIN	TARGET	3D REF	PROTEIN	TARGET	3D REF																																																																																																	
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Protein database codes in red
For other modifying enzymes see further reading.

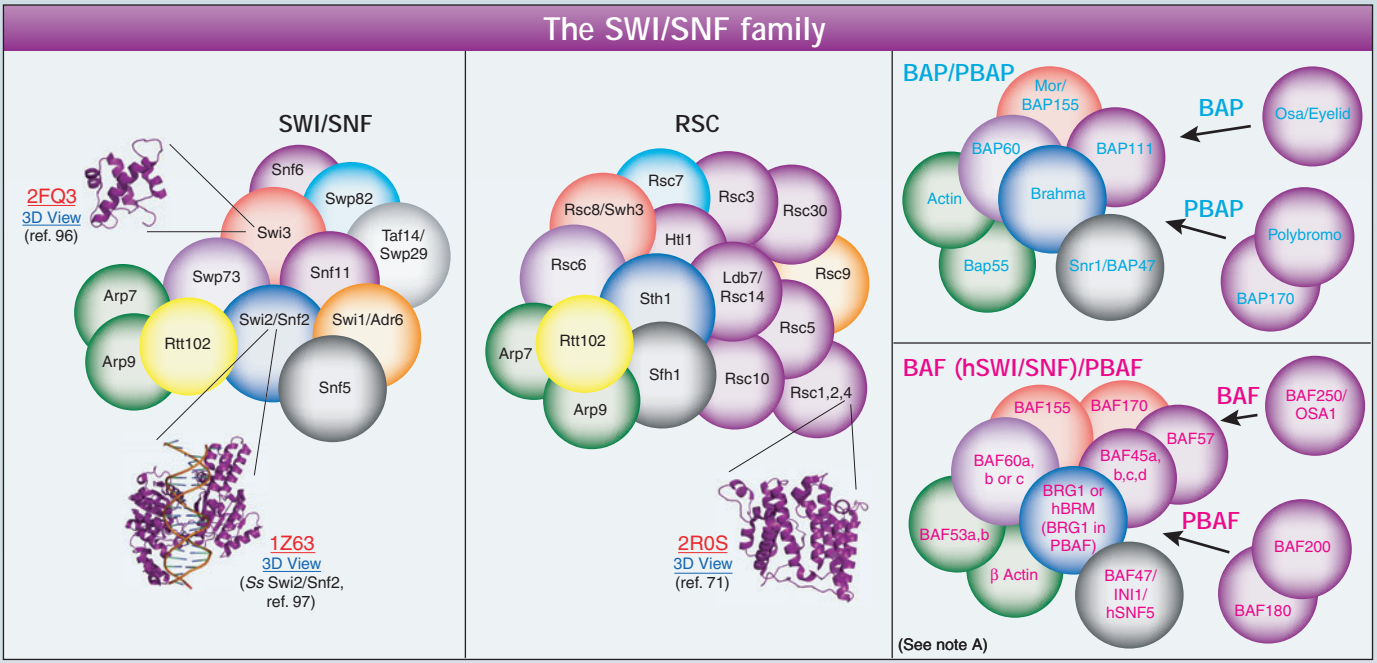
^a In complexes, COMPASS for Set1, EZH2 in PRC complexes.
^b Please see further reading for the full set of mammalian HDACs.

Proteins mammalian except *Sc*, *S. cerevisiae*; *Sp*, *S. pombe*; *Nc*, *N. crassa*; *Tt*, *T. thermophila*;
Dm, *D. melanogaster*
Enzyme may have different *in vitro*, *in vivo* or context-dependent targets, and may have higher efficiency for one residue over others.
Additional structures both awaiting publication and published (e.g. CBP/p300) are available in the protein databank.
The human HDACs and other structures in this family are discussed in ref. 28 and references therein.

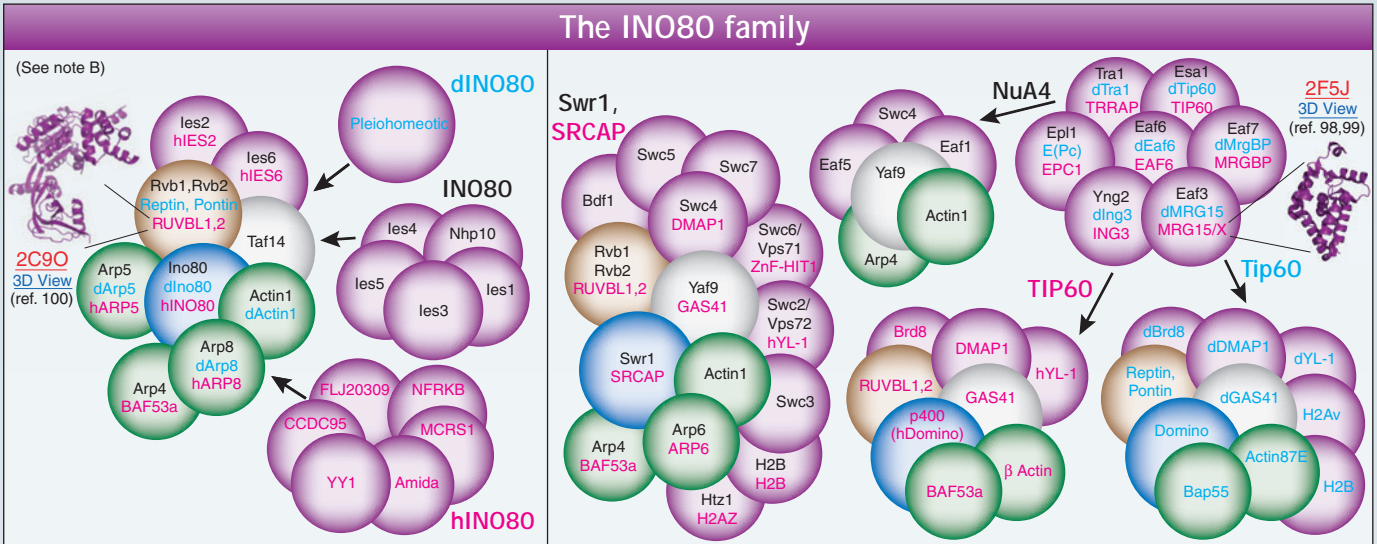
HISTONE RECOGNITION DOMAINS

REPRESENTATIVE STRUCTURE	PROTEIN	TARGET	3D REF	PROTEIN	TARGET	3D REF		
Bromodomain								
 <p>1E6I 3D View</p>	Sc Gcn5	H4K16ac	5,6	CBP/p300	?	140		
	PCAF	H4K16ac	10	Sc Bdf1/BRD8/dBrd8	H4ac			
	TAF1	H4ac	18	Polybromo/BAF180	H3ac			
	hBRG1	H3K14ac	69,70	Sc Rsc1,2,4	H3K14ac (Rsc4)	71 (Rsc4)		
	Sc Snf2	H3ac/H4ac		Dm NURF301/BPTF	?	81 (BPTF)		
	Sc Sth1	?		hACF1/dACF	?			
Chromodomain								
 <p>1KNE 3D View</p>	HP1/Swi6	H3K9me2/3	72,73	dMi-2/CHD3/CHD4/CHD5	?			
	PC1/PC2/Polycomb/LHP1	H3K27me3, H3K9me3	74,75	CHD6/CHD7/CHD8/CHD9	?			
	CHD1	H3K4me1/3	76	hBAF155	?			
	Sc Chd1	?	101,102	dMrg15/hMRG15, Sc Eaf3 ^a	H3K36me, H3K4me	77		
	dTip60/hTIP60, MOF, Esa1	?	17 (Dm MOF)	CDY1	H3K9me2/3			
	Sp Clr4, SUV39H1	H3K9me	33 (Clr4)					
PHD								
 <p>2JMJ 3D View</p>	BHC80	H3K4me0	78	hACF1/dACF	Core histones			
	Yng1	H3K4me2/3	79	Ash1	?			
	ING2	H3K4me2/3	80	JMJD2A/2B/2C	?			
	BPTF/Dm NURF301	H3K4me2/3	81	JHDM1a/b	?			
	NSD1	?		JARID1C	H3K9me3			
	MLL	?		dMi-2/CHD3/CHD4	?			
Tudor								
 <p>2IG0 3D View</p>	JMJD2A	H3K4me3/H4K20me3	55	ESET/SETDB1	H3K9			
	53BP1	H4K20me1/2	82	JMJD2B/2C	?			
	Sp Crb2	H4K20me2	82	PHF20	H4K20me2			
			PROTEIN	TARGET	3D REF	PROTEIN	TARGET	3D REF
WD40				MBT				
 <p>2H6N 3D View</p>	WDR5	H3R2*/H3K4me2*	83-85, 141	L(3)MBTL1	H1bK26me1/2, H4K20me1/2	89		
	RbAp46/48	?		SCML2	?	90		
	p55	?		SFMBT	H3K9me1/2, H4K20me1/2			
				PHF20L1	H3K4me1, H4K20me1			
(*WDR5 can bind unmodified H3 tail)				 <p>1OZ2 3D View</p>				
BRCT				14-3-3				
 <p>2AZM 3D View</p>	MDC1	H2AXPh	86,87	14-3-3	H3S10Ph/H3S28Ph	88		
	Sp Crb2	H2APh						
	53BP1	?						
	MCPH1	H2AXPh						
 <p>2C1N 3D View</p>								

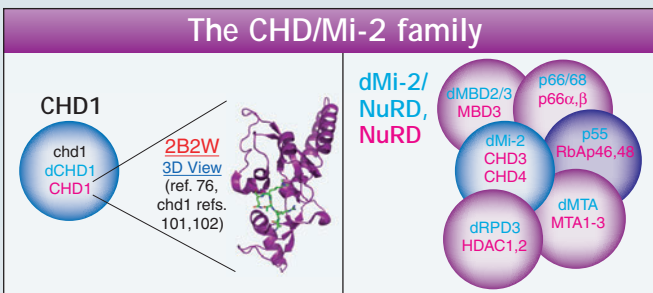
The SWI/SNF family



The INO80 family



The CHD/Mi-2 family

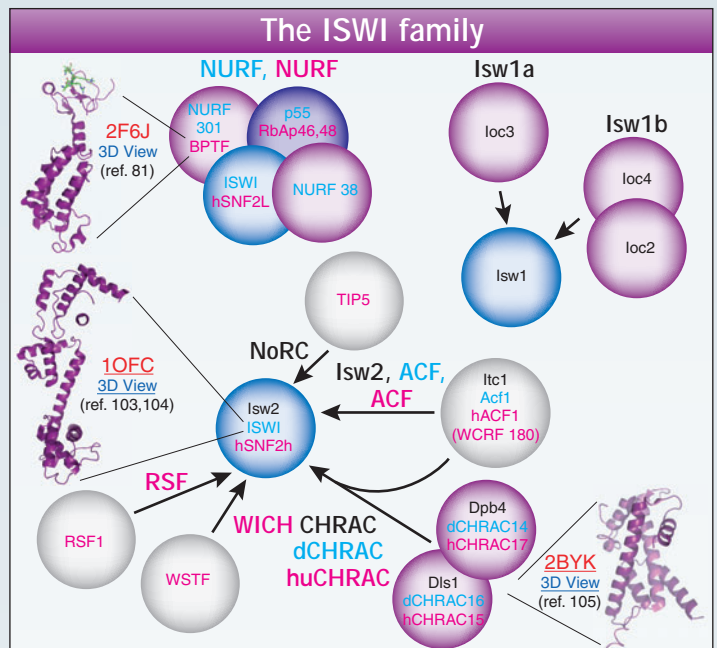


Note A: The BAF complex is combinatorially assembled with interchangeable subunits¹³⁸. The situation is further complicated by the presence of 29 *swi2* homologs in the human genome, and the presence of actin-like subunits in BAF, that differ from yeast SWI/SNF or RSC.

Note B: The INO80 family name used is based on the remodeling catalytic ATPase, though the NuA4 acetyltransferase complex was identified earlier.

For EM structures see refs. 91–95.

The ISWI family



Complex name

YEAST HOMOLOG

FLY HOMOLOG

HUMAN HOMOLOG

Ss, S. solfataricus



Remodeling catalytic ATPase



Sub-family specific



Actin-like

(Similar color sphere denotes similar subunits, i.e. Swi3 and Swh3 are related)

ACKNOWLEDGEMENTS

Thank you to the people that gave us feedback at different stages, including Francisco J. Asturias, Geneviève Almouzni, Peter B. Becker, Mark T. Bedford, Dan Bochar, Karim Bouazoune, Bradley R. Cairns, Joan A. Conaway, Jacques Côté, Gerald R. Crabtree, Yali Dou, Anindya Dutta, Michael Grunstein, Thomas Jeniuwein, Tony Kouzarides, Robert E. Kingston, Sepideh Khorasanizadeh, Ronen Marmorstein, Georges Mer, Jane Mellor, Mary Ann Osley, Tom Owen-Hughes, Craig L. Peterson, Geeta Narlikar, Toshio Tsukiyama, Xuetong Shen, Yang Shi, Ali Shilatifard, Song Tan, Sean D. Taverna, Raymond C. Trievel, Patrick Varga-Weisz, C. Peter Verrijzer and Paul Wade. Cover by Erin Boyle, based on "Crosstalk" by Colleen Buzzard (<http://www.colleenbuzzard.com>).

- Luger, K., Mäder, A.W., Richmond, R.K., Sargent, D.F. & Richmond, T.J. *Nature* **389**, 251–260 (1997).
- Lin, Y., Fletcher, C.M., Zhou, J., Allis, C.D. & Wagner, G. *Nature* **400**, 86–89 (1999).
- Trievel, R.C. *et al. Proc. Natl. Acad. Sci. USA* **96**, 8931–8936 (1999).
- Rojas, J.R. *et al. Nature* **401**, 93–98 (1999).
- Owen, D.J. *et al. EMBO J.* **19**, 6141–6149 (2000).
- Hudson, B.P., Martinez-Yamout, M.A., Dyson, H.J. & Wright, P.E. *J. Mol. Biol.* **304**, 355–370 (2000).
- Clements, A. *et al. Mol. Cell* **12**, 461–473 (2003).
- Poux, A.N. & Marmorstein, R. *Biochemistry* **42**, 14366–14374 (2003).
- Schuetz, A. *et al. Proteins* **68**, 403–407 (2007).
- Dhalluin, C. *et al. Nature* **399**, 491–496 (1999).
- Clements, A. *et al. EMBO J.* **18**, 3521–3532 (1999).
- Angus-Hill, M.L., Duttall, R.N., Tafrov, S.T., Sternglanz, R. & Ramakrishnan, V. *J. Mol. Biol.* **294**, 1311–1325 (1999).
- Duttall, R.N., Tafrov, S.T., Sternglanz, R. & Ramakrishnan, V. *Cell* **94**, 427–438 (1998).
- Yan, Y., Harper, S., Speicher, D.W. & Marmorstein, R. *Nat. Struct. Mol. Biol.* **9**, 862–869 (2002).
- Yan, Y., Barlev, N.A., Haley, R.H., Berger, S.L. & Marmorstein, R. *Mol. Cell* **6**, 1195–1205 (2000).
- Holbert M.A. *et al. J. Biol. Chem.* published online, doi: 10.1074/jbc.M705812200 (9 October 2007).
- Nielsen, P.R. *et al. J. Biol. Chem.* **280**, 32326–32331 (2005).
- Jacobson, R.H., Ladurner, A.G., King, D.S. & Tjian, R. *Science* **288**, 1422–1425 (2000).
- Somoza, J.R. *et al. Structure* **12**, 1325–1334 (2004).
- Vannini, A. *et al. Proc. Natl. Acad. Sci. USA* **101**, 15064–15069 (2004).
- Vannini, A. *et al. EMBO Rep.* **8**, 879–884 (2007).
- Min, J., Landry, J., Sternglanz, J. & Xu, R.M. *Cell* **105**, 269–279 (2001).
- Zhao, K., Chai, X., Clements, A. & Marmorstein, R. *Nat. Struct. Mol. Biol.* **10**, 864–871 (2003).
- Zhao, K., Chai, X. & Marmorstein, R. *Structure* **11**, 1403–1411 (2003).
- Zhao, K., Harshaw, R., Chai, X. & Marmorstein, R. *Proc. Natl. Acad. Sci. USA* **101**, 8563–8568 (2004).
- Sanders, B.D., Zhao, K., Slama, J.T. & Marmorstein, R. *Mol. Cell* **25**, 463–472 (2007).
- Finnin, M.S., Donigian, J.R. & Pavletich, N.P. *Nat. Struct. Mol. Biol.* **8**, 621–625 (2001).
- Hodawadekar, S.C. & Marmorstein, R. *Oncogene* **26**, 5528–5540 (2007).
- Tresaugues, L. *et al. J. Mol. Biol.* **359**, 1170–1181 (2006).
- Allen, M.D. *et al. EMBO J.* **25**, 4503–4512 (2006).
- Zhang, X. *et al. Cell* **111**, 117–127 (2002).
- Zhang, X. *et al. Mol. Cell* **12**, 177–185 (2003).
- Horita, D.A., Ivanova, A.V., Altieri, A.S., Klar, A.J. & Byrd, R.A. *J. Mol. Biol.* **307**, 861–870 (2001).
- Min, J., Zhang, X., Cheng, X., Grewal, S.I. & Xu, R.M. *Nat. Struct. Mol. Biol.* **9**, 828–832 (2002).
- Li, M. *et al. Proc. Natl. Acad. Sci. USA* **102**, 17636–17641 (2005).
- Vojnic, E., Simon, B., Strahl, B.D., Sattler, M. & Cramer, P. *J. Biol. Chem.* **281**, 13–15 (2006).
- Wilson, J.R. *et al. Cell* **111**, 105–115 (2002).
- Jacobs, S.A. *et al. Nat. Struct. Mol. Biol.* **9**, 833–838 (2002).
- Kwon, T. *et al. EMBO J.* **22**, 292–303 (2003).
- Xiao, B. *et al. Nature* **421**, 652–656 (2003).
- Couture, J.-F., Collazo, E., Hauk, G. & Trievel, R.C. *Nat. Struct. Mol. Biol.* **13**, 140–146 (2006).
- Xiao, B. *et al. Genes Dev.* **19**, 1444–1454 (2005).
- Couture, J.-F., Collazo, E., Brunzelle, J.S. & Trievel, R.C. *Genes Dev.* **19**, 1455–1465 (2005).
- Min, J., Feng, Q., Li, Z., Zhang, Y. & Xu, R.M. *Cell* **112**, 711–723 (2003).
- Sawada, K. *et al. J. Biol. Chem.* **279**, 43296–43306 (2004).
- Yue, W.W., Hassler, M., Roe, S.M., Thompson-Vale, V. & Pearl, L.H. *EMBO J.* **26**, 4402–4412 (2007).
- Troffer-Charlier, N., Cura, V., Hassenboehler, P., Moras, D. & Cavarelli, J. *EMBO J.* **26**, 4391–4401 (2007).
- Zhang, X. & Cheng, X. *Structure* **11**, 509–520 (2003).
- Weiss, V.H. *et al. Nat. Struct. Mol. Biol.* **7**, 1165–1171 (2000).
- Stavropoulos, P., Blobel, G. & Hoelz, A. *Nat. Struct. Mol. Biol.* **13**, 626–632 (2006).
- Yang, M. *et al. Mol. Cell* **23**, 377–387 (2006).
- Chen, Y. *et al. Proc. Natl. Acad. Sci. USA* **103**, 13956–13961 (2006).
- Yang, M. *et al. Nat. Struct. Mol. Biol.* **14**, 535–539 (2007).
- Forneris, F., Binda, C., Adamo, A., Battaglioli, E. & Mattevi, A. *J. Biol. Chem.* **282**, 20070–20074 (2007).
- Huang, Y., Fang, J., Bedford, M.T., Zhang, Y. & Xu, R.M. *Science* **312**, 748–751 (2006).
- Chen, Z. *et al. Cell* **125**, 691–702 (2006).
- Couture, J.F., Collazo, E., Ortiz-Tello, P.A., Brunzelle, J.S. & Trievel, R.C. *Nat. Struct. Mol. Biol.* **14**, 689–695 (2007).
- Chen, Z. *et al. Proc. Natl. Acad. Sci. USA* **104**, 10818–10823 (2007).
- Ng, S.S. *et al. Nature* **448**, 87–91 (2007).
- Buchwald, G. *et al. EMBO J.* **25**, 2465–2474 (2006).
- Li, Z. *et al. J. Biol. Chem.* **281**, 20643–20649 (2006).
- Worthylake, D.K., Prakash, S., Prakash, L. & Hill, C.P. *J. Biol. Chem.* **273**, 6271–6276 (1998).
- Smith, K.J. *et al. Structure* **12**, 1067–1077 (2004).
- Amodeo, G.A., Rudolph, M.J. & Tong, L. *Nature* **449**, 492–495 (2007).
- Rudolph, M.J., Amodeo, G.A., Bai, Y. & Tong, L. *Biochem. Biophys. Res. Commun.* **337**, 1224–1228 (2005).
- Nayak, V. *et al. Structure* **14**, 477–485 (2006).
- Arita, K. *et al. Nat. Struct. Mol. Biol.* **11**, 777–783 (2004).
- Arita, K. *et al. Proc. Natl. Acad. Sci. USA* **103**, 5291–5296 (2006).
- Shen, W. *et al. Biochemistry* **46**, 2100–2110 (2007).
- Singh, M., Popowicz, G.M., Krajewski, M. & Holak, T.A. *ChemBioChem* **8**, 1308–1316 (2007).
- VanDemark, A.P. *et al. Mol. Cell* **27**, 817–828 (2007).
- Jacobs, S.A. & Khorasanizadeh, S. *Science* **295**, 2080–2083 (2002).
- Nielsen, P.R. *et al. Nature* **416**, 103–107 (2002).
- Fischle, W. *et al. Genes Dev.* **17**, 1870–1881 (2003).
- Min, J., Zhang, Y. & Xu, R.M. *Genes Dev.* **17**, 1823–1828 (2003).
- Flanagan, J.F. *et al. Nature* **438**, 1181–1185 (2005).
- Zhang, P. *et al. Nucleic Acids Res.* **34**, 6621–6628 (2006).
- Lan, F. *Nature* **448**, 718–722 (2007).
- Taverna, S.D. *et al. Mol. Cell* **24**, 785–796 (2006).
- Pena, P.V. *et al. Nature* **442**, 100–103 (2006).
- Li, H. *et al. Nature* **442**, 91–95 (2006).
- Botuyan, M.V. *et al. Cell* **127**, 1361–1373 (2006).
- Couture, J.F., Collazo, E. & Trievel, R.C. *Nat. Struct. Mol. Biol.* **13**, 698–703 (2006).
- Ruthenberg, A.J. *et al. Nat. Struct. Mol. Biol.* **13**, 704–712 (2006).
- Schuetz, A. *et al. EMBO J.* **25**, 4245–4252 (2006).
- Stucki, M. *et al. Cell* **123**, 1213–1226 (2005).
- Lee, M.S., Edwards, R.A., Thede, G.L. & Glover, J.N. *J. Biol. Chem.* **280**, 32053–32056 (2005).
- Macdonald, N. *et al. Mol. Cell* **20**, 199–211 (2005).
- Wang, W.K. *et al. Structure* **11**, 775–789 (2003).
- Sathyamurthy, A., Allen, M.D., Murzin, A.G. & Bycroft, M. *J. Biol. Chem.* **278**, 46968–46973 (2003).
- Smith, C.L. *et al. Nat. Struct. Mol. Biol.* **10**, 141–145 (2003).
- Leschziner, A.E., Lemon, B., Tjian, R. & Nogales, E. *Structure* **13**, 267–275 (2005).
- Asturias, F.J., Chung, W.H., Kornberg, R.D. & Lorch, Y. *Proc. Natl. Acad. Sci. USA* **99**, 13477–13480 (2002).
- Leschziner, A.E. *et al. Proc. Natl. Acad. Sci. USA* **104**, 4913–4918 (2007).
- Skiniotis, G., Moazed, D. & Walz, T. *J. Biol. Chem.* **282**, 20804–20808 (2007).
- Da, G. *et al. Proc. Natl. Acad. Sci. USA* **103**, 2057–2062 (2006).
- Dürr, H., Koerner, C., Mueller, M., Hickmann, V. & Hopfner, K.P. *Cell* **121**, 363–373 (2005).
- Bowman, B.R. *et al. Structure* **14**, 151–158 (2006).
- Zhang, P. *et al. Protein Sci.* **15**, 2423–2434 (2006).
- Matias, P.M., Gorynia, S., Donner, P. & Carrondo, M.A. *J. Biol. Chem.* **281**, 38918–38929 (2006).
- Okuda, M., Horikoshi, M. & Nishimura, Y. *J. Mol. Biol.* **365**, 1047–1062 (2007).
- Flanagan, J.F. *et al. J. Mol. Biol.* **369**, 334–342 (2007).
- Grune, T. *et al. Mol. Cell* **12**, 449–460 (2003).
- Horton, J.R. *et al. Proteins* **67**, 1198–1202 (2007).
- Hartlepp, K.F. *et al. Mol. Cell. Biol.* **25**, 9886–9896 (2005).
- Allis, C.D., Jeniuwein, T. & Reinberg, D. *Epigenetics* (eds Allis, C.D., Jeniuwein, T. & Reinberg, D.) Appendix 2 (Cold Spring Harbor Press, Cold Spring Harbor, New York, USA, 2007).
- Bhaumik, S., Smith, E. & Shilatifard, A. *Nat. Struct. Mol. Biol.* **14**, 1006–1016 (2007).
- Taverna, S.D., Li, H., Ruthenberg, A., Allis, C.D. & Patel, D.J. *Nat. Struct. Mol. Biol.* **14**, 1025–1040 (2007).
- Latham, J. & Dent, S.Y. *Nat. Struct. Mol. Biol.* **14**, 1017–1024 (2007).
- Buhler, M. & Moazed, D. *Nat. Struct. Mol. Biol.* **14**, 1041–1048 (2007).
- De Koning, L. *et al. Nat. Struct. Mol. Biol.* **14**, 997–1007 (2007).
- Sexton, T., Schober, H., Fraser, P. & Gasser, S.M. *Nat. Struct. Mol. Biol.* **14**, 1049–1055 (2007).
- Barski, A. *et al. Cell* **129**, 823–837 (2007).
- Kouzarides, T. *Cell* **128**, 693–705 (2007).
- Li, B., Carey, M. & Workman, J.L. *Cell* **128**, 707–719 (2007).
- Berger, S.L. *Nature* **447**, 407–412 (2007).
- Mersfelder, E.L. & Parthun, M.R. *Nucleic Acids Res.* **34**, 2653–2662 (2006).
- Hassa, P.O., Haenni, S.S., Elser, M. & Hottiger, M.O. *Microbiol. Mol. Biol. Rev.* **70**, 789–829 (2006).
- Martin, C. & Zhang, Y. *Nat. Rev. Mol. Cell Biol.* **6**, 838–849 (2005).
- Nowak, S.J. & Corces, V.G. *Trends Genet.* **20**, 214–220 (2004).
- Jeniuwein, T. & Allis, C.D. *Science* **293**, 1074–1080 (2001).
- Zhang, Y. & Reinberg, D. *Genes Dev.* **15**, 2343–2360 (2001).
- Strahl, B.D. & Allis, C.D. *Nature* **403**, 41–45 (2000).
- Shi, Y. & Whetstone, J.R. *Mol. Cell* **25**, 1–14 (2007).
- Couture, J.F. & Trievel, R.C. *Curr. Opin. Struct. Biol.* **16**, 753–760 (2006).
- Dillon, S.C., Zhang, X., Trievel, R.C. & Cheng, X. *Genome Biol.* **6**, 227 (2005).
- Holbert, M.A. & Marmorstein, R. *Curr. Opin. Struct. Biol.* **15**, 673–680 (2005).
- Sterner, D.E. & Berger, S.L. *Microbiol. Mol. Biol. Rev.* **64**, 435–459 (2000).
- Kim, J. *et al. EMBO Rep.* **7**, 397–403 (2006).
- Bottomley, M.J. *EMBO Rep.* **5**, 464–469 (2004).
- Chen, M. & Shen, X. *Curr. Opin. Cell Biol.* **19**, 326–330 (2007).
- Bao, Y. & Shen, X. *Mutat. Res.* **618**, 18–29 (2007).
- Denslow, S.A. & Wade, P.A. *Oncogene* **26**, 5433–5438 (2007).
- Moshkin, Y.M., Mohrmann, L., van Ijcken, W.F. & Verrijzer, C.P. *Mol. Cell. Biol.* **27**, 651–661 (2007).
- Varga-Weisz, P.D. & Becker, P.B. *Curr. Opin. Genet. Dev.* **16**, 151–156 (2006).
- Cairns, B.R. *Curr. Opin. Genet. Dev.* **15**, 185–190 (2005).
- Eberharter, A. & Becker, P.B. *J. Cell Sci.* **117**, 3707–3711 (2004).
- Lessard, J. *et al. Neuron* **55**, 201–215 (2007).
- Becker, P.B. & Horz, W. *Annu. Rev. Biochem.* **71**, 247–273 (2002).
- Mujtaba, S. *et al. Mol. Cell* **13**, 251–263 (2004).
- Han, Z. *et al. Mol. Cell* **22**, 137–144 (2006).