A comprehensive compilation and alignment of histones and histone genes

Dan Wells and Celeste McBride

Department of Biology and Institute for Molecular Biology, University of Houston, Houston, TX 77204-5513

This collection of histones and histone genes is a revision and update of an earlier compilation (Wells, 1986). During the past three years close to 150 new histone sequences have been published. As was done in the previous compilation, we have attempted to gather and align all histone sequences available in the GenBank and MBL nucleic acid sequence databases, and in the PIR protein data base. In addition, a comprehensive attempt was made to include all recently published sequence data not currently available in these data bases to make this compilation as current as possible. In situations in which the same gene or protein has been sequenced twice, only one of these sequences was used. For each histone class, the sequences are arranged into phylogenetically related groups *(vertebrates at the beginning and fungi at the end)*. Table 1 is a quick reference guide to the sequences shown in figures 1−14 and refers the reader to the full citations listed at the end of the compilation. The BIONET computer resource operated by IntelliGenetics (Mountain View, CA) was used to collect sequence data using the QUEST program. Using the original manuscripts, new sequences not currently available in the data bases, were entered in duplicate. To detect typing and other entry errors, these duplicate sequences were aligned using the IFIND program and errors were corrected. GENALIGN was used to produce the initial multiple alignments used in figures 1−9. This initial alignment was modified slightly based on previous analysis. QUEST, GENALIGN, and IFIND are products of IntelliGenetics. Any information regarding missing sequence data or erroneous presentation is encouraged.

PROTEIN SEQUENCES

Data from direct amino acid sequence analysis along with data from translated gene sequences are presented for each of the histone subtypes (Figures 1−5). Consensus sequences were generated for each histone subgroup and numbering is based on the consensus sequence. Figure 1 shows the alignments for the H1 proteins. In this figure, the alignments of H1 and H5/H1.0 variants are shown separately to emphasize the similarity of the vertebrate H5 group. The (●) symbols immediately above the H5 consensus indicate amino acids shared in the two variant groups. For the H1 histones, only the central conserved hydrophobic region could be aligned with any degree of certainty. A dash (−) in a sequence indicates an unsequenced region and a colon (:) in a sequence indicates an ambiguous sequence compared to the consensus. Blank spaces in the protein alignments indicate deletions with respect to the consensus. An asterisk (*) in the consensus indicates the absence of a consensus amino acid for that position. A gap in the consensus sequence indicates an insertion was introduced into at least one of the aligned sequences to maximize sequence

similarity. A dot (.) below a consensus amino acid indicates identity with that amino acid.

GENE SEQUENCES

Histone gene alignments are displayed for each of the five subtypes with the coding, upstream, and downstream regions displayed separately. No alignment was attempted for the histone H1 genes due to their extremely diverged nature. In an effort to draw some functional conclusions from these alignments, genes known or presumed to be nonfunctional have been excluded from this compilation.

Coding regions

In each coding region alignment, the consensus (cos) sequence is displayed on the top line followed by each individual histone gene sequence (Figures 6–9). The numbering begins at the first base of the consensus and only bases within the consensus are numbered. A dot (.) below a consensus base indicates identity with the consensus. A dash (–) in a sequence indicates an unsequenced region and a colon (:) in a sequence indicates an ambiguously sequenced base. Blank spaces within a sequence indicates a deletion with respect to the consensus was introduced to maximize the alignment. A gap in the consensus indicates an insertion was introduced into at least one of the sequences to maximize the alignment.

Flanking regions

Where available, up to 150 nucleotides of the sequences upstream and downstream of the coding region were compiled and are shown in figures 10–14. The upstream sequences include the 5′ untranslated portion of the mRNA and the proximal promoter regions upstream of the ATG initiation codon. The sequences downstream of the termination codon includes the 3′ untranslated portion of the mRNA as well as the more distal downstream sequences. No alignments were attempted for these flanking regions and no consensus sequences are shown. The upstream sequences are numbered backward away from the ATG initiation codon and the downstream sequences are numbered immediately after the termination codon. The initiation and termination codons are in bold type.

CONSERVED FLANKING REGIONS

Due to space considerations and the large number of histone genes currently published, a compilation of conserved flanking regions could not be included in this compilation. However, this compilation of conserved flanking regions will be included in subsequent manuscripts currently in preparation on the evolution of the histone multigene family.

Table 1. Sequence List

HISTONE H1

1. Human H1.b (Ohe. *et al.*, 1986)
2. Human H1 (Carozzi *et al.*, 1984)
3. Pig H1t (Cole *et al.*, 1984)
4. Bovine H1–1 (Liao & Cole, 1981)
5. Rabbit H1–3 (Jones *et al.*, 1974)
6. Rabbit H1–4 (Rall & Cole, 1971)
7. Rat testis H1 (Cole *et al.*, 1986)
8. Chicken H1–1A1 (Sugarman *et al.*, 1983)
9. Chicken H1–11 (Coles & Wells, 1985)
10. Chicken H1 H1.10 (Coles *et al.*, 1987)
11. Chicken H1 Ch03 H1 (Coles *et al.*, 1987)
12. Chicken H1 pCH11.5E-1 (Coles *et al.*, 1987)
13. Chicken H1 pCH11.5E-r (Coles *et al.*, 1987)
14. Duck H1 (Tonjes & Doenecke, 1987)
15. *Xenopus* H1-C8 (Turner *et al.*, 1983)
16. *Xenopus* H1-C2 (Turner *et al.*, 1983)
17. *Xenopus* H1B-XLH1 (Perry *et al.*, 1985)
18. *Xenopus* H1A-XLH3 (Perry *et al.*, 1985)
19. Newt H1 (Stephenson *et al.*, 1981)
20. Trout H1 (McLeod *et al.*, 1977)
21. Rainbow Trout H1 (Mezquita *et al.*, 1985)
22. Sea Urchin H1-Sp (Levy *et al.*, 1982)
23. Sea Urchin H1-h22 (Schaffner *et al.*, 1978)
24. Sea Urchin H1B-SP (Lai & Childs, 1988)
25. Sea Urchin late H1-Lp (Knowles & Childs, 1986)
26. Sea Urchin late H1-Sp-g (Knowles *et al.*, 1987)
27. *Parachinus* H1 (Strickland *et al.*, 1980)

28. *Echinolampus* H1 (Strickland *et al.*, 1982)
29. *Drosophila* H1 (Goldberg Ph.D. Thesis, 1979)
30. *Drosophila* H1 (Murphy & Blumenfeld, 1986)
31. *Platynereis* sperm H1a (Kmiecik *et al.*, 1985)
32. *Platynereis* sperm H1b (Kmiecik *et al.*, 1985)
33. Wheat H1.1 (Brandt & von Holt, 1986)
34. Wheat H1.3 (Brandt & von Holt, 1986)
35. *Tetrahymena* H1 (Wu *et al.*, 1986)

HISTONE H5/H1.0

36. Human H1−0 (Doenecke & Tonjes, 1986)
37. Chicken H5 (Ruiz-Carillo & Affolter, 1983)
39. Chicken H5 (Krieg *et al.*, 1983)
40. Goose H5 (Yaguchi *et al.*, 1979)
41. Duck H5 (Doenecke & Tonjes, 1984)

HISTONE H2A

42. Human H2A (Zhong *et al.*, 1983)
43. Human H2A.Z (Hatch & Bonner, 1988)
44. Human H2A.1−1 (Hayashi, *et al.*, 1987)
45. Human H2A.1−2 (Hayashi *et al.*, 1987)
46. Human H2A.1−3 (Hayashi *et al.*, 1987)
47. Human H2A.1−4 (Hayashi *et al.*, 1987)
48. Bovine H2A (Sautiere *et al.*, 1974)
49. Bovine H2A.Z (Hatch & Bonner, 1988)
50. Rat H2A-1 (Laine *et al.*, 1976)
51. Rat H2A-2 (Laine *et al.*, 1976)
52. Rat H2A.Z (Hatch & Bonner, 1988)
53. Mouse H2A (Sittman *et al.*, 1981)
54. Chicken H2A (D'Andrea *et al.*, 1981)
55. Chicken I H2A (Wang *et al.*, 1985)
56. Chicken II H2A (Wang *et al.*, 1985)
57. Chicken H2A-F (Harvey *et al.*, 1983)
58. Chicken H2A (Laine *et al.*, 1978)
59. *Xenopus laevis* H2A-XLH1 (Perry *et al.*, 1985)
60. *Xenopus laevis* H2A-XLH3 (Perry *et al.*, 1985)
61. *Xenopus* H2A-L (Moorman *et al.*, 1982)
62. Newt H2A (Stephenson *et al.*, 1981)
63. Trout H2A (Connor *et al.*, 1984)
65. Sea Urchin H2A-E3 (Sures *et al.*, 1978)
66. Sea Urchin H2A-h22 (Schaffner *et al.*, 1978)
67. Sea Urchin H2A-h19 (Busslinger *et al.*, 1980)
68. Sea Urchin H2A-2.1-Pm (Kemler & Busslinger, 1986)
69. Sea Urchin H2A-2.2-Pm (Kemler & Busslinger, 1986)
70. Sea Urchin H2A-1 (Busslinger & Barberis, 1985)
71. Sea Urchin H2A-2 (Busslinger & Barberis, 1985)
72. Sea Urchin H2A-3 (Busslinger & Barberis, 1985)
73. Sea Urchin gonadal H2A-Pm (Wouters *et al.*, 1978)
74. Sea Urchin testis H2a-B-Sp (Lieber *et al.*, 1986)
75. Sea Urchin testis H2a-Lp (Lieber *et al.*, 1986)
76. Sea Urchin H2A.F/Z (Ernst *et al.*, 1987)
77. Starfish H2A (Martinage *et al.*, 1983)
78. *Drosophila* H2A (Goldberg Ph.D. Thesis, 1979)
79. *Drosophilia* H2AvD (van Daal *et al.*, 1988)
80. *Sipunculus* H2A (Kmiecik *et al.*, 1983)
81. Cuttlefish H2A (Wouters-Tyrou *et al.*, 1982)
82. *Caenorhabditis* H2A (Vanfleteren *et al.*, 1987a)
83. *Tetrahymena* H2A-1 (Fusauchi *et al.*, 1983)
84. *Tetrahymena* H2A-2 (Fusauchi *et al.*, 1983)
85. *Tetrahymena* HV1 (White *et al.*, 1988)
86. Wheat germ H2A (Rodrigues *et al.*, 1979)
87. Wheat H2A1 (Rodrigues *et al.*, 1985)
88. *Aspergillus* H2A (May & Morris, 1987)
89. Yeast H2A-1 (Choe *et al.*, 1982)
90. Yeast H2A-2 (Choe *et al.*, 1982)
91. Yeast H2A-alpha (Choe *et al.*, 1985)
92. Yeast H2A-beta (Choe *et al.*, 1985)

HISTONE H2B

93. Human H2B-1 (Ohe *et al.*, 1979)
94. Human H2B-2 (Ohe *et al.*, 1979)
95. Human H2B (Zhong *et al.*, 1983)
96. Mouse H2B (Sittman *et al.*, 1981)
97. Rat testis TH2B (Kim *et al.*, 1987)
98. Rat somatic H2B (Kim *et al.*, 1987)
99. Bovine H2B (Iwai *et al.*, 1972)
100. Chicken H2B-A2B (Harvey *et al.*, 1982)
101. Chicken H2B-B (Harvey *et al.*, 1982)
102. Chicken H2B-2BA (Grandy *et al.*, 1982)
103. Chicken H2B PP2D-2.3 (Grandy & Dodgson, 1987)
104. Chicken H2B RR3C-3.5 (Grandy & Dodgson, 1987)
105. Chicken H2B BRA-5.4 (Grandy & Dodgson, 1987)
106. Chicken H2B PP2D-4.0 (Grandy & Dodgson, 1987)
107. Chicken H2B BBA-3.0 (Grandy & Dodgson, 1987)
108. Crocodile H2B (van Helden *et al.*, 1978)
109. *Xenopus* H2B-L (Moorman *et al.*, 1982)
110. *Xenopus laevis* H2B-XLH3 (Perry *et al.*, 1985)
111. *Xenopus laevis* H2B-XLH1 (Perry *et al.*, 1985)
112. Newt H2B (Stephenson *et al.*, 1981)
113. Trout H2B (Kootstra & Bailey, 1978)
114. Trout H2B (Winkfein *et al.*, 1985)
115. Sea Urchin H2B-E3 (Sures *et al.*, 1978)
116. Sea Urchin H2B-h22 (Schaffner *et al.*, 1978)
117. Sea Urchin sperm H2B-2 (Busslinger & Barberis, 1985)
118. Sea Urchin H2B-h19 (Busslinger *et al.*, 1980)
119. Sea Urchin testis H2B-2-Sp (Lieber *et al.*, 1986)
120. Sea Urchin sperm H2B-1-Sp (Lai *et al.*, 1986)
121. Sea Urchin testis H2B-Lp (Lieber *et al.*, 1986)
122. Sea Urchin testis H2B (Lai & Childs, 1986)
123. Sea Urchin sperm H2B-1(Busslinger & Barberis, 1985)
124. Sea Urchin H2B-2.1-Pm (Kemler & Busslinger, 1986)
125. Sea Urchin H2B-2.2-Pm (Kemler & Busslinger, 1986)
126. Sea Urchin late H2B-1-Pm (Busslinger & Barberis, 1985)
127. Sea Urchin late H2B-2-Pm (Busslinger & Barberis, 1985)
128. Sea Urchin sperm H2B-Pa (Strickland *et al.*, 1977)
129. Starfish sperm H2B (Strickland *et al.*, 1977)
130. Starfish gonadal H2B (Martinage *et al.*, 1985)
131. *Drosophila* H2B (Goldberg Ph.D. Thesis, 1979)
132. Limpet H2B (van Helden *et al.*, 1979)
133. *Caenorhabditis* H2B (Vanfleteran *et al.*, 1986)
134. *Tetrahymena* H2B-1 (Nomoto, 1987)
135. *Tetrahymena* H2B-2 (Nomoto, 1987)
136. Yeast H2B-1 (Wallis *et al.*, 1980)
137. Yeast H2B-2 (Wallis *et al.*, 1983)
138. Yeast H2B (Choe *et al.*, 1985)
139. Yeast H2B.1-Pombe (Matsumoto & Yanagida, 1985)

HISTONE H3

140. Human H3−5B (Zhong *et al.*, 1983)
141. Human H3−26H (Clark *et al.*, 1981)
142. Human H3-B2 (Wells & Kedes, 1985)
143. Human H3 (Marashi *et al.*, 1986)
144. Bovine H3−1 (DeLange *et al.*, 1973)
145. Bovine H3−2 (Patthy & Smith, 1975)
146. Mouse H3−1 (Sittman *et al.*, 1981)
147. Mouse H3−2 (Sittman *et al.*, 1981)
148. Mouse H3.2−614 (Taylor *et al.*, 1986)
149. Mouse H3.1−291 (Taylor *et al.*, 1986)
150. Chicken H3 (Wang *et al.*, 1985)
151. Chicken H3−3D (Engel *et al.*, 1982)

Table 1. Sequence List (cont.)

152. Chicken H3−4A (Brush *et al.*, 1985)
153. Chicken H3.3B (Dodgson *et al.*, 1987)
155. *Xenopus* H3-LA (Ruberti *et al.*, 1982)
156. *Xenopus* H3-BOR (W. Bains Ph.D. Thesis, 1982)
157. *Xenopus* H3 (Old *et al.*, 1985)
158. *Xenopus laevis* H3-XLH3 (Perry *et al.*, 1985)
159. *Xenopus laevis* H3-XLH1 (Perry *et al.*, 1985)
160. *Xenopus laevis* H3-A-XLH1 (Perry *et al.*, 1985)
161. Newt H3 (Stephenson *et al*, 1981)
162. Trout H3 (Connor *et al.*, 1984)
163. Buffalo Fish H3 (Hooper *et al.*, 1973)
164. Shark H3 (Brandt *et al.*, 1974)
165. Sea Urchin H3-E3 (Sures *et al.*, 1978)
166. Sea Urchin H3-h22 (Schaffner *et al.*, 1978)
168. Sea Urchin H3-h19 (Busslinger *et al.*, 1980)
169. Sea Urchin H3-LP19 (Childs *et al.*, 1982)
170. Sea Urchin H3-Lp21 (Roberts *et al.*, 1984)
171. Sea Urchin H3-LpE (Roberts *et al.*, 1984)
172. Sea Urchin H3 (Kaumeyer *et al.*, 1986)
173. Sea Star H3-PO (Cool *et al.*, 1988)
174. Sea Star H3-PB (Cool *et al.*, 1988)
175. Sea Star H3-DI (Cool *et al.*, 1988)
176. *Spisula* oocytes H3 (Swenson *et al.*, 1987)
177. *Drosophila* H3 (M. Goldberg Ph.D. Thesis, 1979)
178. *Caenorhabditis* H3 (Vanfleteren *et al.*, 1987b)
179. Wheat H3 (Tabata *et al.*, 1984)
180. Pea embryo H3 (Patthy *et al.*, 1973)
181. Rice H3 (Peng & Wu, 1986)
182. Maize H3C2 (Chaubet *et al.*, 1986)
183. Maize H3C4 (Chaubet *et al.*, 1986)
184. *Cycad* H3 (Brandt & von Holt, 1986)
185. Barley H3 (Chojecki, 1986)
186. *Arabidopsis* H3-GB (Chaboute *et al.*, 1987)
187. *Arabidopsis* H3-GA (Chaboute *et al.*, 1987)
188. *Volvox* H3-I (Muller *et al.*, 1988)
189. *Volvox* H3-II (Muller *et al.*, 1988)
190. *Tetrahymena* H3-I (Horowitz & Gorovsky, 1985)
191. *Tetrahymena* H3-II (Horowitz & Gorovsky, 1985)
192. *Neurospora* H3 (Woudt *et al.*,1983)
193. Yeast H3−1 (Smith & Andresson, 1983)
194. Yeast H3−2 (Smith & Andresson, 1983)
195. Yeast H3.1-Pombe (Matsumoto & Yanagida, 1985)
196. Yeast H3.2-Pombe (Matsumoto & Yanagida, 1985)
197. Yeast H3.3-Pombe (Matsumoto & Yanagida, 1985)

HISTONE H4

198. Human H4-A1 (Heintz *et al.*, 1981)
199. Human H4 (Sierra *et al.*, 1983)
200. Human fetal H4 (Pauli *et al.*, 1987)
201. Pig H4 (Sautiere *et al.*, 1971a)
202. Bovine H4 (Wilson *et al.*, 1970)
203. Mouse H4 (Seiler-Tuyns & Birnstiel, 1981)
204. Mouse H4 (Stauber *et al.*, 1986)
205. Rat H4 (Sautiere *et al.*, 1971b)
206. Chicken H4 (Sugarman *et al.*, 1983)
207. Chicken LH4 (Wang *et al.*, 1985)
208. Chicken RH4 (Wang *et al.*, 1985)
209. *Xenopus* H4-B (Turner & Woodland, 1982)
210. *Xenopus* H4-L (Turner & Woodland, 1982)
211. *Xenopus* H4-LB (Moorman *et al.*, 1981)
212. *Xenopus laevis* H4A-XLH1 (Perry *et al.*, 1985)
213. *Xenopus laevis* H4B-XLH1 (Perry *et al.*, 1985)
214. *Xenopus laevis* H4-XLH3 (Perry *et al.*, 1985)
215. *Xenopus* H4 (Clerc *et al.*, 1983)
216. *Xenopus* H4-Z (Zernik *et al.*, 1980)
217. Newt H4 (Stephenson *et al.*, 1981)
218. Trout H4 (Winkfein *et al.*, 1985)
219. Sea Urchin H4-h19 (Busslinger *et al.*, 1980)
220. Sea urchin H4-h22 (Schaffner *et al.*, 1978)
221. Sea urchin H4-Sp (Grunstein *et al.*, 1981)
222. Sea Urchin-Lp19 (Roberts *et al.*, 1984)
223. Sea Urchin-Lp21 (Roberts *et al.*, 1984)
224. Sea Urchin H4-Sp (Kaumeyer & Weinberg, 1986)
225. Sea Star H4-P.B. (Cool *et al.*, 1988)
226. Sea Star H4-D.I. (Cool *et al.*, 1988)
227. Sea Star H4-P.O. (Howell *et al.*, 1987)
228. *Drosophila* H4 (Goldberg Ph.D. Thesis, 1979)
229. Wheat H4 (Tabata *et al.*, 1983)
230. Wheat H4 (Tabata & Iwabuchi, 1984)
231. Pea seedling H4 (DeLange *et al.*, 1969)
232. Maize H4-C7 (Phillips *et al.*, 1986)
233. Maize H4-C14 (Phillips *et al.*, 1986)
234. *Arabidopsis* H4-GA (Chaboute *et al.*, 1987)
235. *Arabidopsis* H4-GB (Chaboute *et al.*, 1987)
236. *Volvox*-I H4 (Muller & Schmitt, 1988)
237. *Volvox*-II H4 (Muller & Schmitt, 1988)
238. *Tetrahymena* H4-I (Horowitz *et al.*, 1987)
239. *Tetrahymena* H4-II (Horowitz *et al.*, 1987)
240. *Tetrahymena* H4 (Bannon *et al.*, 1984)
241. *Physarum* H42 (Wilhelm & Wilhelm, 1987)
242. *Physarum* H41 (Wilhelm & Wilhelm, 1987)
243. *Neurospora* H4 (Woudt *et al.*, 1983)
244. Yeast H4-Sc (Woudt *et al.*, 1983)
245. Yeast (Smith & Andresson, 1983)
246. Yeast H4.1-Pombe (Matsumoto & Yanagida, 1985)
247. Yeast H4.2-Pombe (Matsumoto & Yanagida, 1985)
248. Yeast H4.3-Pombe (Matsumoto & Yanagida, 1985)

Histone H5/H1.0 proteins

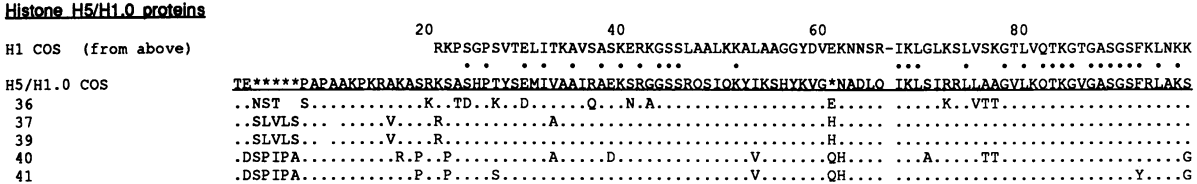


Figure 1. Histone H1 Protein Alignments

Figure 1. (cont.)

```
 1  AASGEAKPKAKKAGAAKAKKPAGAAKKPKKATGAATPKKSAKKTPKKAKKPAAAAGAKKAKSPKKAKSAKPKKAPKSPAKAKAVKPKAAKPKTAKPKAAKPKKAAAKKK
 3  AAPEPRKGKVKKPAAAKTKKLVLSRDSKSPKSAKANKRAKKSRTTAAQKAARSGRKTKEAKVKQQRKAPAKARAAKPKAGNPKLTQQKTNPRKATNRK
 5  AASGEAKPKPKKAGAAKPKKPAGATPKKPKKAAGAKKAVKKTPKKAPKPKAAAKPKVAKPKSPAKVAKSPKKAKAVKPKAAKPKAPKPKAAKAKKTAAKKKK
 7  AASGNDKGKGKKSASAKAKKLGLSRASRSPKSSKTKVVKKPKATPTKGSGSRRKTKGAKGLQQRKSPAKARATNSNSGKSKMVMGKTDLRKAAGRK
 8  PGETKAKATKKKPAAKPKKPAAKKPAAAAKKPKKAAAVKKSPKKAKKPAAAATKKAAKSPKKATKAGRPKKTAKSPAKAKAVKPKAAKSKAAKPKAAKAKKAATKKK
 9  PGEVKEKAPRKRATAAKPKKPAAKKPAAAAKKPKKAAAVKKSPKKAKKPAAAADQEGGQEPQEGRQGWPPQEGRQEPGQGKGGEAQGCQAQGDQTQGGQGEEDGSQEEV
10  PGEVKEKAPRKRTPAAKPKKPAAKKPASAAKKPKKAAAAKKSPKKAKKPAAAATKKAAKSPKKATKAAKPKKAATAKSPAKAKAVKPKAAKPKAAKPKAAKAKKAAAKK
11  SGDVKEKAPKKKTPAAKPKKPAAKKPAAAAKKPKKAVAVKKSPKKAKKPAAAATKKAAKSPKKVTKAAKPKKAVAVKSPAKAKAVKPKAAKPKATKPKAAKAKKAAPKKK
12  PGEVKEKAPKKKASAAKPKKPAAKKPAAAAKKPKKAVAVKKSPKKAKKPAASATKKSAKSPKKVTKAVKPKKAVAAKSPAKAKAVKPKAAKPKAAKPKAAKAKKAAAKKK
13  PGEGLEKAPKKKASAAKPKKAAAKKPAAAAKKPKKAVAVKKSPKKAKKPAASATKKSVKSPKKAAKPKKAVAAKSPAKAKAVKPKAAKPKAAKPKAAKAKKAAAKKK
14  PGETKEKPTKKKPAAKPKKPAAKKPASAAKKPKKAAAVKKSPKKAKKPAAAATKKAAKSPKKAAKAGRPKKAAKSPAKAKAVKPKAAKPKAAKPKAAKAKKAAPKKK
15  QLETKVKAVAKKKLVAPKAKKPVAAKKKPKSPKKPKKVSAAAAKSPKKAKKPVKAAKSPKKPKAVKPKKVTKSPAKKATKPKAAKAKIPAKPKIAKAKAAKGKKAAAKK
16  QLETKVKAVAKKKLVAPKAKKPVTAKKKPKSPKKPKKVSAAAAKSPKKAKKPVKAAKSPKKKAVKSKKVTKSPAKKATKPKAAKAKIAKAKAAKGKKAAAKK
17  QLETKDKAAKKKPAAPKAKKTAAGAKKAPKSlKKPKKVSAAAKSPKKVKPLAKAAKSPKKPKAVKAKKVAKSPAKKATKPKTAKSPAKAKVAKPKAAKAKKPAPKKK
18  QLQSKDKAAAKKKAPLAAEAKKPAAAAKKTAKSPKKPKKVSAAAKSPKKLKPPAkAAKSPAKKTAPKAVKPKVAAKSPAKAKAAKPKVAKAKKAAPKKK
20  VEAKKPAKKAAAPKAKKVAAKKPAAAKKPKKVAAKKAVAAKKSPKKAKKPATPKKAAKSPKKATKAAKAKPKKAAKSPKKVKKPAAAKK
21  AVEAKKPAAKAAAPKAKKVAAKKPAAAKKPKKVAAKKAVAAKKSPKKAKKPATPKKAAKSPKKVKKPAAAAKKAAKSPKKATKAAKPKAAKPKAAKAKKAAPKKK
22  AAKAQASEKAKKEKEKAKLLAQREKAKEKGCSEEGETAEGSRPKKVKAAPKKAKKPVKKTTEKKEKKKTPKKAPKKPAAKKSTPKKTPKKAAAKKPKTAKPKKPAKKAAKSK
23  LDRTLSKKVTQPK
24  KEGKSDAQKARDAAKKAKLAAKKKEAKEKKAARSKAKKEKLAAKKASKKTTKKVKKPAAKKAKKPAAKKAAKKPAAKKPAAKKAAAKPAPAKKAAKKPAAKKAAKKVAKKPAAKKAAKK
25  KAGKTEAQKARAAAKKAKLAAKKKEQKEKKAAKTKARKEKLAAKKAAKKAAKKVKKPAAKAKKPAKKAAKKPAAKKAAKKPAAKKPAKKAAKKPAAKKAAKPAKAAKKPAAKKAAKK
26  KEGKSDAQKARIAAKKAKLAAKKKEGREKKALKTKARKEKVAAKKAAKKATKKTKKVKKPAAKKAKKPAAKKPAAKKPAAKKAKKPAKKVAKPAKKAAAKPAKKAAKPAKKAAKPAKKAAKPAKK
27  AKPKKAKKTSAAAKAKKAKAAAAKKARKAKAAAKRKAALAKKKAAAAKRKAAAKAKKAKKPKKKAAKKAKKPAKKSPKKAKKPAKKSPKKKKAKRSPKKAKKAAGKRKPAAKKARRSPRKAGKRRSPKKARK
28  KRSAASANKLKATREKARARAKAKKAKAAARRKAAAAKRKAAAAKRRAAKKARKAKAKP
29  AKKEKDPKAKSKVLSAEKKVQSKKVASKKIGVSSKKTAVGAADKKPKAKKAVATKKTAENKATKAAKPKAAKPKKAAKSPKKVKKPAAAKKKTEKAKAKDAKKTGIIKSKPAATKAKVTAAKPKA
30  AKKEKDPKAKSKVLSAEKKVQSKKVASKKIGVSSKKTAVGAADKKPKAKKAVATKKTAENKKTEKAKAKDAKKTGIIKSKPAATKAKVTAAKPKAVVAKASKAKPAVSAKPKKTVKKASVSATAKkPKAKTTAAKK
31  KKAAKKPKAKKVKKPKSAAKKKTNRARKPKTKKNRN
32  KKAAKKPKAKKVKKPKSAAKKKTNRARAPKTKKNRN
```

__Histone H5/H1.0 proteins__

```
     100                 120                   140                 160                 180
COS  DKAKRSPA--KKKKKAVRRSTSPKKAARPRKAR--SPAKKPKAT-ARKARKKSRASPKKAKKPKTVKAKSRKASK*KKAKRSKPRAKSGARRSPKKK
36   .EP.K.VA F..T..EIKKVAT....SK.K..ASKAPT......PVK..K..LA.T.............PV....P....PV..K...S.K.AG...
37   .......G  ....................  ........ .........................A..V.................
39   .......G  ..................-.  ........ .........................A..V...........K.....
40   ........GR......A.K.............  ........A ......................L.T..P...R.................
41   ........Gr......a......r.........  ........A ......................L.T..V.....................
```

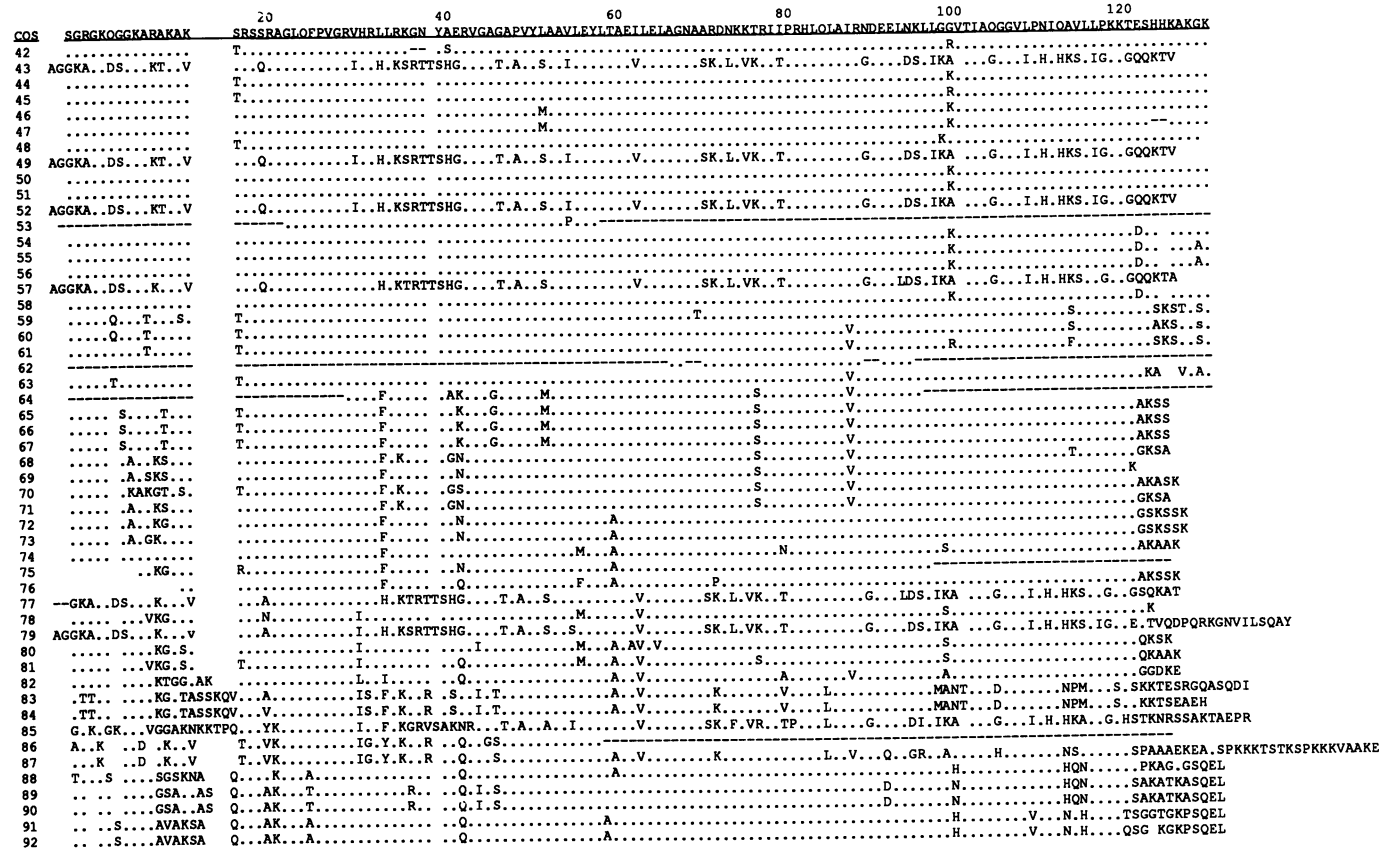


Figure 2. H2A Protein Sequence alignments

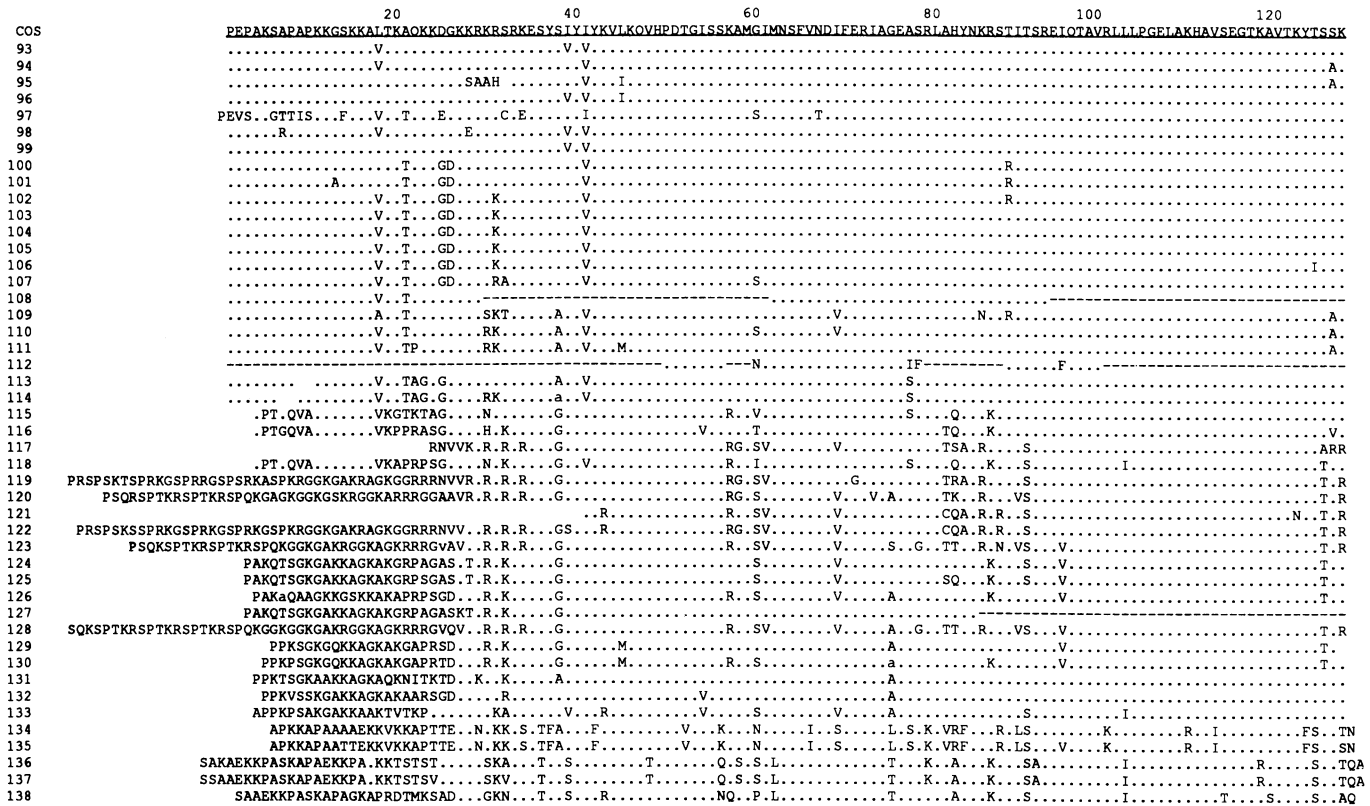


Figure 3. Histone H2B Protein Alignments

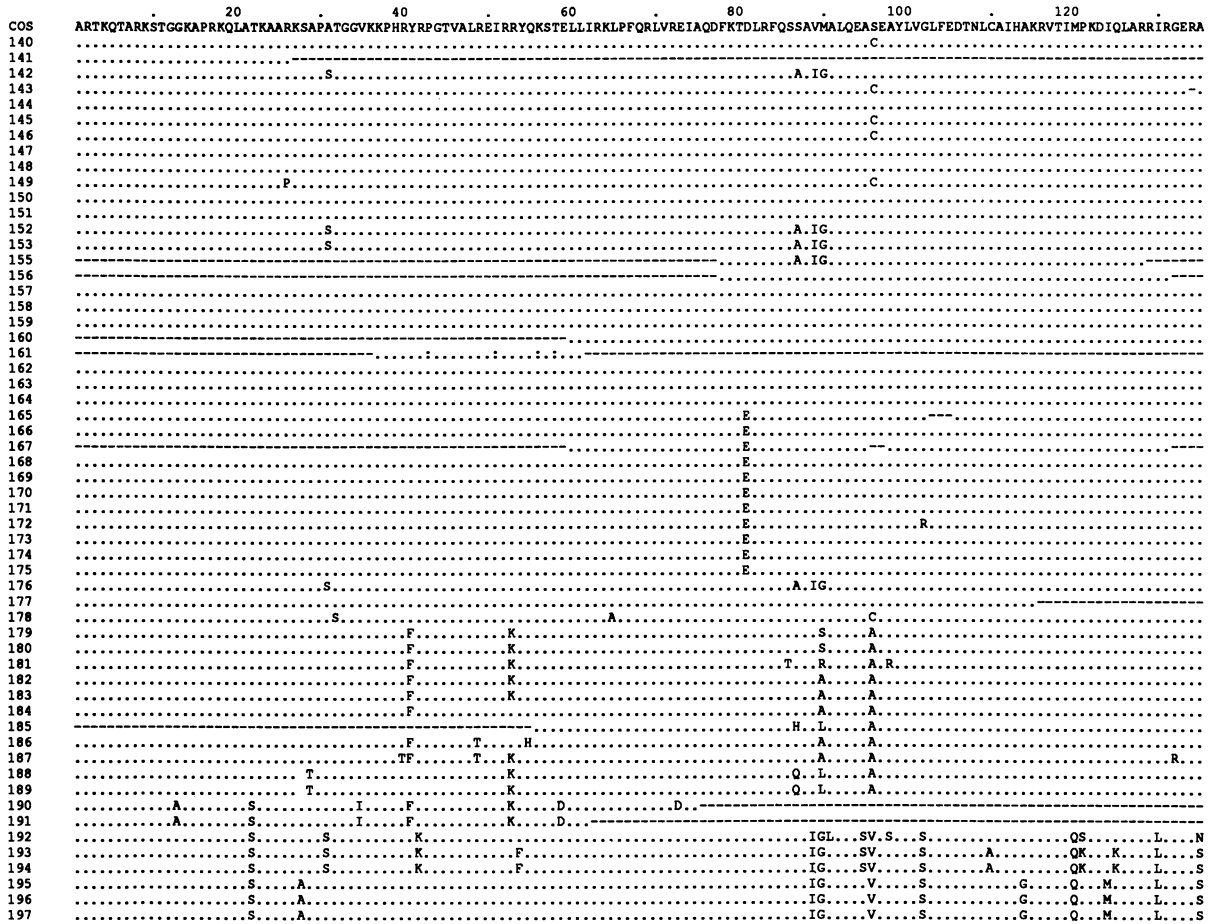


Figure 4. Histone H3 Protein Alignments

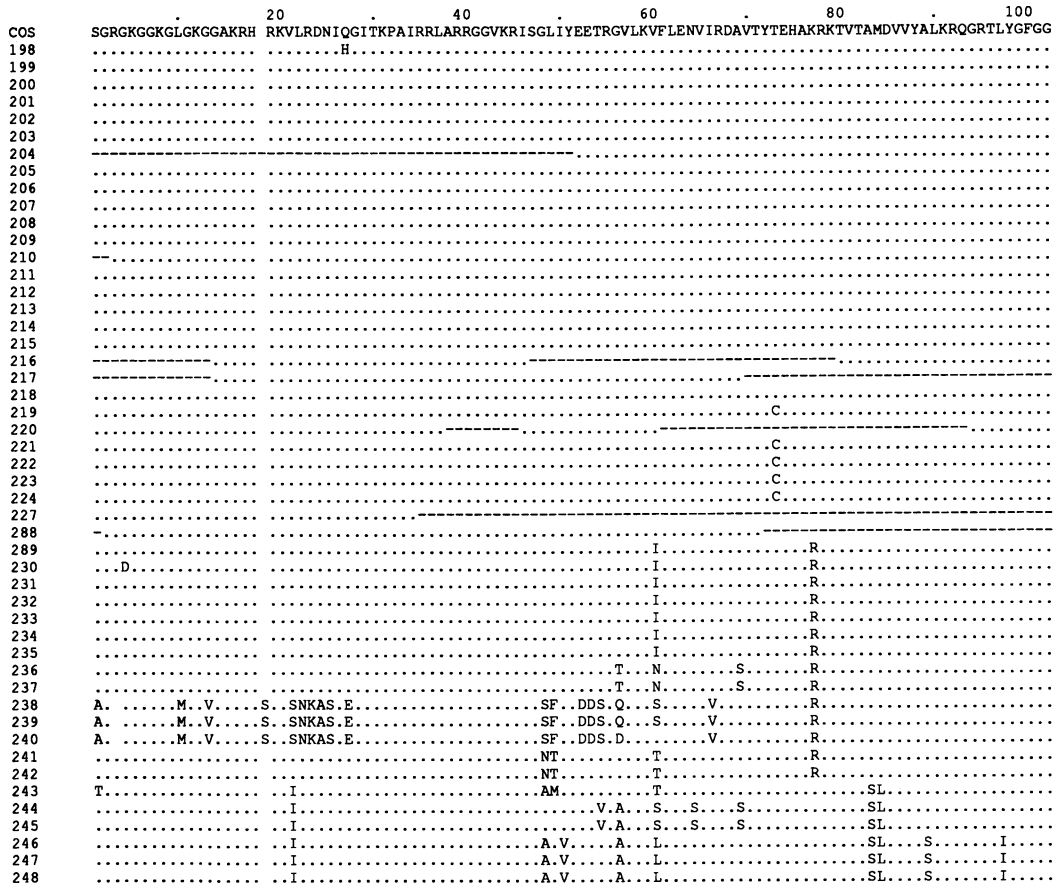


Figure 5. Histone H4 Protein Alignments

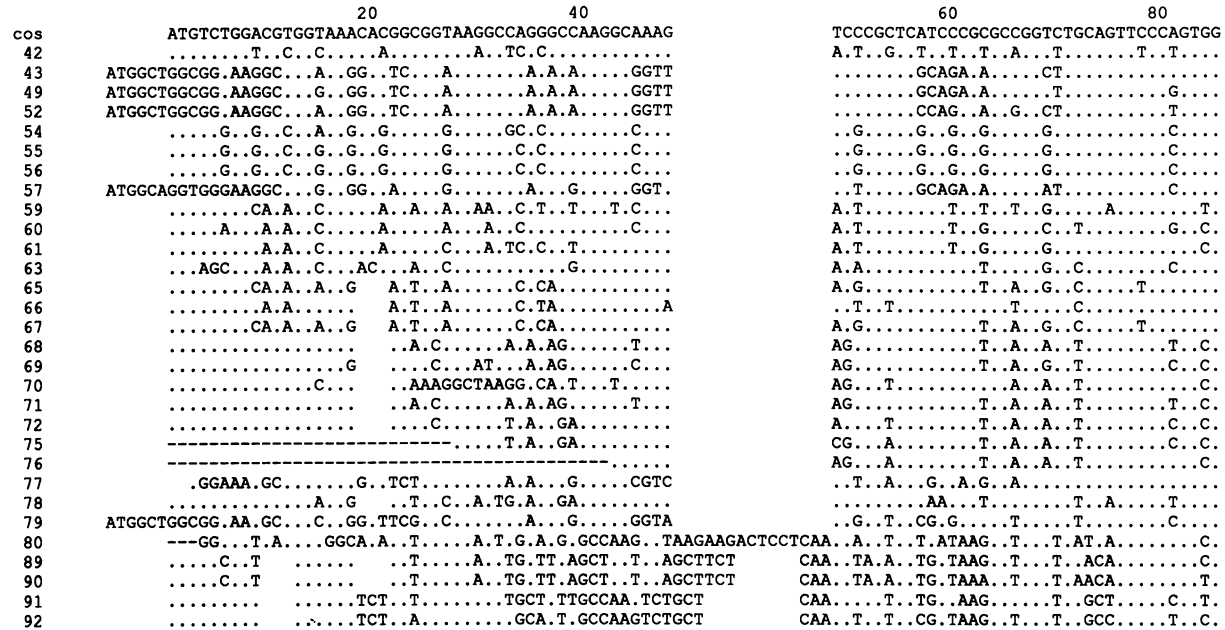


Figure 6. H2A Coding Sequence Alignments

Figure 6. (cont.)

```
                   100                     120                140                 160                     180
cos  GCCGTGTTCACCGGTTGCTGAGAAAGGGCAAC   TACGCCGAGCGTGTCGGCGCTGGTGCCCCAGTGTACCTGGCTGCCGTCCTGGAGTACCTGACCGCTGAGATCCTCGA
 42  ....A..G.....CC....CC.C....----.   ...T.......C.....G.....C.....G.....T..C..G..G..G..T.............C........A..
 43  .....A....T..ACAC..A.A.TCTA.G.CGACCAGTCAT.GA.....G.....GAC....G.T......AGC..A...A............C.....A...G.A..T..
 49  .....A....T..ACAC....A.TCTA.G.CGACTAG.CAT.GA.....G.....GAC....G.T......AGC..A...A............C'....A...G.A..T..
 52  .....A....T..ACAC....A.TCTA.G.CAACAAG.CA..GA.....G.....GACC..AG.T......AGC..A...A............C.....A...G.A..T..
 54  ....C..G......C.....C.C.........   .....G.....G..G.....C..C.....GC.......A..G.....G..............G..C.........G..
 55  ....C..G......C.....C.C.........   .....G.....G..G.....C..C.....G..........G.....G..............G..C.........G..
 56  ....C..G......C.....C.C.........   .....G.....G..G.....C..C.....G..........G.....G..............G..C.........G..
 57  ....CA.C..T...CAC....AG.C.C...C.ACGAG.CAT.G...G.....G..CACC...G.C......AGC......A....C.....T..C..T......G....G..
 59  .T........T..TC..T.......A......   ..T..T..A..G..G..A..C..A..T..G..C..TT.......A..G..C.....T.....T...........G..
 60  ...............CT.......A.....T   ..T........G..G..A..C..A..T.....C.....T..C..G..G..C.....T........C..........
 61  .............C.CT....G........T   ..T........G..G..A..C..A..T..G..C..T.....C..A..G..C.....T...............T.G..
 63  .......G...A..C.....C.T..A......   ......................C..A.............C..A..G..C..........T...........G..
 65  .A........T.....T..CC...........   ..T..AA..A.G.......G...A..T..T..C...A..............A........C..T..C..A...T.G..
 66  .A............A..T..AC.C..A......   ..T..AA..A.G.......G...G..A.....C...A....C..T...T........T....T..C..A..T.....
 67  .A........T.....T..CC...........   ..T..AA..A.G.......G...A..T..T..C...A..............A........C..T..C..A...G.G..
 68  .......G.....T..CT...AG.........   ....G.A.C.GT..T..A....CT.T.....CG..AC.C..A.........C.........C.TC.CT.AG........
 69  .......G.....T..CT....G..A......   ......A.C........A....................C..A.........C.........C.................
 70  .T.....G.....T..CT...AG.........   ....GATCC........A....................C..A.....A..C.........C.................
 71  .......G.....T..CT...AG.........   ....G.A.C.....T..A....................C..A.........C.........C.................
 72  .T.....C.........C..CC.C.........   ..T...A.C.....T..T.....A.........C...T..........T..C..A...T..G.A..............
 75  .T...........A..C..CC.......T...   ......A.C.....T..T.....A.........C...T..........G..C......T..G.A..............
 76  .T.....C..T..A..C..CC.C.....A...   ..T...C.......T..T..C..A.........C.....A..C.....GT.C..A...T..G.T.....A.........
 77  .T...A.....A.ACATT...AG..CA.A.CGACGAG.CAT.GC..C.....T..CACA...G.T..A...TCT..C..TA.TT....A.....C..A.....AG.T..T..
 78  .....A.......T.....CC.G.....A...   .....A.........T..T..A..C..T.....T.....A.........AA....A..T...G.........G.T.....
 79  .T..CA.C..T..TCAT..C.AG.GCC...CTACT.CACAT.GA..C.....A..CAC...AG.C......TCC......A.AT....A............C...G....G..
 85  .TA.AA.C...A.A..TT...AGGGTA.AGTTAGTGCTAAGA.CA.A..T..T...AC...TG.T..T..TGCT.....TA.TT....A..TT.A..A..A..AG.TT.G..
 89  .TA.A..G...A.A.....A....GA..T...   ......C.AA.AA.T..TT.........T.....C...T..A....T...T....A..TT..G.........A..TT.A..
 90  .TA....G...A.A.....A....GA..T...   ......C..A.AA.T..TT.........T.....C..T...A....T...T.A..A..TT..G.T.....A..TT.A..
 91  .T.....C..T..T...T.AC.T.....T...   ..T..TC.A.....T..T.........T..C..T...T....C.....TT....A..TT..G.T.....A..T.....
 92  .T........T..T...T..C.T.....T..T   ..T..TC.A.....T..T.........T..C..T...T............T.......TT.AG.T..C..A........
```

Figure 6. (cont.)

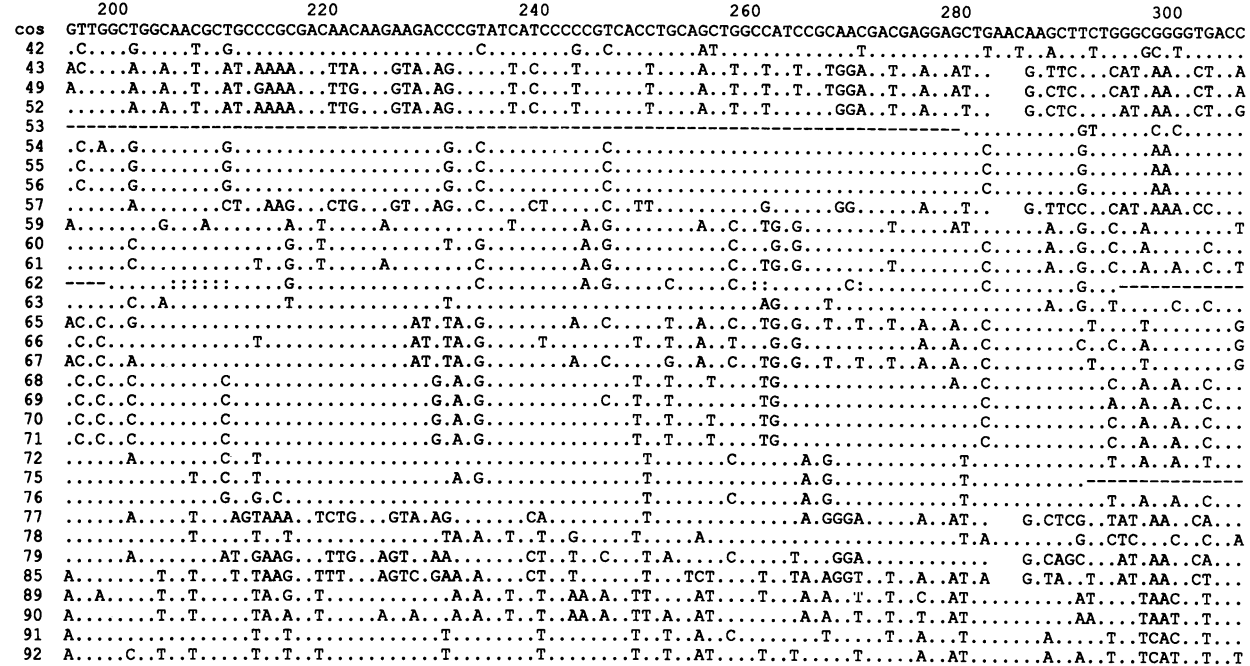


Figure 6. (cont.)

```
          320                 340                 360                 380
cos  ATCGCTCAGGGTGGTGTTCTGCCCAACATCCAGGCCGTGCTGCTGCCCAAGAAGACCGACAAGACCACCAAGGCCAAGGGCAAG
 42  .....G........C...T....T..T..T.....G...........T.....A..T..G.GCCATCAT..............
 43  ..T...GGT........CA.T..AC.......CAAATCT...A.TGGG.....AGGAC.AC...AG..TGTC
 49  ..T...GGT........CA.T..AC.......CAAATCT...A.TGGA.....AGGAC.AC...AG..TGTC
 50  ..T...GGT........CA.C..AC.......CAAATCA...A.TGGG.....AGGAC.AC...AG..TGTC
 53  .....G.....C..C..C.....................................G.GCCA.CAT...C......CA...
 54  .....G.....C..G..G.....................................GCCA.   ..........C....
 55  .....G..........G.....................................GCCA.   ..........CT...
 56  .....G.....C..G..G.....................................GCCA.   ..........CT...
 57  ..A..GGG...A..C..CA.C...C.......CAAGTCT...A.CGGG......GG.C.GC...AA...GC.
 59  ..............A..C..............T.....................A.....G.GTT.T.AATCCA.A...A.....
 60  .....C.....C.....C..............T.T........C........A.....G.GCG...AATCT......A.....
 61  ...........C..G..............T...TT.................A.....G.GCT...AGTC.......A.....
 63  ................................A........C...........T..G...G..GT..........
 65  ........A.....................A...........C........A....TT..AT.A.G.
 66  .....C..A........C.............A...........T.........GGT.TA..AT.G..G
 67  ........A.....................A...........T........A..T.CT..AT.A.G.
 68  ................C..C............A.T..C..C..C.............G....T.TG.A
 69  ................C..C.............T..C..C..C...........G----------
 70  ................C..C.............T..C..C..C.............C....G..T....A
 71  ................C..C.............T..C..T..C.............G....T.TG.A
 72  .....C..........C..C..A............C..T..C...........T.G.TCA.AGT..TCCAAG
 76  .....C..A........C..C.............T..T..T.....T........A.CT..AT.AT.....
 77  ......GGT........CA.C..TC.......CAAGAGTT..A.CGGA......GGATCAC...AGG.A.CA
 78  ..T..A..A.....C..GT....T..T..A.....T..T...T.............G...---------
 79  ......GGT..C.....CA.T..GC....A..CAAGTC....A.CGG.......GAG..A.C.GTGCAGG.TC.GC..C.G...GGCAACGTCATTCTGTCGCAGGCCTAC
 85  ..T...GGT........CA.T..TC.......TAAA.CT..CT..GGT...C.CT.TACT..A.A..GATCTAGTGCTAAG.CTGCTGAACCTCGT
 89  ..T..C..A.........T....A.....T..TCAAAACT..T....A......T.T.C....G.T........TTCTCAAG.ATTA
 90  .....C..A.........T....A.....T..CCAAAACT..T....A......T.T.C..C...TG.......TTCTCAAG.ACTG
 91  ..T.....A.........G.T...........C...CAT..TT.......A.CTT.T.GTGGC..TGGA...C.T.GTCAGG..CTG
 92  ..T..C..A.........G.A..T..T...A.C..TCAT..CT.......AC.AT.T.GT...GG..AGCCTAG.C.A.AGCTT
```

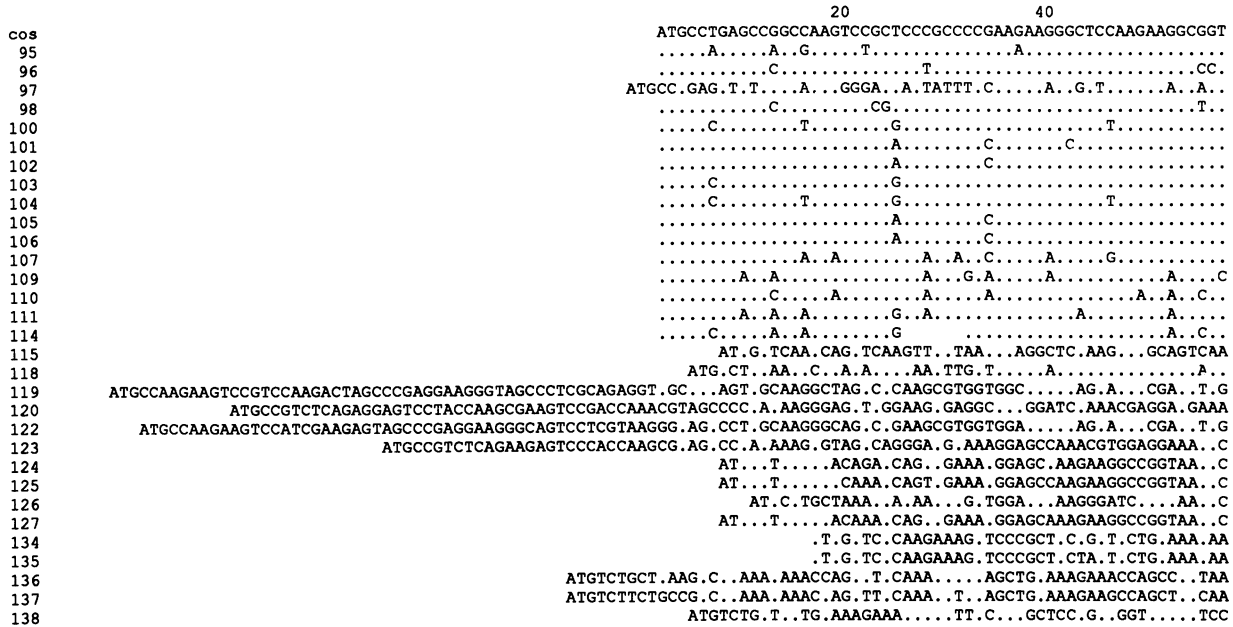


Figure 7. Histone H2B Coding Sequence alignments

Figure 7 (cont.)

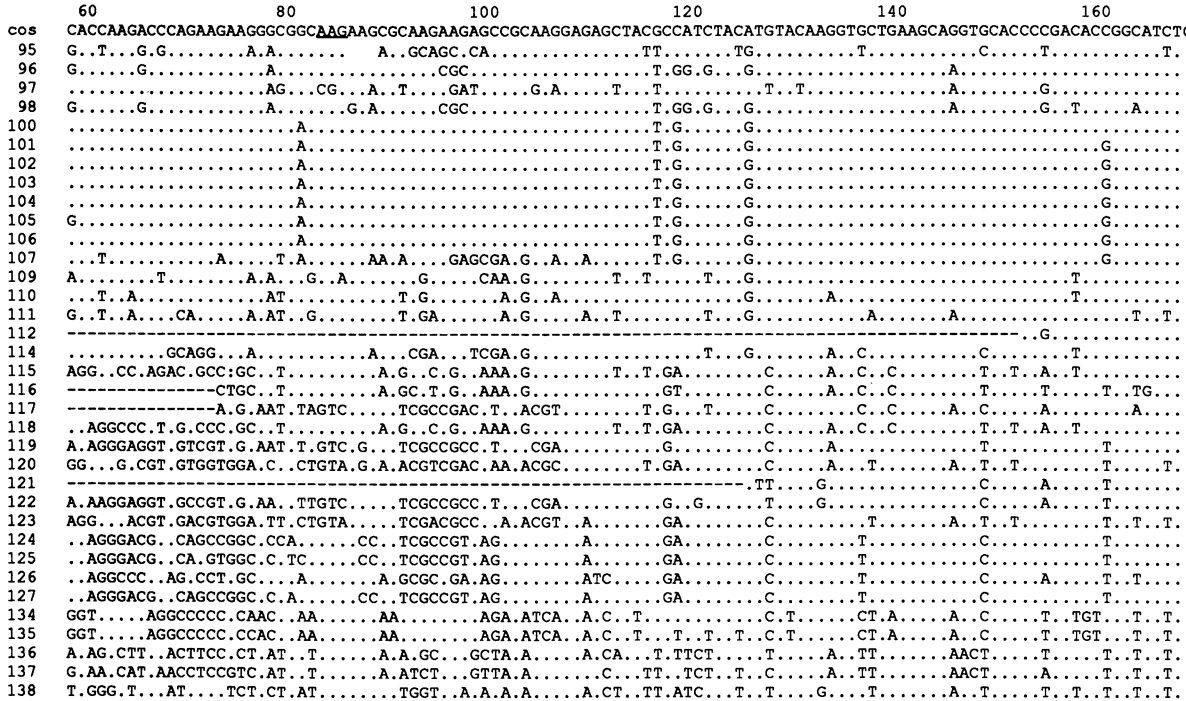


Figure 7 (cont.)

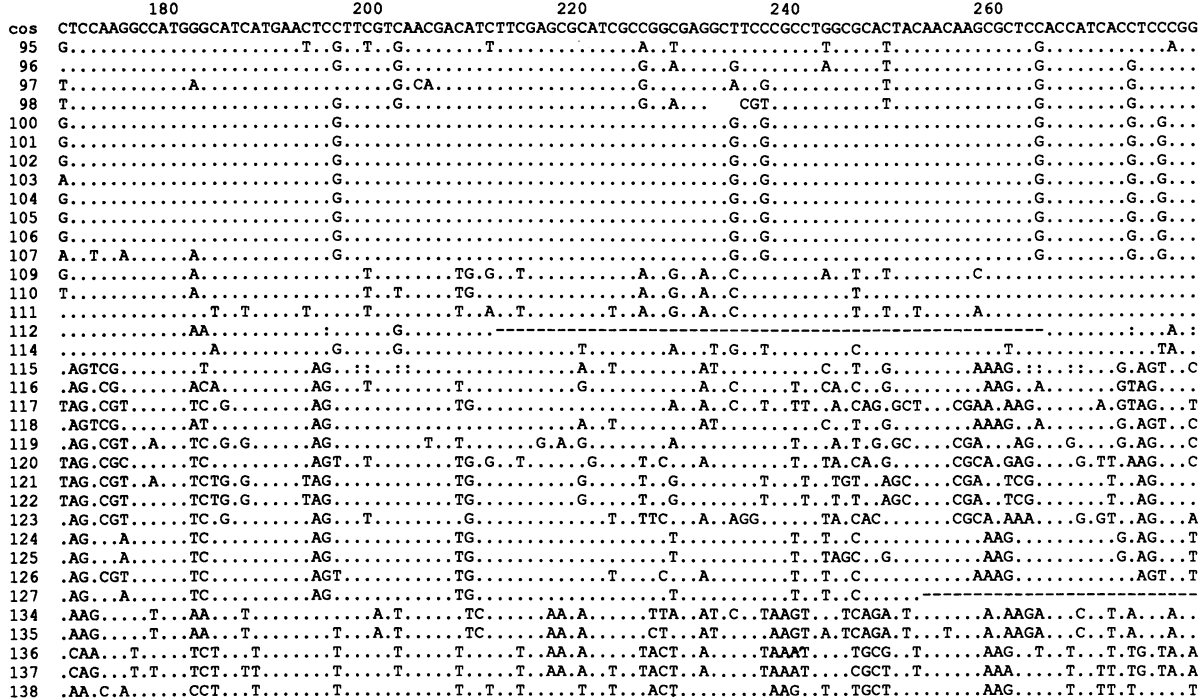
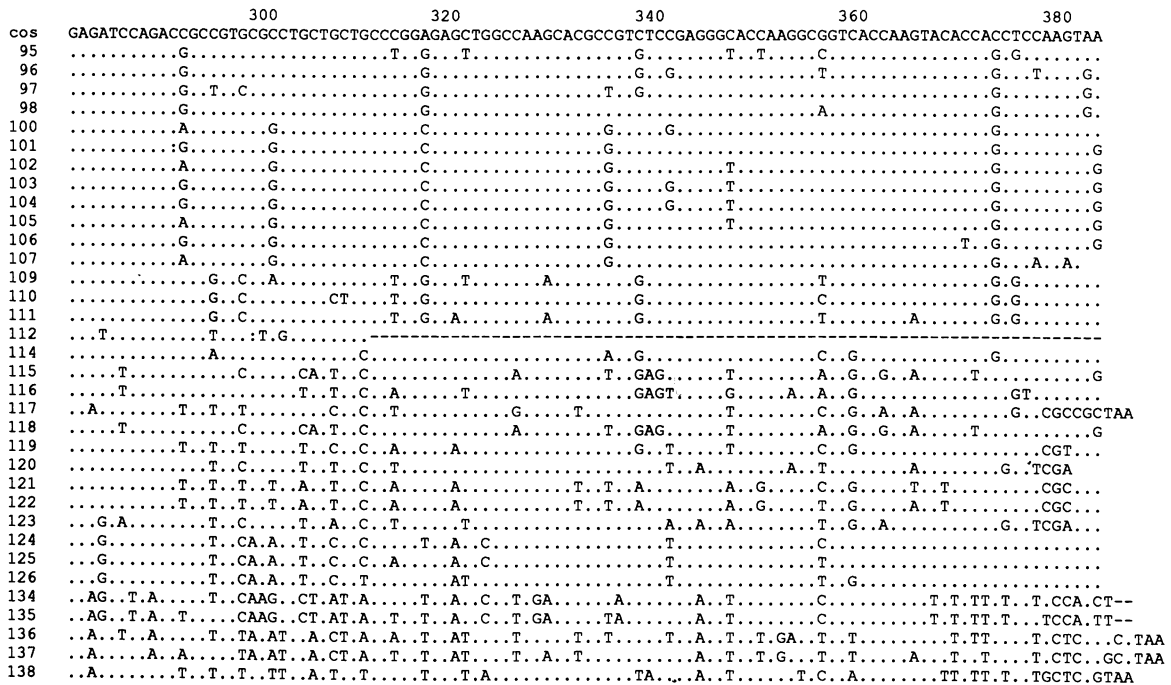


Figure 7 (cont.)



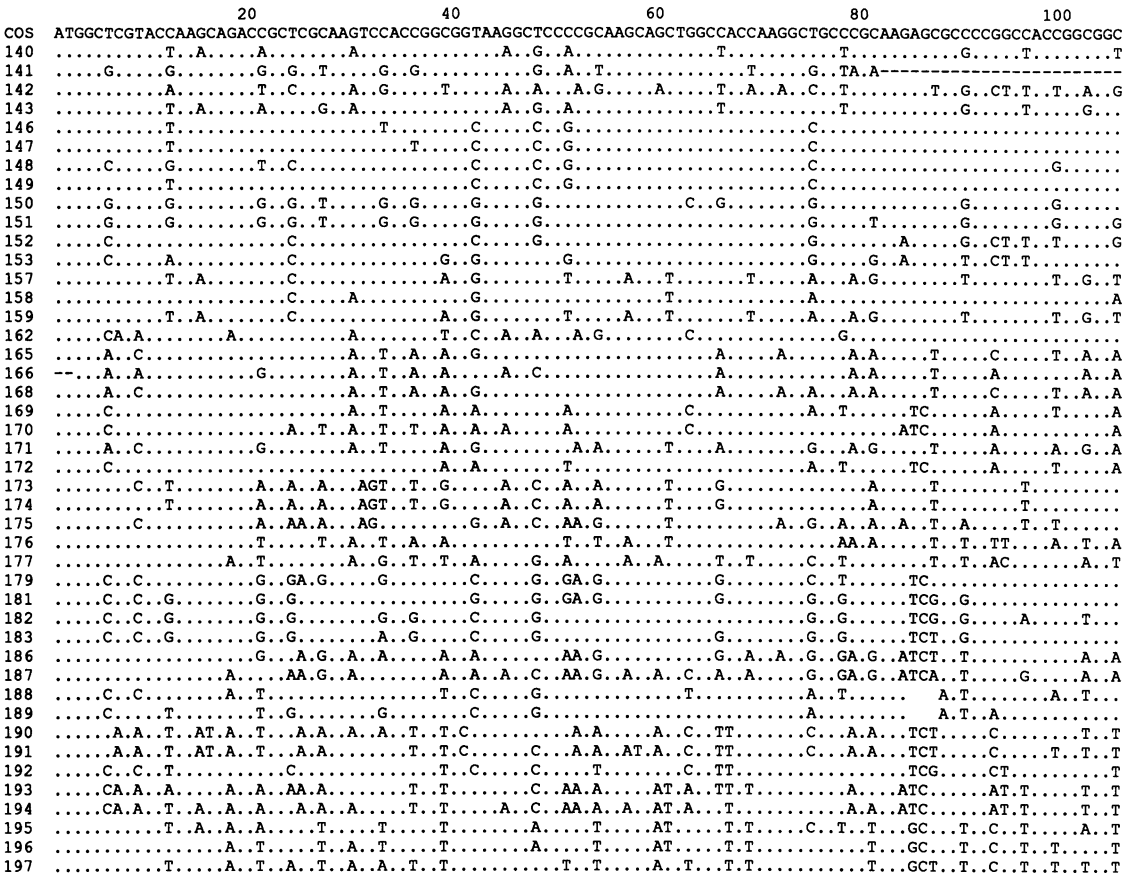


Figure 8. Histone H3 Coding Sequence Alignments.

Figure 8. (cont.)

```
                    120                 140                 160                 180                 200
COS      GTGAAGAAGCCTCACCGTTACAGGCCCGGCACCGTCGCTCTGCGTGAGATCCGTCGCTACCAGAAGTCCACCGAGCTGCTGATCCGCAAGCTGCCCTTCCAGCGC
140      .....A..............C.T..G..T..T..G................C........A....G.....T.......T..G.......G.........
142      ........A.....T..........T..T..T..G..G..C.....A..TA.A..T..T...........T..A..T.....T.....A..T..........T
143      ....................C.C..G.....T..G.......C.......C........A....G.....T.......T..G.......G.........
146      ................C...C.T.......T..G..A.....C.......G..............G........................G.........
147      ........A.......C...C.T..........G..G.....C.......G..............G........................G.........
148      ..........G.....C...C............G..G.....G.......G..............G........................G.........
149      ................C...C.T..........G..C.....C.......G..............G........................G.........
150      ..........G.....C...C.........G..G..G.....C.......G..................G.............................
151      ..........A.......TC.......T..G..G..G.....C..A....G..................G..A..............A..........A...
152      ..........G.....C...C....T..T..T..G..C..C.....A...A.G.....T........A.....A..TT.A...........T..........T
153      ..C.............C.......G..........G..C..........................G...............................G
157      ..C.......C..T......C.C..A..T..T........C..A..A.....A..T........A....T...........T......T....T.........
158      ..C.....A..C..T..C..TC.C..A.........G.....C..G..A..T..C..T........A..............C..T.....A.....T........T
159      ..C.......A..T......C.C..A..T..T........C..A..A.....A..T........A....T...........T......T....T.........
160      ------------------------------------------------------------------------.........T.....AT....T.........
161      ------...........C...C.T.:.........G.....C......:....C........:.:....:.T........C..-------------------
162      ...................................G.....TA.A..........T.............T................A.....T.........
165      ..C...........T..A........T.....A.....C...A.A.....T..C.............AG...T.....T..C.....A..A.....A.......T
166      ..A...........T..C.....A..T..T..A.....AT..A.A.....T................AG......A..T..T.....A.....A...........
167      ---------------------------------------..T..C.....A..A.....A........T---------------------------------
168      ..C...........T..A........T.....A.....C...A.A.....T..C.............AG......A..T..C.....A..A.....A.......T
169      ..C...........T...........T..A...........C.........................AG.........T..C...........C..........T
170      ..C.......C..T...............A...........C.........................AG.........T..C...........C..........T
171      ..T..A.....A..TA.G........T..A.......C...A.A.....T..C.............AG.........T.........A..A..C..A.......T
172      ..C.......C..T...............T...........C.........................AGT...........C...........C..........T
173      ........A..C...........A.....A..T..G..A.....G.....T..C..T........AAGT..A.........T.....A..A..C..G......A.A
174      ........A..C...........A.....A..T..G..A.....G.....T..C..T........AAGT..A.........T.....A.....C..G......A.A
175      ..C.....A..C.....G...C.A..G..A.....A.....C.........................AG............T...A.A...............A.A
176      ..C.......C..T...........A..A..A..T.....A.A..A...A.AA.A...............A..AT....C...A.G..A..C..A......A.A
177      ..........C.....C..TC.C..T..A.....G..CT.......A..T...........A...AG.........T..A...............T........T
179      ..........C.....C...C.C...........G..G..C..C........CAAG..........AG...G.......C...........C...........
181      ..........G.....C.T......G...........G..C............CAAG..........AG...G.......C...........C...........
182      ................C.T.C.C...............G..C..G.....T...AAG..........AG...G.......C.........................
183      ..........C.....C.T.C.C...............G..C..G.....T...AAG..........AG...G.......C.........T.............
186      ..........A...A.A.T...A.....A..T..T...T.AACA..A...A.GAAG.....C...AG...T.....T..T.....T..A..C..T......A.G
187      ..........A...ACA.T.C.T..T..A..T..T..C..AACA..A...A.GAAG..T......AG...T.....T..............T..G........T
188      ..........G.....C...C....T.....T..G.....C..C.....T...AAG..........AGT..T.........T..T........T..T.......G
189      ..C.......C..T..C..TC.C........G...........A........CAAG..........AG...G.......C...........C...........G
190      A.T.......C...A.A.T...A..T..T........CT..A.A..A...A.AAAG...T.A.........T..TT.A..T...A.A.....C....C...AA.A
191      A.C.......C...A.A.T...A..T..T...........CA.A..A...A.AAAG.....A.........T..TT..T.....-------------------
192      ..C.......C.........A.....T..........C........T.....................T.....T..............C..........T
193      ..T...........A.A..T.A...A..T.....T...T..A.A..A...A.AA.A.T...A..A..T..T..A...T.....A.A...T....T.....AA.A
194      ..T...........A.A..T.A...A..T..T..T..CT..A.A..A..TA.AA.A.T...A..A..T..T..A...T.....A.A...T.A..T.....AA.A
195      ..T...........T.....TC.T..T..T..T.........T........T.....T..T..A.....T..T..A..TT.A..T..T.....A..T.....A..T
196      ..............T.....TC.T..T..T..T.........T.....A........T.....A.....T..T..AT..T.....T.....A..T........A..T
197      ..T...........T.....TC.T.....T..A.........T.....A..T.....T..T..A.....T..T..A..TT....T..T.....A..T.....A...
```

Figure 8. (cont.)

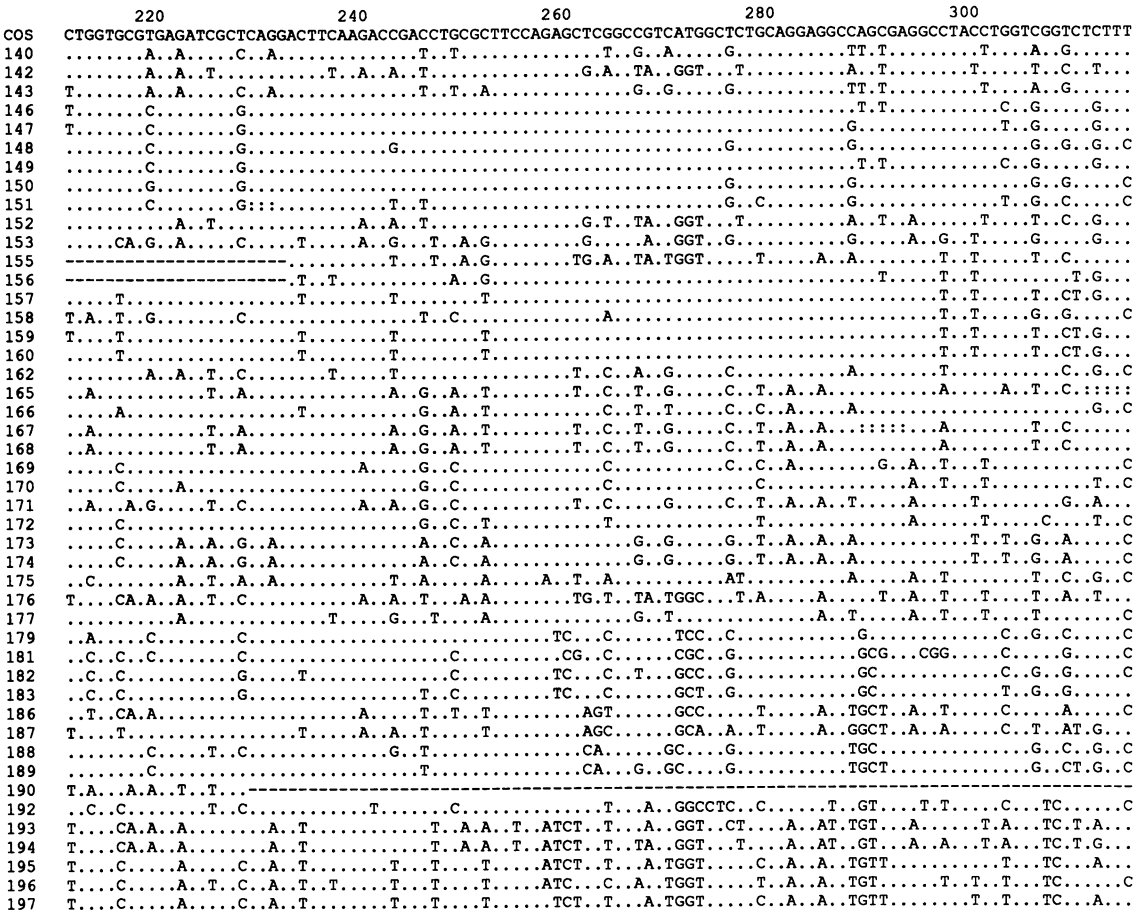
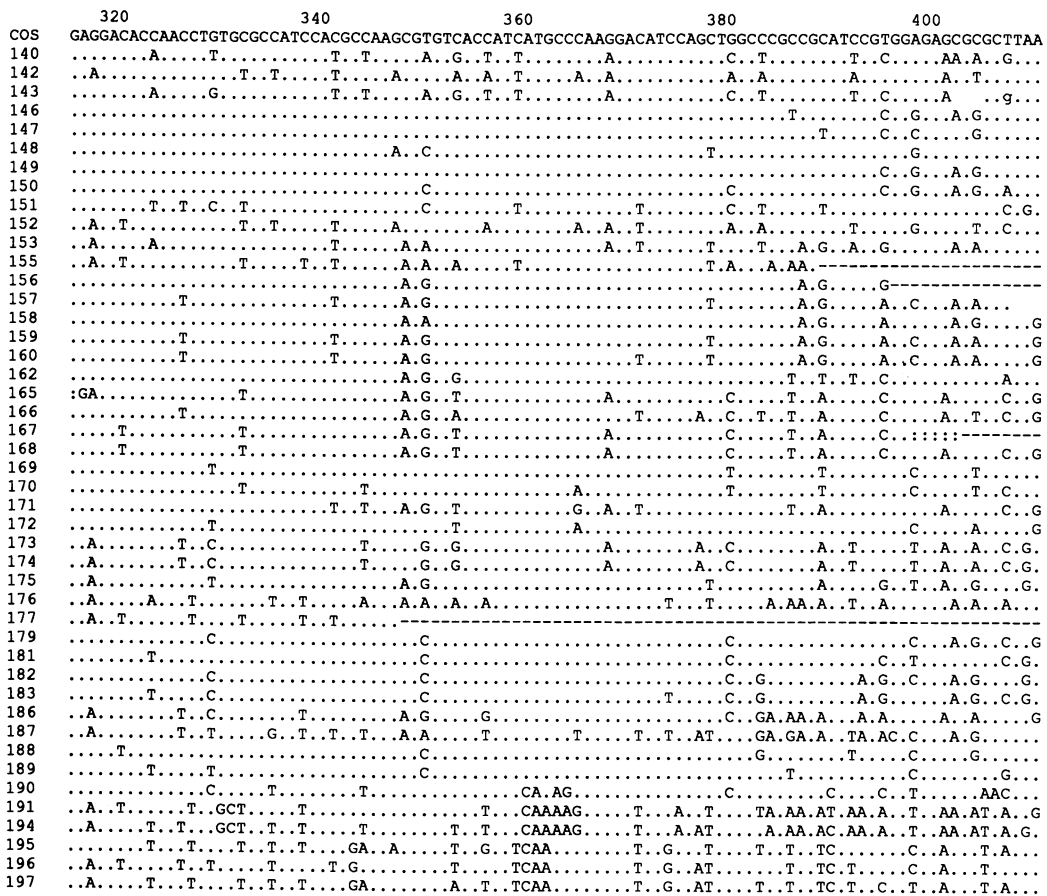


Figure 8. (cont.)



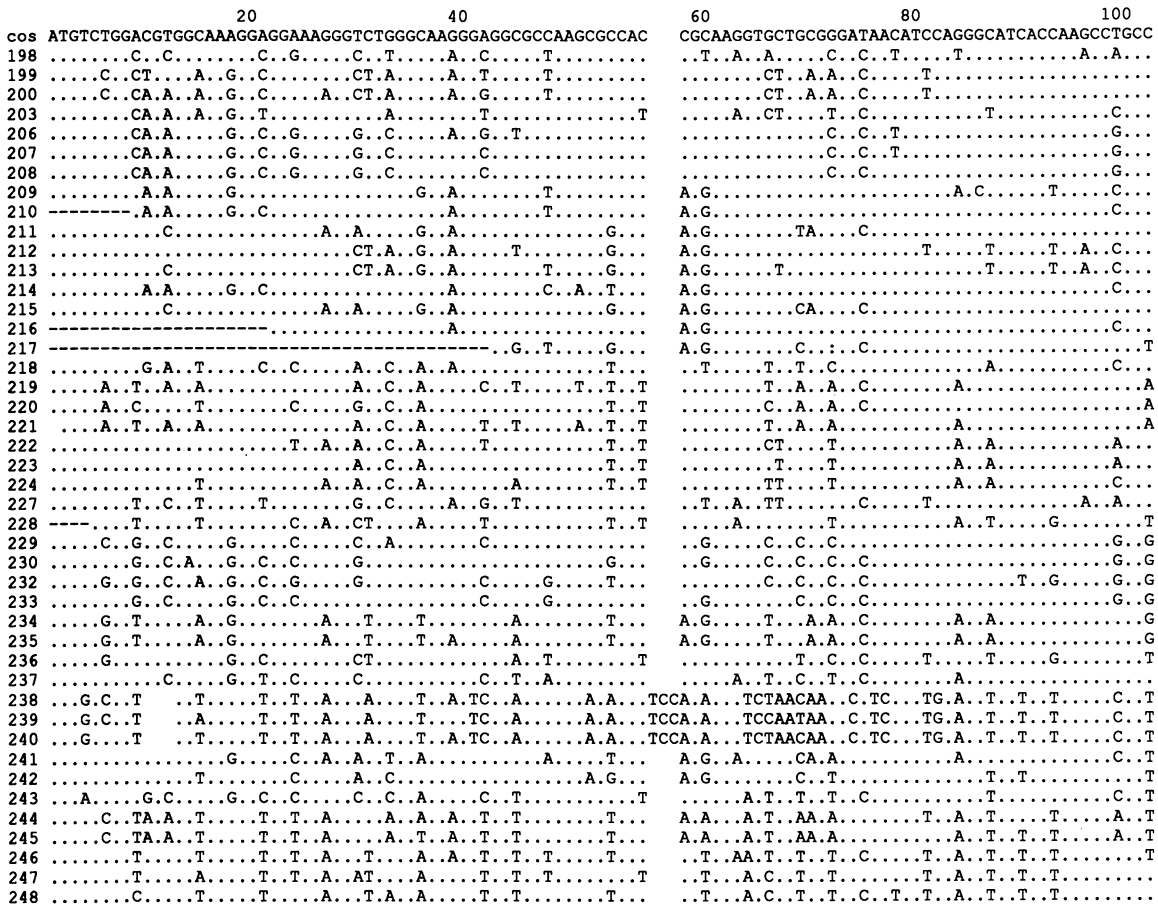


Figure 9. H4 Coding Sequence Alignments

Figure 9. (cont.)

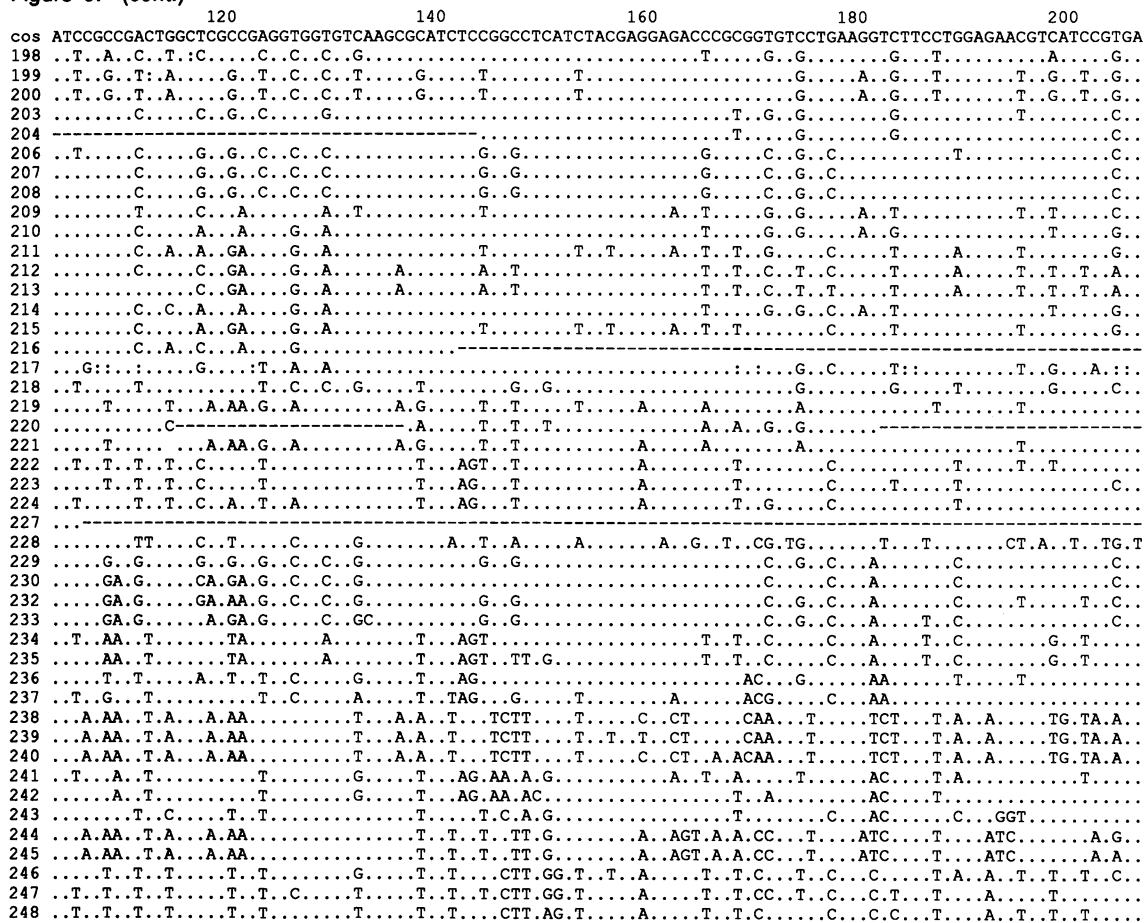
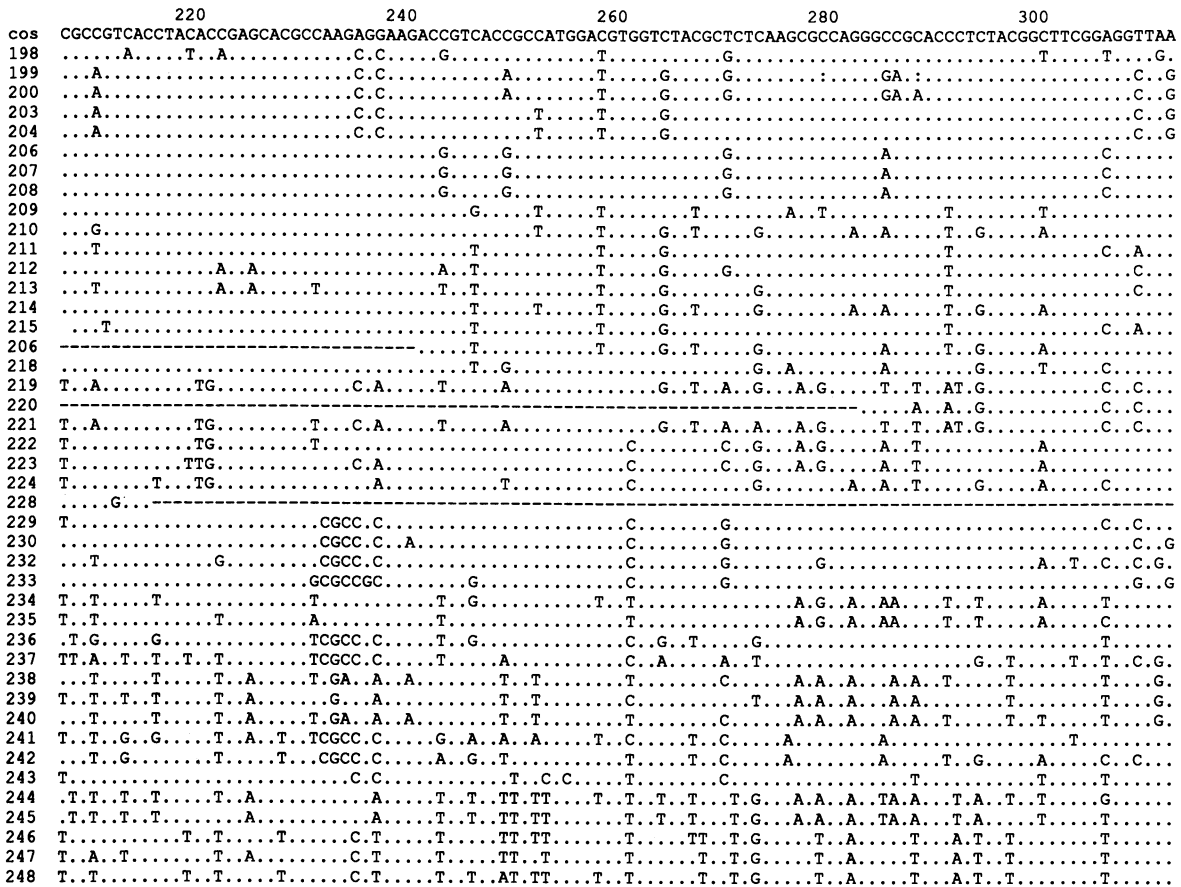


Figure 9. (cont.)



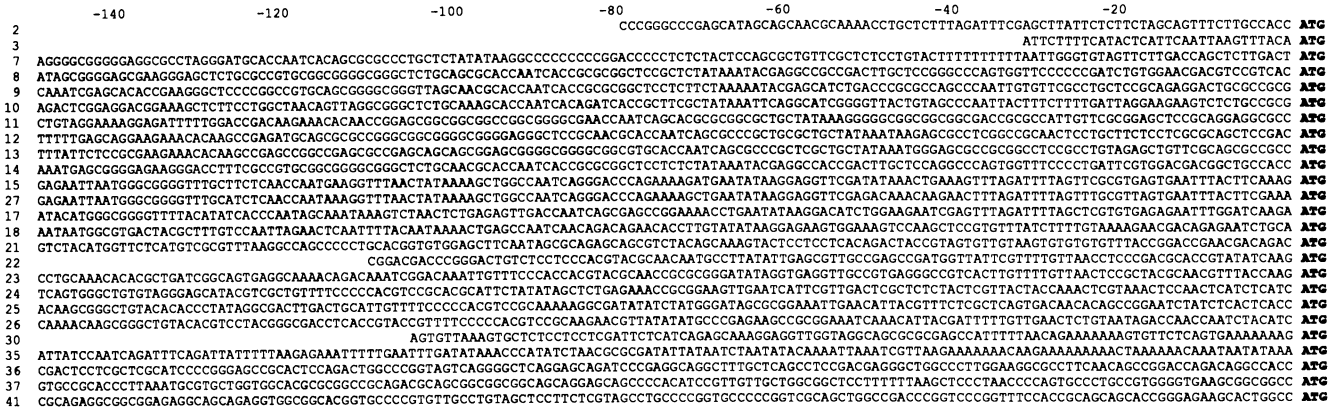


Figure 10A. Histone H1 5' Upstream Alignments

Figure 10B. Histone H1 3' Downstream Alignments

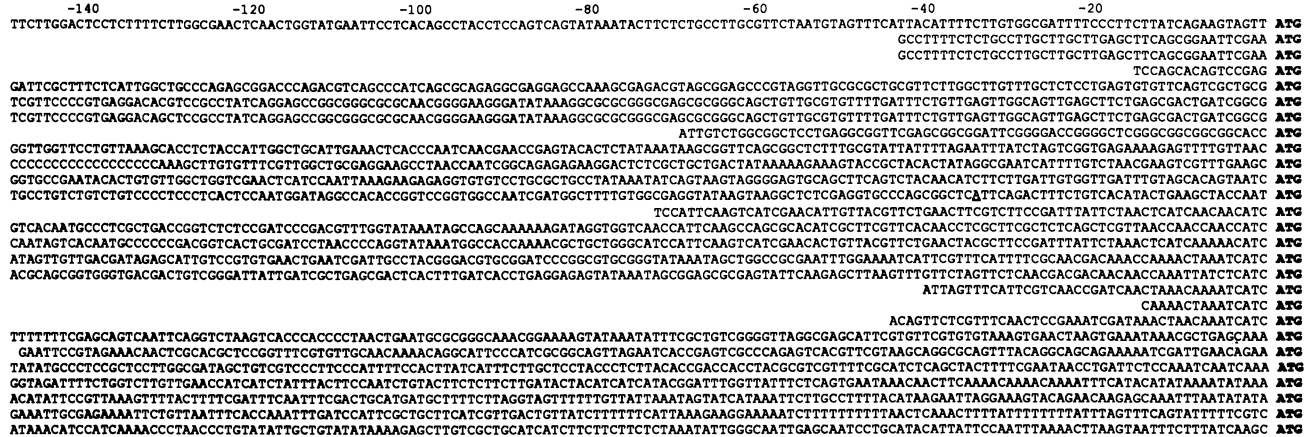


Figure 11A. H2A 5' Upstream Sequences

Figure 11B. H2A 3' Downstream Sequences

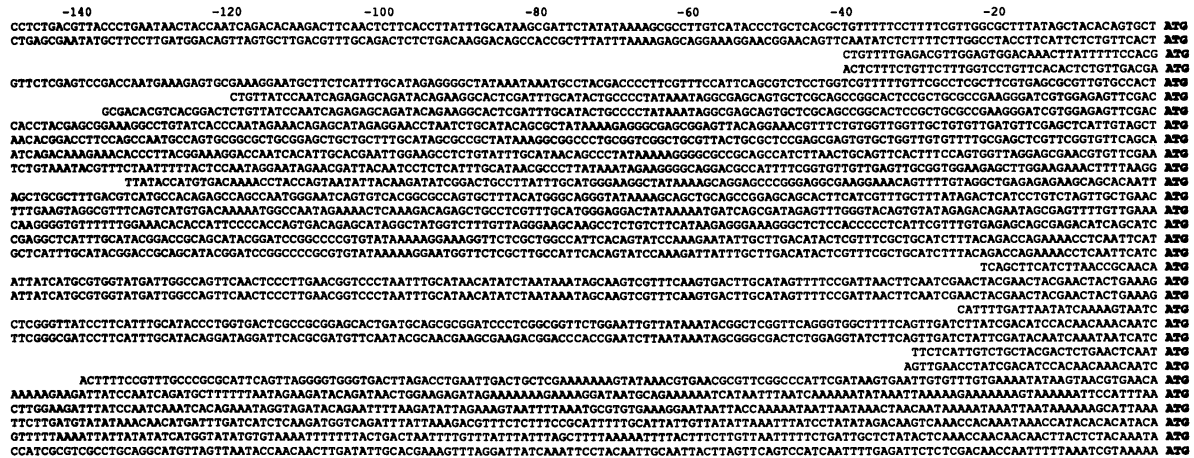


Figure 12A. Histone H2B 5' Upstream Sequences

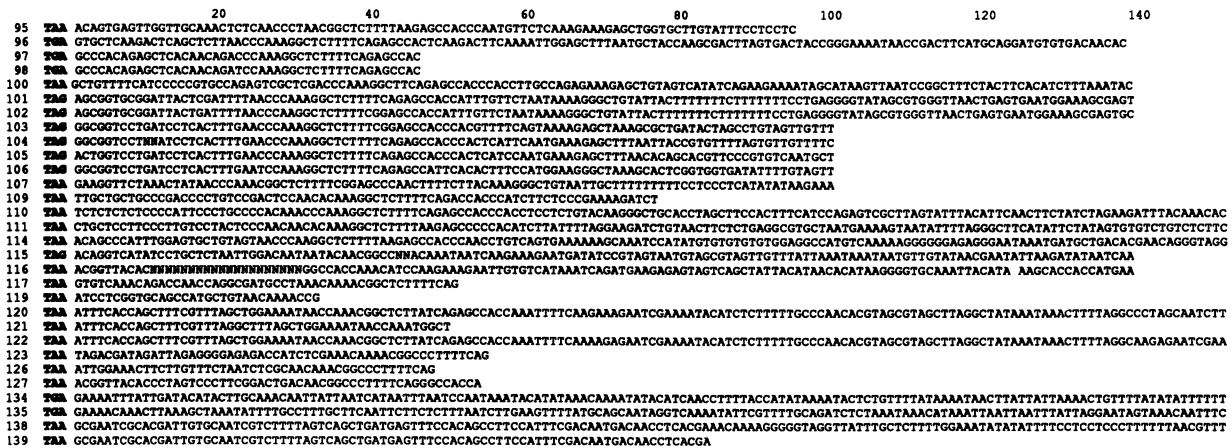


Figure 12B. Histone H2B 3' Downstream Sequences

Figure 13A. Histone H3 5' Upstream Sequences

Figure 13B. Histone H3 3' Downstream Sequences

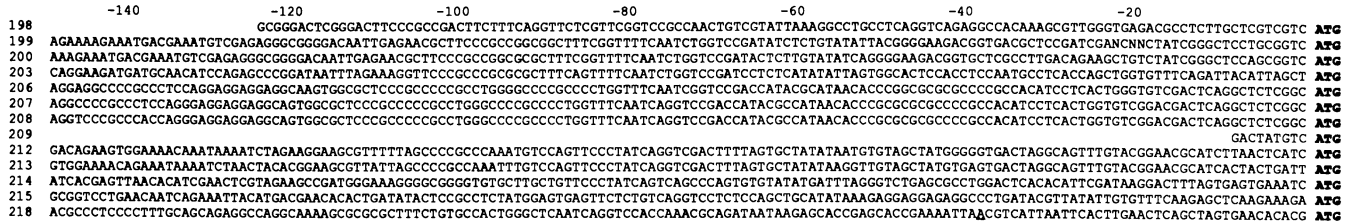


Figure 14A. Histone H4 5' Upstream Sequences

```
                                  20                  40                  60                  80                 100                 120                 140
198 TGA GCGTCCTCTCTACCAATAAGAGGCCTTTTCAGGGCCCCTACTTCCTCAGCTGAAGGTGGTAACACTGGGAGGTGTTTTGGTAGGTACGGAATTTTGCTTGGTTCTGAGTCAGTTCTGGGGGGAACAGTTTTTTGAACAC
199 TAG GCCGCCGCTCCAGCTTTGCACGTTTCGATCCCAAAGGCCCTTTTTGGGCCGACCACTTGCTCATCCTGAGGAGTTGGACACTTGACTGCGTAAAGTGCAACAGTAACGATGTTGGAAGGTAACTTTGG
200 TAG GCGCCGCTCCAGCTTTGCACGTTTCGATCCCAAAGGCCCTTTTTGGGCCGACCACTTGCTCATCCTGAGGAGTTGGACACTTGACTGCGTAAAGTGCAACAGTAACGATGTTGGAAGGTAACTTTGGCAGTGGGGCGACAATCGGATC
203 TAG ACGCCGCCGCTTCAATCCCCCCCCCCCCCCCATCCCTAACGGCCCTTTTTAGGGCCAACCACAGTCTCTTCAGGAGAGCTGACACTGACTTGGGTCGTACAGGTAATAACCGCGGGTTTAGGACTCACGCTACTAGGTGT
204 TAG ACGCCGCCGCTTCAATTCCCCCCCCCCCCCCCATCCCTAACGGCCCTTTTTAGGGCCAACCACAGTCTCTTCAGGAGAGCTGACACTGACTTGGGTCGTACAGGTAATAACCGCGGGTTTAGACTCGGTAAGGTAAAGACGCTAGTTTTCC
206 TAA ACTCGTCTCCGATTCCGGCCACCCGAACTCGTTTTTAGCAACCCAAAGGCTCTTTTCAGAGCCGCCCACTTGGTCCAACAAAGAGCATGAATT
207 TAA ACTCGTCTCCGATTCCGGCCACCCGAACTCGTTTTTAGCAACCCAAAGGCTCTTTTCAGAGCCGCCCACTTGGTTCCAACAAAGAGCTGTGTCACCTCGCCTGATGTGACGGGGCTTTTCACTTAATAGTTAGGCTCTTTTATCTCCCC
208 TAA ACTCGTCTCCGATTCCGGCCACCCGAACTCGTCTTTTAGCAACCCAAAGGCTCTTTTCAGAGCCGCCCACTTGGTTCCAACAAAGAGCTGTGTCACCTCGCCTGATGTGACGGGGCTTTTCTTTTACTTAATAGTTAGGCTCTTTTATCTC
209 TAA GCCATCGCTCCTCTTTTCCTATCACAACGGCCCTTTTAAGGGCCACA
210 TAA AGGCTCGCTTCTGTTTCCTCATCAAAACGGCCCTTTTAAGGGCCACCA
211 TAA ATCTCTTCCTTCCCACTAATCTTATACCCAAGGCTCTTTTCAGAGCCCCCCAGCTCTCACTCCTAGAGCTGTTACTGCTTTTTTTACATATTTAT
212 TAA ATGTTCTACTGCCCATTAATCTTATACTCAAAGGCTCTTTTCAGAGCCACCCACCCACTCATATTAAGAATTGTGATATTTTGAACGAGGTATCTTCTAGATTTTTATTTAATGCTTTATGTGCCCAAGTGTTATTGTAGTTGCTGCACT
213 TAA ATCTTCTACTGCCCATTAATCTTATACCCAAAGGCTCTTTTCAGAGCCACCCACCCACTCATATCAAGAGATTGTGATATTTTGAATGAGAGATTATTTTCTGTGTTTTCATTAACTGCTTTATGGTGATTGTTATATTGTATTTGCTTC
214 TAA GGCTCGCTAAGGTTTTTTATATTTTTCCCCTCATCAAAATAACGGCCCTTTTAAGGGCCACCCACCTATTCCTTCAAAAGGCTGCATCCGTCTATTTAGATCTATTGTTTGAAGTTGTATACCGTAATATCGAAATCTTTCTTATTAACC
215 TAA ATCTCTTCCTTCCCACTAATCTTATACCCAAAGGCTCTTTTCAGAGCCCCCCACACTCTCACTCCTAGAGCTGTTACTGCTTTTTTTACATATTTA
216 TAA AGGCTCGCTTCGGTTTTTTCTGTTTTTTGCCCCCCCACAATCAAGATAAGCCCTTTTAAGGGCCACAA
218 TAA ACGCACTCTTCTCGGAACGTCAACATCCCGACTTGAACCCAAAGGCTCTTTTAAGAGCCACCCACATCCGCTTCAAAAGGGTCAAATCCATTATCGTAGGAAACCATGAGCCACTCTTGAGTGGACAGGGAGGGAGTAT
220 TAA GTGAAGCAGACTTGGCTAGAATAACG
221 TAA GTGTAGCAGACCTGCTAGAATAACAAACGGCTCTTTTCAGAGCCACCAAATAATCAAGAAAGAATACTGTTGTATGTTATGTTACTACCGTAAAGAAAGTAAAGAAAGAAGAAGAAGAA
222 TAA GAAGTTCATCTCTTCAAACCCATCAACAAACCGGCTCTTTTCAGAGCCACCAAATATTCAAGAAAGAAACAATTTGAATGTCTCTTATTTATGTGTTATAATTTATGTAC
223 TAA GAAGTTACTTCTAACCAACGGCTAAACGGCTCTTTTTAGAACCACCAAATACTCAAAGAAAGAATCAATGGTTATTTCTCTGTCATCAATGATAATTTTTTTTGTGTTATTCAAGTCAAATCCCCTTTCCAAAAGAAAA
224 TAA GAAGGAAATACCTCTTAACTCGGCATATCAAACGGCTCTTTTTAGAGCCACCAAATATCCAAGAAAGAATCAATAAGAATCTCTAACTAAGTTTGACAGCACATGATCTAGAGTCTAGTATAAATGAAGTGTGTGTGGTGACCGAAGAAT
225 TGA AAACAACGGCTCTTTTCAGAGCCACCACAAGTTCAAAAAAGAGATAAACAACTTGTCTATTCGTTTCCTACACTCCTATCTTCCTTTTGTTGTCCTATATTTCTGTTTAAATTACGTTTAAATACAAAGTACATAAAGTCTAAAACACTA
226 TAG ACAGAAATCCAAGCATCAACCAAAACGGCTCTATTCAGAGCCACCACAATTTCACAAAAGAGATCAATTCCTATCAAGTACCGTTTGCTCCTACGAACTGGACTCATTATTACAAACTCAAACACTTTTTTTACAAACTCAAACACTTTT
229 TAA GGGCCGGCCGGCCGACGGGAGTCACTCTTTGTCGCCGCCTGCAGATTCCAGAAGCCTGATGAAGCCCCGACTTGTTTAGTTCGCTATTTCCTCTGTAGTTTGAACTCAATCCGTGGAACAAAGTTATTCGCAATATATT
230 TAG ATTTGTGTGGTGAAGCAACTTCCTCGTTTGCTCTGTGATCTGTGCTGTCGTAGATGAGATTTACTGATTTGGCGTGCGCCGGTTGTATTCTGTCATGGGGTTCAGTGGGCTGTGTAATACCTTGCTCTGTACTTCTGTTCAATGCAATCA
232 TGA GGGTCAGGGGTGTCCGCCAGCTGCTGCTGGTCGTGGCAGAAGTCTTGGGTCGCGGTCACGAAATGGAGTGATTCGAGAGTATTCTTGCCCATGGGCTAGTTTCGTAGGCTTATCACTCTAGACTCTAGTGCCTTGGTCCAGTAGTAGCA
233 TAG GCTAGGCGCCTCTTCATAGTCGGGGACTGGTTAGGGGACATGTCTCTTTGTGATGCTTTCTGTGGTAGTATTGCTGCAATAGCTGTGTAATCCATCCCTTCTGCAATGAAGCTATGTTGTGTCTGTGGGTGATTGTATTTCATGGTAGTA
234 TAA TTAGAGTTTTTCAGATCCGCGTTTGTGTTTTCTGGGTTTCTCACTTAAGCGTCTGCGTTTTACTTTTGTATTGGGTTTGGCGTTTAGTAGTTTGCGGTAGGTTCTTGTTATGTGTAATTACGCTTTTTCATCATGCTTCAGCAGTTTCGG
235 TAA GAAGGTTTTTCATATCCGCGTTTGTTTGTTTTTTCTGGATTTCTTACTTAGGCGTATTATTCTGGGATTTTCTAATCAAATCATGTTATCCTTAGCGTCTGCGTTTTACATTTGTATTGGGTTTGCGCTTCAGTTTGCGGTAGCGTTCT
236 TAA GCTGGAGGTGGCGTCGATGGGTTCTGCAAGCCCACCATAAAACCCGGTGTTTTTAAACACCACCAACGTTCATTCAAATTCATTTCTTTTCCGCTGCTCCTGCGTTTTTTTATTTTTCGCCATTGCTTCTGCGAAGTGAAGTGCTAGCAA
237 TAA TCGTCATAACGACTTCATTATCTTCAACTATCCGGTGTTTCTTAACACCACCATCCTTGGATGTAGCGTAC
238 TGA ACAAAATATTTATCTTAAAAAATTAAAAAGTAAAAAGCTGCATGCTTACTCAAAGGTAATAGTGTAATTATCTAGTTCTTTTATCTGAGAGAGTATGCTTTTTTCTATCGAGTGTTAGTGTAGCAATTTTCTAAAGTGCATTGAGAGATT
239 TGA AAAACTTAAACTAACAAATAATAATCCAAAATACTCAAATACAAATATACTCATATATAAAAACAATTTAATTTATATATAAATTTTTTAGTGTCTGTGTATAAATTACATTCATTAACTATTGTACATCGAGTTTAAAGTGTTTCACTATT
240 TGA ACAAAATATTTATCTTAAAAAATTAAAAAGTAAAAAGCTGCATGCTTACTCAAAGGTAATAGTGTAATTATCTAGTTCTTTTATCTGAGAGAGTATGCTTTTTTCTATCGAGTGTTAGTGTAGCAATTTTCTAAAGTGC
241 TAA GTTTCTTGAT
242 TAA TTACCTTTGC
243 TAA ATGTCTCGCCGTCATTAGCAGCAGCGTGTCTTTTTTCTTTTTTCTTCACCATAACGACGACGAATAATCAGTTTC
244 TAA ACAATCGGTGTTTGAAATTATTTTCATGCCTTTCAAAAAATAAAATAACGATCATTCTATTGGGAATATAATAGAACCTTTATGTATGCATTTTTCGGTTTTTTATTATTATTTCATGTACTATATATATTAAA
245 TAA TTTAGCTAATTCTAAGAAAACGGTTTCAACAAGCAAATATTTGGGATTCGTATTCAACTGCCCGGTTTTTCTTCTACAAATATTGAGTGTATTATAGCGGGTTTAGGAGAAATATGTACAATTATAAACATATAAAGGG
246 TAA ACTCCTATTACATTGATTTTTTTCTCCTTGTTTGTATACTTTATTATTTACCACTTAATTCCTTTTTTACCCCTG
247 TAA ACTGGTTGCACACTTTTCGA
248 TAA ATTCGATATCAATTGCCGACTCCGAATTTTTTGTTTCGAGTCTATCAATTTTATGTGTACACTATAACTATTCTATATATACATGCCAAACGAGA
```

Figure 14B. Histone H4 3' Downstream sequences

ACKNOWLEDGEMENTS

We would like to thank Doris Brown for her helpful discussions and editoral persistence regarding this compilation. In addition, we are indebted to Carolyn Barker, Bao Anh Nguyen and Truc Nguyen for their assistance in collecting and entering of new sequences. This effort was supported in part by Grant GM38623 to DW from the National Institute of Health.

REFERENCES

1. Affolter, M., Berneir,D. and Ruiz-Carillo, A. (1986) Cancer Research Center, Quebec, Canada (unpublished).
2. Affolter, M. and Ruiz-Carillo, A. (1986) J. Biol. Chem. 261, 11496-11502.
3. Bains, W. (1986) Nucl. Acids Res. 14, 159-177 .
4. Bannon,G.A., Bowen,J.K., Yao,M.C. and Gorovsky, M.A. (1984) Nucl. Acids Res. 12, 1961-1975.
5. Birnstiel, M.L., Portmann, R., Busslinger, M., Schaffner, W., Probst, E. and Kressman, A. (1978). In "Specific Eukaryotic Genes", Proc. Alfred Benzon Symposium (Engberg, J., Klenow, H. and Lieck, V., eds.). Munksgaard, Copenhagen, 13, 117-129.
6. Brandt, W.F., Strickland, W.N. and Von Holt, C. (1974) FEBS Lett. 40,349-352.
7. Brandt,W.F. and VanHolt,C. (1986a) FEBS Lett. 194, 282-286.
8. Brandt,W.F. and VanHolt,C. (1986b) FEBS Lett. 194, 278-281.
9. Busslinger, M., Portmann, R. and Birnstiel, M.L. (1979). Nucl. Acids Res. 6, 2997-3008.
10. Busslinger, M., Portmann, R., Irminger, J.C. and Birnstiel, M.L. (1980) Nucl. Acids Res. 8, 957-977.
11. Busslinger, M. and Barberis, A. (1985) Proc. Natl. Acad. Sci. USA 82,5676-5680.
12. Carozzi, N., Marashi, F., Plumb, M., Zimmerman, S., Zimmerman, A., Coles,L.S., Wells, J.R.E., Stein, G. and Stein, J. (1984) Science 224,1115-1117.
13. Chaboute, M.E., Chaubet, N., Phillips, G. and Ehling, M. (1987) Plant Mol. Biol. 8, 179-191.
14. Chaubet,N., Phillips, G., Chaboute,M.E., Ehling,M. and Gigot,C. (1986) Plant Mol. Biol. 6, 253-263.
15. Childs, G., Nocente-McGrath, C., Lieber, T., Holt, C. and Knowles, J.A. (1982) Cell 31, 383-393.
16. Choe, J., Kolodrubetz, D. and Grunstein, M. (1982) Proc. Nat. Acad. Sci. USA 79, 1484-1487.
17. Choe, J., Schuster, T. and Grunstein, M. (1985) Mol. Cell. Biol. 11, 3261-3269.
18. Chojecki, J. (1986) Carlsberg Res. Commun. 51, 211-217.
19. Clark, S.J., Krieg, P.A. and Wells, J.R.E. (1981) Nucl. Acid Res. 9, 1583-1590.
20. Clerc, R.G., Bucher, P., Strub, K. and Birnstiel, M.L.(1983) Nucl. Acid Res. 11, 8641-8657.
21. Cole, K.D., Kandala, J.C. and Kistler, W.S. (1986) J. Biol. Chem. 261, 7178-7183.
22. Cole, K.D., York, R.G. and Kistler,W.S. (1984) J. Biol. Chem. 259,13695-13702.
23. Coles, L.S. and Wells, J.R.E. (1985) Nucl. Acids Res. 13, 585-594.
24. Coles, L.S., Robins, A.J., Madley, L.K. and Wells, J.R.E. (1987) J. Biol.Chem. 262, 9656-9663.
25. Conner, W., Mezquita, J., Winkfein, R.J., States, J.C. Dixon, G.H. (1984) J. Mol. Evol. 20, 227-235.
26. Cool, D., Banfield, D., Honda, B.M. and Smith, M.J. (1988) J. Mol. Evol. 27, 36-44.
27. D'Andrea, R., Harvey, R. and Wells, J.R.E. (1981) Nucl. Acids Res. 9, 3119-3128.
28. DeLange, R.J., Fambrough, D.M., Smith, E.L. and Bonner, J. (1969) J. Biol. Chem. 244, 5669-5679
29. DeLange, R.J., Hooper, J.A., and Smith, E.L. (1973) J. Biol. Chem. 248, 3261-3274.
30. Dodgson,J., Yamamoto,M. and Engel,J.D., (1987) Nuc. Acids Res. 15, 6294-6294.
32. Doenecke, D. and Tonjes, R. (1984) J. Mol. Biol. 178, 121-135.
33. Doenecke, D. and Tonjes, R. (1986) J. Mol. Biol. 187, 461-464.
34. Engel, J.D., Sugarman, B.J. and Dodgson, J.B. (1982) Nature 297, 434-436.
35. Ernst, S.G., Miller, H., Brenner, C.A., Nocente-Mcgrath, C., Francis, S. and McIsaac, R. (1987) Nucl. Acid Res. 11, 4629-4643.
36. Fusauchi, Y. and Iwai, K. (1983) J. Biochem. 93, 1487-1497.
37. Goldberg, M.L. (1979) Ph.D. Thesis, Stanford Univ.
38. Grandy, D.K. and Dodgson, J.B. (1987) Nuc. Acids Res.153, 1063-1080.
39. Grandy, D.K., Engel, J.D. and Dodgson, J.B. (1982) J. Biol. Chem. 257, 8577-8580.
40. Grunstein, M., Diamond, K.E., Knoppel, E. and Grunstein, J.E. (1981) Biochem. 20, 1216-1223.
41. Harvey, R.P., Robins, A.J. and Wells, J.R.E. (1982) Nucl. Acid Res. 10, 7851-7863.
42. Harvey, R.P., Whiting, J.A., Coles, L.S., Krieg, P.A. and Wells, J.R.E. (1983) Proc. Nat. Acad. Sci. USA 80, 2819-2823.
43. Hatch, C.L. and Bonner, W.M. (1988) Nucl. Acid Res. 3, 1113-1124.
44. Hayashi,T., Ohe,Y., Hayashi,H. and Iwai,K., (1980) J. Biochem. 88, 27-34.
45. Heintz, N., Zernik, M. and Roeder, R.G. (1981) Cell 24, 661-668.

46. Hentschel, C.C. and Birstiel, M.L. (1981) Cell 25, 301-313.
47. Hooper, J.A., Smith, E.L., Sommer, K.R. and Chalkley, R. (1973) J. Biol.Chem. 248, 3275-3279.
48. Horowitz, S., Bowen, J.K., Bannon, G.A. and Gorovsky, M.A. (1987) Nucl. Acid Res. 1, 141-160.
49. Horowitz, S. and Gorovsky, M.A. (1985) Proc. Nat. Acad. Sci. 82, 2452-2455.
50. Howell,A., Cool, D., Hewitt, J., Ydenberg, B., Smith, M. and Honda, B. (1987) J. Mol. Evol. 25,29-3€
51. Iwai, K., Hayashi, H. and Ishikawa, K. (1972) J. Biochem. 72, 357-367.
52. Jones, G.M.T., Rall, S.C. and Cole, R.D. (1974) J. Biol. Chem. 249, 2548-2553.
53. Kaumeyer, J.F. and Weinberg, E.S. (1986) Nucl. Acid Res. 11, 4557-4576.
54. Kemler, I. and Busslinger, M. (1986) Mol. Cell. Biol. 11, 3746-3754.
55. Kim, Y.-J., Hwang, I., Tres, L.L. and Kierszenbaum, A.L. (1987) Dev. Biol. 124, 23-24.
56. Kmiecik, D., Couppez, M., Belaiche, D. and Sautiere, P. (1983) Eur. J. Biochem. 135, 113-121.
57. Kmiecik, D., Sellos,D., Belaiche D. and Sautiere, P. (1985) Eur. J. Biochem. 150, 359-370.
58. Knowles, J.A. and Childs, G.J. (1986) Nucl. Acid Res. 14, 8121-8133.
59. Knowles, J.A., Lai, Z.-C. and Childs, G.J. (1987) Mol. Cell. Biol. 7,478-485.
60. Kootstra, A. and Bailey, G.S. (1978) Biochemistry 17, 2504-2510.
61. Krieg, P.A., Robins, A.J., D'Andrea, R. and Wells, J.R.E., (1983) Nucl. Acids Res. 11, 619-627.
62 .Lai,Z.C. and Childs, G. (1986) Nucl. Acids Res. 14, 6845-6856.
63. Lai, Z.C. and Childs, G. (1988) Mol. Cell. Biol. 8,1842-1844.
64. Laine, B., Sautiere, P. and Biserte, G. (1976) Biochemistry 15, 1640-1645.
65. Laine, B., Kmiecik, D., Sautiere, P. and Biserte, G. (1978) Biochimie 60,147-150.
66. Levy, S., Sures, I. and Kedes, L. (1982) J. Biol. Chem. 16, 9438-9443.
67. Liao, L.W. and Cole, R.D. (1981) J. Biol. Chem. 256, 3024-3029.
68. Lieber, T., Weisser,K. and Childs, G. (1986) Mol. Cell. Biol. 7, 2602-2612.
69. Liebermann, D., Hoffman-Liebermann, B., Weinthal, J., Childs, G., Maxson, R., Mauron, A., Cohen, S.N. and Kedes, L. (1983) Nature 306, 342-347.
70. MacLeod, A.R., Wong, N.C.W. and Dixon, G.H. (1978) Eur. J. Biochem. 78, 281-291.
71. Marashi, F., Prokopp, K., Stein, J. and Stein, G. (1984) Proc. Natl. Acad. Sci. USA 81, 1936-1940.
72. Marashi,F., Helms,S., Sheils,A., Silverstein,S., Greenspan,D., Stein,G. and Stein,J. (1986) Biochem. Cell Biol. 64, 277-289.
73. Martinage, A., Belaiche, D., Dupressoir, T. and Sautiere, P. (1983) Eur. J. Biochem. 130, 465-472.
74. Martinage, A., Briand, G., VanDorsselaer,A., Turner, C.H. and Sautiere, P. (1985) Eur. J. Biochem. 147, 351-359.
75. Matsumoto, S. and Yanagida, M. (1985) EMBO Journal 13A, 3531-3538.
76. May, G.S. and Morris, N.R. (1987) Gene 58, 59-66.
77. Mezquita, J., Connor, W., Winkfein, R.J. and Dixon, G.H. (1985) J. Mol. Evol. 21, 209-219.
78. Moorman, A.F.M., DeLaaf, R.T.M., Destree, O.H.J., Telford, J. and Birnstiel, M.L. (1980) Gene 10, 185-193.
79. Moorman, A.F.M., DeBoer, P.A.J., DeLaaf, R.T.M., Van Dongen, W.M.A.M. and Destree, O.H.J. (1981) FEBS Lett.136, 45-52.
80. Moorman, A.F.M., DeBoer, P.A.J., DeLaaf, R.T.M. and Destree, O.H.J. (1982) FEBS Lett. 144, 235-241.
81. Muller, K. and Schmitt, R. (1988) Nucl. Acid Res. 9, 4121-4135.
82. Murphy, T.J., and Blumenfeld, M. (1986) Nucl. Acid Res. 14, 5563.
83. Nomoto, M., Imai, N., Saiga, H., Matsui, T. and Mita, T. (1987) Nucl. Acid Res. 14, 5681-5697.
84. Ogawa, Y., Quagliarotti, G., Jordan, J., Taylor, C.W., Starbuck, W.C. and Busch, H. (1969) J. Biol. Chem. 244, 4387-4392.
85. Ohe, Y., Hayashi, H. and Iwai, K. (1979) J. Biochem. 85, 615-624.
86. Ohe, Y., Hayashi, H. and Iwai ,K. (1986) J. Biochem. 100, 359-368.
87. Old, R.W., Sheikh, S.A., Chambers, A., Newton, C.A., Mohammed, A. and Aldridge, T.C. (1985) Nuc. Acids Res. 13, 7341-7358.
88. Pauli, U., Chrysogelos, S., Stein, G., Stein, J. and Nick, H. (1987)Science 236, 1308-1311.
89. Patthy, L., Smith, E.L. and Johnson, J. (1973) J. Biol. Chem. 248, 6834-6840.
90. Patthy, L. and Smith, E.L. (1975) J. Biol. Chem. 250, 1919-1920.
91. Peng,K. and Wu,R. (1986) Gene 45, 247-252.
92. Perry, M., Thomsen, G.H. and Roeder, R.G. (1985) J. Mol. Biol. 185, 479-499.
93. Phillips, G., Cahaubet, N., Chaubet, M., Ehling, M. and Gigot,C. (1986) Gene 42, 225-229.
94. Rall, S.C. and Cole, R.D. (1971) J. Biol. Chem. 246, 7175-7190.
95. Roberts, S.B., Weisser, K.E. and Childs, G. (1984) J. Mol. Biol. 174, 647-662.
96. Rodrigues, J. A., Brandt, W.F. and Von Holt, C. (1979) Biochim. Biophys. Acta 578, 196-206.
97. Rodrigues, J. A., Brandt, W.F. and Von Holt,C. (1985) Eur. J. Biochem 150, 499-506.
98. Ruberti, I., Fragapane, P., Pierandrei-Amaldi, P., Beccari, E., Amaldi, F. and Bozzoni, I. (1982) Nucl. Acid Res. 10, 7543-7559.

99. Ruiz-Carrillo, A., Affolter, M. and Renaud, J. (1983) J. Mol. Biol. 170, 843-859.
100.Sautiere, P., Lambelin-Breynaert, M., Moschetto, Y. and Biserte, G. (1971a) Biochimie 53, 711-715.
101. Sautiere, P., Tyrou, D., Moschetto, Y. and Biserte, G. (1971b) Biochimie 53, 479-483.
102. Sautiere, P., Tyrou, D., Laine, B., Mizon, J., Ruffin, P. and Biserte, G. (1974) Eur. J. Biochem. 41, 563-576.
103. Sautiere, P., Kmiecik, D., Loy, O., Briand, G., Biserte, G., Garel, A. and Champagne, M. (1975) FEBS Lett. 50, 200-203.
104. Schaffner, W., Kunz, G., Daetwyler, H., Telford, J., Smith, H.O. and Birnstiel, M.L. (1978) Cell 14, 655-671.
105. Seiler-Tuyns, A. and Birnstiel, M.L. (1981) J. Mol. Biol. 151, 607-625.
106. Sierra, F., Stein, G. and Stein, J. (1983) Nucl. Acids Res. 11, 7069-7086.
107. Sittman, D.B., Chiu, I.M., Pan, C.J., Cohn, R.H., Kedes, L.H. and Marzluff, W.F. (1981) Proc. Nat. Acad. Sci. USA 78, 4078-4082.
108. Smith, M.M., and Andresson, O.S. (1983) J.Mol. Biol. 169, 633-690.
109. Stauber, C., Luescher, B., Eckner, R. and Loetscher, E. (1986) EMBO J. 5, 3297-3303.
110. Stephenson, E.C., Erba, H.P. and Gall, J.G. (1981) Nucl. Acid Res. 9, 2281-2295.
111. Strickland, M., Strickland, W.N., Brandt, W.F. and Von Holt, C. (1977) Eur. J. Biochem. 77, 263-275.
112. Strickland, M., Strickland, W.N., Brandt, W.F., Von Holt, C., Wittmann-Liebold, B. and Lehmann, A. (1978) Eur. J. Biochem. 89, 443-452.
113. Strickland, W.N., Strickland, M., de Groot, P.C., Von Holt, C. and Wittmann-Liebold, B. (1980) Eur. J. Biochem. 104, 559-566V
114. Strickland, W.N., Strickland, M.S., de Groot, P.C. and von Holt, C. (1980) Eur. J. Biochem. 109, 151-158.
115. Strickland, W.N., Strickland, M. and Von Holt, C. (1982) Biochim. Biophys. Acta 700, 127-129.
116. Sugarman, B.J., Dodgson, J.B. and Engel, J.D. (1983) J. Biol. Chem. 258, 9005-9016.
117. Sures, I., Lowry, J. and Kedes, L.H. (1978) Cell 15, 1033-1044,
118. Swenson, K.I., Borgese, N., Pietrini, G. and Ruderman, J. (1987) 123,10-16.
119. Tabata, T., Sasaki, K. and Iwabuchi, M. (1983) Nucl. Acids Res. 11, 5865-5875.
120. Tabata, T., Fukasawa, M. and Iwabuchi, M. (1984) Mol. Gen. Genet. 196, 397-400.
121. Taylor, J.D., Wellman, S.E. and Marzluff, W.F. (1986) J. Mol. Evol. 23,
122. Tonjes, R. and Doenecke, D. (1987) J. Mol. Evol. 25, 361-370.
123. Tonjes, R. and Doenedke,D. (1985) Gene 39, 275-279.
124. Turner, P.C. and Woodland, H.R. (1982) Nucl. Acids Res. 10, 3769-3780.
125. Turner, P.C., Aldridge, T.C., Woodland, H.R. and Old, R.W. (1983) Nucl. Acids Res. 11, 4093-4107.
126. Van Daal, A., White, E., Gorovsky, M.A. and Elgin, S.C.R. (1988) 15,7487-7497.
127. Van Helden, P., Strickland, W., Brandt, W. and Von Holt, C. (1978) Biochim. Biophys. Acta 533, 278-281.
128. Van Helden, P.D., Strickland, W.N., Brandt, W.F., Von Holt, C. (1979) Eur. J. Biochem. 93, 71-78.
129. Vanfleteren, J.R.,VanBun,S.M. and VanBeeumen,J.J. (1986) J. Biochem. 235, 769-773.
130. Vanfleteren, J.R.,VanBun,S.M. and VanBeeumen,J.J. (1987a) J. Biochem. 243, 297-300.
131. Vanfleteren, J.R.,VanBun,S.M, VanBeeumen,J.J. (1987b) FEBS Lett. 211, 59-63.
132. Wallis, J.W., Hereford, L. and Grunstein, M. (1980) Cell 22, 799-805.
133. Wang, SW., Robins, A.J., D'Andrea, R. and Wells, J.R.E. (1985) Nucl. Acids Res. 13, 1369-1397.
134. Wells, D. (1986) Nucl. Acids Res.14 Supplement, r119-r149.
135. Wells, D. and Kedes, L. (1985) Proc. Nat. Acad. Sci. USA 82, 2834-2838.
136. Wells, D., Bains, W. and Kedes, L. (1986) J. Mol. Evol. 23, 224-241.
137. White, E.L., Shapiro, D.L., Allis, C.D. and Gorovsky, M.A. (1988) Nucl. Acid Res. 1, 179-198.
138. Wilhelm, M.L. and Wilhelm, F.X. (1984) FEBS Lett. 168, 249-254.
139. Wilhelm, M.L. and Wilhelm, F.X. (1987) Nucl. Acid Res. 13, 5478.
140. Wilson, R.K., Starbuck, W.C., Taylor, C., Jordan, J. and Busch, H. (1970) Cancer Res. 30, 2942 - 2951.
141. Winkfein, R.J., Conner, W., Mezquita, J. and Dixon, G.H. (1985) J. Mol. Evol. 22, 1-19.
142. Woudt, L.P., Pastink, A., Kempers-Veenstra, A.E., Jansen, A.E.M., Mager, W.H. and Planta, R.J. (1983) Nucl. Acids Res. 11, 5347-5360.
143. Wouters-Tyrou, D., Martin-Ponthieu, A., Briand, G., Sautiere, P. and Biserte, G. (1982) Eur. J. Biochem. 124, 489-498.
144. Wouters, D., Sautiere, P. and Biserte, G. (1978) Eur. J. Biochem. 90,231-239.
145. Wu, M., Allis, C.D., Richman, R., Cook, R.G. and Gorovsky, M.A. (1986) Proc. Nat. Acad. Sci. USA 83, 8674-8678.
146. Yaguchi, M., Roy, C. and Seligy, V.L. (1979) Biochem. Biophys. Res. Commun. 90, 1400-1406.
147. Zernik, M., Heintz, N., Boime, I. and Roeder, R.G. (1984) Cell 22, 807-815.
148. Zhong, R., Roeder, R.G. and Heintz, N. (1983) Nucl. Acids Res. 11, 7409-7425.