Research Article

Conservation of Nucleosome Positions in Duplicated and Orthologous Gene Pairs

Hiromi Nishida

Agricultural Bioinformatics Research Unit, Graduate School of Agriculture and Life Sciences, The University of Tokyo, Bunkyo-ku, Tokyo 113-8657, Japan

Correspondence should be addressed to Hiromi Nishida, hnishida@iu.a.u-tokyo.ac.jp

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Although nucleosome positions tend to be conserved in gene promoters, whether they are conserved in duplicated and orthologous genes is unknown. In order to elucidate how nucleosome positions are conserved between duplicated and orthologous gene pairs, I performed 2 comparative studies. First, I compared the nucleosome position profiles of duplicated genes in the filamentous ascomycete Aspergillus fumigatus. After identifying 63 duplicated gene pairs among 9630 protein-encoding genes, I compared the nucleosome position profiles of the paired genes. Although nucleosome positions are conserved more in gene promoters than in gene bodies, their profiles were diverse, suggesting evolutionary changes after gene duplication. Next, I examined the conservation of nucleosome position profiles in 347 A. fumigatus orthologs of S. cerevisiae genes that showed notably high conservation of nucleosome positions between the parent strain and 2 deletion mutants. In only 11 (3.2%) of the 347 gene pairs, the nucleosome position profile was highly conserved (Spearman’s rank correlation coefficient > 0.7). The absence of nucleosome position conservation in promoters of orthologous genes suggests organismal specificity of nucleosome arrangements.

1. Introduction

Nucleosomes are histone octamers around which DNA is wrapped in 1.65 turns [1]. Neighboring nucleosomes are separated by unwrapped linker DNA. Nucleosome density is lower, and nucleosome position is more conserved in the promoters than in the bodies of genes [2–5]. It is thought that nucleosome positioning in the gene promoter plays an important role in transcriptional regulation.

Although nucleosome positions can be partially simulated using a DNA-sequence-based approach [6], these simulations are limited due to variations between species. The nucleosome positioning mechanism varies between the 2 ascomycete yeasts, Saccharomyces cerevisiae, and Schizosaccharomyces pombe [7]. Nucleosome positioning differs even among phylogenetically close ascomycete yeast species [5].

Gene duplication is a driving force behind gene creation, and generating novel functions in newly created genes. Approximately one-half of cellular functions have been gained through gene duplication [8]. The duplicated genes encode similar amino acid sequences and often similar protein functions. It is uncertain, however, whether duplicated genes have similar nucleosome position profiles. In this study, I compared nucleosome positions in the promoter and body regions of duplicated gene pairs in the filamentous ascomycete Aspergillus fumigatus.

Previous analyses have found that nucleosome positions in A. fumigatus are conserved more in gene promoters than in gene bodies, even after treatment with the histone deacetylase inhibitor trichostatin A [4, 9]. In addition, nucleosome positions in S. cerevisiae are more conserved in gene promoters than in gene bodies between the control and the histone acetyltransferase gene ELP3 deletion mutant, and between the control and the histone deacetylase gene HOS2 deletion mutant [10]. The proteins Elp3 and Hos2 show the highest and the third highest evolutionary conservation, respectively, among the fungal histone modification proteins [11].

How well are nucleosome positions conserved in genes of the same origins? If there is a “nucleosome position code” that regulates nucleosome positioning, common nucleosome
### Table 1: Duplicated gene pairs in *Aspergillus fumigatus*.

| Gene pair                 | Chromosome | Gene body region | Gene direction | Function                                           |
|---------------------------|------------|------------------|----------------|----------------------------------------------------|
| AFUA1G00150               | 1          | 25442            | 27017          | + RING finger protein                               |
| AFUA6G09370               | 6          | 2245549          | 2247121        | + RING finger protein                               |
| AFUA1G00420               | 1          | 135528           | 137781         | + Carboxypeptidase S1, putative                    |
| AFUA8G04120               | 8          | 897824           | 900076         | − Carboxypeptidase S1, putative                    |
| AFUA1G00440               | 1          | 138359           | 140093         | − DUF895 domain membrane protein                   |
| AFUA8G04110               | 8          | 895512           | 897246         | + DUF895 domain membrane protein                   |
| AFUA1G00450               | 1          | 143117           | 144466         | + N-acetylglucosamine-6-phosphate deacetylase(NagA), putative |
| AFUA8G04100               | 8          | 891135           | 892484         | − N-acetylglucosamine-6-phosphate deacetylase(NagA), putative |
| AFUA1G00470               | 1          | 148615           | 150219         | + Betaine aldehyde dehydrogenase, putative        |
| AFUA8G04080               | 8          | 885376           | 886980         | − Betaine aldehyde dehydrogenase (BadH), putative |
| AFUA1G00530               | 1          | 164101           | 164771         | − Thermoresistant gluconokinase family protein    |
| AFUA4G12050               | 4          | 316374           | 3164330        | − Thermoresistant gluconokinase                    |
| AFUA1G00550               | 1          | 177114           | 178593         | + Hypothetical protein                             |
| AFUA1G00910               | 1          | 328785           | 330274         | + Hypothetical protein                             |
| AFUA1G00580               | 1          | 184790           | 186873         | + Acid phosphatase (PhoG), putative                |
| AFUA8G04050               | 8          | 870757           | 872487         | − Acid phosphatase (PhoG), putative                |
| AFUA1G00650               | 1          | 215584           | 217006         | + Alpha-1,3-glucanase, putative                    |
| AFUA7G08510               | 7          | 1973398          | 1974759        | + Alpha-1,3-glucanase, putative                    |
| AFUA1G00920               | 1          | 331676           | 332955         | − Hypothetical protein                             |
| AFUA3G06425               | 3          | 1582748          | 1584037        | − Hypothetical protein                             |
| AFUA1G01050               | 1          | 385302           | 386244         | − Hypothetical protein                             |
| AFUA8G06160               | 8          | 1465695          | 1466634        | + Hypothetical protein                             |
| AFUA1G02550               | 1          | 744583           | 746335         | − Tubulin alpha-1 subunit                         |
| AFUA2G14990               | 2          | 3947008          | 3948834        | − Tubulin alpha-2 subunit                         |
| AFUA1G02730               | 1          | 788249           | 789373         | − Mitochondrial phosphate carrier protein (Ptp), putative |
| AFUA1G15140               | 1          | 4070230          | 4071449        | − Mitochondrial phosphate carrier protein (Mir1), putative |
| AFUA1G05760               | 1          | 1658382          | 1659697        | − Arsenite efflux transporter                      |
| AFUA5G15010               | 5          | 3882425          | 3883746        | + Arsenite permease (ArsB), putative               |
| AFUA1G05760               | 1          | 1658382          | 1659697        | − Arsenite efflux transporter                      |
| AFUA1G16100               | 1          | 4378898          | 4380216        | + Arsenite permease (ArsB), putative               |
| AFUA1G10910               | 1          | 2848155          | 2850137        | − Tubulin beta, putative                           |
| AFUA7G00250               | 7          | 70221            | 71948          | + Tubulin beta-2 subunit                           |
| AFUA1G11260               | 1          | 2971529          | 2971889        | − Conserved hypothetical protein                   |
| AFUA6G00270               | 6          | 79542            | 79866          | − Conserved hypothetical protein                   |
| AFUA1G11610               | 1          | 3060058          | 3060510        | + 3-Dehydroquinase dehydratase, type II            |
| AFUA3G14850               | 3          | 3929721          | 3930173        | + 3-Dehydroquinase dehydratase, type II            |
| AFUA1G11890               | 1          | 3129447          | 3131489        | + Serine palmitoyltransferase 2, putative          |
| AFUA6G00300               | 6          | 85851            | 87692          | − Serine palmitoyltransferase 1, putative          |
| AFUA1G12850               | 1          | 3398837          | 3400611        | + Nitrate transporter (nitrate permease)           |
| AFUA1G17470               | 1          | 4782320          | 4783995        | + High-affinity nitrate transporter NrtB            |
| AFUA1G15970               | 1          | 4338407          | 4339712        | + Aldo-keto reductase (AKR13), putative            |
| AFUA8G01560               | 8          | 401581           | 402815         | − Aldo-keto reductase (YakC), putative             |
| AFUA1G16030               | 1          | 4358866          | 4360256        | − Conserved hypothetical protein                   |
| AFUA5G14930               | 5          | 3863218          | 3864521        | − Conserved hypothetical protein                   |
| Gene pair     | Chromosome | Gene body region       | Gene direction | Function                                                                 |
|---------------|------------|------------------------|----------------|---------------------------------------------------------------------------|
| AFUA1G16040   | 1          | 4363493 - 4365310      | +              | Metalloreductase, putative                                                |
| AFUA5G14940   | 5          | 3867797 - 3869542      | +              | Cell surface metalloreductase (FreA), putative                           |
| AFUA1G16050   | 1          | 4366573 - 4368232      | +              | Hypothetical protein                                                      |
| AFUA5G14950   | 5          | 3870635 - 3872465      | +              | Hypothetical protein                                                      |
| AFUA1G16070   | 1          | 4370346 - 4373694      | +              | Conserved hypothetical protein                                            |
| AFUA5G14980   | 5          | 3874539 - 3877890      | +              | Conserved hypothetical protein                                            |
| AFUA1G16080   | 1          | 4374579 - 4375298      |                 | Hypothetical protein                                                      |
| AFUA5G14990   | 5          | 387797 - 3879579       |                 | Hypothetical protein                                                      |
| AFUA1G16090   | 1          | 4377842 - 4378249      |                 | Arsenate reductase (ArsC), putative                                      |
| AFUA5G15000   | 5          | 3881386 - 3881835      |                 | Arsenate reductase (ArsC), putative                                      |
| AFUA1G16100   | 1          | 4378898 - 4380216      | +              | Arsenite permease (ArsB), putative                                       |
| AFUA5G15010   | 5          | 3882425 - 3883746      | +              | Arsenite permease (ArsB), putative                                       |
| AFUA1G16110   | 1          | 4380474 - 4381455      |                 | Arsenic methyltransferase (Cyt19), putative                              |
| AFUA5G15020   | 5          | 3883929 - 3884993      |                 | Arsenic methyltransferase (Cyt19), putative                              |
| AFUA1G16120   | 1          | 4385650 - 4386671      |                 | Arsenic resistance protein (ArsH), putative                              |
| AFUA5G07150   | 8          | 1751693 - 1752688      | +              | ArsH protein                                                             |
| AFUA1G16120   | 1          | 4385650 - 4386671      |                 | Arsenic resistance protein (ArsH), putative                              |
| AFUA5G15030   | 5          | 3887287 - 3888230      |                 | Arsenic resistance protein (ArsH), putative                              |
| AFUA2G00800   | 2          | 178081 - 179459        |                 | PelA protein                                                             |
| AFUA5G10380   | 5          | 2658656 - 2659968      | +              | Pectin lyase, putative                                                    |
| AFUA2G00800   | 2          | 178081 - 179459        |                 | PelA protein                                                             |
| AFUA7G05030   | 7          | 1182104 - 1183794      |                 | Pectin lyase B                                                           |
| AFUA2G04010   | 2          | 1092973 - 1094679      |                 | Alpha, alpha-trehalose-phosphate synthase subunit, putative              |
| AFUA6G12950   | 6          | 3268958 - 3270783      |                 | Alpha, alpha-trehalose-phosphate Synthase subunitTSP1, putative          |
| AFUA2G11270   | 2          | 2897275 - 2904954      |                 | Alpha-1,3-glucan synthase, putative                                      |
| AFUA3G00910   | 3          | 210186 - 217666        | +              | Alpha-1,3-glucan synthase, putative                                      |
| AFUA3G00340   | 3          | 71186 - 72734          | +              | Glycosyl hydrolase, putative                                             |
| AFUA4G02720   | 4          | 751306 - 752715        |                 | Glycosyl hydrolase, putative                                             |
| AFUA3G00680   | 3          | 151397 - 153549        |                 | Copper amine oxidase                                                     |
| AFUA7G04180   | 7          | 943893 - 946136        |                 | Amine oxidase                                                            |
| AFUA3G01560   | 3          | 393032 - 394802        |                 | Aminoacid permease, putative                                             |
| AFUA5G04260   | 5          | 1140953 - 1142714      |                 | Arginine transporter, putative                                            |
| AFUA3G02420   | 3          | 597476 - 598286        |                 | ThiP/PfP family protein                                                  |
| AFUA4G01400   | 4          | 369123 - 369944        |                 | ThiP/PfP family protein                                                  |
| AFUA3G03080   | 3          | 824479 - 825425        | +              | Endo-1,3-(4)-beta-glucanase, putative                                     |
| AFUA6G14540   | 6          | 3702416 - 3703833      | +              | Endo-1,3-(4)-beta-glucanase, putative                                     |
| AFUA3G03980   | 3          | 1134609 - 1136404      |                 | Cytochrome P450 monoxygenase, putative                                   |
| AFUA5G10050   | 5          | 2589301 - 2591081      |                 | Cytochrome P450 monoxygenase, putative                                   |
| AFUA3G08160   | 3          | 2094223 - 2095759      |                 | Eukaryotic translation initiation Factor eIF4A, putative                 |
| AFUA5G02410   | 5          | 621886 - 623486        |                 | DEAD/DEAH box helicase, putative                                         |
| AFUA3G14420   | 3          | 3831868 - 3834921      | +              | Chitin synthase G                                                        |
| AFUA5G00760   | 5          | 211013 - 213795        | +              | Chitin synthase C                                                        |
| AFUA4G00510   | 4          | 133477 - 135102        |                 | Hypothetical protein                                                     |
| AFUA7G08600   | 7          | 2009436 - 2011052      |                 | Hypothetical protein                                                     |
| AFUA4G03110   | 4          | 868474 - 870249        |                 | Monosaccharide transporter                                               |
| AFUA5G10690   | 5          | 2737348 - 2739178      |                 | Monosaccharide transporter                                               |
Table 1: Continued.

| Gene pair       | Chromosome | Gene body region | Gene direction | Function                                                                 |
|-----------------|------------|------------------|---------------|---------------------------------------------------------------------------|
| AFUA4G03680     | 4          | 1031586 – 1032539| –             | Oxidoreductase, short-chain dehydrogenase/reductase family                |
| AFUA6G03520     | 6          | 764308 – 765294  | –             | Short-chain dehydrogenase/reductase family protein, putative             |
| AFUA4G09440     | 4          | 2462920 – 2466158| –             | Sodium P-type ATPase, putative                                            |
| AFUA6G03690     | 6          | 810027 – 813632  | –             | Sodium transport ATPase, putative                                         |
| AFUA4G14360     | 4          | 3774307 – 3776166| +             | Capsular associated protein, putative                                     |
| AFUA5G07560     | 5          | 1889791 – 1891689| –             | Capsular associated protein, putative                                     |
| AFUA5G00145     | 5          | 15749 – 16327    | –             | Hypothetical protein                                                     |
| AFUA6G11710     | 6          | 2915903 – 2916483| +             | Conserved hypothetical protein                                           |
| AFUA5G0130      | 5          | 266294 – 267439  | –             | Glyceraldehyde 3-phosphate dehydrogenase(Ccg-7), putative                 |
| AFUA5G01970     | 5          | 503797 – 505194  | +             | Glyceraldehyde 3-phosphate dehydrogenase GpdA                           |
| AFUA5G06240     | 5          | 1494455 – 1495619| –             | Alcohol dehydrogenase, putative                                          |
| AFUA7G10101     | 7          | 270494 – 271675  | –             | Alcohol dehydrogenase, putative                                          |
| AFUA5G07980     | 5          | 2019069 – 2020841| +             | Hypothetical protein                                                     |
| AFUA5G14920     | 5          | 3857350 – 3859167| +             | Hypothetical protein                                                     |
| AFUA5G09130     | 5          | 2345689 – 2346728| –             | Polysaccharide deacetylase family protein                                |
| AFUA6G05030     | 6          | 1195846 – 1196956| +             | Polysaccharide deacetylase family protein                                |
| AFUA5G15030     | 5          | 3887287 – 3888230| –             | Arsenic resistance protein (ArsH), putative                              |
| AFUA5G07150     | 8          | 1751693 – 1752688| +             | ArsH protein                                                             |
| AFUA6G06750     | 6          | 1475239 – 1476209| +             | 14-3-3 family protein                                                    |
| AFUA2G03290     | 2          | 867203 – 868250  | –             | 14-3-3 family protein                                                    |
| AFUA6G07070     | 6          | 1587643 – 1589124| +             | Cellobiohydrolase D                                                      |
| AFUA6G11610     | 6          | 2878078 – 2879676| –             | 1,4-beta-D-glucan-cellobiohydrolyase, putative                            |
| AFUA6G11430     | 6          | 2837140 – 2839051| +             | Aldehyde dehydrogenase, putative                                         |
| AFUA7G10100     | 7          | 267518 – 269163  | –             | Aldehyde dehydrogenase, putative                                         |
| AFUA6G11710     | 6          | 2915903 – 2916483| +             | Conserved hypothetical protein                                           |
| AFUA7G08440     | 7          | 1942319 – 1942804| +             | Hypothetical protein                                                     |
| AFUA6G13490     | 6          | 3431912 – 3433612| –             | Glutamate decarboxylase                                                  |
| AFUA8G06020     | 8          | 1428812 – 1430515| +             | Glutamate decarboxylase                                                  |
| AFUA7G00360     | 7          | 102030 – 103064  | –             | UDP-galactose 4-epimerase, putative                                       |
| AFUA8G00860     | 8          | 203496 – 204338  | +             | UDP-galactose 4-epimerase, putative                                       |
| AFUA7G07050     | 7          | 1725686 – 1726402| –             | Hypothetical protein                                                     |
| AFUA7G08300     | 7          | 1870244 – 1870960| –             | Hypothetical protein                                                     |
| AFUA7G07060     | 7          | 1728876 – 1732992| –             | Hypothetical protein                                                     |
| AFUA7G08310     | 7          | 1873437 – 1877817| –             | Hypothetical protein                                                     |

Positions should remain in the promoters of orthologous genes across distinct species. In this study, I compared nucleosome positions in the promoters of duplicated and orthologous genes in *A. fumigatus* and *S. cerevisiae*.

2. Materials and Methods

2.1. Identification of Duplicated Gene Pairs in *Aspergillus fumigatus*. Protein-coding gene pairs aligned over more than 80% of query length and more than 70% aminoacid sequence identity were selected by performing a BLAST search of 9630 *A. fumigatus* proteins at Fungal Genomes Central on NCBI (http://www.ncbi.nlm.nih.gov/projects/genome/guide/fungi/). Pairs in which the lengths differ by more than 25% were not used. Thus, we identified 63 duplicated *A. fumigatus* gene pairs (Tables 1 and 2).

2.2. Identification of Orthologous Gene Pairs in *Aspergillus fumigatus* and *Saccharomyces cerevisiae*. In a comparison
Table 2: Spearman's rank correlation coefficients of nucleosome position profiles in the promoter and body regions of 63 duplicated gene pairs in *Aspergillus fumigatus*.

| Gene pair | Gene promoter | Gene body |
|-----------|---------------|-----------|
| AFUA1G00150 | AFUA6G09370 | 0.750176913 | 0.215204254 |
| AFUA1G00420 | AFUA8G04120 | 0.80370974 | 0.723149072 |
| AFUA1G00440 | AFUA8G04110 | 0.856048361 | 0.225149091 |
| AFUA1G00450 | AFUA8G04100 | 0.9213602 | 0.94633912 |
| AFUA1G00470 | AFUA8G04080 | 0.433118045 | 0.818800395 |
| AFUA1G00530 | AFUA4G12050 | 0.326735006 | −0.199291887 |
| AFUA1G00550 | AFUA1G00910 | 0.676910334 | 0.678763937 |
| AFUA1G00580 | AFUA8G04050 | 0.305291793 | 0.312927993 |
| AFUA1G00650 | AFUA7G08510 | 0.448171525 | −0.036644732 |
| AFUA1G00920 | AFUA3G06425 | 0.719748778 | −0.340001527 |
| AFUA1G01050 | AFUA8G04110 | 0.635149308 | 0.176679577 |
| AFUA1G02550 | AFUA2G14990 | 0.139079116 | −0.397363108 |
| AFUA1G02730 | AFUA1G15140 | 0.452193259 | 0.067186644 |
| AFUA1G05760 | AFUA5G15010 | 0.395849711 | 0.117006666 |
| AFUA1G05760 | AFUA1G16100 | 0.127911436 | −0.397363108 |
| AFUA1G09090 | AFUA6G00270 | 0.617303556 | −0.02397179 |
| AFUA1G11610 | AFUA3G14850 | 0.134790545 | −0.14813806 |
| AFUA1G11890 | AFUA6G00300 | 0.254487564 | 0.429087849 |
| AFUA1G12850 | AFUA1G17470 | 0.644447287 | 0.008468365 |
| AFUA1G15970 | AFUA8G01560 | 0.373850536 | −0.106800689 |
| AFUA1G16030 | AFUA5G14930 | 0.618349765 | 0.858488283 |
| AFUA1G16040 | AFUA5G14940 | 0.481054005 | 0.017330056 |
| AFUA1G16050 | AFUA5G14950 | −0.345037268 | −0.392132138 |
| AFUA1G16070 | AFUA5G14980 | 0.930922124 | 0.902581516 |
| AFUA1G16080 | AFUA5G14990 | 0.559980787 | 0.136819379 |
| AFUA1G16090 | AFUA5G15000 | 0.773867924 | 0.338119153 |
| AFUA1G16100 | AFUA5G15010 | 0.681170098 | 0.70434823 |
| AFUA1G16110 | AFUA5G15020 | −0.26184905 | 0.632982505 |
| AFUA1G16120 | AFUA5G17150 | 0.35689915 | 0.074502754 |
| AFUA1G16120 | AFUA5G15030 | −0.135442129 | −0.239074416 |
| AFUA2G00800 | AFUA5G10380 | 0.352063916 | 0.460712971 |
| AFUA2G00800 | AFUA7G05030 | −0.114184443 | 0.457081245 |
| AFUA2G04010 | AFUA6G12950 | 0.134790545 | −0.14813806 |
| AFUA2G11270 | AFUA5G00910 | −0.004207858 | 0.192024608 |
| AFUA3G00340 | AFUA4G02720 | −0.050259987 | 0.055757479 |
| AFUA3G00680 | AFUA7G04180 | 0.399912713 | −0.044615588 |
| AFUA3G01560 | AFUA5G04260 | 0.179359067 | 0.125177632 |
| AFUA3G02420 | AFUA4G01400 | 0.662712481 | 0.646400554 |
| AFUA3G03080 | AFUA6G14540 | 0.3401707 | −0.021961056 |
| AFUA3G03980 | AFUA5G10050 | 0.486726534 | 0.318475376 |
| AFUA3G08160 | AFUA5G02410 | 0.309645464 | −0.255654021 |
| AFUA3G14420 | AFUA5G00760 | 0.917685134 | 0.41511431 |
| AFUA4G00510 | AFUA7G08600 | 0.578582743 | 0.441363777 |
| AFUA4G03110 | AFUA5G10690 | 0.721540193 | 0.176996881 |
| AFUA4G03680 | AFUA6G03520 | 0.662657833 | −0.320417166 |
| AFUA4G09440 | AFUA6G03690 | 0.204159184 | 0.006092098 |
| AFUA4G14360 | AFUA5G07560 | 0.038083073 | 0.515103795 |
| AFUA5G00145 | AFUA6G11710 | 0.809402393 | −0.741045496 |
Table 2: Continued.

| Gene pair       | Gene promoter | Gene body          |
|-----------------|---------------|--------------------|
| AFUA5G00145     | AFUA7G08440   | 0.01962845         |
| AFUA5G01030     | AFUA5G01970   | 0.576211178        |
| AFUA5G06240     | AFUA7G01010   | 0.163674862        |
| AFUA5G07980     | AFUA5G14920   | 0.669562689        |
| AFUA5G09130     | AFUA6G05030   | 0.092452938        |
| AFUA5G15030     | AFUA8G07150   | 0.337482368        |
| AFUA6G06750     | AFUA2G03290   | 0.333402926        |
| AFUA6G07070     | AFUA6G11610   | −0.048961745       |
| AFUA6G11430     | AFUA7G01000   | 0.0145492          |
| AFUA6G11710     | AFUA7G08440   | 0.243362623        |
| AFUA6G13490     | AFUA8G06020   | 0.768186533        |
| AFUA7G00360     | AFUA8G00860   | −0.115050268       |
| AFUA7G07050     | AFUA7G08300   | 0.70756842         |
| AFUA7G07060     | AFUA7G08310   | 0.906852725        |

Figure 1: Boxplots of Spearman’s rank correlation coefficients of nucleosome position profiles in the promoter and body regions of 63 duplicated gene pairs. Circles represent the correlation coefficients and values of the same genes are connected by lines.

Figure 2: Boxplots of Spearman’s rank correlation coefficients between nucleosome position profiles in the promoters of 347 orthologous gene pairs between Aspergillus fumigatus and Saccharomyces cerevisiae. The same number of gene pairs was chosen at random to serve as a control. Dots indicate correlation coefficients. The distributions of correlation coefficients did not significantly differ (P-value = 0.28 in Kolmogorov-Smirnov test) between the orthologous gene promoters and the controls.

of nucleosome positioning between A. fumigatus and S. cerevisiae, I focused on 466 genes (Table 3) that showed notably high conservation of nucleosome positioning in the promoters of the control and the ELP3 and HOS2 deletion mutants from the previous study [10].

A total of 3339 ortholog clusters were identified (See table 1 in Supplementary Material available at doi: 10.1100/2012/298174) between A. fumigatus and S. cerevisiae by ortholog cluster analysis in the Microbial Genome Database for Comparative Analysis (MBGD, http://mbgd.nibb.ac.jp/) [12]. Of these orthologous gene pairs, 347 (Table 4) are yeast genes that showed a high level of nucleosome positioning conservation in the control and deletion mutants. I focused on these 347 orthologous pairs to compare nucleosome positioning between species. The same number of pairs of A. fumigatus and S. cerevisiae genes chosen at random were used as a control.

2.3. Nucleosome Position Profile. Nucleosome mapping numbers at each genomic position were determined [13] based
Table 3: Genes of *Saccharomyces cerevisiae* with highly conserved nucleosome positions in the promoters of the control and histone modification gene deletion mutants.

| Chromosome | Gene       | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|------------|-----------------------------------------------------------------|-----------------------------------------------------------------|--------------------------|------------------------|
| chr01      | YAL064W-B  | 0.974719955                                                      | 0.965814243                                                      | 12047                    | +                      |
| chr01      | YAL056W    | 0.989801003                                                      | 0.982157328                                                      | 39260                    | +                      |
| chr01      | YAL047C    | 0.950243691                                                      | 0.953129232                                                      | 56858                    | −                      |
| chr01      | YAR019C    | 0.970115162                                                      | 0.960628643                                                      | 175133                   | −                      |
| chr01      | YAR033W    | 0.968807875                                                      | 0.987221166                                                      | 188101                   | +                      |
| chr02      | YBL111C    | 0.995802065                                                      | 0.99455065                                                       | 5009                     | −                      |
| chr02      | YBL108C-A  | 0.959497013                                                      | 0.969965642                                                      | 7733                     | −                      |
| chr02      | YBL101C    | 0.958517125                                                      | 0.991324096                                                      | 28299                    | −                      |
| chr02      | YBL087C    | 0.95719187                                                      | 0.957273203                                                      | 60735                    | −                      |
| chr02      | YBL061C    | 0.984960212                                                      | 0.992728731                                                      | 107408                   | −                      |
| chr02      | YBL060W    | 0.960330289                                                      | 0.99357258                                                       | 107934                   | +                      |
| chr02      | YBL051C    | 0.97653734                                                      | 0.89165943                                                       | 124762                   | −                      |
| chr02      | YBL032W    | 0.956874854                                                      | 0.980366627                                                      | 161087                   | +                      |
| chr02      | YBL005W-B  | 0.950781322                                                      | 0.952679326                                                      | 221333                   | +                      |
| chr02      | YBL005W-A  | 0.950781322                                                      | 0.952679326                                                      | 221333                   | +                      |
| chr02      | YBR023C    | 0.960238499                                                      | 0.992906362                                                      | 287925                   | −                      |
| chr02      | YBR029C    | 0.959231389                                                      | 0.987223773                                                      | 297742                   | −                      |
| chr02      | YBR047W    | 0.964564522                                                      | 0.963289004                                                      | 331831                   | +                      |
| chr02      | YBR060C    | 0.959229871                                                      | 0.974718825                                                      | 362512                   | −                      |
| chr02      | YBR084W    | 0.962172866                                                      | 0.981530879                                                      | 41048                    | +                      |
| chr02      | YBR090C    | 0.967658785                                                      | 0.971792497                                                      | 427052                   | −                      |
| chr02      | YBR091C    | 0.965037862                                                      | 0.98590321                                                      | 427478                   | −                      |
| chr02      | YBR131W    | 0.953323249                                                      | 0.969685452                                                      | 497157                   | +                      |
| chr02      | YBR136W    | 0.963546822                                                      | 0.974854426                                                      | 50662                    | +                      |
| chr02      | YBR173C    | 0.978518391                                                      | 0.961438459                                                      | 582167                   | −                      |
| chr02      | YBR179C    | 0.988489146                                                      | 0.991754907                                                      | 589109                   | −                      |
| chr02      | YBR180W    | 0.987132322                                                      | 0.975974209                                                      | 589736                   | +                      |
| chr02      | YBR204C    | 0.970958946                                                      | 0.978433534                                                      | 633376                   | −                      |
| chr02      | YBR243C    | 0.972253467                                                      | 0.96125065                                                       | 706788                   | −                      |
| chr02      | YBR244W    | 0.974202306                                                      | 0.992702483                                                      | 707523                   | +                      |
| chr02      | YBR249C    | 0.955742682                                                      | 0.976101912                                                      | 717989                   | −                      |
| chr02      | YBR250W    | 0.954149188                                                      | 0.976352348                                                      | 719028                   | +                      |
| chr02      | YBR251W    | 0.96273261                                                      | 0.961120273                                                      | 721385                   | +                      |
| chr02      | YBR258C    | 0.966018999                                                      | 0.955155711                                                      | 730157                   | −                      |
| chr02      | YBR260C    | 0.969346019                                                      | 0.970918059                                                      | 734634                   | −                      |
| chr02      | YBR279W    | 0.956081387                                                      | 0.964625588                                                      | 761253                   | +                      |
| chr02      | YBR290W    | 0.981586823                                                      | 0.967935658                                                      | 782587                   | +                      |
| chr03      | YCI064C    | 0.957150698                                                      | 0.95270514                                                      | 16880                    | −                      |
| chr03      | YCL058W-A  | 0.969895345                                                      | 0.992394829                                                      | 23584                    | +                      |
| chr03      | YCL057C-A  | 0.990886192                                                      | 0.987170576                                                      | 24325                    | −                      |
| chr03      | YCL057W    | 0.963062357                                                      | 0.961804623                                                      | 24768                    | +                      |
| chr03      | YCL038C    | 0.978210537                                                      | 0.957633548                                                      | 56527                    | −                      |
| chr03      | YCL035C    | 0.981360705                                                      | 0.973568151                                                      | 61173                    | −                      |
| chr03      | YCL019W    | 0.953241664                                                      | 0.97868459                                                       | 85102                    | +                      |
| chr03      | YCR026C    | 0.96886665                                                      | 0.97932414                                                      | 166335                   | −                      |
| chr03      | YCR043C    | 0.951764864                                                      | 0.966166673                                                      | 206640                   | −                      |
Table 3: Continued.

| Chromosome | Gene   | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|--------|---------------------------------------------------------------|---------------------------------------------------------------|--------------------------|--------------------------|
| chr03      | YCR053W | 0.989728241                                                  | 0.992623598                                                  | 216693                   | +                        |
| chr03      | YCR087C-A | 0.975398919                                                 | 0.993232435                                                  | 264464                   | −                        |
| chr03      | YCR090C | 0.965637294                                                  | 0.95018878                                                  | 272860                   | −                        |
| chr03      | YCR108C | 0.985803086                                                  | 0.993860549                                                  | 316185                   | −                        |
| chr04      | YDL248W | 0.964701365                                                    | 0.980217326                                                   | 1802                     | +                        |
| chr04      | YDL247W | 0.989681199                                                   | 0.997997741                                                  | 5985                     | +                        |
| chr04      | YDL233W | 0.957672252                                                   | 0.97857489                                                   | 36798                    | +                        |
| chr04      | YDL232W | 0.979592686                                                   | 0.970413477                                                  | 38488                    | +                        |
| chr04      | YDL225W | 0.950053133                                                    | 0.978441348                                                   | 52446                    | +                        |
| chr04      | YDL208W | 0.987264893                                                    | 0.987894794                                                   | 87513                    | +                        |
| chr04      | YDL189W | 0.965185356                                                    | 0.98561241                                                   | 122217                   | +                        |
| chr04      | YDL174C | 0.956215571                                                   | 0.953787348                                                   | 147590                   | −                        |
| chr04      | YDL147W | 0.971758509                                                    | 0.950911485                                                   | 190925                   | +                        |
| chr04      | YDL116W | 0.965936123                                                    | 0.976379579                                                   | 251566                   | +                        |
| chr04      | YDL110C | 0.974238254                                                    | 0.97295169                                                   | 264964                   | −                        |
| chr04      | YDL102W | 0.957786538                                                    | 0.980122821                                                   | 276872                   | +                        |
| chr04      | YDL085W | 0.97887937                                                    | 0.960150217                                                   | 303211                   | +                        |
| chr04      | YDL035C | 0.975573212                                                   | 0.977145228                                                   | 392054                   | −                        |
| chr04      | YDL025C | 0.96134673                                                    | 0.972526893                                                   | 407203                   | −                        |
| chr04      | YDR019C | 0.95260772                                                    | 0.953653877                                                   | 485362                   | −                        |
| chr04      | YDR028C | 0.960937436                                                   | 0.959981321                                                   | 500876                   | −                        |
| chr04      | YDR034C-C | 0.967222636                                               | 0.9814374                                                   | 519353                   | −                        |
| chr04      | YDR034C-D | 0.967222636                                          | 0.981437429                                                   | 519353                   | −                        |
| chr04      | YDR037W | 0.951365292                                                   | 0.956861294                                                   | 525437                   | +                        |
| chr04      | YDR054C | 0.955928802                                                   | 0.982048103                                                   | 563225                   | −                        |
| chr04      | YDR055W | 0.950321012                                                   | 0.952540035                                                   | 563252                   | +                        |
| chr04      | YDR062W | 0.974021833                                                   | 0.967688258                                                   | 576471                   | +                        |
| chr04      | YDR109C | 0.954396163                                                   | 0.952291074                                                   | 675664                   | −                        |
| chr04      | YDR110W | 0.986081905                                                   | 0.974553387                                                   | 676099                   | +                        |
| chr04      | YDR120C | 0.960200845                                                   | 0.969981962                                                   | 693258                   | −                        |
| chr04      | YDR162C | 0.967301741                                                   | 0.984347121                                                   | 781097                   | −                        |
| chr04      | YDR233C | 0.967024058                                                   | 0.967951444                                                   | 930353                   | −                        |
| chr04      | YDR234W | 0.967415159                                                   | 0.980945022                                                   | 931125                   | +                        |
| chr04      | YDR238C | 0.97602642                                                    | 0.973622322                                                   | 940812                   | −                        |
| chr04      | YDR261C-D | 0.984848646                                               | 0.993722663                                                   | 992345                   | −                        |
| chr04      | YDR261C-C | 0.984848646                                          | 0.9937227                                                   | 992345                   | −                        |
| chr04      | YDR262W | 0.990899397                                                   | 0.995915841                                                   | 993130                   | +                        |
| chr04      | YDR270W | 0.951139826                                                   | 0.96263534                                                   | 1005671                   | +                        |
| chr04      | YDR281C | 0.984691329                                                   | 0.959392909                                                   | 102317                   | −                        |
| chr04      | YDR300C | 0.975849644                                                   | 0.971677938                                                   | 1062787                   | −                        |
| chr04      | YDR301W | 0.952923341                                                   | 0.977515222                                                   | 1063348                   | +                        |
| chr04      | YDR307W | 0.951918866                                                   | 0.970033626                                                   | 1075861                   | +                        |
| chr04      | YDR310C | 0.951723931                                                   | 0.969237153                                                   | 1084312                   | −                        |
| chr04      | YDR311W | 0.953685357                                                   | 0.980595738                                                   | 1085062                   | +                        |
| chr04      | YDR317W | 0.98969221                                                    | 0.991598049                                                   | 1102181                   | +                        |
| chr04      | YDR322W | 0.954843272                                                   | 0.97204312                                                   | 1110586                   | +                        |
| chr04      | YDR328C | 0.957421993                                                   | 0.983957835                                                   | 1126013                   | −                        |
| chr04      | YDR334W | 0.953030288                                                   | 0.963155512                                                   | 1135927                   | +                        |
Table 3: Continued.

| Chromosome | Gene   | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|--------|---------------------------------------------------------------|---------------------------------------------------------------|--------------------------|-------------------------|
| chr04      | YDR359C| 0.977489172                                                  | 0.969606029                                                  | 1194877                  | –                       |
| chr04      | YDR363C| 0.985073544                                                  | 0.998926611                                                  | 1206375                  | –                       |
| chr04      | YDR367W| 0.990041805                                                  | 0.994689201                                                  | 1212840                  | +                       |
| chr04      | YDR369C| 0.957655919                                                  | 0.96987305                                                   | 1217572                  | –                       |
| chr04      | YDR379W| 0.962899057                                                  | 0.974939821                                                  | 1230159                  | +                       |
| chr04      | YDR397C| 0.966298918                                                  | 0.975133337                                                  | 1266890                  | –                       |
| chr04      | YDR420W| 0.971217177                                                  | 0.991886941                                                  | 1306259                  | +                       |
| chr04      | YDR424C| 0.966881808                                                  | 0.989813233                                                  | 1319833                  | –                       |
| chr04      | YDR432W| 0.955728738                                                  | 0.98217178                                                   | 1328775                  | +                       |
| chr04      | YDR438W| 0.971626925                                                  | 0.98904082                                                   | 1338266                  | +                       |
| chr04      | YDR444W| 0.973566433                                                  | 0.97602447                                                   | 1350282                  | +                       |
| chr04      | YDR453C| 0.952661492                                                  | 0.954481014                                                  | 1365654                  | –                       |
| chr04      | YDR476C| 0.969940159                                                  | 0.964679279                                                  | 1411119                  | –                       |
| chr04      | YDR477W| 0.954743343                                                  | 0.979243738                                                  | 1412365                  | +                       |
| chr04      | YDR479C| 0.977460825                                                  | 0.994501786                                                  | 1416866                  | –                       |
| chr05      | YER004W| 0.968131913                                                  | 0.977435534                                                  | 13720                    | +                       |
| chr05      | YER026C| 0.964952897                                                  | 0.993875293                                                  | 208473                   | –                       |
| chr05      | YER076C| 0.965398244                                                  | 0.971982059                                                  | 313494                   | –                       |
| chr05      | YER083C| 0.953185048                                                  | 0.981521771                                                  | 327027                   | –                       |
| chr05      | YER094C| 0.976027049                                                  | 0.98595427                                                   | 349342                   | –                       |
| chr05      | YER095W| 0.963423619                                                  | 0.988752501                                                  | 349976                   | +                       |
| chr05      | YER107C| 0.982024941                                                  | 0.98488468                                                   | 374541                   | –                       |
| chr05      | YER109C| 0.969371754                                                  | 0.986034001                                                  | 377610                   | –                       |
| chr05      | YER173W| 0.960496827                                                  | 0.952930419                                                  | 536295                   | +                       |
| chr05      | YER188C-A| 0.991489293                                                  | 0.99638184                                                   | 569902                   | –                       |
| chr05      | YER189W| 0.997057108                                                  | 0.998333831                                                  | 571150                   | +                       |
| chr06      | YFL066C| 0.970012372                                                  | 0.993098415                                                  | 2615                     | –                       |
| chr06      | YFL065C| 0.957034943                                                  | 0.97004682                                                   | 3338                     | –                       |
| chr06      | YFL060C| 0.987757312                                                  | 0.995138274                                                  | 10969                    | –                       |
| chr06      | YFL059W| 0.976205235                                                  | 0.962195117                                                  | 11363                    | +                       |
| chr06      | YFL058W| 0.9750941                                                  | 0.994474768                                                  | 12929                    | +                       |
| chr06      | YFL028C| 0.966244522                                                  | 0.959308346                                                  | 80211                    | –                       |
| chr06      | YFL026W| 0.957755207                                                  | 0.952711873                                                  | 82578                    | +                       |
| chr06      | YFR009W| 0.979200258                                                  | 0.985703835                                                  | 162482                   | +                       |
| chr06      | YFR013W| 0.972958971                                                  | 0.986214291                                                  | 169914                   | +                       |
| chr06      | YFR037C| 0.965415915                                                  | 0.972070667                                                  | 229173                   | –                       |
| chr07      | YGL255W| 0.961366208                                                  | 0.972062316                                                  | 20978                    | +                       |
| chr07      | YGL248W| 0.971369747                                                  | 0.97156841                                                   | 35653                    | +                       |
| chr07      | YGL223C| 0.956215218                                                  | 0.984994924                                                   | 80364                    | –                       |
| chr07      | YGL215W| 0.965861339                                                  | 0.95181154                                                  | 87980                    | +                       |
| chr07      | YGL201C| 0.954296336                                                  | 0.979120204                                                  | 120911                   | –                       |
Table 3: Continued.

| Chromosome | Gene     | Correlation coefficient between the control and the \( ELP3 \) deletion | Correlation coefficient between the control and the \( HOS2 \) deletion | Translational start site | Transcription direction |
|------------|----------|-------------------------------------------------|-------------------------------------------------|-------------------------|------------------------|
| chr07      | YGL180W  | 0.982084299                                     | 0.994334205                                     | 160071                  | +                       |
| chr07      | YGL171W  | 0.969321982                                     | 0.974163208                                     | 182396                  | +                       |
| chr07      | YGL163C  | 0.975825825                                     | 0.968348392                                     | 196409                  | −                       |
| chr07      | YGL138C  | 0.971247145                                     | 0.983410766                                     | 249536                  | −                       |
| chr07      | YGL120C  | 0.981452639                                     | 0.964320425                                     | 283943                  | −                       |
| chr07      | YGL119W  | 0.986610225                                     | 0.98152372                                       | 284448                  | +                       |
| chr07      | YGL108C  | 0.961840326                                     | 0.985939242                                     | 304074                  | −                       |
| chr07      | YGL058W  | 0.977732494                                     | 0.975176081                                     | 393992                  | +                       |
| chr07      | YGL056C  | 0.960426378                                     | 0.969119302                                     | 397624                  | −                       |
| chr08      | YGR001C  | 0.958621356                                     | 0.990717019                                     | 498038                  | −                       |
| chr07      | YGR006W  | 0.980877392                                     | 0.97721459                                     | 506074                  | +                       |
| chr07      | YGR027W-B| 0.973589999                                     | 0.969942324                                     | 536061                  | +                       |
| chr07      | YGR027W-A| 0.973589999                                     | 0.969942324                                     | 536061                  | +                       |
| chr07      | YGR054W  | 0.964434273                                     | 0.980689617                                     | 596697                  | +                       |
| chr07      | YGR076C  | 0.981588154                                     | 0.958402031                                     | 637581                  | −                       |
| chr07      | YGR082W  | 0.986433799                                     | 0.977608093                                     | 644048                  | +                       |
| chr07      | YGR084C  | 0.952879595                                     | 0.959716787                                     | 648146                  | −                       |
| chr07      | YGR109C  | 0.967037071                                     | 0.989224447                                     | 706505                  | −                       |
| chr07      | YGR109W-B| 0.964433838                                     | 0.990506548                                     | 707614                  | +                       |
| chr07      | YGR109W-A| 0.964433838                                     | 0.990506548                                     | 707614                  | +                       |
| chr07      | YGR149W  | 0.957244122                                     | 0.960107682                                     | 789036                  | +                       |
| chr07      | YGR161W-B| 0.958455297                                     | 0.972873884                                     | 811743                  | +                       |
| chr07      | YGR161W-A| 0.958455297                                     | 0.9728739                                       | 811743                  | +                       |
| chr07      | YGR161C-D| 0.9711882                                       | 0.974318881                                     | 823020                  | −                       |
| chr07      | YGR161C-C| 0.9711882                                       | 0.9743189                                       | 823020                  | −                       |
| chr07      | YGR162W  | 0.967152562                                     | 0.972476532                                     | 824064                  | +                       |
| chr07      | YGR165W  | 0.959886658                                     | 0.951709091                                     | 829121                  | +                       |
| chr07      | YGR166W  | 0.978481923                                     | 0.950610672                                     | 830520                  | +                       |
| chr07      | YGR173W  | 0.978946749                                     | 0.974220242                                     | 843859                  | +                       |
| chr07      | YGR178C  | 0.97338186                                     | 0.951056442                                     | 853220                  | −                       |
| chr07      | YGR193C  | 0.977703185                                     | 0.9816188                                       | 885746                  | −                       |
| chr07      | YGR198W  | 0.954889766                                     | 0.972754857                                     | 894698                  | +                       |
| chr07      | YGR239C  | 0.968883325                                     | 0.989258725                                     | 970058                  | −                       |
| chr07      | YGR240C  | 0.966313371                                     | 0.971843468                                     | 973739                  | −                       |
| chr07      | YGR255C  | 0.966583058                                     | 0.991666026                                     | 1003967                 | −                       |
| chr07      | YGR267C  | 0.960278778                                     | 0.969707488                                     | 1025741                 | −                       |
| chr07      | YGR280C  | 0.961084505                                     | 0.952670993                                     | 1051732                 | −                       |
| chr07      | YGR295C  | 0.967286944                                     | 0.964457386                                     | 1082736                 | −                       |
| chr07      | YGR296W  | 0.971310914                                     | 0.991185295                                     | 1084871                 | +                       |
| chr08      | YHL044W  | 0.958725508                                     | 0.965538017                                     | 13563                   | +                       |
| chr08      | YHL029C  | 0.988947037                                     | 0.966700586                                     | 47966                   | −                       |
| chr08      | YHL028W  | 0.983034685                                     | 0.977043411                                     | 48761                   | +                       |
| chr08      | YHL024W  | 0.961645582                                     | 0.966633627                                     | 56647                   | +                       |
| Chromosome | Gene       | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|------------|----------------------------------------------------------------|-----------------------------------------------------------------|--------------------------|-------------------------|
| chr08      | YHL020C    | 0.978013871                                                      | 0.986901259                                                      | 67453                    | −                       |
| chr08      | YHL016C    | 0.976082816                                                      | 0.988408432                                                      | 74241                    | −                       |
| chr08      | YHL007C    | 0.973847748                                                      | 0.981293306                                                      | 97933                    | −                       |
| chr08      | YHL004W    | 0.97418766                                                       | 0.993677693                                                      | 99215                    | +                       |
| chr08      | YHL001W    | 0.959021584                                                     | 0.965334128                                                      | 104272                   | +                       |
| chr08      | YHR001W-A  | 0.991644256                                                      | 0.988918444                                                      | 107821                   | +                       |
| chr08      | YHR056C    | 0.972836967                                                      | 0.982728846                                                      | 217836                   | −                       |
| chr08      | YHR081W    | 0.961720079                                                      | 0.960688905                                                      | 267540                   | +                       |
| chr08      | YHR091C    | 0.955695121                                                      | 0.987437891                                                      | 28672                    | −                       |
| chr08      | YHR101C    | 0.984820398                                                      | 0.996893941                                                      | 315971                   | −                       |
| chr08      | YHR102W    | 0.96127201                                                      | 0.995534701                                                      | 316575                   | +                       |
| chr08      | YHR107C    | 0.950250496                                                      | 0.982165489                                                      | 328039                   | −                       |
| chr08      | YHR118C    | 0.973725305                                                      | 0.961118169                                                      | 34563                    | −                       |
| chr08      | YHR127W    | 0.950141044                                                     | 0.981438554                                                      | 360916                   | +                       |
| chr08      | YHR136C    | 0.953476026                                                      | 0.965665058                                                      | 375103                   | −                       |
| chr08      | YHR148W    | 0.978585198                                                      | 0.950179497                                                      | 39537                    | +                       |
| chr08      | YHR153C    | 0.959414518                                                      | 0.982780385                                                      | 402685                   | −                       |
| chr08      | YHR165C    | 0.958747068                                                      | 0.984253541                                                      | 436950                   | −                       |
| chr08      | YHR214C-D  | 0.987951207                                                      | 0.96688891                                                      | 550941                   | −                       |
| chr08      | YHR215W    | 0.987951207                                                      | 0.96688891                                                      | 552099                   | +                       |
| chr08      | YHR216W    | 0.972948554                                                      | 0.975124764                                                      | 554396                   | +                       |
| chr09      | YIL158W    | 0.961579117                                                      | 0.957386446                                                      | 46201                    | +                       |
| chr09      | YIL154C    | 0.954401073                                                      | 0.971892535                                                      | 50021                    | −                       |
| chr09      | YIL137C    | 0.976010283                                                      | 0.976810775                                                      | 92788                    | −                       |
| chr09      | YIL135C    | 0.976089791                                                      | 0.979613921                                                      | 96375                    | −                       |
| chr09      | YIL134W    | 0.974541094                                                      | 0.979148771                                                      | 97395                    | −                       |
| chr09      | YIL129C    | 0.958227819                                                      | 0.99048832                                                      | 113237                   | −                       |
| chr09      | YIL123W    | 0.963070211                                                      | 0.960333013                                                      | 122689                   | +                       |
| chr09      | YIL063C    | 0.970956253                                                      | 0.957414461                                                      | 243741                   | −                       |
| chr09      | YIL061C    | 0.95394965                                                      | 0.989156182                                                      | 245556                   | −                       |
| chr09      | YIL046W    | 0.967209958                                                      | 0.952996831                                                      | 268650                   | +                       |
| chr09      | YIL033C    | 0.989017477                                                      | 0.989306501                                                      | 291668                   | −                       |
| chr09      | YIL031W    | 0.985799922                                                      | 0.98683422                                                      | 292632                   | +                       |
| chr09      | YIL030C    | 0.957494018                                                      | 0.97109633                                                      | 300008                   | −                       |
| chr09      | YIR022W    | 0.960636707                                                      | 0.971998311                                                      | 398730                   | +                       |
| chr09      | YIR024C    | 0.961569219                                                      | 0.970038905                                                      | 403488                   | −                       |
| chr09      | YIR038C    | 0.973108358                                                      | 0.975735046                                                      | 424510                   | −                       |
| chr10      | YJL221C    | 0.992889333                                                      | 0.995409763                                                      | 18536                    | −                       |
| chr10      | YJL219W    | 0.992889333                                                      | 0.995409763                                                      | 19497                    | +                       |
| chr10      | YJL197W    | 0.963017116                                                      | 0.967339021                                                      | 63804                    | +                       |
| chr10      | YJL181W    | 0.971567753                                                      | 0.971225117                                                      | 85658                    | +                       |
| chr10      | YJL176C    | 0.979890865                                                      | 0.967535459                                                      | 94528                    | −                       |
| chr10      | YJL174W    | 0.98347082                                                      | 0.9822043                                                      | 95090                    | +                       |
| chr10      | YJL173C    | 0.986867668                                                      | 0.989398406                                                      | 96527                    | −                       |
| chr10      | YJL151C    | 0.952976229                                                      | 0.987631587                                                      | 136770                   | −                       |
| chr10      | YJL149W    | 0.975756648                                                      | 0.990848833                                                      | 137376                   | +                       |
| chr10      | YJL118W    | 0.953268112                                                      | 0.959468203                                                      | 191638                   | +                       |
| chr10      | YJL113W    | 0.982940363                                                      | 0.963188993                                                      | 197913                   | +                       |
| Chromosome | Gene       | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|------------|---------------------------------------------------------------|---------------------------------------------------------------|--------------------------|------------------------|
| chr10      | YJL114W    | 0.982940363                                                  | 0.963188993                                                   | 197913                   | +                      |
| chr10      | YJL093C    | 0.967675882                                                  | 0.964352732                                                   | 256807                   | −                      |
| chr10      | YJL092W    | 0.963240719                                                  | 0.958166876                                                   | 257418                   | +                      |
| chr10      | YJL066C    | 0.953982678                                                  | 0.974252054                                                   | 314867                   | −                      |
| chr10      | YJL050W    | 0.950677364                                                  | 0.95235067                                                   | 342517                   | +                      |
| chr10      | YJL048C    | 0.96132641                                                  | 0.958967756                                                   | 348632                   | −                      |
| chr10      | YJL039C    | 0.950918953                                                  | 0.970567445                                                   | 373794                   | −                      |
| chr10      | YJL034W    | 0.963347804                                                  | 0.980266739                                                   | 381322                   | +                      |
| chr10      | YJR010W    | 0.97167854                                                  | 0.97428271                                                   | 456232                   | +                      |
| chr10      | YJR021C    | 0.956762721                                                  | 0.994264722                                                   | 469572                   | −                      |
| chr10      | YJR029W    | 0.958070547                                                  | 0.9742799                                                    | 478337                   | +                      |
| chr10      | YJR028W    | 0.958070547                                                  | 0.9742799                                                    | 478337                   | +                      |
| chr10      | YJR041C    | 0.976618081                                                  | 0.981063923                                                   | 513756                   | −                      |
| chr10      | YJR048W    | 0.960606245                                                  | 0.97505837                                                   | 526328                   | +                      |
| chr10      | YJR049C    | 0.954983464                                                  | 0.986149168                                                   | 528469                   | −                      |
| chr11      | YJL114W    | 0.950933251                                                  | 0.978937364                                                   | 81040                    | +                      |
| chr11      | YK1179C    | 0.975704733                                                  | 0.967918905                                                   | 112508                   | −                      |
| chr11      | YK167C     | 0.956085616                                                  | 0.955561088                                                   | 134139                   | −                      |
| chr11      | YK165C     | 0.960609423                                                  | 0.96621061                                                   | 140966                   | −                      |
| chr11      | YK157W     | 0.95635277                                                  | 0.9813363                                                   | 154996                   | +                      |
| chr11      | YK127W     | 0.955985661                                                  | 0.982208081                                                   | 203185                   | +                      |
| chr11      | YK125W     | 0.976449752                                                  | 0.96074911                                                   | 207891                   | +                      |
| chr11      | YK113C     | 0.971544612                                                  | 0.954413703                                                   | 225519                   | −                      |
| chr11      | YK1065C    | 0.96005541                                                  | 0.969818928                                                   | 316701                   | −                      |
| chr11      | YK1064W    | 0.974644257                                                  | 0.972632809                                                   | 317408                   | +                      |
| chr11      | YK1059C    | 0.957153957                                                  | 0.961241915                                                   | 329087                   | −                      |
| chr11      | YK1020C    | 0.953860253                                                  | 0.977812511                                                   | 401723                   | −                      |
| chr11      | YK1013C    | 0.972958978                                                  | 0.953446409                                                   | 417666                   | −                      |
| chr11      | YKR007W    | 0.98138104                                                  | 0.97227081                                                   | 451077                   | +                      |
| chr11      | YKR024C    | 0.971944038                                                  | 0.981215773                                                   | 487015                   | −                      |
| chr11      | YKR031C    | 0.952123552                                                  | 0.969614994                                                   | 506037                   | −                      |
| chr11      | YKR036C    | 0.959340192                                                  | 0.988104612                                                   | 510275                   | −                      |
| chr11      | YKR041W    | 0.982786597                                                  | 0.957524998                                                   | 517840                   | +                      |
| chr11      | YKR052C    | 0.954392373                                                  | 0.96688713                                                   | 533106                   | −                      |
| chr11      | YKR082W    | 0.962931616                                                  | 0.991018501                                                   | 592467                   | +                      |
| chr11      | YKR084C    | 0.953228662                                                  | 0.976903834                                                   | 598532                   | −                      |
| chr11      | YKR086W    | 0.952006608                                                  | 0.97653657                                                   | 599499                   | +                      |
| chr12      | YLL050C    | 0.976179673                                                  | 0.990695339                                                   | 40413                    | −                      |
| chr12      | YLL002W    | 0.972688874                                                  | 0.981122544                                                   | 146290                   | +                      |
| chr12      | YLR001C    | 0.966206724                                                  | 0.98012374                                                   | 153976                   | −                      |
Table 3: Continued.

| Chromosome | Gene        | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|-------------|---------------------------------------------------------------|---------------------------------------------------------------|--------------------------|--------------------------|
| chr12      | YLR012C     | 0.956516633                                                  | 0.962463803                                                  | 170280                   | −                        |
| chr12      | YLR013W     | 0.978873849                                                  | 0.985557204                                                  | 171338                   | +                        |
| chr12      | YLR024C     | 0.953442868                                                  | 0.956160837                                                  | 193282                   | −                        |
| chr12      | YLR025W     | 0.971468039                                                  | 0.96202948                                                  | 194453                   | +                        |
| chr12      | YLR029C     | 0.961637928                                                  | 0.991619508                                                  | 202591                   | −                        |
| chr12      | YLR059C     | 0.963450626                                                  | 0.974770886                                                  | 260548                   | −                        |
| chr12      | YLR085C     | 0.9560163                                                    | 0.990085627                                                  | 315732                   | −                        |
| chr12      | YLR087C     | 0.977966477                                                  | 0.97421157                                                  | 346586                   | +                        |
| chr12      | YLR104W     | 0.966174553                                                  | 0.97921157                                                  | 404846                   | +                        |
| chr12      | YLR133W     | 0.97560494                                                  | 0.977991425                                                  | 413282                   | +                        |
| chr12      | YLR137W     | 0.96714193                                                  | 0.98356278                                                  | 417007                   | +                        |
| chr12      | YLR162W-A   | 0.968123219                                                  | 0.962766706                                                  | 490407                   | +                        |
| chr12      | YLR208W     | 0.96802684                                                  | 0.969296393                                                  | 559553                   | +                        |
| chr12      | YLR223C     | 0.96783973                                                  | 0.97489936                                                  | 585942                   | −                        |
| chr12      | YLR224W     | 0.974582795                                                  | 0.978003757                                                  | 586466                   | +                        |
| chr12      | YLR286C     | 0.972231318                                                  | 0.978358686                                                  | 710138                   | −                        |
| chr12      | YLR299W     | 0.962625418                                                  | 0.970226227                                                  | 726071                   | +                        |
| chr12      | YLR307W     | 0.962710223                                                  | 0.990591743                                                  | 745622                   | +                        |
| chr12      | YLR323C     | 0.953205594                                                  | 0.975247431                                                  | 778952                   | −                        |
| chr12      | YLR326W     | 0.97969576                                                  | 0.991583861                                                  | 782174                   | +                        |
| chr12      | YLR355C     | 0.967858474                                                  | 0.973834311                                                  | 839252                   | −                        |
| chr12      | YLR356W     | 0.968277882                                                  | 0.974767083                                                  | 840320                   | +                        |
| chr12      | YLR378C     | 0.974122358                                                  | 0.97246394                                                  | 87177                    | −                        |
| chr12      | YLR380W     | 0.973258508                                                  | 0.97821865                                                  | 887282                   | +                        |
| chr12      | YLR410W-A   | 0.951545011                                                  | 0.9529714                                                   | 944148                   | +                        |
| chr12      | YLR410W-B   | 0.951545011                                                  | 0.9529714                                                   | 944148                   | +                        |
| chr12      | YLR426W     | 0.9668981                                                    | 0.993017101                                                  | 987059                   | +                        |
| chr12      | YLR427W     | 0.968631588                                                  | 0.972538491                                                  | 988425                   | +                        |
| chr12      | YLR429W     | 0.950464544                                                  | 0.951528134                                                  | 990774                   | +                        |
| chr12      | YLR443W     | 0.964525656                                                  | 0.991440098                                                  | 1022622                  | +                        |
| chr13      | YML121W     | 0.974659011                                                  | 0.987969584                                                  | 26930                    | +                        |
| chr13      | YML115C     | 0.97337994                                                  | 0.990603492                                                  | 41794                    | −                        |
| chr13      | YML080W     | 0.989320306                                                  | 0.988318735                                                  | 108806                   | +                        |
| chr13      | YML078W     | 0.975873108                                                  | 0.974136336                                                  | 111002                   | +                        |
| chr13      | YML045W     | 0.993016416                                                  | 0.993250991                                                  | 184461                   | +                        |
| chr13      | YML045W-A   | 0.993016416                                                  | 0.993251                                                     | 184461                   | +                        |
| chr13      | YML041C     | 0.969801821                                                  | 0.979224272                                                  | 195735                   | −                        |
| chr13      | YML020W     | 0.975260683                                                  | 0.95439232                                                  | 231149                   | +                        |
| chr13      | YML004C     | 0.966616377                                                  | 0.98388072                                                  | 262685                   | −                        |
| chr13      | YML003W     | 0.968338912                                                  | 0.981828638                                                  | 263483                   | +                        |
| chr13      | YMR010W     | 0.985774326                                                  | 0.979191015                                                  | 285099                   | +                        |
| chr13      | YMR011W     | 0.983732981                                                  | 0.98128367                                                  | 288078                   | +                        |
| chr13      | YMR027W     | 0.961041993                                                  | 0.957831173                                                  | 325876                   | +                        |
| chr13      | YMR036C     | 0.969260192                                                  | 0.963784402                                                  | 343519                   | −                        |
| chr13      | YMR060C     | 0.990018805                                                  | 0.990517987                                                  | 392514                   | −                        |
| chr13      | YMR066W     | 0.98321165                                                  | 0.95995151                                                  | 401540                   | +                        |
| Chromosome | Gene    | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|---------|---------------------------------------------------------------|---------------------------------------------------------------|--------------------------|-------------------------|
| chr13      | YMR078C | 0.969392941                                                  | 0.976546196                                                  | 424727                   | –                       |
| chr13      | YMR081C | 0.981254312                                                  | 0.956294421                                                  | 431094                   | –                       |
| chr13      | YMR110C | 0.96142621                                                  | 0.983151943                                                  | 491991                   | –                       |
| chr13      | YMR116C | 0.977129849                                                  | 0.989254306                                                  | 500687                   | –                       |
| chr13      | YMR137C | 0.971971845                                                  | 0.978526214                                                  | 544962                   | –                       |
| chr13      | YMR138W | 0.978634859                                                  | 0.963623922                                                  | 545154                   | +                       |
| chr13      | YMR152W | 0.958913422                                                  | 0.961601086                                                  | 563095                   | +                       |
| chr13      | YMR197C | 0.960464224                                                  | 0.981756931                                                  | 659197                   | –                       |
| chr13      | YMR210W | 0.974579381                                                  | 0.983178959                                                  | 687515                   | +                       |
| chr13      | YMR214W | 0.977906077                                                  | 0.98639434                                                  | 695349                   | +                       |
| chr13      | YMR219W | 0.964555974                                                  | 0.962486321                                                  | 707132                   | +                       |
| chr13      | YMR224C | 0.975063127                                                  | 0.95620617                                                  | 720652                   | –                       |
| chr13      | YMR229C | 0.96014554                                                   | 0.957025636                                                  | 731122                   | –                       |
| chr13      | YMR241W | 0.956225901                                                  | 0.967912184                                                  | 751960                   | +                       |
| chr13      | YMR319C | 0.950340769                                                  | 0.968043162                                                  | 914536                   | –                       |
| chr14      | YNL339C | 0.975221324                                                  | 0.997373072                                                  | 6098                     | –                       |
| chr14      | YNL344C | 0.968865734                                                  | 0.991228175                                                  | 12876                    | –                       |
| chr14      | YNL322C | 0.954706246                                                  | 0.977992903                                                  | 34234                    | –                       |
| chr14      | YNL311C | 0.986814003                                                  | 0.993782307                                                  | 51687                    | –                       |
| chr14      | YNL310C | 0.956852702                                                  | 0.980516471                                                  | 52430                    | –                       |
| chr14      | YNL309W | 0.988062215                                                  | 0.993825499                                                  | 52661                    | +                       |
| chr14      | YNL301C | 0.968107997                                                  | 0.966680876                                                  | 64562                    | –                       |
| chr14      | YNL295W | 0.952849161                                                  | 0.964836983                                                  | 76946                    | +                       |
| chr14      | YNL261W | 0.950477134                                                  | 0.976226949                                                  | 155101                   | +                       |
| chr14      | YNL260C | 0.96893453                                                   | 0.96562883                                                   | 157456                   | –                       |
| chr14      | YNL255C | 0.95918743                                                   | 0.961868386                                                  | 167791                   | –                       |
| chr14      | YNL248C | 0.959305496                                                  | 0.962132738                                                  | 182609                   | –                       |
| chr14      | YNL241C | 0.952591706                                                  | 0.968306617                                                  | 197944                   | –                       |
| chr14      | YNL234W | 0.975005906                                                  | 0.964281927                                                  | 210234                   | +                       |
| chr14      | YNL224C | 0.973438019                                                  | 0.985601741                                                  | 227100                   | –                       |
| chr14      | YNL212W | 0.967303893                                                  | 0.964441355                                                  | 247462                   | +                       |
| chr14      | YNL166C | 0.973079673                                                  | 0.979903307                                                  | 323567                   | –                       |
| chr14      | YNL156C | 0.961076874                                                  | 0.96913283                                                  | 341970                   | –                       |
| chr14      | YNL112W | 0.953769466                                                  | 0.987266001                                                  | 413641                   | +                       |
| chr14      | YNL099C | 0.959678116                                                  | 0.95727388                                                  | 439285                   | –                       |
| chr14      | YNL097C | 0.978605808                                                  | 0.98440434                                                  | 442360                   | –                       |
| chr14      | YNL082W | 0.955790378                                                  | 0.980457797                                                  | 437392                   | +                       |
| chr14      | YNL055C | 0.982685169                                                  | 0.981068004                                                  | 518846                   | –                       |
| chr14      | YNL042W-B| 0.956836355                                                  | 0.979900708                                                  | 547114                   | +                       |
| chr14      | YNL029C | 0.976101029                                                  | 0.988675718                                                  | 578774                   | –                       |
| chr14      | YNL027W | 0.96462873                                                  | 0.978413199                                                  | 579581                   | +                       |
| chr14      | YNR012W | 0.958403399                                                  | 0.977490746                                                  | 647434                   | +                       |
| chr14      | YNR015W | 0.967843094                                                  | 0.979265652                                                  | 653389                   | +                       |
| chr14      | YNR023W | 0.975180387                                                  | 0.972628935                                                  | 670420                   | +                       |
| chr14      | YNR026C | 0.966267575                                                  | 0.984095961                                                  | 674691                   | –                       |
| chr14      | YNR036C | 0.955455936                                                  | 0.956914254                                                  | 694824                   | –                       |
| chr14      | YNR039C | 0.97056523                                                   | 0.9708253                                                    | 699433                   | –                       |
| chr14      | YNR075W | 0.950188074                                                  | 0.953766447                                                  | 779916                   | +                       |
| Chromosome | Gene      | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|-----------|----------------------------------------------------------------|----------------------------------------------------------------|--------------------------|-------------------------|
| chr14      | YNR075C-A | 0.986389631                                                       | 0.991000914                                                       | 781603                   | –                       |
| chr15      | YOL166W-A | 0.969218719                                                       | 0.964760148                                                       | 585                      | +                       |
| chr15      | YOL157C   | 0.977029388                                                       | 0.9845557                                                        | 24293                    | –                       |
| chr15      | YOL156W   | 0.979765672                                                       | 0.992685071                                                       | 25272                    | +                       |
| chr15      | YOL148C   | 0.957761501                                                       | 0.971157209                                                       | 47573                    | –                       |
| chr15      | YOL104C   | 0.976917372                                                       | 0.981386975                                                       | 117454                   | –                       |
| chr15      | YOL100W   | 0.961328138                                                       | 0.959394148                                                       | 129237                   | +                       |
| chr15      | YOL089C   | 0.971692903                                                       | 0.98460678                                                        | 153490                   | –                       |
| chr15      | YOL086C   | 0.976082094                                                       | 0.96682518                                                        | 160594                   | –                       |
| chr15      | YOL077C   | 0.956963602                                                       | 0.983941333                                                       | 186723                   | –                       |
| chr15      | YOL068C   | 0.959180595                                                       | 0.953847172                                                       | 201879                   | –                       |
| chr15      | YOL062C   | 0.954102242                                                       | 0.967526899                                                       | 211995                   | –                       |
| chr15      | YOL058W   | 0.969401099                                                       | 0.978364009                                                       | 219210                   | +                       |
| chr15      | YOL045W   | 0.966108727                                                       | 0.955785397                                                       | 243496                   | +                       |
| chr15      | YOL031C   | 0.971563515                                                       | 0.959211572                                                       | 267530                   | –                       |
| chr15      | YOL026C   | 0.954115513                                                       | 0.976281121                                                       | 274354                   | –                       |
| chr15      | YOL023W   | 0.960879668                                                       | 0.960550998                                                       | 278057                   | +                       |
| chr15      | YOL006C   | 0.971249281                                                       | 0.978082289                                                       | 315388                   | –                       |
| chr15      | YOR043W   | 0.970409112                                                       | 0.977199399                                                       | 410870                   | +                       |
| chr15      | YOR048C   | 0.952405355                                                       | 0.972598244                                                       | 421651                   | –                       |
| chr15      | YOR056C   | 0.95552512                                                        | 0.980351823                                                       | 431628                   | –                       |
| chr15      | YOR058C   | 0.977288174                                                       | 0.978577416                                                       | 436347                   | –                       |
| chr15      | YOR071C   | 0.980341941                                                       | 0.989920087                                                       | 461278                   | –                       |
| chr15      | YOR075W   | 0.983591979                                                       | 0.981471486                                                       | 468214                   | +                       |
| chr15      | YOR089C   | 0.978934603                                                       | 0.984660665                                                       | 490830                   | –                       |
| chr15      | YOR104W   | 0.965107091                                                       | 0.973591736                                                       | 517643                   | +                       |
| chr15      | YOR124C   | 0.97179062                                                        | 0.983946384                                                       | 558643                   | –                       |
| chr15      | YOR129C   | 0.979558976                                                       | 0.983142651                                                       | 569559                   | –                       |
| chr15      | YOR132W   | 0.955282168                                                       | 0.96555781                                                       | 573176                   | +                       |
| chr15      | YOR148C   | 0.987044445                                                       | 0.98569999                                                        | 609198                   | –                       |
| chr15      | YOR192C-C | 0.980704362                                                       | 0.966062169                                                       | 704225                   | –                       |
| chr15      | YOR193W   | 0.973179583                                                       | 0.992657727                                                       | 710447                   | +                       |
| chr15      | YOR204W   | 0.985619071                                                       | 0.960639074                                                       | 722912                   | +                       |
| chr15      | YOR216C   | 0.971045967                                                       | 0.970515948                                                       | 748980                   | –                       |
| chr15      | YOR247W   | 0.959363754                                                       | 0.952710052                                                       | 797677                   | +                       |
| chr15      | YOR294W   | 0.972999786                                                       | 0.97236413                                                       | 868339                   | +                       |
| chr15      | YOR336W   | 0.973501735                                                       | 0.969442343                                                       | 949770                   | +                       |
| chr15      | YOR365C   | 0.981766719                                                       | 0.98630012                                                       | 1025570                  | –                       |
| chr15      | YOR372C   | 0.95936893                                                       | 0.971693401                                                       | 1036469                  | –                       |
| chr15      | YOR389W   | 0.964833697                                                       | 0.976852438                                                       | 1074211                  | +                       |
| chr15      | YOR390W   | 0.98673199                                                       | 0.997343789                                                       | 1067682                  | +                       |
| chr15      | YOR391C   | 0.952090431                                                       | 0.990889663                                                       | 1079256                  | –                       |
| chr15      | YOR393W   | 0.952090431                                                       | 0.990889663                                                       | 1080274                  | +                       |
| chr16      | YPL283C   | 0.990485958                                                       | 0.9953985                                                        | 6007                     | –                       |
| chr16      | YPL281C   | 0.961921468                                                       | 0.977623026                                                       | 10870                    | –                       |
| chr16      | YPL280W   | 0.961921468                                                       | 0.977623026                                                       | 11887                    | +                       |
| chr16      | YPL278C   | 0.965633274                                                       | 0.959753752                                                       | 15355                    | –                       |
| chr16      | YPL257W-B | 0.976897418                                                       | 0.976806903                                                       | 56748                    | +                       |
Table 3: Continued.

| Chromosome | Gene               | Correlation coefficient between the control and the ELP3 deletion | Correlation coefficient between the control and the HOS2 deletion | Translational start site | Transcription direction |
|------------|--------------------|---------------------------------------------------------------|---------------------------------------------------------------|-------------------------|-------------------------|
| chr16      | YPL257W-A          | 0.976897148                                                   | 0.976807                                                     | 56748                   | +                       |
| chr16      | YPL253W            | 0.96664841                                                   | 0.970267728                                                  | 67725                   | +                       |
| chr16      | YPL254W            | 0.95123182                                                   | 0.962107221                                                  | 69485                   | +                       |
| chr16      | YPL206C            | 0.975807996                                                  | 0.972912432                                                  | 163596                  | −                       |
| chr16      | YPL196W            | 0.978338347                                                  | 0.984467392                                                  | 175042                  | +                       |
| chr16      | YPL180W            | 0.97652618                                                  | 0.987674392                                                  | 205247                  | +                       |
| chr16      | YPL171C            | 0.96524809                                                  | 0.961521166                                                  | 227370                  | −                       |
| chr16      | YPL158C            | 0.980225654                                                  | 0.985491741                                                  | 254309                  | −                       |
| chr16      | YPL157W            | 0.98638216                                                  | 0.988124386                                                  | 254813                  | +                       |
| chr16      | YPL146C            | 0.98509812                                                  | 0.956540524                                                  | 277528                  | −                       |
| chr16      | YPL139C            | 0.981115998                                                 | 0.987215069                                                  | 291050                  | −                       |
| chr16      | YPL126W            | 0.988937478                                                  | 0.982334739                                                  | 310209                  | +                       |
| chr16      | YPL082C            | 0.980458525                                                  | 0.992300343                                                  | 404080                  | −                       |
| chr16      | YPL078C            | 0.95476311                                                   | 0.95576197                                                  | 408741                  | −                       |
| chr16      | YPL058W            | 0.953416137                                                  | 0.966495031                                                  | 480352                  | +                       |
| chr16      | YPL030W            | 0.973101156                                                  | 0.97502429                                                  | 495341                  | +                       |
| chr16      | YPL007C            | 0.954338314                                                  | 0.983931954                                                  | 543845                  | −                       |
| chr16      | YPR010C            | 0.983770387                                                  | 0.983449754                                                  | 581193                  | −                       |
| chr16      | YPR017C            | 0.986325514                                                  | 0.989002388                                                  | 593914                  | −                       |
| chr16      | YPR018W            | 0.981145288                                                  | 0.96510122                                                  | 594473                  | +                       |
| chr16      | YPR020W            | 0.950323294                                                  | 0.983815562                                                  | 599867                  | +                       |
| chr16      | YPR048W            | 0.980910651                                                  | 0.976100682                                                  | 659179                  | +                       |
| chr16      | YPR060C            | 0.960902075                                                  | 0.969265445                                                  | 675628                  | −                       |
| chr16      | YPR062W            | 0.96911875                                                  | 0.967204709                                                  | 677162                  | +                       |
| chr16      | YPR088C            | 0.975671837                                                  | 0.976321629                                                  | 713026                  | −                       |
| chr16      | YPR141C            | 0.978516693                                                  | 0.973377917                                                  | 817919                  | −                       |
| chr16      | YPR145C-A          | 0.961127516                                                  | 0.965220022                                                  | 824929                  | −                       |
| chr16      | YPR156C            | 0.966866802                                                  | 0.956230015                                                  | 839773                  | −                       |
| chr16      | YPR158C-D          | 0.981640164                                                  | 0.971311933                                                  | 856253                  | −                       |
| chr16      | YPR158C-C          | 0.981640164                                                  | 0.971311933                                                  | 856253                  | −                       |
| chr16      | YPR161C            | 0.99622155                                                  | 0.984283791                                                  | 86418                  | −                       |
| chr16      | YPR165W            | 0.959239007                                                  | 0.967323233                                                  | 875364                  | +                       |
| chr16      | YPR176C            | 0.986542093                                                  | 0.977514778                                                  | 892074                  | −                       |
| chr16      | YPR187W            | 0.964480751                                                  | 0.98804279                                                  | 911253                  | +                       |
| chr16      | YPR203W            | 0.968955474                                                  | 0.985644074                                                  | 943876                  | +                       |

on genome-wide nucleosome mapping data for *A. fumigatus* [9] and *S. cerevisiae* [10]. In this analysis, a 1-kb region upstream of the translational start site was defined as a gene promoter. When the length of the gene body region is more than 1 kb, a 1-kb region downstream of the translational start site was defined as the gene body. When the length of the gene body is less than 1 kb, the region between the translational start and end sites was defined as the gene body. Analyses of nucleosome position data including calculation of Spearman’s rank correlation coefficient were performed using the statistics software R (http://www.r-project.org/).

3. Results and Discussion

3.1. Nucleosome Position Profiles of Duplicated Genes in *Aspergillus fumigatus*. I compared nucleosome position profiles in each of the 63 duplicated gene pairs. Nucleosome positioning was conserved more in gene promoters than in gene bodies (Figure 1), as observed in the comparison of nucleosome positioning between trichostatin A-treated and -untreated *A. fumigatus* [4]. This result suggests that nucleosome positioning in the gene promoter plays an important role in transcriptional regulation [14].
Table 4: Spearman's rank correlation coefficients between nucleosome position profiles in the promoters of 347 orthologous gene pairs between Aspergillus fumigatus and Saccharomyces cerevisiae.

| S. cerevisiae gene | A. fumigatus gene | Correlation coefficient |
|--------------------|-------------------|------------------------|
| YCR053W            | AFUA_3G08980      | 0.851750303            |
| YOL066C            | AFUA_1G03500      | 0.814728478            |
| YLR208W            | AFUA_4G06090      | 0.810778356            |
| YJR160C            | AFUA_8G07240      | 0.807607644            |
| YKL064W            | AFUA_2G08070      | 0.771984405            |
| YDL208W            | AFUA_1G13570      | 0.763687527            |
| YDL247W            | AFUA_8G07240      | 0.751799318            |
| YJL034W            | AFUA_2G04620      | 0.751475734            |
| YJL174W            | AFUA_2G07590      | 0.731359519            |
| YGL006W            | AFUA_1G10880      | 0.706118907            |
| YLR307W            | AFUA_6G10430      | 0.701428537            |
| YOR056C            | AFUA_5G04000      | 0.693624039            |
| YJR049C            | AFUA_5G12870      | 0.6873278              |
| YOR132W            | AFUA_5G07150      | 0.684358232            |
| YDR028C            | AFUA_8G02720      | 0.681519128            |
| YKL059C            | AFUA_2G06220      | 0.677236775            |
| YDR019C            | AFUA_1G10780      | 0.673590566            |
| YDR262W            | AFUA_8G05360      | 0.668577442            |
| YJR160C            | AFUA_3G01700      | 0.655149877            |
| YBL087C            | AFUA_2G03380      | 0.654275917            |
| YDR120C            | AFUA_3G04200      | 0.653965099            |
| YMR110C            | AFUA_4G13500      | 0.649573592            |
| YDR479C            | AFUA_2G01510      | 0.649340576            |
| YLR307W            | AFUA_4G09940      | 0.641152119            |
| YLL050C            | AFUA_5G10570      | 0.63692762             |
| YMR011W            | AFUA_2G11520      | 0.631877767            |
| YGR149W            | AFUA_3G08240      | 0.627253467            |
| YKL125W            | AFUA_1G02590      | 0.626251676            |
| YDL247W            | AFUA_3G01700      | 0.621782331            |
| YHR165C            | AFUA_2G03030      | 0.616638486            |
| YLR355C            | AFUA_3G14490      | 0.615946987            |
| YLR307W            | AFUA_3G07210      | 0.615345397            |
| YNL156C            | AFUA_4G07680      | 0.605490705            |
| YOL157C            | AFUA_8G07070      | 0.600254438            |
| YPL196W            | AFUA_3G08740      | 0.596649007            |
| YOL156W            | AFUA_2G11520      | 0.589475104            |
| YGL055W            | AFUA_7G05920      | 0.583471232            |
| YER094C            | AFUA_4G07420      | 0.580111415            |
| YER026C            | AFUA_4G13680      | 0.579632053            |
| YKR031C            | AFUA_3G05630      | 0.578947614            |
| YJR041C            | AFUA_1G13200      | 0.577042969            |
| YCL057C-A          | AFUA_1G13195      | 0.56703028             |
| YKL167C            | AFUA_6G12620      | 0.566497151            |
| YDR334W            | AFUA_7G02370      | 0.556810391            |
| YDL085W            | AFUA_1G11960      | 0.535058025            |
| YIR038C            | AFUA_8G02500      | 0.533657653            |
| YGL056C            | AFUA_1G06660      | 0.550891198            |
| YLR133W            | AFUA_1G15930      | 0.547961885            |
| YLR137W            | AFUA_2G09930      | 0.542448721            |
Table 4: Continued.

| S. cerevisiae gene | A. fumigatus gene | Correlation coefficient |
|--------------------|-------------------|------------------------|
| YER095W            | AFUA_1G10410      | 0.540102076            |
| YCR090C            | AFUA_2G15510      | 0.540015424            |
| YIR022W            | AFUA_3G12840      | 0.539096148            |
| YJR048W            | AFUA_2G13110      | 0.537701308            |
| YDL247W            | AFUA_8G01340      | 0.536753536            |
| YGL119W            | AFUA_6G04380      | 0.528264148            |
| YDR054C            | AFUA_5G09200      | 0.520282879            |
| YNR036C            | AFUA_5G10750      | 0.51817226             |
| YJR050W            | AFUA_4G07160      | 0.517374235            |
| YKR036C            | AFUA_5G13140      | 0.515007541            |
| YML041C            | AFUA_2G05030      | 0.514819597            |
| YML080W            | AFUA_1G16550      | 0.512494533            |
| YJL093C            | AFUA_1G14250      | 0.5107227              |
| YDR238C            | AFUA_1G10970      | 0.509749906            |
| YJL197W            | AFUA_2G14130      | 0.501902821            |
| YER173W            | AFUA_8G02820      | 0.501581347            |
| YJR160C            | AFUA_8G01340      | 0.499250408            |
| YOL058W            | AFUA_2G04310      | 0.497155736            |
| YGR006W            | AFUA_1G16990      | 0.496383573            |
| YPR161C            | AFUA_5G05510      | 0.495551014            |
| YBR136W            | AFUA_4G04760      | 0.49434371             |
| YJR049C            | AFUA_2G01350      | 0.493221085            |
| YPR060C            | AFUA_5G13130      | 0.490832735            |
| YDR055W            | AFUA_4G06820      | 0.482973721            |
| YLR104W            | AFUA_5G04040      | 0.47610876             |
| YIL129C            | AFUA_6G11010      | 0.473123981            |
| YDR300C            | AFUA_2G07570      | 0.469287567            |
| YOL156W            | AFUA_7G00950      | 0.46726022             |
| YGL201C            | AFUA_5G10890      | 0.462753539            |
| YKR086W            | AFUA_1G03820      | 0.461061937            |
| YPL157W            | AFUA_6G08610      | 0.460257721            |
| YIL046W            | AFUA_2G14110      | 0.45798838             |
| YGL048C            | AFUA_4G04660      | 0.457664607            |
| YHR216W            | AFUA_2G03610      | 0.456902272            |
| YDR424C            | AFUA_1G04850      | 0.455530713            |
| YPR141C            | AFUA_2G14280      | 0.452133975            |
| YLR427W            | AFUA_1G07150      | 0.444534443            |
| YHL004W            | AFUA_1G06570      | 0.439699159            |
| YLL002W            | AFUA_5G09540      | 0.431520497            |
| YKR052C            | AFUA_6G12550      | 0.429429023            |
| YNL260C            | AFUA_1G09000      | 0.425937756            |
| YNL112W            | AFUA_2G10750      | 0.423331447            |
| YFL026W            | AFUA_3G14330      | 0.422540136            |
| YCL038C            | AFUA_2G15370      | 0.420548714            |
| YPR156C            | AFUA_4G01140      | 0.419838437            |
| YHL024W            | AFUA_3G06230      | 0.417835282            |
| YJR173C            | AFUA_5G10740      | 0.414366599            |
| YGR178C            | AFUA_1G09630      | 0.410618083            |
| YMR036C            | AFUA_6G08200      | 0.408252022            |
| *S. cerevisiae* gene | *A. fumigatus* gene | Correlation coefficient |
|---------------------|---------------------|------------------------|
| YDL147W             | AFUA_3G06610        | 0.40670988             |
| YJR095W             | AFUA_2G16930        | 0.405617695            |
| YPL171C             | AFUA_2G17960        | 0.40043227             |
| YBL061C             | AFUA_8G05620        | 0.398124519            |
| YHL001W             | AFUA_6G03830        | 0.39741165             |
| YNL255C             | AFUA_1G07630        | 0.390527675            |
| YGL006W             | AFUA_3G0690         | 0.389206341            |
| YIL125W             | AFUA_4G1650         | 0.38564721             |
| YMR011W             | AFUA_5G01160        | 0.38168332             |
| YMR010W             | AFUA_5G03510        | 0.378223656            |
| YMR319C             | AFUA_4G14640        | 0.376638524            |
| YDL110C             | AFUA_1G09160        | 0.37650694             |
| YOL086C             | AFUA_5G06240        | 0.376281416            |
| YGR076C             | AFUA_4G09000        | 0.373900773            |
| YOR204W             | AFUA_4G07660        | 0.368301524            |
| YMR229C             | AFUA_2G16040        | 0.367246087            |
| YLR025W             | AFUA_1G06420        | 0.36373278             |
| YPL281C             | AFUA_6G06770        | 0.36263962             |
| YOR294W             | AFUA_7G04430        | 0.36077313             |
| YLR299W             | AFUA_7G04760        | 0.36169498             |
| YCL038C             | AFUA_2G06170        | 0.359699115            |
| YKL113C             | AFUA_3G06060        | 0.35198628             |
| YHL020C             | AFUA_5G09420        | 0.350312962            |
| YMR224C             | AFUA_6G11410        | 0.348946198            |
| YDR444W             | AFUA_3G04240        | 0.345928111            |
| YER107C             | AFUA_1G09020        | 0.34238252             |
| YDR162C             | AFUA_2G03680        | 0.342381673            |
| YNL212W             | AFUA_3G08750        | 0.341561675            |
| YNL097C             | AFUA_3G11940        | 0.339603963            |
| YKL191W             | AFUA_6G07100        | 0.337319743            |
| YPL030W             | AFUA_6G02570        | 0.336821966            |
| YNL224C             | AFUA_3G05330        | 0.336636223            |
| YKR024C             | AFUA_5G10500        | 0.328747023            |
| YPR020W             | AFUA_1G16280        | 0.323479927            |
| YPL171C             | AFUA_2G04060        | 0.322952534            |
| YOR393W             | AFUA_6G06770        | 0.321210691            |
| YPR088C             | AFUA_5G03880        | 0.31284654             |
| YGL058W             | AFUA_6G14210        | 0.312000165            |
| YFL059W             | AFUA_5G08090        | 0.309971957            |
| YBR243C             | AFUA_2G11240        | 0.307271969            |
| YIL048C             | AFUA_3G06360        | 0.306215007            |
| YNL055C             | AFUA_4G06910        | 0.305279025            |
| YOR058C             | AFUA_2G16260        | 0.305221634            |
| YGR240C             | AFUA_4G00960        | 0.304340045            |
| YBR279W             | AFUA_2G11000        | 0.303224               |
| YPL078C             | AFUA_8G05440        | 0.300712891            |
| YLR059C             | AFUA_3G11820        | 0.296403753            |
| YLR380W             | AFUA_6G12690        | 0.295562758            |
| YDL174C             | AFUA_1G17520        | 0.29517154             |
Table 4: Continued.

| *S. cerevisiae* gene | *A. fumigatus* gene | Correlation coefficient |
|----------------------|---------------------|------------------------|
| YCL057W              | AFUA_7G05930        | 0.293762978            |
| YDR234W              | AFUA_5G08890        | 0.293096856            |
| YDR438W              | AFUA_5G12140        | 0.287954196            |
| YGL028C              | AFUA_8G05610        | 0.28799385             |
| YML004C              | AFUA_6G07940        | 0.285261452            |
| YOL045W              | AFUA_2G02850        | 0.284622252            |
| YLR429W              | AFUA_2G14270        | 0.283845667            |
| YDR397C              | AFUA_3G02340        | 0.283499213            |
| YBR260C              | AFUA_3G06280        | 0.282196097            |
| YCR087C-A            | AFUA_7G04700        | 0.281322207            |
| YMR011W              | AFUA_7G00950        | 0.280854319            |
| YOL148C              | AFUA_1G16580        | 0.274850272            |
| YDR379W              | AFUA_1G12680        | 0.273041289            |
| YJL151C              | AFUA_5G10590        | 0.272979399            |
| YML020W              | AFUA_5G2090         | 0.266526854            |
| YGR082W              | AFUA_6G11380        | 0.265129767            |
| YJR113C              | AFUA_1G04280        | 0.262789584            |
| YL031W               | AFUA_5G03200        | 0.256820972            |
| YDR322W              | AFUA_3G01100        | 0.255963453            |
| YDR359C              | AFUA_4G07560        | 0.255317292            |
| YDR233C              | AFUA_6G13670        | 0.253861938            |
| YGR255C              | AFUA_4G12930        | 0.252312468            |
| YFR089W              | AFUA_4G06070        | 0.249534257            |
| YPL280W              | AFUA_3G08490        | 0.243781447            |
| YOR075W              | AFUA_2G09670        | 0.239487119            |
| YJL219W              | AFUA_7G00950        | 0.239124986            |
| YCR026C              | AFUA_2G14770        | 0.234276623            |
| YOR391C              | AFUA_3G08499        | 0.233098887            |
| YGL180W              | AFUA_4G09050        | 0.231299038            |
| YLR323C              | AFUA_5G07720        | 0.231114462            |
| YGL006W              | AFUA_2G01030        | 0.222088168            |
| YBR179C              | AFUA_5G13392        | 0.219453048            |
| YKR082W              | AFUA_4G05840        | 0.214144582            |
| YLR087C              | AFUA_2G13520        | 0.209434557            |
| YCL064C              | AFUA_4G07810        | 0.20494803             |
| YOL156W              | AFUA_5G01160        | 0.203740073            |
| YBR249C              | AFUA_2G04070        | 0.202306902            |
| YJL039C              | AFUA_3G07540        | 0.201465401            |
| YOL077C              | AFUA_1G02210        | 0.196710807            |
| YLR426W              | AFUA_1G06280        | 0.196041865            |
| YMR060C              | AFUA_2G03840        | 0.194299595            |
| YOR048C              | AFUA_1G13730        | 0.193994391            |
| YDL174C              | AFUA_2G02560        | 0.193117882            |
| YJL221C              | AFUA_8G07070        | 0.187015236            |
| YGR054W              | AFUA_3G05970        | 0.181434929            |
| YPR176C              | AFUA_7G04460        | 0.180215936            |
| YML003W              | AFUA_1G09870        | 0.173517378            |
| YKR084C              | AFUA_2G04630        | 0.171646807            |
| YDR270W              | AFUA_4G12620        | 0.171601357            |
Table 4: Continued.

| *S. cerevisiae* gene | *A. fumigatus* gene | Correlation coefficient |
|----------------------|---------------------|------------------------|
| YOR336W              | AFUA_2G02360        | 0.164107564            |
| YFL058W              | AFUA_5G02470        | 0.160695353            |
| YNL031C              | AFUA_2G07380        | 0.151927636            |
| YJL221C              | AFUA_7G06380        | 0.150927464            |
| YGR280C              | AFUA_7G03690        | 0.150422383            |
| YOL089C              | AFUA_6G01960        | 0.149731857            |
| YGR193C              | AFUA_3G08270        | 0.14875632             |
| YDR328C              | AFUA_5G06060        | 0.143711765            |
| YPL254W              | AFUA_2G06060        | 0.143220591            |
| YPL206C              | AFUA_2G00990        | 0.13850935             |
| YEL021W              | AFUA_2G08360        | 0.13720587             |
| YOL068C              | AFUA_4G12120        | 0.134069861            |
| YJR160C              | AFUA_7G06390        | 0.131179873            |
| YNL310C              | AFUA_6G08230        | 0.130305791            |
| YIL061C              | AFUA_5G13480        | 0.126828721            |
| YGL163C              | AFUA_6G12910        | 0.12597657             |
| YGR173W              | AFUA_5G06770        | 0.123606414            |
| YJL092W              | AFUA_2G03910        | 0.122708164            |
| YJR065C              | AFUA_5G11560        | 0.121854722            |
| YBR023C              | AFUA_8G05630        | 0.120791924            |
| YBR084W              | AFUA_3G08650        | 0.118154138            |
| YMR197C              | AFUA_4G10710        | 0.114428905            |
| YMR241W              | AFUA_5G04220        | 0.114113659            |
| YNL097C              | AFUA_7G01870        | 0.109316946            |
| YGL171W              | AFUA_1G16290        | 0.103112508            |
| YOR365C              | AFUA_4G13340        | 0.094260129            |
| YHR215W              | AFUA_6G11330        | 0.092128581            |
| YKL013C              | AFUA_6G02370        | 0.088958318            |
| YOR043W              | AFUA_4G06130        | 0.087990985            |
| YPR062W              | AFUA_1G05050        | 0.087018417            |
| YDR497C              | AFUA_2G07910        | 0.078863767            |
| YDR477W              | AFUA_2G01700        | 0.074801159            |
| YLR378C              | AFUA_5G08130        | 0.074624328            |
| YBR060C              | AFUA_5G08110        | 0.073589072            |
| YGL120C              | AFUA_5G1620         | 0.069009268            |
| YIL063C              | AFUA_2G10810        | 0.06328373             |
| YOL157C              | AFUA_7G06380        | 0.06047767             |
| YGL043C              | AFUA_3G07670        | 0.059398891            |
| YMR027W              | AFUA_5G06710        | 0.058232831            |
| YHR215W              | AFUA_8G01910        | 0.05787337             |
| YDL247W              | AFUA_7G05190        | 0.05184022             |
| YPR048W              | AFUA_5G07290        | 0.049809159            |
| YBL051C              | AFUA_5G01940        | 0.04851444             |
| YHR148W              | AFUA_2G08320        | 0.047441878            |
| YJL160C              | AFUA_7G05190        | 0.045923723            |
| YL039C               | AFUA_5G12670        | 0.042943521            |
| YNL029C              | AFUA_5G12160        | 0.031203315            |
| YGR267C              | AFUA_5G03140        | 0.029526621            |
| YNL027W              | AFUA_1G06900        | 0.02747405             |
| S. cerevisiae gene | A. fumigatus gene | Correlation coefficient |
|-------------------|------------------|------------------------|
| YDL247W          | AFUA_2G06390     | 0.023887472            |
| YHR107C          | AFUA_5G03080     | 0.020068991            |
| YKL165C          | AFUA_4G03970     | 0.01938034             |
| YNR012W          | AFUA_2G05430     | 0.019075112            |
| YLR085C          | AFUA_4G04420     | 0.018617278            |
| YPL082C          | AFUA_1G05830     | 0.017285628            |
| YCL064C          | AFUA_1G06150     | 0.014476469            |
| YNR039C          | AFUA_1G12090     | 0.011820922            |
| YOR216C          | AFUA_1G08830     | 0.008439713             |
| YOR148C          | AFUA_4G05550     | 0.006702846             |
| YDR420W          | AFUA_4G05050     | 0.006566287             |
| YPR018W          | AFUA_5G03720     | -0.000683184            |
| YDR322W          | AFUA_5G12810     | -0.002517201            |
| YNR015W          | AFUA_3G08390     | -0.013154917            |
| YBR251W          | AFUA_5G11540     | -0.01637247             |
| YHL028W          | AFUA_5G09020     | -0.020657813            |
| YPL146C          | AFUA_2G05550     | -0.023787247            |
| YKL127W          | AFUA_3G11830     | -0.026619404            |
| YJR160C          | AFUA_2G09109     | -0.029508087            |
| YIR038C          | AFUA_1G17010     | -0.030714781            |
| YDL247W          | AFUA_2G09109     | -0.033905332            |
| YBR204C          | AFUA_1G03540     | -0.038361835            |
| YJR010W          | AFUA_3G06530     | -0.038908707            |
| YMR210W          | AFUA_6G04640     | -0.046477426            |
| YPR187W          | AFUA_1G05160     | -0.048502572            |
| YDR037W          | AFUA_6G07640     | -0.052027721            |
| YIL134W          | AFUA_6G05170     | -0.053118026            |
| YLR286C          | AFUA_5G03760     | -0.062116063            |
| YKL179C          | AFUA_1G14240     | -0.062203351            |
| YDR109C          | AFUA_4G04680     | -0.063717983            |
| YOL157C          | AFUA_3G07380     | -0.064624439            |
| YIR038C          | AFUA_2G17300     | -0.068756542            |
| YDL102W          | AFUA_2G16600     | -0.088010728            |
| YOR389W          | AFUA_2G09140     | -0.09375584             |
| YBR244W          | AFUA_3G12270     | -0.097477745            |
| YJL219W          | AFUA_2G11520     | -0.098366126            |
| YPL126W          | AFUA_7G02610     | -0.101632712            |
| YDL189W          | AFUA_1G09400     | -0.104331651            |
| YHL016C          | AFUA_1G04870     | -0.106608293            |
| YLR380W          | AFUA_4G13930     | -0.111437921            |
| YPR165W          | AFUA_6G06900     | -0.117573203            |
| YOL062C          | AFUA_5G07930     | -0.122120003            |
| YGL248W          | AFUA_1G14890     | -0.124318908            |
| YLR029C          | AFUA_1G04660     | -0.129375946            |
| YMR214W          | AFUA_2G08300     | -0.130867913            |
| YOR124C          | AFUA_6G12270     | -0.136050424            |
| YOL023W          | AFUA_1G06520     | -0.136914472            |
| YPL280W          | AFUA_3G01210     | -0.13706189             |
| YLR380W          | AFUA_2G06760     | -0.141209958            |
| S. cerevisiae gene | A. fumigatus gene | Correlation coefficient |
|--------------------|-------------------|------------------------|
| YNL241C            | AFUA_3G08470      | -0.153108798           |
| YOR391C            | AFUA_3G01210      | -0.154014157           |
| YOL089C            | AFUA_6G02330      | -0.161608796           |
| YGL215W            | AFUA_3G10040      | -0.170171082           |
| YMR137C            | AFUA_2G15220      | -0.174259735           |
| YER004W            | AFUA_6G08930      | -0.179730339           |
| YDR365C            | AFUA_2G05420      | -0.181946191           |
| YDR529C            | AFUA_4G06790      | -0.185927497           |
| YDR062W            | AFUA_6G0300       | -0.189190157           |
| YOL086C            | AFUA_7G01010      | -0.190813468           |
| YOL026C            | AFUA_5G03630      | -0.19138562            |
| YIL033C            | AFUA_3G10000      | -0.195925157           |
| YBR290W            | AFUA_4G13740      | -0.19955841            |
| YAR019C            | AFUA_4G06750      | -0.204744755           |
| YHL007C            | AFUA_2G04680      | -0.20737573            |
| YMR078C            | AFUA_7G05480      | -0.222707833           |
| YDR311W            | AFUA_4G11690      | -0.22686955            |
| YOL100W            | AFUA_3G12670      | -0.230714484           |
| YGR162W            | AFUA_2G09490      | -0.232235851           |
| YGL255W            | AFUA_1G01550      | -0.248116851           |
| YPL038W            | AFUA_6G01910      | -0.252388553           |
| YCL035C            | AFUA_1G06100      | -0.255759517           |
| YNL082W            | AFUA_2G13410      | -0.259394819           |
| YDR062W            | AFUA_1G11890      | -0.263523207           |
| YOR390W            | AFUA_2G16210      | -0.269616243           |
| YJR141W            | AFUA_3G07970      | -0.2738444             |
| YOR365C            | AFUA_2G17650      | -0.274036262           |
| YDL116W            | AFUA_1G01860      | -0.278315121           |
| YKL020C            | AFUA_1G12550      | -0.278379939           |
| YDL174C            | AFUA_3G06682      | -0.286419799           |
| YBR029C            | AFUA_1G07010      | -0.296926336           |
| YLR096W            | AFUA_1G11080      | -0.297540349           |
| YFL028C            | AFUA_6G05080      | -0.303502181           |
| YOR089C            | AFUA_3G01704      | -0.30892361            |
| YPR010C            | AFUA_2G13000      | -0.309890067           |
| YJL219W            | AFUA_5G01160      | -0.321415181           |
| YNL097C            | AFUA_4G11660      | -0.329160424           |
| YMR116C            | AFUA_4G13170      | -0.329415498           |
| YPL280W            | AFUA_5G01430      | -0.331554435           |
| YHR091C            | AFUA_2G14030      | -0.337931682           |
| YIL030C            | AFUA_2G08650      | -0.350942099           |
| YFR037C            | AFUA_7G05510      | -0.356342064           |
| YOR391C            | AFUA_5G01430      | -0.356843862           |
| YDL174C            | AFUA_1G00510      | -0.402217656           |
| YML121W            | AFUA_5G09650      | -0.410825283           |
| YFL060C            | AFUA_2G08580      | -0.411505108           |
| YDR301W            | AFUA_8G04040      | -0.413112754           |
| YJL221C            | AFUA_3G07380      | -0.413321446           |
| YLR326W            | AFUA_5G12410      | -0.458648708           |
Single-gene duplications and gene cluster duplications consisting of multiple genes were identified. One cluster of 4 genes (AFUA_1G00420 to AFUA_1G00470) is a duplication of another 4-gene cluster (AFUA_8G04120 to AFUA_8G04080) (Table 2). Among these gene pairs, the nucleosome position profile was poorly conserved in the gene promoter between AFUA_1G00470 and AFUA_8G04080 and in the gene body between AFUA_1G00440 and AFUA_8G04110 (Spearman’s rank correlation coefficients were 0.43 and 0.23, resp.) (Table 2). With the exception of these 2 cases, the nucleosome position profile was highly conserved (correlation coefficients were higher than 0.7) (Table 2).
We analyzed another pair of duplicated clusters (9 genes) (AFUA_AG16030 to AFUA_AG16120 and AFUA_SG14930 to AFUA_SG15030). The genes in each cluster have evolved for the same period after the duplication (Table 2). At present, conservation of the nucleosome position varies among the 9 genes (Table 2). For example, the nucleosome position profile is poorly conserved in the gene promoters of 3 gene pairs (AFUA_AG16050 and AFUA_SG14950, AFUA_AG16110 and AFUA_AG15020, AFUA_AG16120 and AFUA_AG15030) (Spearman’s rank correlation coefficients are −0.35, −0.26, and −0.14, resp.). On the other hand, the nucleosome position profile is highly conserved in the promoters of AFUA_AG16070 and AFUA_SG14980 and was strongly correlated (correlation coefficient = 0.93). These results suggest that transcriptional regulation of duplicated genes is associated with nucleosome positions in the gene promoters.

3.2. Nucleosome Position Profiles of Orthologous Gene Promoters in Aspergillus fumigatus and Saccharomyces cerevisiae. I compared the nucleosome position profiles in the promoters of 347 orthologous pairs of yeast genes that showed notably high conservation in the control and mutant strains. In the 63 duplicated A. fumigatus gene pairs, 13 (20.6%) gene promoter profiles and 11 (17.5%) gene body profiles were highly correlated (Spearman’s rank correlation coefficient > 0.7) (Table 1, Figure 1). On the other hand, of the 347 orthologous gene pairs, only 11 (3.2%) nucleosome position profiles were highly correlated (Spearman’s rank correlation coefficient > 0.7) (Table 4, Figure 2). The distribution of correlation coefficients of the 347 orthologous gene promoters did not significantly differ from that of the control (gene pairs chosen at random) (P-value = 0.28 Kolmogorov-Smirnov test). One potential cause of this low conservation is the large evolutionary distance between the 2 fungi. A. fumigatus and S. cerevisiae belong to the subphyla Pezizomycotina and Saccharomycotina, respectively. Alternatively, this low conservation may represent a difference in mechanisms regulating the nucleosome arrangement, since the nucleosomal (nucleosome-bound) DNA lengths differ between the 2 fungi [9, 10].

Nucleosome position profiles in gene promoters are thought to be related to gene function. For example, YIR038C of S. cerevisiae encodes an amino acid sequence protein (glutathione S-transferase) similar to 3 genes (AFUA_AG17010, AFUA_AG17300, and AFUA_AG802500) in A. fumigatus (Table 4). Although the nucleosome position profiles show some conservation between YIR038C and AFUA_AG802500 (Spearman’s rank correlation coefficient = 0.55, except for one nucleosome position loss in A. fumigatus), they are poorly conserved between YIR038C and AFUA_AG17010 (Spearman’s rank correlation coefficient = −0.03) and between YIR038C and AFUA_AG17300 (Spearman’s rank correlation coefficient = −0.07) (Table 4, Figure 3).

Interestingly, although the nucleosome position profile of AFUA_AG17300 is completely different from that of AFUA_AG17300, the transcription start site patterns are very similar between these genes (Figure 3), suggesting that the relationship between transcription start site and nucleosome position in the gene promoter varies.

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