Supplementary 5. Enrichment analysis results of ESR1, GOPC, and BRD4 proteins

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| **No** | **Category** | **Description** | **P-value** | **Genes** | **Term** |
| 1 | GO Biological Processes | regulation of I-kappaB kinase/NF-kappaB signaling | 3.72E-04 | ESR1;BRD4 | GO:0043122 |
| 2 | GO Biological Processes | negative regulation of anion transmembrane transport | 7.50E-04 | GOPC | GO:1903960 |
| 3 | GO Biological Processes | regulation of anion channel activity | 9.00E-04 | GOPC | GO:0010359 |
| 4 | GO Biological Processes | positive regulation of RNA polymerase II transcription preinitiation complex assembly | 0.001049661 | ESR1 | GO:0045899 |
| 5 | GO Biological Processes | apical protein localization | 0.001499295 | GOPC | GO:0045176 |
| 6 | GO Biological Processes | regulation of RNA polymerase II transcription preinitiation complex assembly | 0.001499295 | ESR1 | GO:0045898 |
| 7 | GO Biological Processes | positive regulation of transcription elongation from RNA polymerase II promoter | 0.001649143 | BRD4 | GO:0032968 |
| 8 | GO Biological Processes | negative regulation of protein localization to cell surface | 0.001649143 | GOPC | GO:2000009 |
| 9 | GO Biological Processes | negative regulation of production of miRNAs involved in gene silencing by miRNA | 0.001798976 | ESR1 | GO:1903799 |
| 10 | GO Biological Processes | negative regulation of gene silencing by miRNA | 0.001798976 | ESR1 | GO:0060965 |
| 11 | GO Biological Processes | positive regulation of nucleic acid-templated transcription | 0.001921469 | ESR1;BRD4 | GO:1903508 |
| 12 | GO Biological Processes | cytoplasmic sequestering of protein | 0.001948794 | GOPC | GO:0051220 |
| 13 | GO Biological Processes | positive regulation of intracellular signal transduction | 0.002191371 | ESR1;BRD4 | GO:1902533 |
| 14 | GO Biological Processes | regulation of phospholipase C activity | 0.002248385 | ESR1 | GO:1900274 |
| 15 | GO Biological Processes | steroid hormone mediated signaling pathway | 0.002248385 | ESR1 | GO:0043401 |
| 16 | GO Biological Processes | regulation of production of miRNAs involved in gene silencing by miRNA | 0.00269766 | ESR1 | GO:1903798 |
| 17 | GO Biological Processes | intracellular estrogen receptor signaling pathway | 0.00269766 | ESR1 | GO:0030520 |
| 18 | GO Biological Processes | negative regulation of RNA metabolic process | 0.002847389 | ESR1 | GO:0051253 |
| 19 | GO Biological Processes | positive regulation of G2/M transition of mitotic cell cycle | 0.002997102 | BRD4 | GO:0010971 |
| 20 | GO Biological Processes | negative regulation of ion transmembrane transporter activity | 0.003146801 | GOPC | GO:0032413 |
| 21 | GO Biological Processes | protein localization to chromatin | 0.003146801 | ESR1 | GO:0071168 |
| 22 | GO Biological Processes | cellular response to estradiol stimulus | 0.003146801 | ESR1 | GO:0071392 |
| 23 | GO Biological Processes | positive regulation of transcription initiation from RNA polymerase II promoter | 0.003446153 | ESR1 | GO:0060261 |
| 24 | GO Biological Processes | positive regulation of cell cycle G2/M phase transition | 0.003446153 | BRD4 | GO:1902751 |
| 25 | GO Biological Processes | positive regulation of phospholipase activity | 0.003595807 | ESR1 | GO:0010518 |
| 26 | GO Biological Processes | positive regulation of DNA-templated transcription, elongation | 0.003745445 | BRD4 | GO:0032786 |
| 27 | GO Biological Processes | regulation of transcription elongation from RNA polymerase II promoter | 0.004044678 | BRD4 | GO:0034243 |
| 28 | GO Biological Processes | regulation of intracellular estrogen receptor signaling pathway | 0.004792498 | ESR1 | GO:0033146 |
| 29 | GO Biological Processes | regulation of transcription involved in G1/S transition of mitotic cell cycle | 0.004792498 | BRD4 | GO:0000083 |
| 30 | GO Biological Processes | regulation of protein localization to cell surface | 0.004942017 | GOPC | GO:2000008 |
| 31 | GO Biological Processes | protein localization to chromosome | 0.005091521 | ESR1 | GO:0034502 |
| 32 | GO Biological Processes | response to estrogen | 0.00524101 | ESR1 | GO:0043627 |
| 33 | GO Biological Processes | negative regulation of cellular protein localization | 0.005390484 | GOPC | GO:1903828 |
| 34 | GO Biological Processes | regulation of intracellular steroid hormone receptor signaling pathway | 0.005539943 | ESR1 | GO:0033143 |
| 35 | GO Biological Processes | response to estradiol | 0.005689388 | ESR1 | GO:0032355 |
| 36 | GO Biological Processes | negative regulation of I-kappaB kinase/NF-kappaB signaling | 0.005988231 | ESR1 | GO:0043124 |
| 37 | GO Biological Processes | positive regulation of transcription by RNA polymerase II | 0.005990338 | ESR1;BRD4 | GO:0045944 |
| 38 | GO Biological Processes | positive regulation of phospholipase C activity | 0.006436385 | ESR1 | GO:0010863 |
| 39 | GO Biological Processes | intracellular steroid hormone receptor signaling pathway | 0.006585739 | ESR1 | GO:0030518 |
| 40 | GO Biological Processes | Golgi to plasma membrane transport | 0.007183008 | GOPC | GO:0006893 |
| 41 | GO Biological Processes | positive regulation of mitotic cell cycle phase transition | 0.008675133 | BRD4 | GO:1901992 |
| 42 | GO Biological Processes | response to organic cyclic compound | 0.008973378 | ESR1 | GO:0014070 |
| 43 | GO Biological Processes | positive regulation of transcription, DNA-templated | 0.0100748 | ESR1;BRD4 | GO:0045893 |
| 44 | GO Biological Processes | phospholipase C-activating G protein-coupled receptor signaling pathway | 0.012101347 | ESR1 | GO:0007200 |
| 45 | GO Biological Processes | regulation of defense response | 0.012398905 | BRD4 | GO:0031347 |
| 46 | GO Biological Processes | G1/S transition of mitotic cell cycle | 0.012696404 | BRD4 | GO:0000082 |
| 47 | GO Biological Processes | post-Golgi vesicle-mediated transport | 0.013291222 | GOPC | GO:0006892 |
| 48 | GO Biological Processes | chromatin remodeling | 0.015371203 | ESR1 | GO:0006338 |
| 49 | GO Biological Processes | regulation of Wnt signaling pathway | 0.016558451 | ESR1 | GO:0030111 |
| 50 | GO Biological Processes | response to lipid | 0.017003422 | ESR1 | GO:0033993 |
| 51 | GO Biological Processes | positive regulation of protein-containing complex assembly | 0.017596509 | ESR1 | GO:0031334 |
| 52 | GO Biological Processes | regulation of response to external stimulus | 0.019374339 | BRD4 | GO:0032101 |
| 53 | GO Biological Processes | transcription initiation from RNA polymerase II promoter | 0.020854225 | ESR1 | GO:0006367 |
| 54 | GO Biological Processes | chromatin organization | 0.021150023 | ESR1 | GO:0006325 |
| 55 | GO Biological Processes | negative regulation of DNA-binding transcription factor activity | 0.0212979 | ESR1 | GO:0043433 |
| 56 | GO Biological Processes | positive regulation of cytosolic calcium ion concentration | 0.021889258 | ESR1 | GO:0007204 |
| 57 | GO Biological Processes | regulation of cytosolic calcium ion concentration | 0.022037061 | ESR1 | GO:0051480 |
| 58 | GO Biological Processes | regulation of G2/M transition of mitotic cell cycle | 0.022184848 | BRD4 | GO:0010389 |
| 59 | GO Biological Processes | cellular response to organic cyclic compound | 0.022332621 | ESR1 | GO:0071407 |
| 60 | GO Biological Processes | positive regulation of protein kinase B signaling | 0.023957137 | ESR1 | GO:0051897 |
| 61 | GO Biological Processes | DNA-templated transcription, initiation | 0.024989983 | ESR1 | GO:0006352 |
| 62 | GO Biological Processes | positive regulation of I-kappaB kinase/NF-kappaB signaling | 0.025432408 | BRD4 | GO:0043123 |
| 63 | GO Biological Processes | endoplasmic reticulum to Golgi vesicle-mediated transport | 0.027495289 | GOPC | GO:0006888 |
| 64 | GO Biological Processes | negative regulation of macromolecule metabolic process | 0.028819889 | ESR1 | GO:0010605 |
| 65 | GO Biological Processes | negative regulation of intracellular signal transduction | 0.029408213 | ESR1 | GO:1902532 |
| 66 | GO Biological Processes | regulation of signal transduction | 0.029408213 | ESR1 | GO:0009966 |
| 67 | GO Biological Processes | regulation of inflammatory response | 0.03058415 | BRD4 | GO:0050727 |
| 68 | GO Biological Processes | regulation of protein kinase B signaling | 0.030731075 | ESR1 | GO:0051896 |
| 69 | GO Biological Processes | cellular response to lipid | 0.03249302 | ESR1 | GO:0071396 |
| 70 | GO Biological Processes | regulation of transcription by RNA polymerase II | 0.033802747 | ESR1;BRD4 | GO:0006357 |
| 71 | GO Biological Processes | regulation of transcription, DNA-templated | 0.034929781 | ESR1;BRD4 | GO:0006355 |
| 72 | GO Biological Processes | positive regulation of DNA-binding transcription factor activity | 0.036449588 | ESR1 | GO:0051091 |
| 73 | GO Biological Processes | regulation of protein phosphorylation | 0.039373415 | BRD4 | GO:0001932 |
| 74 | GO Biological Processes | protein deubiquitination | 0.039519451 | ESR1 | GO:0016579 |
| 75 | GO Biological Processes | protein modification by small protein removal | 0.040833108 | ESR1 | GO:0070646 |
| 76 | GO Biological Processes | transcription by RNA polymerase II | 0.047238192 | ESR1 | GO:0006366 |
| 77 | GO Biological Processes | negative regulation of gene expression | 0.047528653 | ESR1 | GO:0010629 |
| 78 | GO Biological Processes | cellular response to oxygen-containing compound | 0.047673861 | ESR1 | GO:1901701 |
| 79 | GO Biological Processes | regulation of nucleic acid-templated transcription | 0.063126019 | ESR1 | GO:1903506 |
| 80 | GO Biological Processes | regulation of cellular macromolecule biosynthetic process | 0.068573215 | ESR1 | GO:2000112 |
| 81 | GO Biological Processes | negative regulation of transcription by RNA polymerase II | 0.099135562 | ESR1 | GO:0000122 |
| 82 | GO Biological Processes | negative regulation of transcription, DNA-templated | 0.135572329 | ESR1 | GO:0045892 |
| 83 | GO Biological Processes | regulation of gene expression | 0.153282109 | ESR1 | GO:0010468 |
| 84 | GO Cellular Component | trans-Golgi network transport vesicle | 0.002248385 | GOPC | GO:0030140 |
| 85 | GO Cellular Component | condensed nuclear chromosome | 0.002997102 | BRD4 | GO:0000794 |
| 86 | GO Cellular Component | Golgi-associated vesicle membrane | 0.003595807 | GOPC | GO:0030660 |
| 87 | GO Cellular Component | Golgi-associated vesicle | 0.007033713 | GOPC | GO:0005798 |
| 88 | GO Cellular Component | condensed chromosome | 0.008078462 | BRD4 | GO:0000793 |
| 89 | GO Cellular Component | clathrin-coated vesicle | 0.011952546 | GOPC | GO:0030136 |
| 90 | GO Cellular Component | nuclear chromosome | 0.012398905 | BRD4 | GO:0000228 |
| 91 | GO Cellular Component | lytic vacuole membrane | 0.039519451 | GOPC | GO:0098852 |
| 92 | GO Cellular Component | lysosomal membrane | 0.048689906 | GOPC | GO:0005765 |
| 93 | GO Cellular Component | cytoplasmic vesicle membrane | 0.055926357 | GOPC | GO:0030659 |
| 94 | GO Cellular Component | lysosome | 0.06986024 | GOPC | GO:0005764 |
| 95 | GO Cellular Component | bounding membrane of organelle | 0.110699237 | GOPC | GO:0098588 |
| 96 | GO Cellular Component | nucleus | 0.128243049 | ESR1;BRD4 | GO:0005634 |
| 97 | GO Cellular Component | intracellular membrane-bounded organelle | 0.167172213 | ESR1;BRD4 | GO:0043231 |
| 98 | GO Molecular Function | RNA polymerase II general transcription initiation factor binding | 7.50E-04 | ESR1 | GO:0001091 |
| 99 | GO Molecular Function | RNA polymerase II C-terminal domain binding | 0.001199554 | BRD4 | GO:0099122 |
| 100 | GO Molecular Function | RNA polymerase II CTD heptapeptide repeat kinase activity | 0.001798976 | BRD4 | GO:0008353 |
| 101 | GO Molecular Function | transcription coactivator binding | 0.002997102 | ESR1 | GO:0001223 |
| 102 | GO Molecular Function | acetylation-dependent protein binding | 0.003146801 | BRD4 | GO:0140033 |
| 103 | GO Molecular Function | lysine-acetylated histone binding | 0.003146801 | BRD4 | GO:0070577 |
| 104 | GO Molecular Function | TBP-class protein binding | 0.003296484 | ESR1 | GO:0017025 |
| 105 | GO Molecular Function | general transcription initiation factor binding | 0.003895069 | ESR1 | GO:0140296 |
| 106 | GO Molecular Function | transcription corepressor binding | 0.004343851 | ESR1 | GO:0001222 |
| 107 | GO Molecular Function | RNA polymerase II complex binding | 0.004792498 | BRD4 | GO:0000993 |
| 108 | GO Molecular Function | estrogen receptor binding | 0.00524101 | ESR1 | GO:0030331 |
| 109 | GO Molecular Function | transcription coregulator binding | 0.007929257 | ESR1 | GO:0001221 |
| 110 | GO Molecular Function | ATPase binding | 0.010910517 | ESR1 | GO:0051117 |
| 111 | GO Molecular Function | nuclear receptor binding | 0.017892963 | ESR1 | GO:0016922 |
| 112 | GO Molecular Function | DNA-binding transcription activator activity, RNA polymerase II-specific | 0.049125132 | ESR1 | GO:0001228 |
| 113 | GO Molecular Function | protein serine/threonine kinase activity | 0.050719826 | BRD4 | GO:0004674 |
| 114 | GO Molecular Function | kinase binding | 0.067571375 | ESR1 | GO:0019900 |
| 115 | GO Molecular Function | protein kinase binding | 0.073999256 | ESR1 | GO:0019901 |
| 116 | GO Molecular Function | double-stranded DNA binding | 0.094510249 | ESR1 | GO:0003690 |
| 117 | GO Molecular Function | sequence-specific DNA binding | 0.102349932 | ESR1 | GO:0043565 |
| 118 | GO Molecular Function | sequence-specific double-stranded DNA binding | 0.103047695 | ESR1 | GO:1990837 |
| 119 | GO Molecular Function | RNA polymerase II cis-regulatory region sequence-specific DNA binding | 0.162645402 | ESR1 | GO:0000978 |
| 120 | GO Molecular Function | cis-regulatory region sequence-specific DNA binding | 0.162645402 | ESR1 | GO:0000987 |
| 121 | GO Molecular Function | RNA polymerase II transcription regulatory region sequence-specific DNA binding | 0.190320607 | ESR1 | GO:0000977 |
| 122 | KEGG Pathway | Endocrine and other factor-regulated calcium reabsorption | 0.00529304 | ESR1 | hsa04961 |
| 123 | KEGG Pathway | Prolactin signaling pathway | 0.006987842 | ESR1 | hsa04917 |
| 124 | KEGG Pathway | Thyroid hormone signaling pathway | 0.012063584 | ESR1 | hsa04919 |
| 125 | KEGG Pathway | Estrogen signaling pathway | 0.013653296 | ESR1 | hsa04915 |
| 126 | KEGG Pathway | Breast cancer | 0.014646216 | ESR1 | hsa05224 |
| 127 | KEGG Pathway | Proteoglycans in cancer | 0.020395294 | ESR1 | hsa05205 |
| 128 | KEGG Pathway | Chemical carcinogenesis | 0.023757625 | ESR1 | hsa05207 |
| 129 | KEGG Pathway | Pathways in cancer | 0.052396156 | ESR1 | hsa05200 |