The Hsp70 chaperone system: distinct roles in erythrocyte formation and maintenance

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Supplementary material

Table S1: Mass fractions of individual chaperone proteins from Jurkat cells and mature erythrocytes.

Table S2: Mass fractions of chaperone groups in Jurkat cells and mature erythrocytes.

Table S3: Mass fractions of individual ubiquitin proteasome system proteins from Jurkat cells and mature erythrocytes.

Table S4: Mass fractions of ubiquitin proteasome system protein groups from Jurkat cells and mature erythrocytes.

Figure S1: Expression profiles of selected chaperone systems in red cell progenitors, erythroblasts and mature erythrocytes\(^1,2\) versus unstressed and heat-shocked Jurkat cells,\(^3\) obtained from quantitative proteomics data. The black dotted line represents the median relative abundance of non-hemoglobin proteins in each cell type. Inset: zoom on the HSP70/110, HSP90 and HSP60 categories in unstressed versus heat-shocked Jurkat cells. CT indicates control/unstressed; HS stands for heat-shocked (41°C for 4 hours).

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Table S1: mass fractions of individual chaperone proteins from Jurkat cells and erythrocytes

| Mass fractions (% of total protein) | Jurkat (control) | Jurkat (Heat-Shocked) | RBC (total) |
|-----------------------------------|------------------|-----------------------|-------------|
| **HSP70**                         |                  |                       |             |
| HSC70                             | 1.62E+00         | 1.87E+00              | 7.17E-02    |
| HSPA1A/B                          | 1.46E-03         | 3.84E-03              | 1.89E-02    |
| BIP                               | 2.80E-01         | 3.25E-01              | 6.58E-04    |
| HSPA9                             | 2.19E-01         | 2.41E-01              | 0.00E+00    |
| HSPA2                             | 0.00E+00         | 0.00E+00              | 0.00E+00    |
| HSPA6/7                           | 4.09E-02         | 5.13E-02              | 0.00E+00    |
| HSPA11                            | 0.00E+00         | 0.00E+00              | 0.00E+00    |
| HSPA14                            | 5.50E-03         | 4.06E-03              | 0.00E+00    |
| HSPA13                            | 3.34E-04         | 1.13E-04              | 0.00E+00    |
| **HSP110**                        |                  |                       |             |
| APG2                              | 2.40E-01         | 2.40E-01              | 7.54E-03    |
| APG1                              | 4.77E-02         | 4.40E-02              | 3.09E-06    |
| HSP105                            | 1.68E-03         | 5.24E-03              | 1.80E-04    |
| HYOU1                             | 8.16E-02         | 8.02E-02              | 0.00E+00    |
| **DNAJ A**                        |                  |                       |             |
| DNAJA4                            | 8.01E-05         | 0.00E+00              | 1.20E-03    |
| DNAJA2                            | 7.10E-03         | 6.65E-03              | 1.68E-04    |
| DNAJA1                            | 4.55E-02         | 4.53E-02              | 0.00E+00    |
| DNAJA3                            | 6.34E-03         | 5.47E-03              | 0.00E+00    |
| **DNAJ B**                        |                  |                       |             |
| DNAJB2                            | 0.00E+00         | 0.00E+00              | 3.25E-03    |
| DNAJB1                            | 1.22E-02         | 1.88E-02              | 1.35E-03    |
| DNAJB4                            | 0.00E+00         | 0.00E+00              | 1.77E-04    |
| DNAJB11                           | 1.23E-02         | 1.14E-02              | 0.00E+00    |
| DNAJB6                            | 1.17E-03         | 8.28E-04              | 0.00E+00    |
| DNAJB14                           | 4.43E-03         | 5.76E-03              | 0.00E+00    |
| DNAJB12                           | 6.48E-04         | 6.38E-04              | 0.00E+00    |
| DNAJB9                            | 8.62E-06         | 0.00E+00              | 0.00E+00    |
| **HSP90 NEFs**                    |                  |                       |             |
| BAG6                              | 3.64E-02         | 2.90E-02              | 1.70E-04    |
| BAG1                              | 0.00E+00         | 0.00E+00              | 8.15E-05    |
| BAG2                              | 2.60E-02         | 2.81E-02              | 5.97E-05    |
| HSPBP1                            | 2.88E-03         | 2.16E-03              | 0.00E+00    |
| BAG5                              | 1.79E-03         | 1.26E-03              | 0.00E+00    |
| BAG3                              | 2.44E-04         | 2.54E-04              | 0.00E+00    |
| **HSP90**                         |                  |                       |             |
| HSP90AA1                          | 2.39E+00         | 2.91E+00              | 3.29E-02    |
| HSP90B1                           | 2.14E-01         | 2.04E-01              | 2.67E-05    |
| HSP90AB1                          | 9.92E-01         | 1.07E+00              | 3.61E-03    |
| HSP90AB4P                         | 1.03E-03         | 3.94E-04              | 0.00E+00    |
| HSP90AB2P                         | 1.97E-02         | 1.95E-02              | 0.00E+00    |
| **HSP60 / CCT**                   |                  |                       |             |
| CCT2                              | 3.03E-01         | 3.04E-01              | 2.77E-02    |
| CCT3                              | 2.59E-01         | 2.49E-01              | 1.11E-02    |
| CCT5                              | 2.26E-01         | 2.24E-01              | 1.53E-02    |
| CCT8                              | 2.61E-01         | 2.64E-01              | 2.42E-02    |
| TCP1                              | 2.64E-01         | 2.76E-01              | 1.18E-02    |
| CCT7                              | 2.31E-01         | 2.19E-01              | 1.32E-02    |
| CCT6A                             | 2.58E-01         | 2.50E-01              | 1.35E-02    |
| CCT4                              | 1.67E-01         | 1.58E-01              | 1.40E-02    |
| CCT6B                             | 0.00E+00         | 0.00E+00              | 0.00E+00    |
| HSPD1                             | 8.91E-01         | 9.76E-01              | 0.00E+00    |
| HSPE1                             | 1.39E-01         | 1.82E-01              | 0.00E+00    |
| **sHSP**                          |                  |                       |             |
| HSPB1                             | 0.00E+00         | 0.00E+00              | 2.11E-03    |
| HSPB11                            | 4.64E-03         | 4.63E-03              | 0.00E+00    |

**sum:** 9.31E+00 1.03E+01 2.75E-01
### Table S2: Mass fractions of chaperone groups in Jurkat cells and erythrocytes

| class      | Jurkat (control) | Jurkat (Heat-Shocked) | RBC (total) |
|------------|------------------|------------------------|-------------|
| HSP70s     | 2.163            | 2.492                  | 0.091       |
| HSP110s    | 0.371            | 0.369                  | 0.008       |
| DNAJAs     | 0.059            | 0.057                  | 0.001       |
| DNAIBs     | 0.031            | 0.037                  | 0.005       |
| NEFs       | 0.067            | 0.061                  | 0.000       |
| HSP90s     | 3.613            | 4.203                  | 0.037       |
| HSP60s / CCTs | 2.999          | 3.103                  | 0.131       |
| sHSPs      | 0.005            | 0.005                  | 0.002       |
| class | GeneNames               | Jurkat (control) | Jurkat (Heat-Shocked) | RBC (total) |
|-------|-------------------------|------------------|-----------------------|-------------|
| E1    | UBA3;UBE1C              | 8.3E-03          | 7.1E-03               | 3.9E-04     |
|       | UBA6                    | 2.3E-03          | 1.6E-03               | 0.0E+00     |
|       | UBA2                    | 1.1E-02          | 1.0E-02               | 0.0E+00     |
|       | SAE1                    | 9.5E-03          | 7.0E-03               | 0.0E+00     |
|       | UBE2N;UBE2NL            | 2.6E-02          | 2.4E-02               | 8.4E-03     |
|       | UBE2L3;hCG_1789329      | 2.6E-02          | 2.6E-02               | 5.2E-03     |
|       | UBE2D                   | 1.1E-02          | 6.7E-03               | 6.9E-03     |
|       | UBE2I                   | 3.0E-02          | 2.6E-02               | 0.0E+00     |
|       | UBE2K;HIP2              | 6.9E-03          | 5.8E-03               | 5.2E-03     |
|       | UBE2M                   | 5.4E-03          | 4.0E-03               | 1.2E-03     |
|       | USE1                    | 5.2E-04          | 4.1E-04               | 0.0E+00     |
|       | UBE2D4                  | 0.0E+00          | 0.0E+00               | 0.0E+00     |
|       | UBE2H;Ube2h             | 5.7E-04          | 2.5E-04               | 0.0E+00     |
|       | UBE2L6                  | 2.3E-03          | 4.9E-04               | 0.0E+00     |
|       | UBE2F                   | 9.6E-04          | 5.3E-04               | 0.0E+00     |
|       | UBE2G1                  | 9.2E-04          | 7.3E-04               | 0.0E+00     |
|       | UBE2Z                   | 5.1E-04          | 7.4E-04               | 0.0E+00     |
|       | UBE2C                   | 2.3E-04          | 0.0E+00               | 0.0E+00     |
|       | UBE2S                   | 1.5E-02          | 1.4E-02               | 0.0E+00     |
|       | UBE2A                   | 3.0E-03          | 2.3E-03               | 0.0E+00     |
|       | UBE2G2                  | 2.7E-03          | 1.9E-03               | 0.0E+00     |
|       | UBE2R2                  | 1.8E-03          | 1.1E-03               | 0.0E+00     |
|       | BIRC6                   | 1.8E-03          | 1.2E-03               | 0.0E+00     |
|       | UBE2E2;UBE2E3;UBE2E1     | 8.7E-04          | 4.0E-04               | 0.0E+00     |
| E2    | SKP1                    | 3.3E-02          | 2.7E-02               | 7.8E-03     |
|       | CUL1                    | 1.9E-03          | 1.6E-03               | 2.3E-03     |
|       | DDB1                    | 1.0E-01          | 8.3E-02               | 5.0E-03     |
|       | HUWE1                   | 3.2E-02          | 2.4E-02               | 1.2E-03     |
|       | CUL3;Cul3               | 6.1E-03          | 4.7E-03               | 1.7E-03     |
|       | CUL2                    | 5.7E-03          | 4.3E-03               | 1.3E-03     |
|       | CUL5                    | 1.3E-03          | 8.7E-04               | 5.4E-04     |
|       | TCEB2                   | 1.1E-02          | 1.2E-02               | 6.3E-04     |
|       | TCEB1                   | 2.1E-02          | 1.9E-02               | 6.9E-04     |
|       | RBX1                    | 1.0E-02          | 9.0E-03               | 4.7E-04     |
|       | STUB1                   | 3.1E-03          | 2.8E-03               | 0.0E+00     |
|       | ANAPC4                   | 6.4E-05          | 6.1E-05               | 0.0E+00     |
|       | UBE4B                   | 6.5E-04          | 6.3E-04               | 0.0E+00     |
|       | UBE3C                   | 0.0E+00          | 0.0E+00               | 0.0E+00     |
|       | SMURF1                  | 0.0E+00          | 0.0E+00               | 0.0E+00     |
|       | UBE4A                   | 3.2E-03          | 2.6E-03               | 0.0E+00     |
|       | CDC23                   | 1.6E-03          | 1.5E-03               | 0.0E+00     |
|       | NEDD4L                  | 0.0E+00          | 0.0E+00               | 0.0E+00     |
|       | UBE3A                   | 7.5E-03          | 5.8E-03               | 0.0E+00     |
|       | ANAPC5                  | 2.2E-04          | 1.8E-04               | 0.0E+00     |
|       | CUL4B                   | 1.9E-03          | 1.1E-03               | 0.0E+00     |
|       | CDC27                   | 1.9E-03          | 1.1E-03               | 1.1E-02     |
|       | RNF7                    | 1.4E-03          | 7.6E-04               | 0.0E+00     |
|       | CDC16                   | 1.8E-04          | 3.0E-05               | 0.0E+00     |

Table S3: Mass fractions of individual UPS proteins from Jurkat cells and erythrocytes
| Gene            | 20S CP | 19S RP |
|-----------------|--------|--------|
| PRPF19;LILRB4   | 1.3e-01| 1.4e-01| 0.0e+00 |
| PPI2            | 1.6e-03| 9.3e-04| 0.0e+00 |
| PML             | 9.5e-03| 8.8e-03| 0.0e+00 |
| CDC20           | 7.2e-03| 1.7e-03| 0.0e+00 |
| TRIP12          | 6.4e-03| 4.1e-03| 0.0e+00 |
| ANAPC2          | 3.8e-03| 4.1e-03| 0.0e+00 |
| ANAPC7          | 3.5e-03| 1.9e-03| 0.0e+00 |
| UBR5            | 1.5e-03| 9.1e-04| 0.0e+00 |
| ITCH            | 9.7e-04| 5.3e-04| 0.0e+00 |
| FBXW11;BTRC;DKFZp781ND11 | 6.0e-04| 3.9e-04| 0.0e+00 |
| ANAPC11         | 4.4e-04| 5.8e-04| 0.0e+00 |
| TRAF6           | 3.4e-04| 3.1e-04| 0.0e+00 |
| TRIM32          | 2.7e-04| 2.0e-04| 0.0e+00 |
| HERC4           | 1.7e-04| 7.8e-05| 0.0e+00 |
| RCHY1           | 1.2e-04| 7.1e-05| 0.0e+00 |
| SYVN1           | 1.1e-04| 7.1e-05| 0.0e+00 |
| VHL             | 9.1e-05| 1.1e-05| 0.0e+00 |
| FBXW8           | 0.0e+00| 0.0e+00| 0.0e+00 |
| PSMB5           | 3.0e-02| 2.8e-02| 7.3e-03 |
| PSMA5           | 1.0e-01| 9.8e-02| 1.0e-02 |
| PSMA7           | 8.7e-02| 7.8e-02| 1.2e-02 |
| PSMA1           | 7.8e-02| 7.0e-02| 1.7e-02 |
| PSMB4           | 3.1e-02| 3.2e-02| 3.8e-03 |
| PSMA3           | 4.9e-02| 6.0e-02| 7.0e-03 |
| PSMA6           | 6.0e-02| 5.6e-02| 7.5e-03 |
| PSMA4           | 7.8e-02| 7.2e-02| 8.8e-03 |
| PSMB1           | 4.4e-02| 4.4e-02| 7.7e-03 |
| PSMA2           | 6.1e-02| 5.3e-02| 3.7e-03 |
| PSMB2           | 3.8e-02| 4.2e-02| 3.9e-03 |
| PSMB6           | 4.2e-02| 3.2e-02| 5.4e-03 |
| PSMB3           | 2.8e-02| 2.6e-02| 2.2e-03 |
| PSMB7           | 3.8e-02| 3.2e-02| 7.6e-03 |
| PSMB8;PSM8      | 9.6e-03| 7.1e-03| 0.0e+00 |
| PSMB11          | 0.0e+00| 0.0e+00| 0.0e+00 |
| PSMB10          | 0.0e+00| 0.0e+00| 3.6e-06 |
| PSMB9           | 0.0e+00| 0.0e+00| 0.0e+00 |
| PSMD2;Psm2      | 8.5e-02| 7.6e-02| 6.2e-03 |
| PSME1           | 3.3e-02| 4.8e-02| 1.4e-02 |
| PSMF1           | 1.2e-02| 1.1e-02| 4.0e-03 |
| PSMC4           | 2.8e-02| 2.5e-02| 2.5e-03 |
| PSME2           | 1.7e-02| 1.9e-02| 8.4e-03 |
| PSMD9           | 5.8e-03| 6.4e-03| 8.2e-03 |
| PSMD5           | 1.5e-02| 9.6e-03| 2.8e-03 |
| PSMC2           | 3.9e-02| 3.4e-02| 9.3e-03 |
| PSMC5           | 3.7e-02| 6.9e-02| 5.3e-03 |
| PSMC3           | 2.8e-02| 2.5e-02| 4.0e-03 |
| PSMD13          | 3.0e-02| 2.8e-02| 2.6e-03 |
| PSMD6           | 3.1e-02| 3.3e-02| 2.1e-03 |
| PSMC1           | 4.4e-02| 4.8e-02| 4.1e-03 |
| PSMD1           | 5.8e-02| 5.2e-02| 3.5e-03 |
| PSMD11          | 4.4e-02| 4.2e-02| 3.6e-03 |
| PSMC6           | 2.8e-02| 2.5e-02| 3.9e-03 |
| Gene       | Value1 | Value2 | Value3 |
|------------|--------|--------|--------|
| PSMD3      | 4.4E-02| 3.9E-02| 3.4E-03|
| PSMD12     | 2.5E-02| 2.5E-02| 1.6E-03|
| PSMD8;Psm8 | 1.2E-02| 1.1E-02| 7.0E-04|
| PSMD14     | 3.1E-02| 2.3E-02| 9.5E-04|
| PSMD10     | 1.3E-02| 1.6E-02| 1.2E-03|
| PSMD4      | 2.7E-02| 2.7E-02| 1.2E-03|
| PSMD7      | 2.8E-02| 2.5E-02| 1.3E-03|
| PSME4      | 1.1E-03| 9.4E-04| 0.0E+00|
| PSME3      | 2.8E-02| 3.1E-02| 0.0E+00|
| PSMC3IP    | 4.8E-04| 3.3E-04| 0.0E+00|
| SHFM1      | 0.0E+00| 0.0E+00| 0.0E+00|
| ubiquitin  | 4.8E-01| 6.9E-01| 7.4E-02|

**Note:** The table includes gene names and numerical values in scientific notation.
| class     | Jurkat (control) | Jurkat (Heat-Shocked) | RBC (total) |
|-----------|------------------|-----------------------|-------------|
| E1        | 3,1E-02          | 2,6E-02               | 3,9E-04     |
| E2        | 1,4E-01          | 1,2E-01               | 2,7E-02     |
| E3        | 4,1E-01          | 3,7E-01               | 3,2E-02     |
| 20S CP    | 7,8E-01          | 7,3E-01               | 1,0E-01     |
| 19S RP    | 7,4E-01          | 7,5E-01               | 9,5E-02     |
| ubiquitin | 4,8E-01          | 6,9E-01               | 7,4E-02     |

Table S4: mass fractions of UPS protein groups from Jurkat cells and erythrocytes
Figure S1