Supporting Information for:

Probes for Protein Adduction in Cholesterol Biosynthesis Disorders. Alkynyl Lanosterol as a Viable Sterol Precursor.

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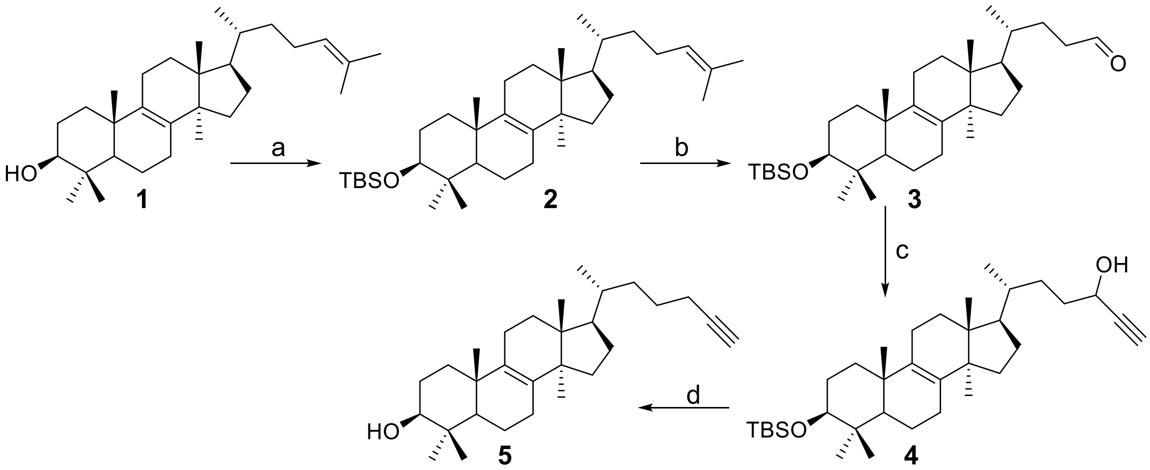
Scheme S1. Full synthetic procedures for alkynyl lanosterol.

Scheme S2. Full synthetic procedures for alkynyl lathosterol.

Figure S1. Structure of photo-cleavable azido biotin.

Table S1. Enrichment factors for the 423 proteins found common to the *a*-7-DHC and *a*-Lan experiments and the ranking of each protein based on enrichment.

Scheme S1. Synthesis of *a*-Lan.



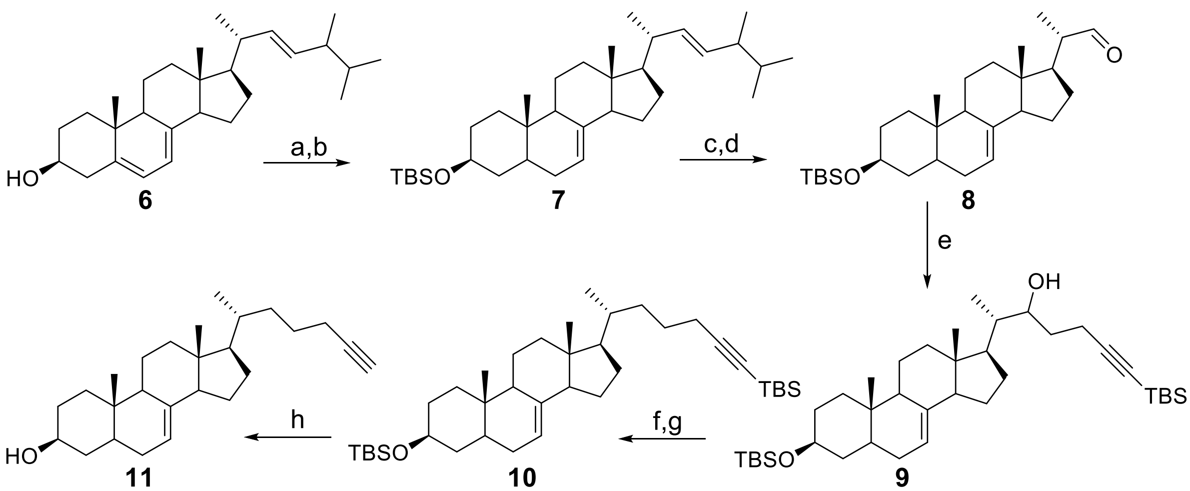
Reagents: a) TBSCl, im, DMF; b) i. O_3, CH_2Cl_2; ii. PPh_3; c) ethynylmagnesium bromide, THF; d) i. $Co_2(CO)_8$, CH_2Cl_2; ii. BH_3-Me_2S, TFA; iii. $Fe(NO_3)_3$.

*Synthesis of aldehyde **3***. The aldehyde **3** was synthesized following procedures from the literature. Lanosterol (**1**) was purchased as a mixture of sterols, but the desired aldehyde is separable since the impurities do not undergo ozonolysis. TBDMSCl (2.4 g, 0.016 mol) and imidazole (2.0 g, 0.029 mol) were added to a solution of lanosterol (5.0 g, 0.012 mol) in DMF (60 mL) and heated to 100 °C. The lanosterol dissolved upon heating. After 3 h, the reaction mixture was cooled and diluted with EtOAc. The solution was washed with H_2O, brine, and dried over $MgSO_4$. Purification by column chromatography (10% EtOAc/hexanes) yielded the product (**2**) as a yellow waxy solid (6.2 g, 97%). Ozone was bubbled through a solution of **2** (6.2 g, 0.011 mol) in CH_2Cl_2 (110 mL) at 0 °C. After 15 min, ozone was stopped and the reaction quenched with PPh_3 (2.8 g, 0.011 mol). After 30 min, the reaction mixture was concentrated. The product was purified by column chromatography (5% EtOAc/hexanes) and isolated as a white powder (1.6 g, 27%). ^{1}H NMR ($CDCl_3$) δ 9.76 (t, 1H, J = 1.9 Hz), 3.19 (dd, 1H, J = 4.9, 10.9 Hz), 2.49-2.28 (m, 2H), 2.10-1.90 (m, 5H), 1.90-1.15 (m, 16H), 0.97 (s, 3H), 0.90 (s, 3H), 0.87 (s, 12H), 0.86 (d, 3H, J = 4.6 Hz), 0.76 (s, 3H), 0.67 (s, 3H), 0.019 (s, 3H), 0.014 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 203.1, 134.7, 134.1, 79.3, 50.4, 50.3, 49.8, 44.5, 41.1, 39.4, 36.9, 36.0, 35.5, 31.0, 30.8, 28.3, 28.2, 28.1, 26.5, 25.9, 24.2, 20.9, 19.2, 18.4, 18.1, 15.9, 15.7, -3.8, -5.0; HRMS (ESI) calculated 514.4201 (M + H), observed 514.4228.

*Synthesis of **4***. Ethynylmagnesium bromide (0.5 M/THF, 2.0 mL, 1.0 mmol) was added to a solution of the aldehyde **3** (0.33 g, 0.64 mmol) in THF (3 mL). After 1 h, the reaction mixture was quenched with saturated NH_4Cl and extracted with EtOAc. The organics were washed with brine and dried over $MgSO_4$. Purification by column chromatography (10% EtOAc/hexanes) afforded the product as a white powder (0.29 g, 83%). ^1H NMR ($CDCl_3$) δ 4.32 (dt, 1H, J = 1.7, 5.9 Hz), 3.18 (dd, 1H, J = 4.8, 10.9 Hz), 2.44 (t, 1H, J = 2.0 Hz), 2.05-1.93 (m, 4H), 1.92-1.40 (m, 14H), 1.40-1.00 (m, 6H), 0.95 (s, 3H), 0.90 (d, 3H, J = 5.6 Hz), 0.89 (s, 3H), 0.87 (s, 9H), 0.85 (s, 3H), 0.75 (s, 3H), 0.67 (s, 3H), 0.015 (s, 3H), 0.010 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 134.6, 134.1, 85.0, 79.4, 72.9, 72.7, 62.8, 62.7, 50.4, 50.2, 49.8, 44.4, 39.4, 36.9, 36.0, 35.5, 34.5, 34.4, 31.3, 31.2, 31.0, 30.8, 28.3, 28.2, 28.1, 26.5, 25.9, 24.2, 21.0, 19.2, 18.7, 18.4, 18.1, 15.9, 15.7, -3.8, -5.0; HRMS (ESI) calculated 514.4201 (M + H), observed 514.4228.

*Synthesis of a-Lan (**5**)*. $Co_2(CO)_8$ (0.37 g, 1.1 mmol) was added to a solution of the alkyne **4** (0.48 g, 0.89 mmol) in CH_2Cl_2 (9 mL). After 30 min, the reaction mixture was cooled to 0 °C. BH_3-Me_2S complex (1 M/ CH_2Cl_2, 1.1 mL, 1.1 mmol) was added, followed by TFA (0.9 mL, 10% v). After an additional 30 min, the reaction was quenched with H_2O and extracted with EtOAc. The organic layer was washed with brine and dried over $MgSO_4$. The crude product was dissolved in CH_3CN (7 mL) and MeOH (2 mL). $Fe(NO_3)_3$ (1.9 g, 4.6 mmol) was added to the reaction mixture and stirred for 3 h to deprotect the alkyne. The alcohol was also deprotected under these conditions. The workup was repeated as above. The product was isolated as a white powder (0.19 g, 52%) after purification by column chromatography (10 → 20% EtOAc/hexanes). ^1H NMR ($CDCl_3$) δ 3.21 (dd, 1H, J = 4.7, 11.4 Hz), 2.15-2.10 (m, 2H), 2.02-1.98 (m, 4H), 1.92 (t, 1H, J = 2.6 Hz), 1.73-1.21 (m, 20H), 0.97 (s, 3H), 0.95 (s, 3H), 0.88 (d, 3H, J = 6.2 Hz), 0.85 (s, 3H), 0.78 (s, 3H), 0.66 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 134.4, 134.3, 84.8, 78.9, 68.0, 50.3, 50.2, 49.8, 44.4, 38.8, 37.0, 36.0, 35.5, 35.3, 30.9, 30.8, 28.1, 27.9, 27.8, 26.4, 25.3, 24.2, 20.9, 19.1, 18.8, 18.6, 18.2, 15.8, 15.7; HRMS (ESI) calculated 410.3543 (M + H), observed 410.3516.

Scheme S2. Synthesis of *a*-Lath.



Reagents: a) H_2, Raney Ni, EtOAc/THF; b) TBSCl, im, DMF/THF; c) OsO_4, NMO, THF/*t*BuOH; d) $NaIO_4$, THF/pH 7 buffer; e) 4-(*tert*-butyldimethylsilyloxy)-1-bromo-3-butyne , Mg, THF; f) MsCl, pyridine; g) LAH/THF; h) TBAF, THF.

Synthesis of 7. Raney Ni (5 g) was added to a solution of ergosterol **6** (5.0 g, 0.013 mol) in EtOAc/THF (90 mL, 2:1). The reaction mixture was sparged with H_2, then left under a balloon of H_2 for the duration of the reaction. After 3 h, the reaction mixture was filtered through a pad of Celite, dried over $MgSO_4$, and concentrated. No purification was necessary and the product was isolated as a white powder (4.5 g, 88%). ^1H NMR ($CDCl_3$) δ 5.23-5.09 (m, 3H), 3.62-3.52 (m, 1H), 2.00-1.95 (m, 2H), 1.83-1.66 (m, 8H), 1.65-1.21 (m, 14H), 0.99 (d, 3H, J = 6.4 Hz), 0.89 (d, 3H, J = 6.8 Hz), 0.81 (d, 3H, J = 4.6 Hz), 0.79 (d, 3H, J = 4.6 Hz), 0.77 (s, 3H), 0.52 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 139.5, 135.6, 131.8, 117.4, 71.0, 55.9, 55.1, 49.4, 43.2, 42.8, 40.4, 40.2, 39.4, 37.9, 37.1, 34.2, 33.0, 31.4, 29.6, 28.1, 22.9, 21.5, 21.1, 19.9, 19.6, 17.6, 13.0, 132.0.

TBSCl (2.2 g, 0.015 mol) and imidazole (1.9 g, 0.028 mol) were added to a solution of this sterol (4.5 g, 0.011 mol) in a mixture of DMF/THF (60 mL, 1:1). A white precipitate formed. After the reaction had stirred overnight, it was diluted with EtOAc and washed with H_2O, brine, and dried over $MgSO_4$. The product was purified by column chromatography (10% EtOAc/hexanes) and isolated as a white powder (5.2 g, 90%). ^1H NMR ($CDCl_3$) δ 5.23-5.09 (m, 3H), 3.58-3.49 (m, 1H), 2.02-1.95 (m, 2H), 1.90-1.20 (m, 21H), 0.99 (d, 3H, J = 6.6 Hz), 0.89 (d, 3H, J = 6.9 Hz), 0.87 (s, 9H), 0.82 (d, 3H, J = 4.6 Hz), 0.80 (d, 3H, J = 4.6 H), 0.77 (s, 3H), 0.52 (s, 3H), 0.032 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 139.5, 135.7, 131.8, 117.5, 71.8, 55.9, 55.1, 49.5, 43.3, 42.8, 40.5, 40.4, 39.5, 38.4, 37.3, 34.2, 33.0, 31.8, 29.7, 28.1, 25.9, 22.9, 21.5, 21.1, 19.9, 19.6, 18.2, 17.6, 13.0, 12.0, -4.6; HRMS (ESI) calculated 513.4486 (M + H), observed 513.4485.

*Synthesis of aldehyde **8***. OsO_4 (~0.16 M/H_2O, 1.2 mL, 0.19 mmol) was added to a solution of **7** (0.51 g, 0.99 mmol) and NMO (0.13 g, 1.1 mmol) in a mixture of THF (8 mL) and *t*BuOH (3 mL). After 3 d, the reaction mixture was quenched with saturated Na_2SO_3 and extracted with EtOAc. The organic layer was washed with brine and dried over $MgSO_4$. The product (0.23 g, 42%) was purified by column chromatography (20% EtOAc/hexanes). The product was isolated as a mixture of diastereomers. ^{1}H NMR ($CDCl_3$) δ 5.11 (br s, 1H), 3.66-3.65 (m, 1H), 3.55-3.50 (m, 1.6 H), 3.34 (t, 0.4H, J = 5.5 Hz), 2.42 (br s, 2H), 2.05-1.90 (m, 2H), 1.90-1.19 (m, 21H), 0.97 (d, 3H, J – 6.9 Hz), 0.91 (d, 3H, J = 6.7 Hz), 0.86-0.80 (m, 15H), 0.74 (s, 3H), 0.51 (s, 1.8H), 0.50 (s, 1.2H), 0.005 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 139.2 (minor), 139.0 (major), 117.8 (major), 117.7 (minor), 76.1, 73.1, 72.5, 71.8, 70.2, 54.8, 54.6, 52.6, 52.5, 49.4, 43.8, 43.2, 42.4, 41.5, 40.8, 40.3, 39.5, 38.4, 37.3, 34.1, 31.8, 31.5, 29.6, 27.8, 27.6, 26.9, 25.9, 23.1, 22.8, 22.1, 21.5, 21.0, 18.7, 18.2, 17.2, 14.1, 13.0, 12.6, 11.7, 11.6, 10.8, 9.9, -4.6; HRMS (ESI) calculated 547.4541 (M + H), observed 547.4513.

$NaIO_4$ (0.35 g, 1.6 mmol) was added to a solution of the diol (0.54 g, 0.99 mmol) in THF/pH 7 buffer (4 mL, 3:1). After 2 h, the reaction mixture was diluted with EtOAc and washed with H_2O, brine, and dried over $MgSO_4$. Purification by column chromatography (10% EtOAc/hexanes) afforded the product as a white powder (0.43 g, 99%). ^{1}H NMR ($CDCl_3$) δ 9.55 (d, 1H, J = 6.0 Hz), 5.15 (s, 1H), 3.57-3.48 (m, 1H), 2.39-2.33 (m, 1H), 1.96-1.54 (m, 12H), 1.48-1.22 (m, 8H), 1.10 (d, 3H, J = 6.9 Hz), 0.85 (s, 9H), 0.76 (s, 3H), 0.55 (s, 3H), 0.022 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 205.0, 138.6, 118.2, 71.8, 54.2, 50.9, 49.8, 49.4, 43.9, 40.3, 39.2, 38.4, 37.3, 34.2, 31.8, 29.6, 26.7, 25.9, 23.3, 21.4, 18.2, 13.5, 13.0, 12.2, -4.6; HRMS (ESI) calculated 445.3496 (M + H), observed 445.3477.

Synthesis of 4-(tert-butyldimethylsilyloxy)-1-bromo-3-butyne. *n*BuLi (2.5 M/hexanes, 60 mL, 0.15 mol) was added to a solution of 3-butyn-1-ol (5.0 mL, 0.066 mol) in THF (160 mL) at 0 °C. After 30 min, a solution of TBSCl (23 g, 0.15 mol) in THF (10 mL) was added. The reaction was allowed to stir overnight, then quenched with H_2O and extracted with EtOAc. The crude product was dissolved in HOAc:H_2O (160 mL, 2:1) and heated to 80 °C. After 1 h, the reaction mixture was cooled and extracted with toluene. The organic layer was washed with saturated $NaHCO_3$, brine, and dried over $MgSO_4$. The product was purified by column chromatography (20% EtOAc/hexanes) and isolated as a yellow liquid (7.4 g, 60%). ^{1}H NMR ($CDCl_3$) δ 3.68 (t, 2H, J = 6.3 Hz), 2.47 (t, 2H, J = 6.4 Hz), 1.96 (br s, 1H), 0.89 (s, 9H), 0.06 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 103.8, 85.0, 60.9, 26.0, 25.6, 24.2, 17.9, 16.4, -3.7, -4.6.

NBS (8.6 g, 0.048 mol) was added in portions to a solution of the alcohol (7.4 g, 0.040 mol) and PPh_3 (13 g, 0.048 mol) in CH_2Cl_2 (150 mL) at 0 °C. After 30 min, the reaction mixture was diluted with ether and filtered through a pad of silica. Purification by column chromatography (10% EtOAc/hexanes) afforded the product as a pale yellow liquid (5.9 g, 60%). ^{1}H NMR ($CDCl_3$) δ 3.41 (t, 2H, J = 7.4 Hz), 2.76 (t, 2H, J = 7.4 Hz), 0.91 (s, 9H), 0.07 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 103.7, 85.2, 29.4, 26.0, 24.2, 16.4, -4.7.

*Synthesis of **9***. A solution of 4-(*tert*-butyldimethylsilyloxy)-1-bromo-3-butyne (2.2 g, 8.9 mmol) in THF (8 mL) was added dropwise to Mg turnings (1.1 g, 45 mmol) that had been vigorously stirred overnight. After 1 h, the Grignard reagent was added to a solution of the aldehyde **8** (1.3 g, 3.0 mmol) in THF (15 mL) at 0 °C. After 1 h, the reaction was quenched with saturated NH_4Cl and extracted with EtOAc. The organic layer was washed with brine and dried over $MgSO_4$. The product was purified by column chromatography (10% EtOAc/hexanes) and isolated as an off-white foam (1.1 g, 58%). ^{1}H NMR ($CDCl_3$) δ 5.14 (br s, 1H), 3.86-3.83 (m, 1H), 3.57-3.47 (m, 1H), 2.32 (t, 2H, J = 7.0 Hz), 2.00-1.95 (m, 2H), 1.90-1.20 (m, 22H), 0.90 (s, 9H), 0.89 (d, 3H, J = 3.8 Hz), 0.86 (s, 9H), 0.76 (s, 3H), 0.52 (s, 3H), 0.05 (s, 6H), 0.03 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 139.3, 117.7, 107.4, 83.2, 72.6, 71.8, 54.9, 52.5, 49.4, 43.3, 40.9, 40.3, 39.5, 38.4, 37.3, 34.2, 34.1, 31.8, 29.7, 27.4, 26.0, 25.9, 22.8, 21.5, 18.2, 17.1, 16.4, 13.0, 11.9, 11.7, -4.5, -4.6; HRMS (ESI) calculated 613.4831 (M + H), observed 613.4841.

*Synthesis of **10***. MsCl (0.30 mL, 3.9 mmol) was added to a solution of **9** (1.2 g, 1.9 mmol) in anhydrous pyridine (10 mL). After 1 h, the reaction mixture was diluted with EtOAc and washed with H_2O, brine, and dried over $MgSO_4$. Purification by column chromatography (10% EtOAc/hexanes) afforded the product as a white foam (1.2 g, 89%). ^{1}H NMR ($CDCl_3$) δ 5.12 (br s, 1H), 4.90 (t, 1H, J = 6.8 Hz), 3.53-3.47 (m, 1H), 2.98 (s, 3H), 2.28 (t, 2H, J = 6.8 Hz), 2.15-1.92 (m, 3H), 1.82-1.21 (m, 20H), 0.95 (d, 3H, J = 6.0 Hz), 0.88 (s, 9H), 0.84 (s, 9H), 0.74 (s, 3H), 0.51 (s, 3H), 0.04 (s, 6H), 0.004 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 138.9, 118.0, 105.4, 85.1, 84.2, 71.7, 54.8, 52.0, 49.4, 43.3, 40.2, 39.8, 39.4, 38.7, 38.4, 37.3, 34.1, 31.8, 31.2, 29.6, 27.6, 26.0, 25.9, 22.9, 21.4, 18.2, 16.6, 16.3, 13.1, 13.0, 11.7, -4.5, -4.6; HRMS (ESI) calculated *m/z* 713.4426 (M + Na), observed *m/z* 713.4401.

LAH (1M/THF, 5.0 mL, 5.0 mmol) was added to a solution of the mesylate (1.2 g, 1.7 mmol) in THF (9 mL), then heated to reflux. After 1 h, the reaction mixture was cooled and quenched cautiously with 10% HCl, then extracted with EtOAc. The organics were washed with brine and dried over $MgSO_4$. The product was isolated as a white powder (0.66 g, 65%) after purification by column chromatography (5% EtOAc/hexanes). Some elimination occurred and the products were inseparable. They were purified after deprotection. ^{1}H NMR ($CDCl_3$) δ 5.13 (br s, 1H), 3.57-3.49 (m, 1H), 2.24-2.15 (m, 2H), 2.01-1.02 (m, 25H), 0.91 (d, 3H, J = 4.3 Hz), 0.90 (s, 9H), 0.86 (s, 9H), 0.76 (s, 3H), 0.51 (s, 3H), 0.06 (s, 6H), 0.03 (s, 6H); ^{13}C NMR ($CDCl_3$) δ 139.4, 117.5, 107.9, 82.3, 71.8, 55.9, 55.0, 49.6, 43.3, 40.4, 39.5, 38.4, 37.3, 36.7, 35.6, 34.9, 34.2, 31.8, 31.6, 29.7, 27.9, 26.1, 26.0, 24.5, 22.9, 21.5, 20.4, 18.8, 18.2, 16.5, 14.1, 13.0, 11.8, -4.5, -4.6; HRMS (ESI) calculated 597.4881 (M + H), observed 597.4885.

*Synthesis of a-Lath **(11)***. TBAF (1M/THF, 3.3 mL, 3.3 mmol) was added to a solution of **10** (0.66 g, 1.1 mmol) in THF (5 mL). After stirring overnight, the reaction mixture was diluted with EtOAc and washed with H_2O, brine, and dried over $MgSO_4$. The product was purified by column chromatography (20% EtOAc/hexanes) and isolated as a white powder (0.31 g, 75%). Higher purity product was obtained by HPLC purification on a C18 column using CH_3CN:MeOH (70:30). ^{1}H NMR ($CDCl_3$) δ 5.14 (d, 1H, J = 2.3 Hz), 3.62-3.52 (m, 1H), 2.16-2.09 (m, 2H), 2.02-1.96 (m, 1H), 1.92 (t, 1H, J = 2.6 Hz), 1.82-1.71 (m, 6H), 1.59-1.05 (m, 18H), 0.91 (d, 3H, J = 6.5 Hz), 0.77 (s, 3H), 0.51 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 139.5, 117.5, 84.8, 71.0, 68.0, 55.9, 55.0, 49.4, 43.3, 40.2, 39.5, 37.9, 37.1, 35.7, 35.0, 34.1, 31.4, 29.6, 27.8, 25.1, 22.9, 21.5, 18.8, 13.0, 11.8; HRMS (ESI) calculated 351.3046 (M + H), observed 351.3044.

Figure S1. Structure of photo-cleavable azido biotin.

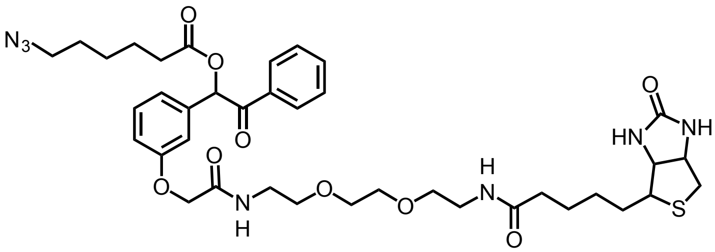


Figure S2. 3 Biological replica of (A) Streptavidin westerns after click reaction (B) short-stacking SDS Page stained with Simply blue after photo-release. Control (DMSO), 10 µM of *a*-Lanosterol , and 5 µM of *a*-7-DHC were treated in *Dhcr7*-defficient N2aCells for 24 h.

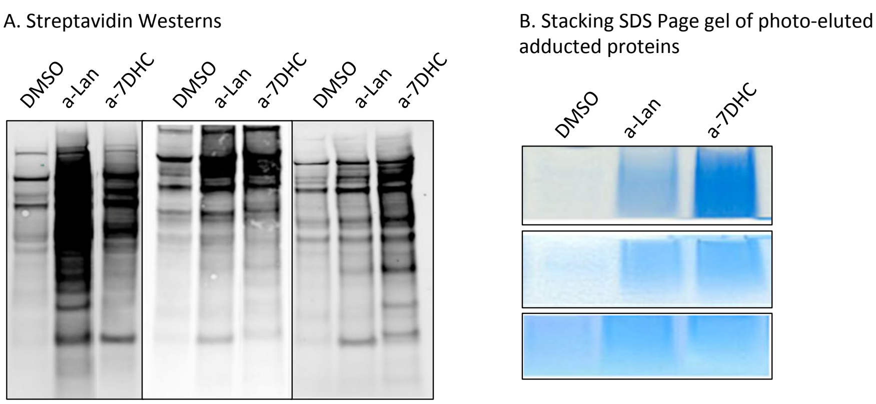


Table S1. Enrichment factors for the 423 proteins found common to the *a*-7-DHC and *a*-Lan experiments and the ranking of each protein based on enrichment.

	a-7-DHC	Enrichment Factors		*a*-Lan	Enrichment Factors
Rank	Gene ID	log2 (count1*/count2*)	Rank	Gene ID	log2 (count1*/count2*)
1	Crmp1	2.12	1	Tnpo1	2.03
2	Atp5a1	2.14	2	Psmd2	2.04
3	Vdac2	2.15	3	Mcm7	2.07
4	Gnao1	2.17	4	Vdac2	2.08
5	Ncapg	2.22	5	Mtap1b	2.09
6	Tm9sf2	2.32	6	Cct4	2.09
7	Tubgcp3	2.32	7	Immt	2.09
8	Srrt	2.32	8	Iars	2.10
9	Slc16a6	2.32	9	Atp5a1	2.10
10	Nup133	2.32	10	Rps16	2.12
11	Nop56	2.32	11	Cct2	2.14
12	Birc6	2.32	12	Eef1d	2.17
13	Hspa14	2.32	13	Eif3i	2.17
14	Lmna	2.32	14	Fads2	2.17
15	Mcm7	2.32	15	Hist1h2bc	2.17
16	Ndufs1	2.32	16	Nap1l1	2.17

17	Nisch	2.32	17	Rps20	2.17
18	Akap9	2.32	18	Hspa4	2.20
19	Bub3	2.46	19	Tars	2.22
20	Immt	2.52	20	Rpl7	2.22
21	Myh10	2.53	21	Ncapg	2.22
22	Hnrnpf	2.54	22	Fkbp4	2.22
23	Prdx4	2.54	23	Eif3e	2.22
24	Psmd2	2.56	24	Ahsa1	2.22
25	Slc1a5	2.56	25	Slc1a5	2.24
26	Tmtc3	2.58	26	Atp2a1	2.25
27	Ube4a	2.58	27	Gdi1	2.25
28	Usp10	2.58	28	Rcc2	2.25
29	Vps26b	2.58	29	Rps2	2.25
30	Timm50	2.58	30	Eif3b	2.29
31	Spcs2	2.58	31	Myh10	2.30
32	Abcd3	2.58	32	Prdx4	2.32
33	Chordc1	2.58	33	Prdx6	2.32
34	Eef1d	2.58	34	Rad21	2.32
35	Ephx1	2.58	35	Rpl19	2.32
36	Etf1	2.58	36	Rpl21	2.32
37	Fads2	2.58	37	Serinc1	2.32
38	Gps1	2.58	38	Slc16a6	2.32
39	Hba-a1	2.58	39	Slc1a4	2.32
40	Hist1h2bc	2.58	40	Smc1a	2.32
41	Iars	2.58	41	Srrt	2.32
42	Kif11	2.58	42	Timm44	2.32
43	Lss	2.58	43	Tm9sf2	2.32
44	Msh6	2.58	44	Tm9sf3	2.32
45	Ret	2.58	45	Tubgcp3	2.32
46	Rif1	2.58	46	Ube4a	2.32
47	Rps16	2.58	47	Uchl1	2.32
48	Slc1a4	2.58	48	Zmpste24	2.32
49	Cad	2.70	49	Pdcd6ip	2.32
50	Cct2	2.70	50	Nup188	2.32
51	Rps20	2.70	51	Oat	2.32
52	Atp2a1	2.73	52	Nisch	2.32
53	Ahsa1	2.74	53	Ncdn	2.32
54	Trim28	2.74	54	Nceh1	2.32
55	Pgd	2.77	55	Myo5a	2.32
56	Dhx9	2.77	56	Msh2	2.32
57	Rpl7	2.77	57	Luc7l2	2.32
58	Atp2a2	2.78	58	Ipo4	2.32
59	Cct4	2.78	59	Kcmf1	2.32
60	Tnpo1	2.79	60	Hnrnpf	2.32
61	Cend1	2.81	61	4930572J05Rik	2.32

62	Cpsf2	2.81	62	Abcd3	2.32
63	Elovl5	2.81	63	Actr3	2.32
64	Fam134c	2.81	64	Aimp2	2.32
65	Fam38a	2.81	65	Atp5f1	2.32
66	Glt25d1	2.81	66	Bag3	2.32
67	Hsd17b4	2.81	67	BC055324	2.32
68	Myo1c	2.81	68	Birc6	2.32
69	Ncln	2.81	69	Btaf1	2.32
70	Nlrp4e	2.81	70	Capn2	2.32
71	Nudcd1	2.81	71	Cd151	2.32
72	Pgk1	2.81	72	Cd47	2.32
73	Psmb6	2.81	73	Cdc42	2.32
74	Rab3gap2	2.81	74	Cyb5r3	2.32
75	Rad21	2.81	75	Derl1	2.32
76	Rpl10	2.81	76	Dnaja1	2.32
77	Rpl26	2.81	77	Ephx1	2.32
78	Thoc2	2.81	78	Fam38a	2.32
79	Tram1	2.81	79	Fkbp8	2.32
80	Tti1	2.81	80	Gps1	2.32
81	Umps	2.81	81	Gstp1	2.32
82	Urb1	2.81	82	Hba-a1	2.32
83	Cd47	2.81	83	Bcap31	2.37
84	4930572J05Rik	2.81	84	Iqgap1	2.38
85	Atl3	2.81	85	Pgd	2.38
86	Eif3b	2.85	86	Flnc	2.39
87	Tufm	2.91	87	Tkt	2.43
88	Rpl28	2.91	88	Flna	2.44
89	Rcc2	2.91	89	Dhx9	2.45
90	Hspa4	2.91	90	Tufm	2.46
91	Atp1a1	2.94	91	Rpl28	2.46
92	Smc1a	3.00	92	Cct5	2.46
93	Sun1	3.00	93	Lrrc59	2.46
94	Tm9sf3	3.00	94	Matr3	2.46
95	Tomm70a	3.00	95	Rpl10	2.46
96	Slc29a1	3.00	96	Atp2a2	2.48
97	Rps2	3.00	97	Crmp1	2.50
98	Rpl21	3.00	98	Sars	2.52
99	Aldh9a1	3.00	99	Slc2a3	2.58
100	Atp5c1	3.00	100	Smarca4	2.58
101	Btaf1	3.00	101	Spcs2	2.58
102	Cyb5r3	3.00	102	Supt16h	2.58
103	Gnas	3.00	103	Tex10	2.58
104	Med23	3.00	104	Thoc2	2.58
105	Prkaa1	3.00	105	Timm50	2.58
106	Prkaca	3.00	106	Tmtc3	2.58

107	Prkacb	3.00	107	Tomm70a	2.58
108	Rpl10a	3.00	108	Vps26b	2.58
109	Flna	3.01	109	Slc16a3	2.58
110	Cct5	3.04	110	Scarb2	2.58
111	Fkbp4	3.06	111	Rpsa	2.58
112	Tars	3.06	112	Rsl1d1	2.58
113	Gnb2l1	3.07	113	Ret	2.58
114	Ap1g1	3.09	114	Pgk1	2.58
115	Dnmt1	3.09	115	Prkaa1	2.58
116	Gdi1	3.09	116	Prkaca	2.58
117	Lrrc59	3.09	117	Prkacb	2.58
118	Nap1l1	3.09	118	Psmb6	2.58
119	Tpr	3.09	119	Psmc4	2.58
120	Tkt	3.10	120	Paics	2.58
121	Eif3e	3.12	121	Pafah1b1	2.58
122	Xpo1	3.14	122	Nup107	2.58
123	1300001I01Rik	3.17	123	Bub3	2.58
124	Actr3	3.17	124	Cacybp	2.58
125	Atad3a	3.17	125	Chordc1	2.58
126	Bcap31	3.17	126	Cul7	2.58
127	Cd151	3.17	127	D10Wsu52e	2.58
128	Dpysl2	3.17	128	Dync1i2	2.58
129	Eif3m	3.17	129	Eftud2	2.58
130	Emc1	3.17	130	Eif3m	2.58
131	Fkbp8	3.17	131	Esyt1	2.58
132	Lap3	3.17	132	Esyt2	2.58
133	Lmf2	3.17	133	Gaa	2.58
134	Lpcat3	3.17	134	Gls	2.58
135	Nbas	3.17	135	Glt25d1	2.58
136	Nmt1	3.17	136	Gnai2	2.58
137	Nup107	3.17	137	Gnao1	2.58
138	Pelp1	3.17	138	Gnas	2.58
139	Pfkl	3.17	139	Hdlbp	2.58
140	Pfn1	3.17	140	Heatr6	2.58
141	Psmd12	3.17	141	Hspa14	2.58
142	Rnh1	3.17	142	Lss	2.58
143	Rps18	3.17	143	Mat2a	2.58
144	Rpsa	3.17	144	Me1	2.58
145	Rsl1d1	3.17	145	Metap2	2.58
146	Slc16a3	3.17	146	Msh6	2.58
147	Slc2a3	3.17	147	Myadm	2.58
148	Syne2	3.17	148	Ndufs1	2.58
149	Tex10	3.17	149	Nudcd1	2.58
150	Flnc	3.19	150	Atl3	2.58

151	Ipo5	3.26	151	Ap1g1	2.58
152	Tnpo2	3.26	152	Cct7	2.62
153	Vdac3	3.29	153	Cad	2.64
154	Serinc1	3.32	154	Pfkl	2.66
155	Smarca4	3.32	155	Trim28	2.66
156	Ppp2r2a	3.32	156	Dnmt1	2.70
157	Rpl36	3.32	157	Lmf2	2.70
158	Ruvbl2	3.32	158	Sept7	2.70
159	Oat	3.32	159	Atp1a1	2.72
160	Polr2b	3.32	160	Eprs	2.72
161	Myadm	3.32	161	Hnrnpa1	2.75
162	Ncdn	3.32	162	Kpnb1	2.75
163	Msh2	3.32	163	Mybbp1a	2.76
164	Luc7l2	3.32	164	Gnb2l1	2.77
165	Armc6	3.32	165	Tmx3	2.81
166	Atad1	3.32	166	Top2a	2.81
167	Bag3	3.32	167	Tram1	2.81
168	Cse1l	3.32	168	Tti1	2.81
169	Cul4a	3.32	169	Ube4b	2.81
170	Dync1i2	3.32	170	Urb1	2.81
171	Fads1	3.32	171	Usp10	2.81
172	Gstp1	3.32	172	Vcl	2.81
173	Kcmf1	3.32	173	Vps13c	2.81
174	Spnb2	3.36	174	Slc29a1	2.81
175	Cct7	3.36	175	Rps18	2.81
176	Kpnb1	3.37	176	Rpl9	2.81
177	Agpat4	3.46	177	Armc6	2.81
178	Ap3d1	3.46	178	Arpc1b	2.81
179	Arpc1b	3.46	179	Atad3a	2.81
180	Bzw1	3.46	180	Atp5c1	2.81
181	Derl1	3.46	181	Cend1	2.81
182	Eif3i	3.46	182	Elovl5	2.81
183	Ermp1	3.46	183	Fads1	2.81
184	Hdlbp	3.46	184	Fam134c	2.81
185	Hnrnpa1	3.46	185	Heatr5b	2.81
186	Idh3a	3.46	186	Idh3a	2.81
187	Ints3	3.46	187	Kdelr2	2.81
188	Kdelr2	3.46	188	Ktn1	2.81
189	Ktn1	3.46	189	Lap3	2.81
190	Lass2	3.46	190	Lass2	2.81
191	Mat2a	3.46	191	Lmna	2.81
192	Mcm3	3.46	192	Lmnb1	2.81
193	Mms19	3.46	193	Nmt1	2.81
194	Mtap1b	3.46	194	Nup85	2.81
195	Myo1b	3.46	195	Oxct1	2.81

196	Numa1	3.46	196	Ppp2r2a	2.81
197	Psmc5	3.46	197	Psmd12	2.81
198	Pycr2	3.46	198	Ptbp1	2.81
199	Rap1a	3.46	199	Pycr2	2.81
200	Rpl19	3.46	200	Rap1a	2.81
201	Slc38a1	3.46	201	Rpl36	2.81
202	Gnai3	3.52	202	Abhd12	2.81
203	Mcm2	3.52	203	Agpat4	2.81
204	Sept7	3.52	204	Ap3d1	2.81
205	Eprs	3.54	205	Abcb6	2.81
206	Zmpste24	3.58	206	Cand1	2.85
207	Vps13c	3.58	207	Ipo5	2.87
208	Unc45a	3.58	208	Ddx21	2.87
209	Psat1	3.58	209	Psat1	2.91
210	Skiv2l2	3.58	210	Rpl26	2.91
211	Smc4	3.58	211	Vdac3	2.91
212	BC05532 4	3.58	212	Nop56	3.00
213	Gnai2	3.58	213	Nup133	3.00
214	Heatr2	3.58	214	Pfas	3.00
215	Lmnb1	3.58	215	Rab3gap2	3.00
216	Lnpep	3.58	216	Ruvbl2	3.00
217	Metap2	3.58	217	Slc7a1	3.00
218	Naa25	3.58	218	Suclg2	3.00
219	Nceh1	3.58	219	Umps	3.00
220	Pdcd6ip	3.58	220	Wdr1	3.00
221	Pds5b	3.58	221	Xpo7	3.00
222	Gdi2	3.62	222	Nlrp4e	3.00
223	Mybbp1a	3.66	223	Ncam1	3.00
224	Cand1	3.68	224	Myo1c	3.00
225	Slc3a2	3.68	225	Mms19	3.00
226	Iqgap1	3.70	226	Akap9	3.00
227	Matr3	3.70	227	Atad1	3.00
228	Mif	3.70	228	Bzw1	3.00
229	Nomo1	3.70	229	Cisd1	3.00
230	Rdh11	3.70	230	Clptm1	3.00
231	Slc25a12	3.70	231	Dcakd	3.00
232	Slc25a33	3.70	232	Emc1	3.00
233	Suclg2	3.70	233	Etf1	3.00
234	Supt16h	3.70	234	Heatr2	3.00
235	Timm44	3.70	235	Itgb1	3.00
236	Uchl1	3.70	236	Lpcat3	3.00
237	Vcl	3.70	237	Mcm2	3.00
238	Heatr5b	3.70	238	Tnpo2	3.04
239	Ddx21	3.70	239	Xpo1	3.05
240	Copa	3.70	240	Gnai3	3.09

241	Atm	3.70	241	Gdi2	3.12
242	Atp5f1	3.70	242	Gemin5	3.12
243	Abcb6	3.70	243	Slc25a12	3.17
244	Aimp2	3.70	244	Soat1	3.17
245	Lbr	3.75	245	Skiv2l2	3.17
246	Nup205	3.79	246	Sec63	3.17
247	Abhd12	3.81	247	Cul4a	3.17
248	Atp6v1a	3.81	248	Dnaja2	3.17
249	Capn2	3.81	249	Enpp3	3.17
250	Cul2	3.81	250	Ermp1	3.17
251	Esyt2	3.81	251	Gbf1	3.17
252	Gls	3.81	252	Hsd17b4	3.17
253	Heatr6	3.81	253	Idh3g	3.17
254	Me1	3.81	254	Lnpep	3.17
255	Nup188	3.81	255	Mcm3	3.17
256	Pafah1b1	3.81	256	Mcm5	3.17
257	Prdx6	3.81	257	Mif	3.17
258	Psmc4	3.81	258	Ncln	3.17
259	Rhot1	3.81	259	Pds5b	3.17
260	Sars	3.81	260	Pelp1	3.17
261	Soat1	3.81	261	Rangap1	3.17
262	Stt3b	3.81	262	Rdh11	3.17
263	Tbc1d15	3.81	263	Rif1	3.17
264	Top2a	3.81	264	Rpl10a	3.17
265	Urb2	3.81	265	Rrp12	3.17
266	Ipo7	3.83	266	Cul2	3.17
267	Mcm5	3.86	267	Aldh9a1	3.17
268	Rpl7a	3.86	268	Cpsf2	3.17
269	Abcf2	3.86	269	Ipo7	3.21
270	Gemin5	3.87	270	Yars	3.25
271	Srsf6	3.91	271	Smc4	3.25
272	Tmx3	3.91	272	Tpr	3.25
273	Rrp12	3.91	273	Atic	3.27
274	Ptbp1	3.91	274	Nup205	3.29
275	Psmc6	3.91	275	Cse1l	3.30
276	Pfas	3.91	276	Slc3a2	3.30
277	Cdc42	3.91	277	Lbr	3.32
278	Dcakd	3.91	278	Polr2b	3.32
279	Idh3g	3.91	279	Rhot1	3.32
280	Kif5b	3.91	280	Rpl7a	3.32
281	Nup160	3.91	281	Snrnp200	3.32
282	Nup85	3.91	282	Unc45a	3.32
283	Atic	3.97	283	Ints3	3.32
284	Dnaja2	4.00	284	1300001I01 Rik	3.32
285	Drg2	4.00	285	Atm	3.32

286	Ipo4	4.00	286	Atp6v1h	3.32
287	Myo5a	4.00	287	Copa	3.32
288	Ncam1	4.00	288	Dpysl2	3.32
289	Tmem97	4.00	289	Eif2s3x	3.32
290	Vps18	4.00	290	Gart	3.32
291	Cisd1	4.00	291	Tbc1d15	3.46
292	Snrnp200	4.07	292	Sun1	3.46
293	Cul7	4.09	293	Myo1b	3.46
294	D10Wsu52e	4.09	294	Nbas	3.46
295	Eftud2	4.09	295	Nomo1	3.46
296	Gaa	4.09	296	Pfn1	3.46
297	Gspt1	4.09	297	Psmc5	3.46
298	Gtpbp4	4.09	298	Psmc6	3.46
299	Oxct1	4.09	299	Rpl13a	3.46
300	Ruvbl1	4.09	300	Slc25a33	3.46
301	Ube4b	4.09	301	Slc38a1	3.46
302	Yars	4.09	302	Srsf6	3.46
303	Nipbl	4.17	303	Acat1	3.46
304	Nsdhl	4.17	304	Atp6v1a	3.46
305	Paics	4.17	305	Ctps	3.46
306	Tbcd	4.17	306	Gm17296	3.46
307	Ube3c	4.17	307	H13	3.46
308	Xpo7	4.17	308	Med23	3.46
309	Idh3b	4.17	309	Abcf2	3.52
310	Lass5	4.17	310	Bzw2	3.52
311	Atp6v1h	4.17	311	Stt3b	3.58
312	Fanci	4.17	312	Syne2	3.58
313	Gbf1	4.17	313	Tmem97	3.58
314	Gfpt1	4.17	314	Ube3c	3.58
315	Dync1h1	4.20	315	Spnb2	3.58
316	Bzw2	4.25	316	Naa25	3.58
317	Lonp1	4.25	317	Nipbl	3.58
318	Nup155	4.25	318	Pgam1	3.58
319	Pgam1	4.25	319	Rnh1	3.58
320	Tmem214	4.25	320	Rtn4	3.58
321	Slc7a1	4.32	321	Gmps	3.58
322	Wdr1	4.32	322	Hadha	3.58
323	Zw10	4.32	323	Kif5b	3.58
324	Sept9	4.32	324	Nsdhl	3.64
325	Acat1	4.32	325	Ruvbl1	3.70
326	Adpgk	4.32	326	Sept2	3.70
327	Ctps	4.32	327	Sept9	3.70
328	Ints1	4.32	328	Vac14	3.70
329	Ptplad1	4.32	329	Vps18	3.70
330	Xpo5	4.38	330	Ptplad1	3.70

331	Gm17296	4.39	331	Acsl3	3.70
332	Gm364	4.39	332	Akap12	3.70
333	Kntc1	4.39	333	Gdpd1	3.70
334	Rpl13a	4.39	334	Gfpt1	3.70
335	Stt3a	4.39	335	Nup160	3.70
336	Dctn1	4.39	336	Dync1h1	3.72
337	Sept2	4.46	337	Lonp1	3.75
338	Clptm1	4.46	338	Cand2	3.81
339	Cyb5b	4.46	339	Fanci	3.81
340	Dnaja1	4.46	340	Gspt1	3.81
341	Rangap1	4.46	341	Kif11	3.81
342	Sec63	4.46	342	Urb2	3.81
343	Vac14	4.52	343	Adpgk	3.81
344	Esyt1	4.52	344	Cyb5b	3.91
345	Itgb1	4.52	345	Lass5	3.91
346	Nup93	4.52	346	Surf4	3.91
347	Atp13a1	4.52	347	Srprb	4.00
348	Coro1c	4.52	348	Tbcd	4.00
349	Cacybp	4.58	349	Dctn1	4.00
350	Gdpd1	4.58	350	Etfa	4.00
351	Gmps	4.58	351	Ncapd2	4.00
352	Sgpl1	4.58	352	Sec31a	4.00
353	Sec31a	4.64	353	Atp2b1	4.00
354	Far1	4.64	354	Sf3b1	4.04
355	Arfgef2	4.64	355	Stt3a	4.06
356	Xpot	4.68	356	Xpo5	4.08
357	Cyfip1	4.70	357	Huwe1	4.09
358	Eif3h	4.70	358	Ncapd3	4.09
359	Enpp3	4.70	359	Tmem214	4.09
360	H13	4.70	360	Utp20	4.09
361	Srprb	4.70	361	Zw10	4.09
362	Ipo11	4.75	362	Eif3h	4.09
363	Scarb2	4.75	363	Gtpbp4	4.09
364	Eif2s3x	4.75	364	Sgpl1	4.17
365	Copg2	4.81	365	Atp13a1	4.17
366	Etfa	4.81	366	Chd4	4.17
367	Heatr1	4.81	367	Idh3b	4.17
368	Rtn4	4.81	368	Mest	4.17
369	Akap12	4.81	369	Far1	4.25
370	C330027 C09Rik	4.81	370	Ipo11	4.25
371	Cand2	4.81	371	Numa1	4.25
372	Sf3b1	4.83	372	Coro1c	4.25
373	Chd4	4.86	373	Usp9x	4.32
374	Surf4	4.86	374	Xpot	4.32
375	Ap1b1	4.91	375	Nup93	4.32

376	Ncapd3	4.91	376	Rpn2	4.32
377	Pds5a	4.95	377	Cyp51	4.32
378	Rpl9	4.95	378	Ipo9	4.32
379	Mtch2	4.95	379	Gm364	4.36
380	Gart	4.95	380	Ints1	4.39
381	Ggt7	4.95	381	Nup155	4.39
382	Cyp51	5.00	382	Ckap4	4.39
383	Ckap4	5.00	383	Mthfd1	4.52
384	Ctage5	5.00	384	Trrap	4.52
385	Atp2b1	5.04	385	Drg2	4.52
386	Rpn2	5.09	386	Copg2	4.52
387	Mtor	5.09	387	Pds5a	4.58
388	Acsl3	5.13	388	Arfgef2	4.58
389	Mest	5.13	389	Hsd17b12	4.58
390	Mon2	5.17	390	Ap2b1	4.58
391	Ap2b1	5.17	391	Mtch2	4.64
392	Ltn1	5.25	392	Ggt7	4.64
393	Ncapd2	5.29	393	Cyfip1	4.64
394	Ipo9	5.32	394	Aldh1l2	4.64
395	Hadha	5.32	395	Tpp2	4.75
396	Huwe1	5.36	396	Kpna2	4.75
397	Mthfd1	5.36	397	Ltn1	4.75
398	Tnpo3	5.43	398	Heatr1	4.75
399	Plec	5.43	399	Tfrc	4.78
400	Eif3a	5.43	400	Mtor	4.81
401	Tpp2	5.46	401	Copb1	4.81
402	Tfrc	5.48	402	Ckap5	4.81
403	Abce1	5.49	403	Ap1b1	4.81
404	Utp20	5.52	404	Acsl4	4.86
405	Trrap	5.52	405	Tnpo3	4.91
406	Copb1	5.55	406	Abce1	5.04
407	Acsl4	5.55	407	Eif3a	5.13
408	Ubr4	5.63	408	Ubr4	5.20
409	Aldh1l2	5.67	409	Ctage5	5.21
410	Usp9x	5.67	410	Kntc1	5.21
411	Ranbp2	5.70	411	C330027C0 9Rik	5.32
412	Kpna2	5.73	412	Sympk	5.39
413	Copg	5.75	413	Prpf8	5.39
414	Sympk	5.88	414	Lars	5.49
415	Hsd17b12	5.91	415	Tln1	5.52
416	Lars	5.95	416	Ranbp2	5.55
417	Ckap5	6.07	417	Mon2	5.55
418	Prpf8	6.09	418	Copg	5.67
419	Tln1	6.15	419	AI314180	5.82
420	AI314180	6.30	420	Cnot1	5.91

421	Cnot1	6.43	421	Plec	6.41
422	Gcn1l1	6.85	422	Gcn1l1	6.53
423	Mdn1	7.14	423	Mdn1	6.77