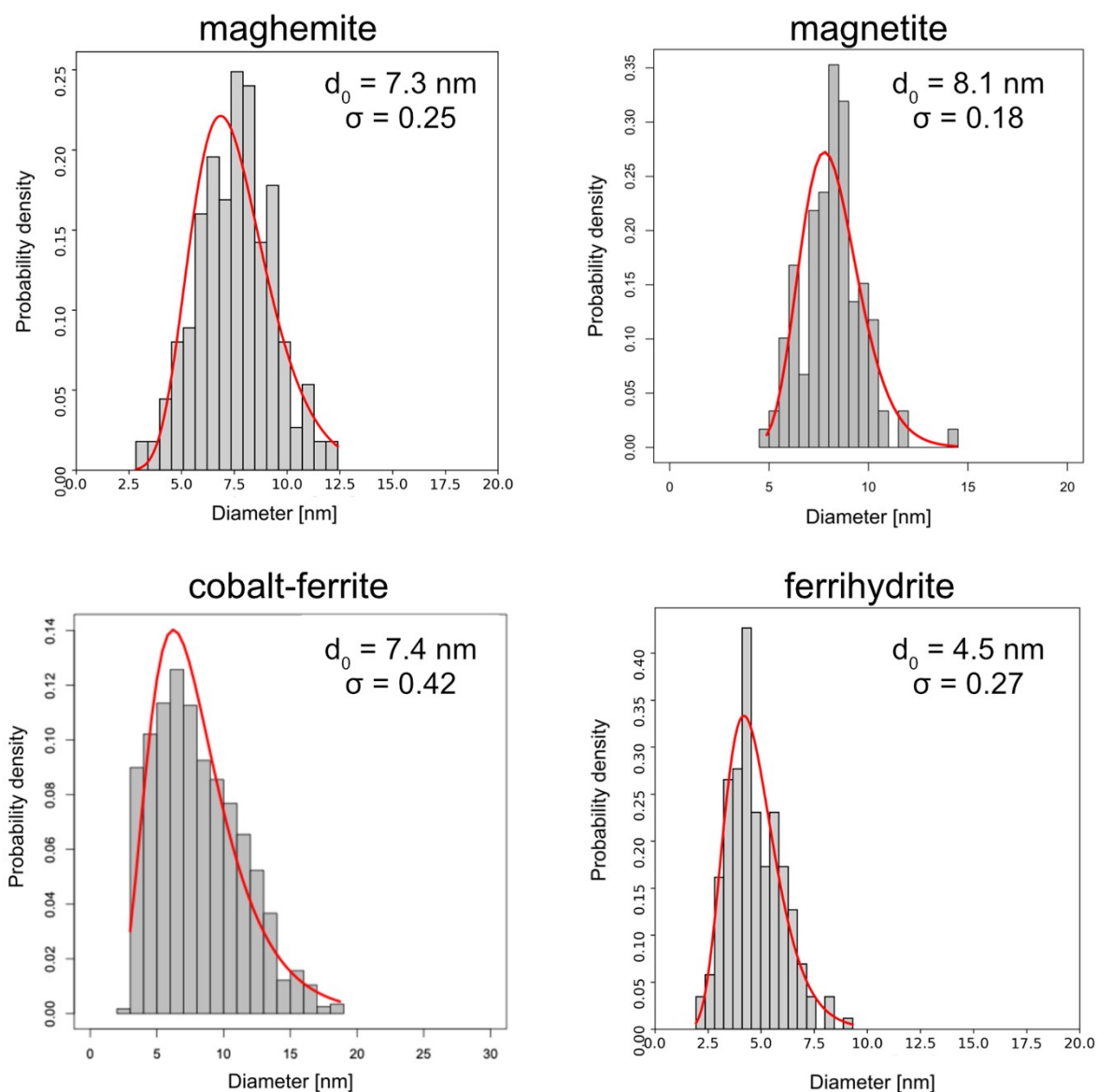
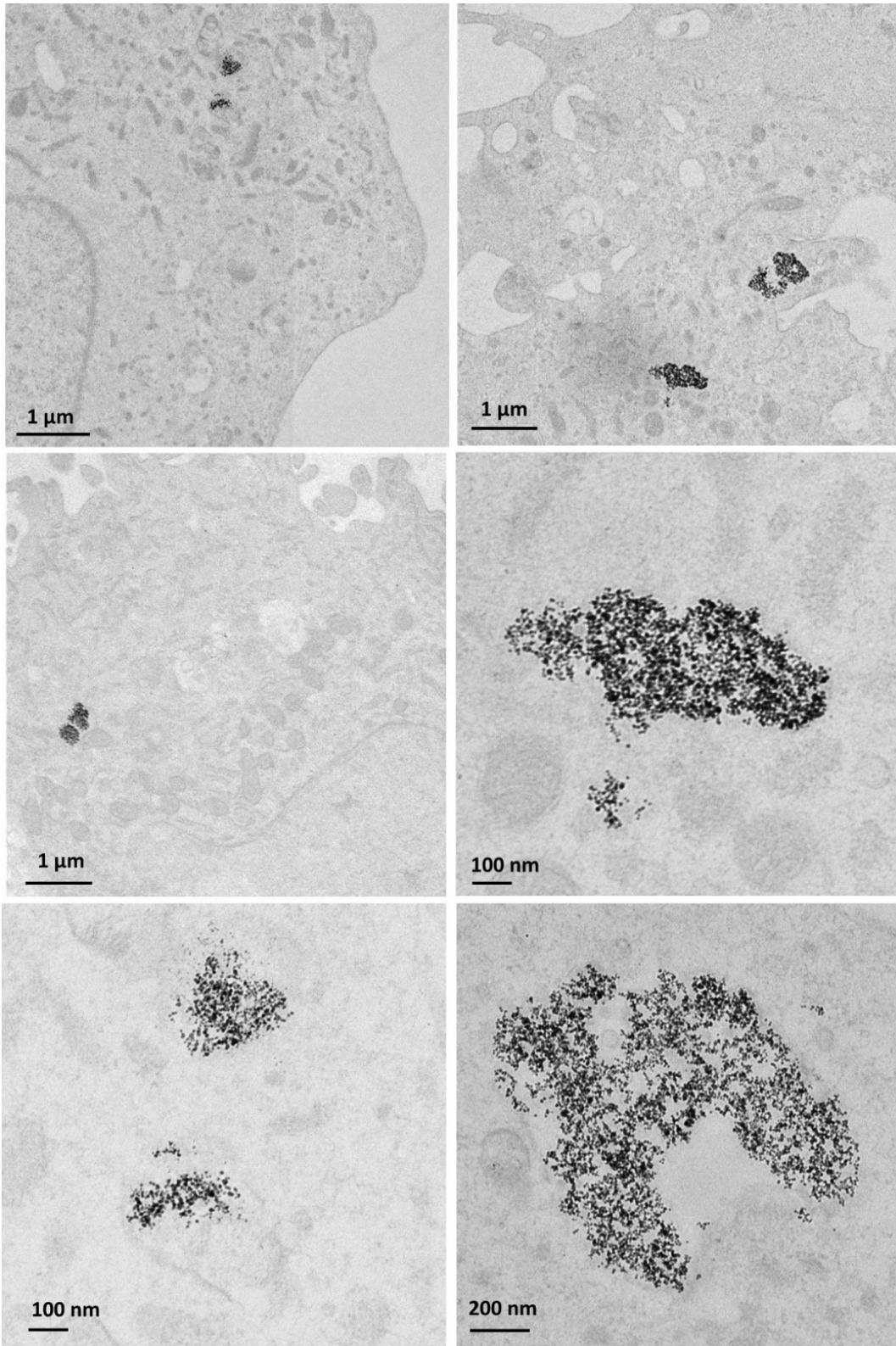


## Supplementary Information

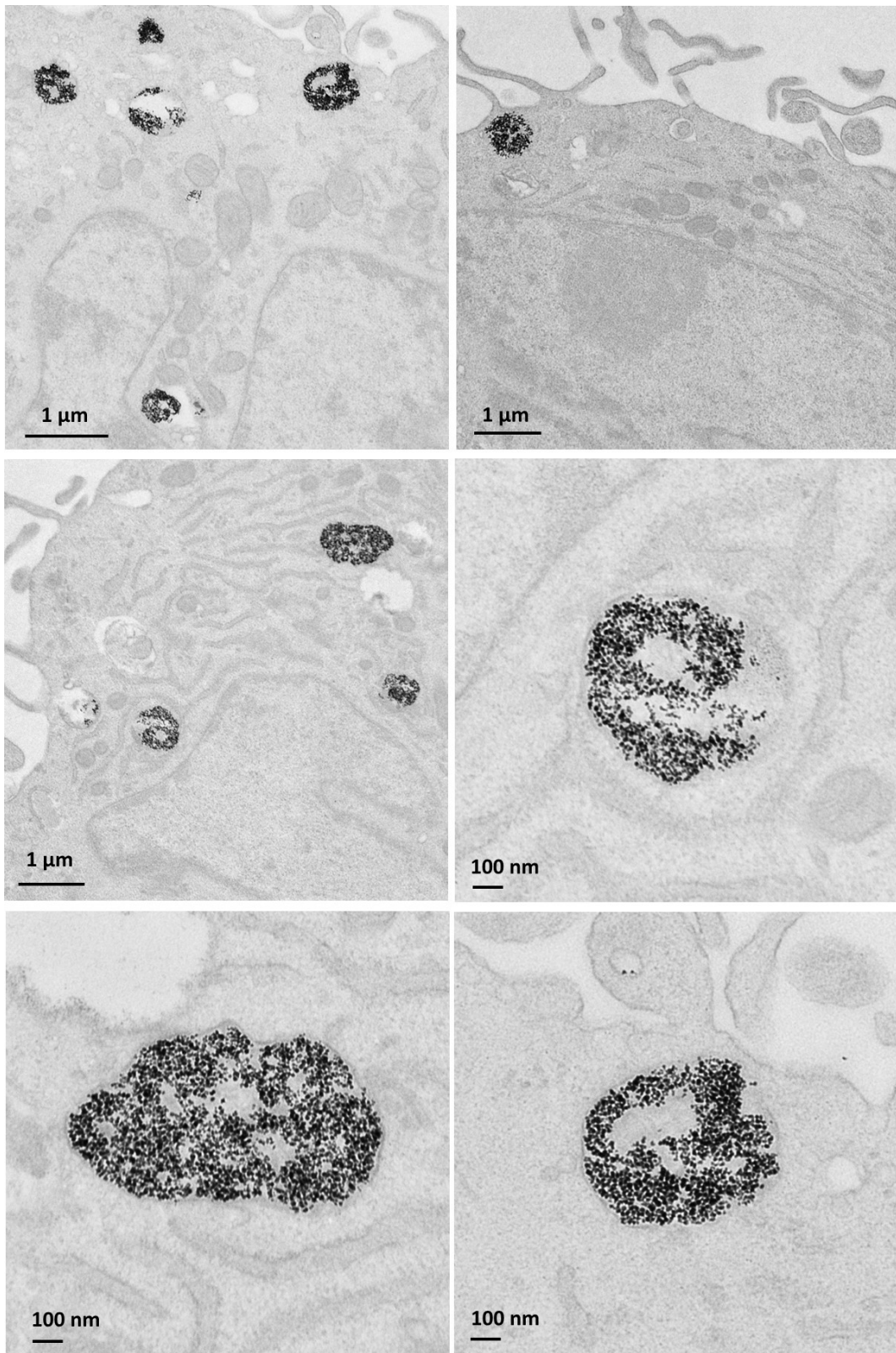
### From degradation to (re)magnetization: magnetic reprogramming of maghemite (Massart), magnetite, cobalt ferrite and ferrihydrite nanoparticles by human stem cells



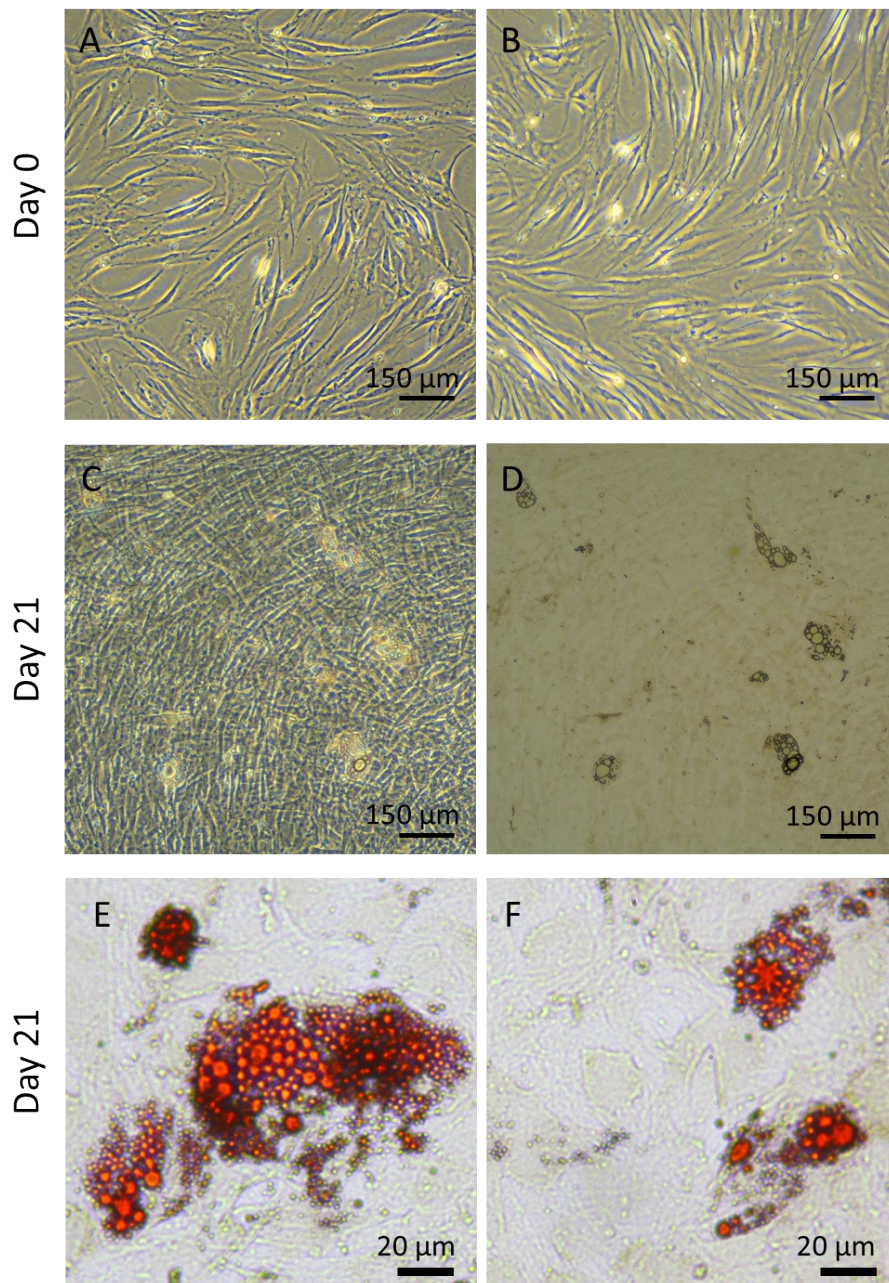
**Figure S1:** Particle size distributions of different nanoparticles, extracted from the TEM images from the manuscript for magnetite and ferrihydrite ( $n=200$ ), and coming from larger datasets for maghemite and cobalt-ferrite.



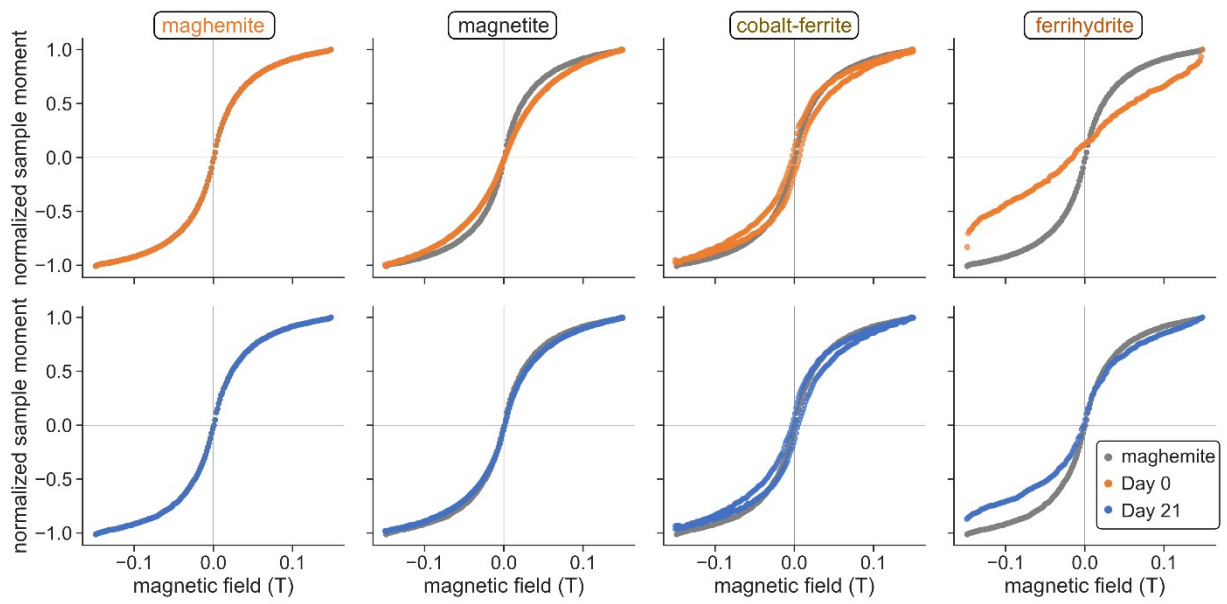
**Figure S2:** TEM images of magnetite ( $\text{Fe}_3\text{O}_4$ ) localized into endosomal compartments of hMSCs at day 0.



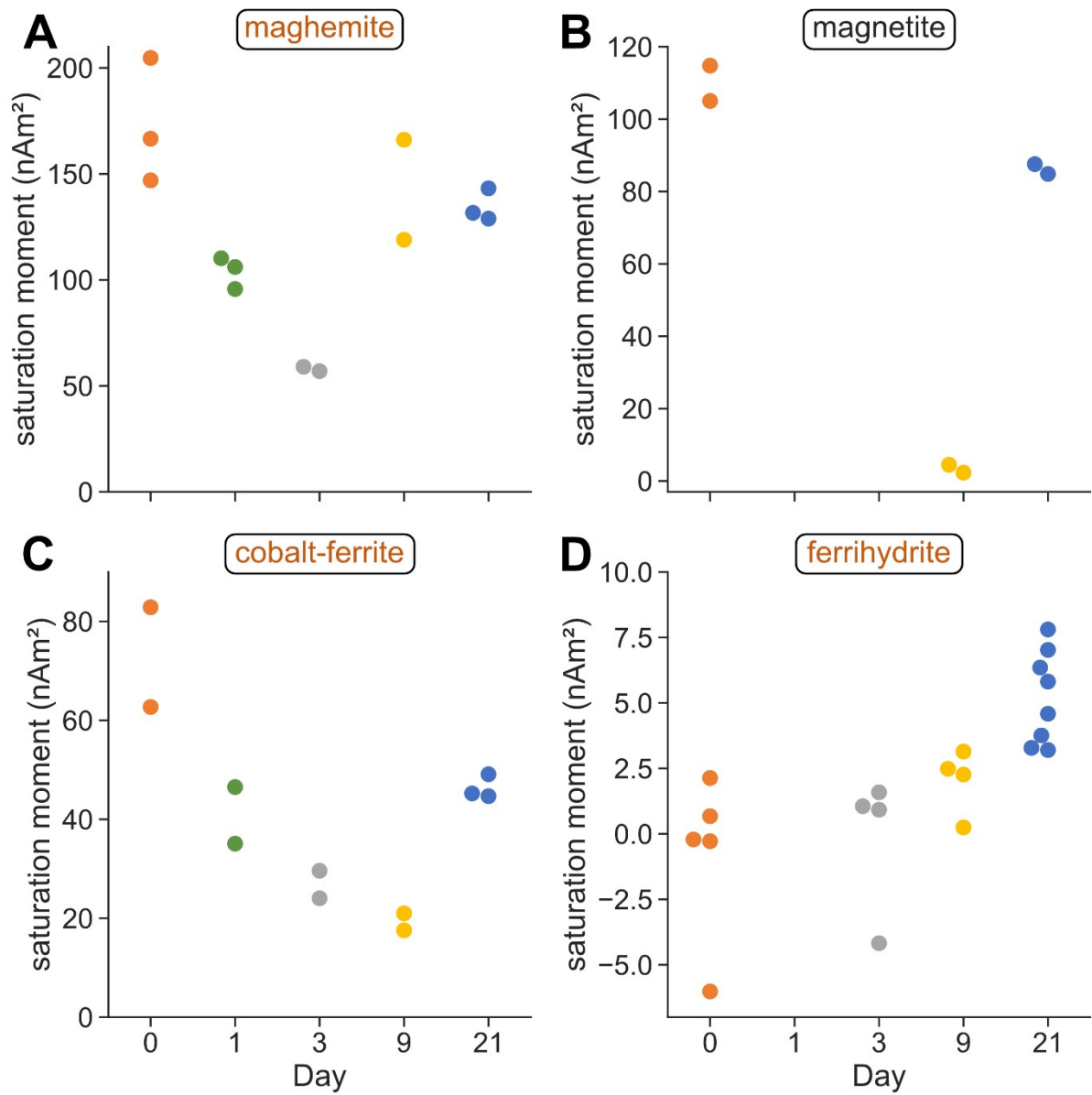
**Figure S3:** TEM images of cobalt ferrite (CoFe<sub>2</sub>O<sub>4</sub>) upon their internalization within hMSCs (day 0).



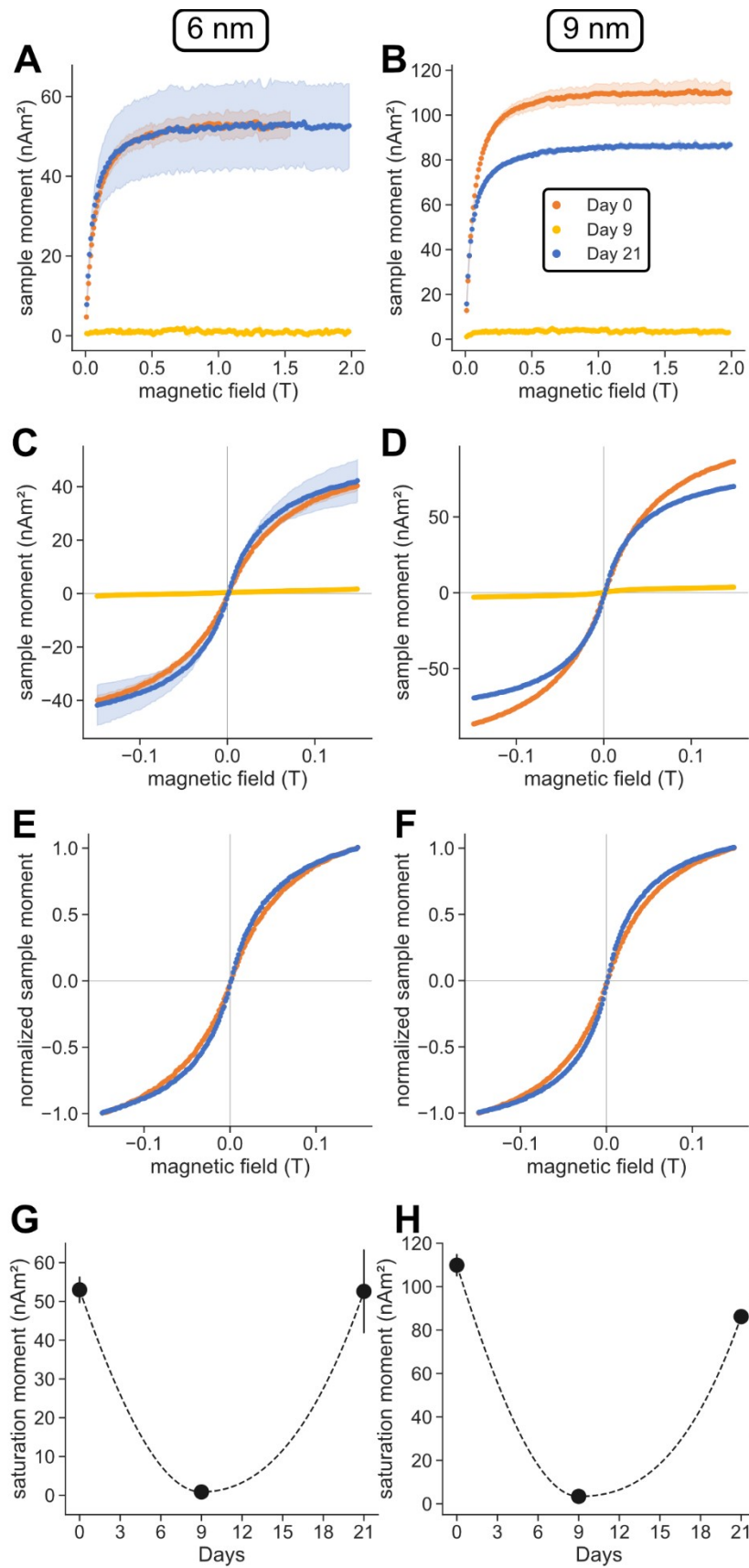
**Figure S4:** Differentiation of hMSCs into adipocytes when cultured under biosynthesis conditions. (A, B) hMSCs labeled with magnetic nanoparticles seeded in a well of a 6-well plate (200 000 cells per well). (C, D) Upon 21 days of culture in adipogenic medium, the cells proliferated and differentiated into adipocytes. C and D show the identical area, with C being focused on the cells and D on the lipid droplets. (E, F) Lipid droplets visualized on day 21 in adipocytes, fixed with 10% formalin and stained with Oil Red O and hematoxylin, to detect cytoplasmic triglycerides and nuclei.



**Figure S5:** Normalized low magnetic field curves of hMSCs incubated with the four different magnetic nanostructures on days 0 and 21. Maghemite internalized in hMSCs on day 0 and 21 (gray curves) is superimposed for each condition, enabling a comparison of magnetic properties.

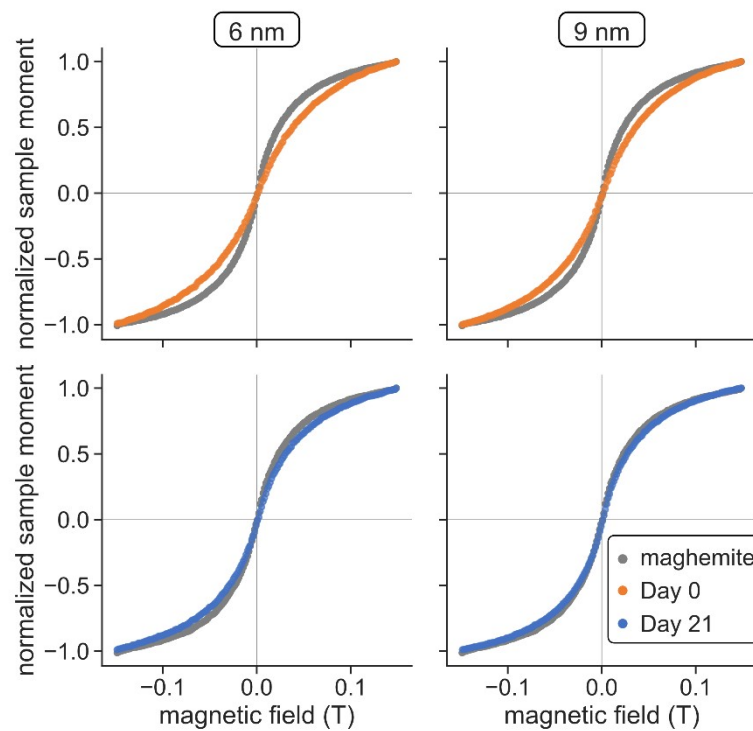


**Figure S6:** Magnetic moment at saturation for all independent pooled cell samples analyzed, following the internalization of maghemite, magnetite, cobalt ferrite, or ferrihydrite nanostructures.

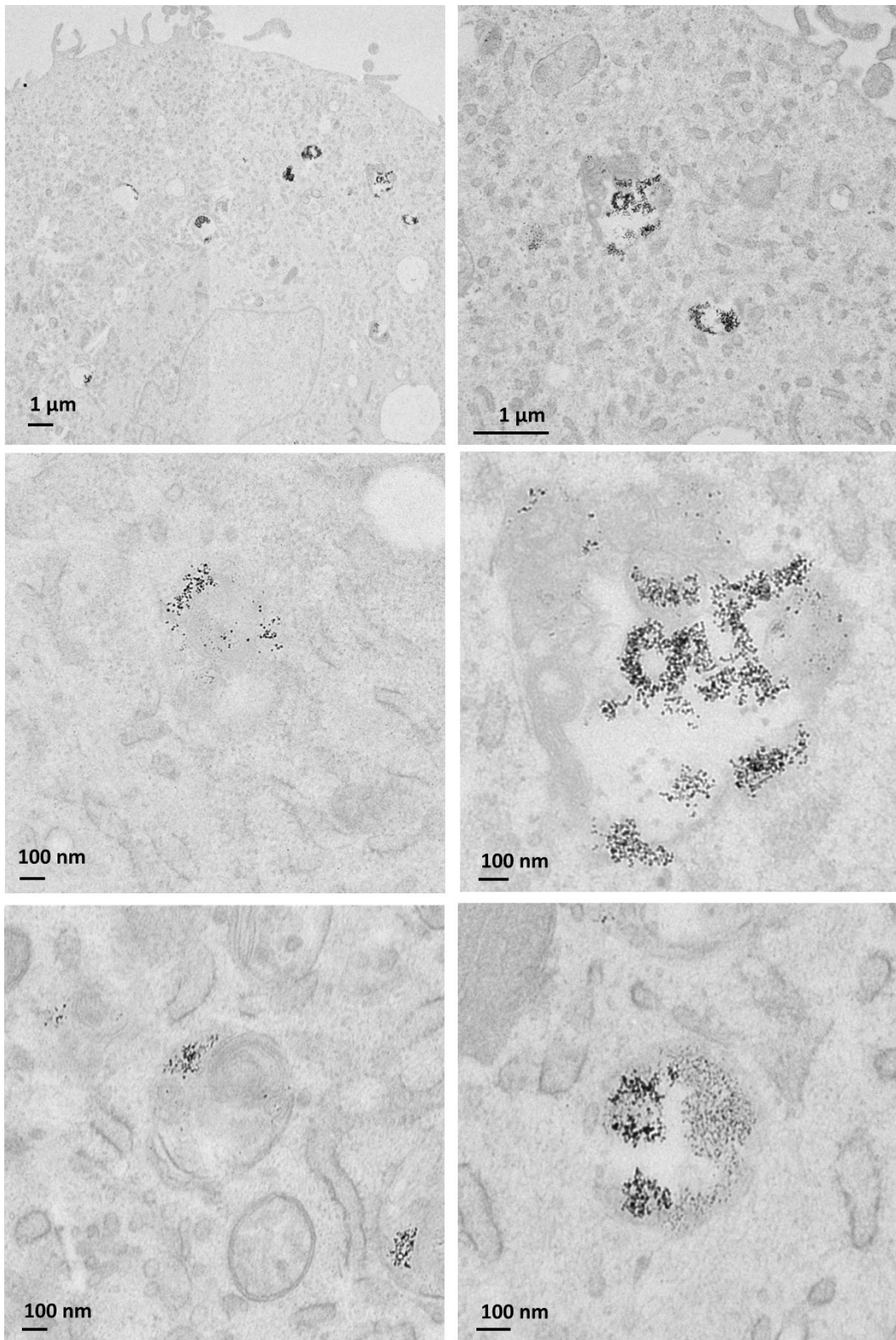


**Figure S7:** Magnetometry measurement of hMSCs incubated with magnetite nanoparticles of three different sizes (6 or 9 nm) and cultured under biosynthesis conditions. A pool of 200 000 hMSCs per well were plated, then labeled with magnetite of 6 nm (A, C, E, G) and 9 nm (B, D, F, H) on day 0. The

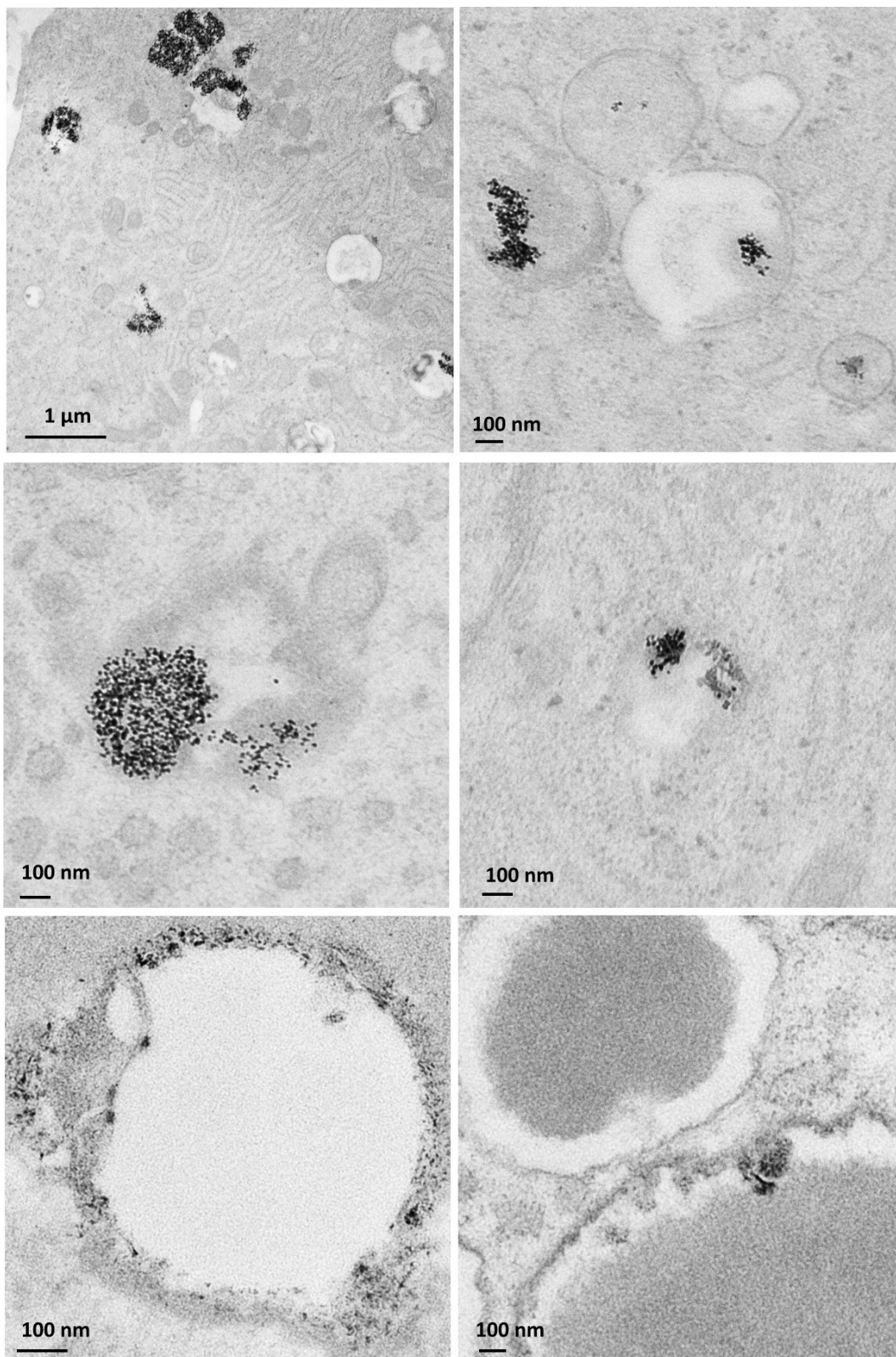
cells were cultured in biosynthesis medium for 21 days. Pools of cells were detached and fixed on day 0, 9, or 21, and their magnetic signal was subsequently measured with a VSM. Measurements were obtained at high (A,B) and low (C,D) magnetic fields. Curves show the average magnetic moments for each day and condition, with the standard deviation illustrated by shaded color. Values obtained at low magnetic fields were normalized between -1 and 1 to compare curve forms (E,F). Magnetic moments at saturation were extracted from the high magnetic field curves and averaged for all replicates (mean and standard error shown in G,H).



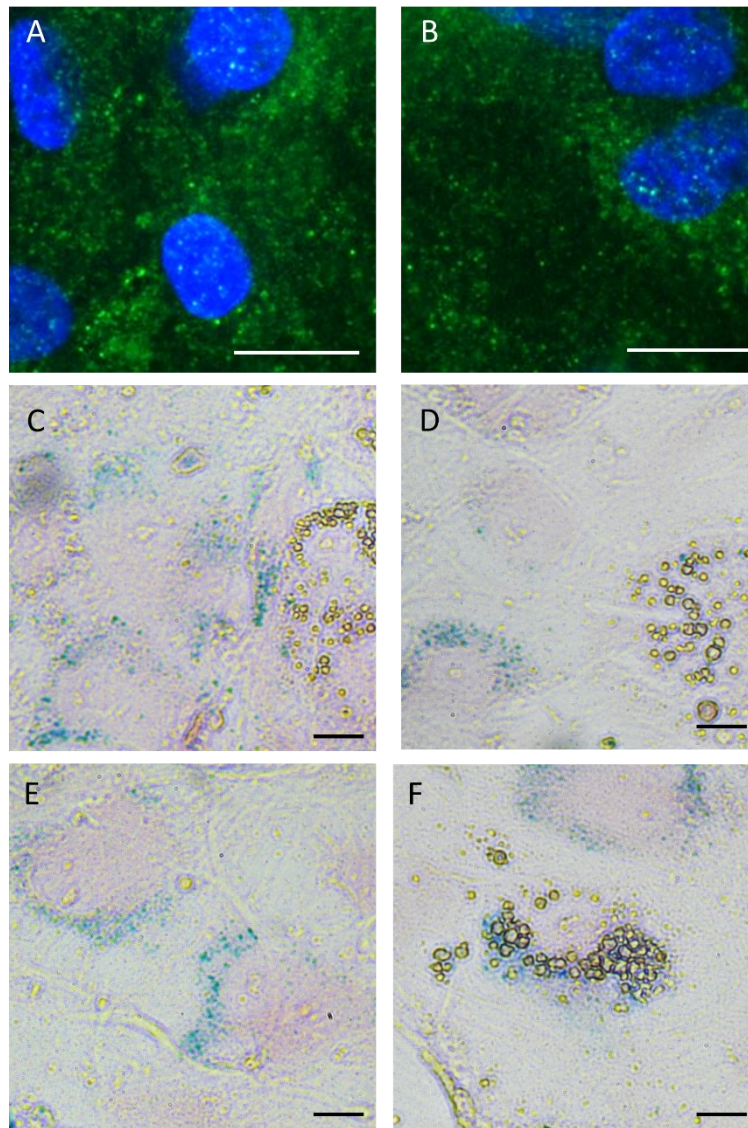
**Figure S8:** Normalized low magnetic field curves of hMSCs cultured under 6 nm and 9 nm magnetite conditions on days 0 and 21. Curves from maghemite internalized in hMSCs on day 0 and 21 (gray curves) enable a comparison of magnetic properties from magnetite to maghemite conditions. Curves from both magnetite conditions changed over time to maghemite-like curves.



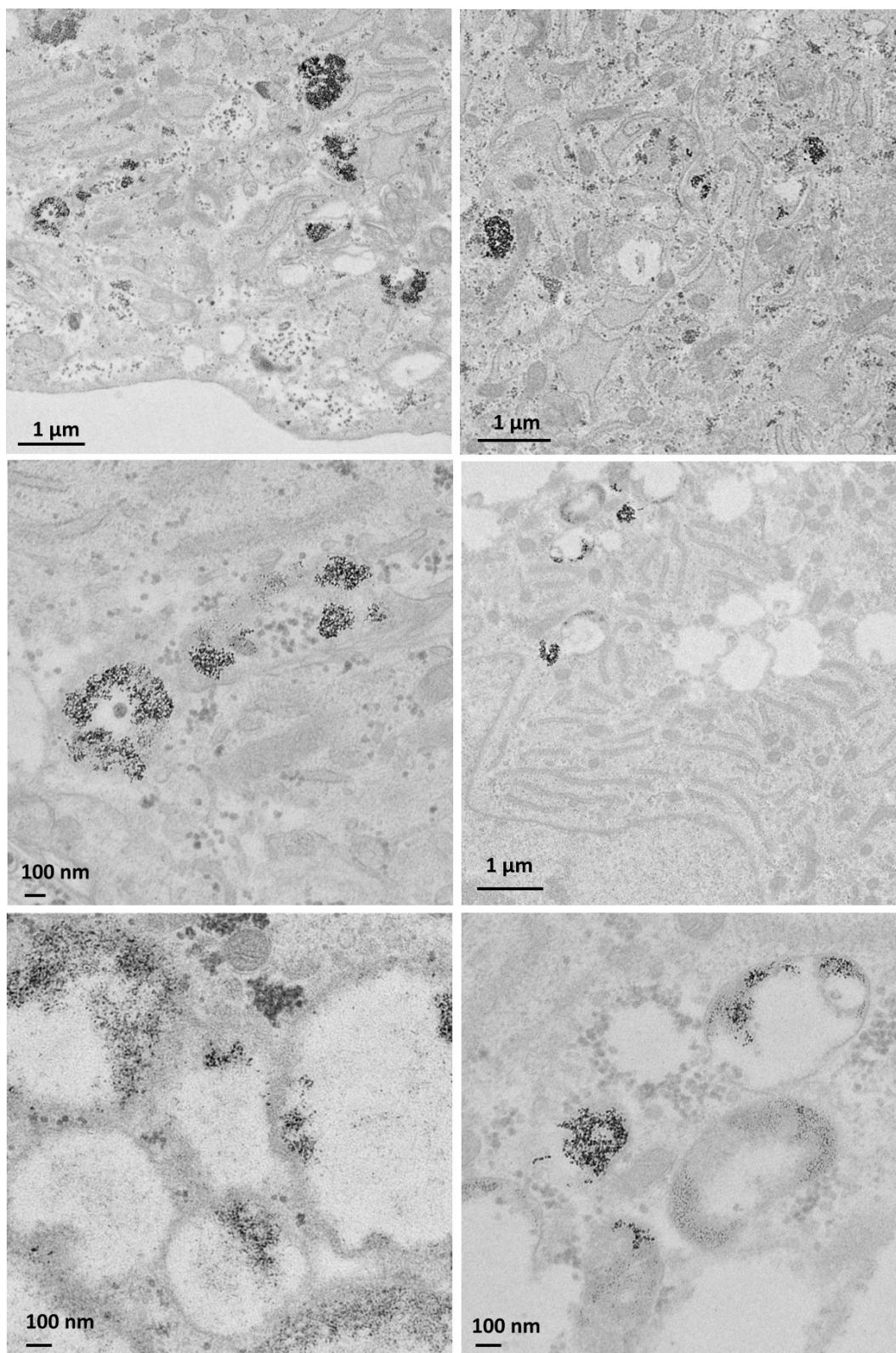
**Figure S9:** TEM images of magnetite ( $\text{Fe}_3\text{O}_4$ ) with hMSCs after 9 days of culture under the biosynthesis conditions.



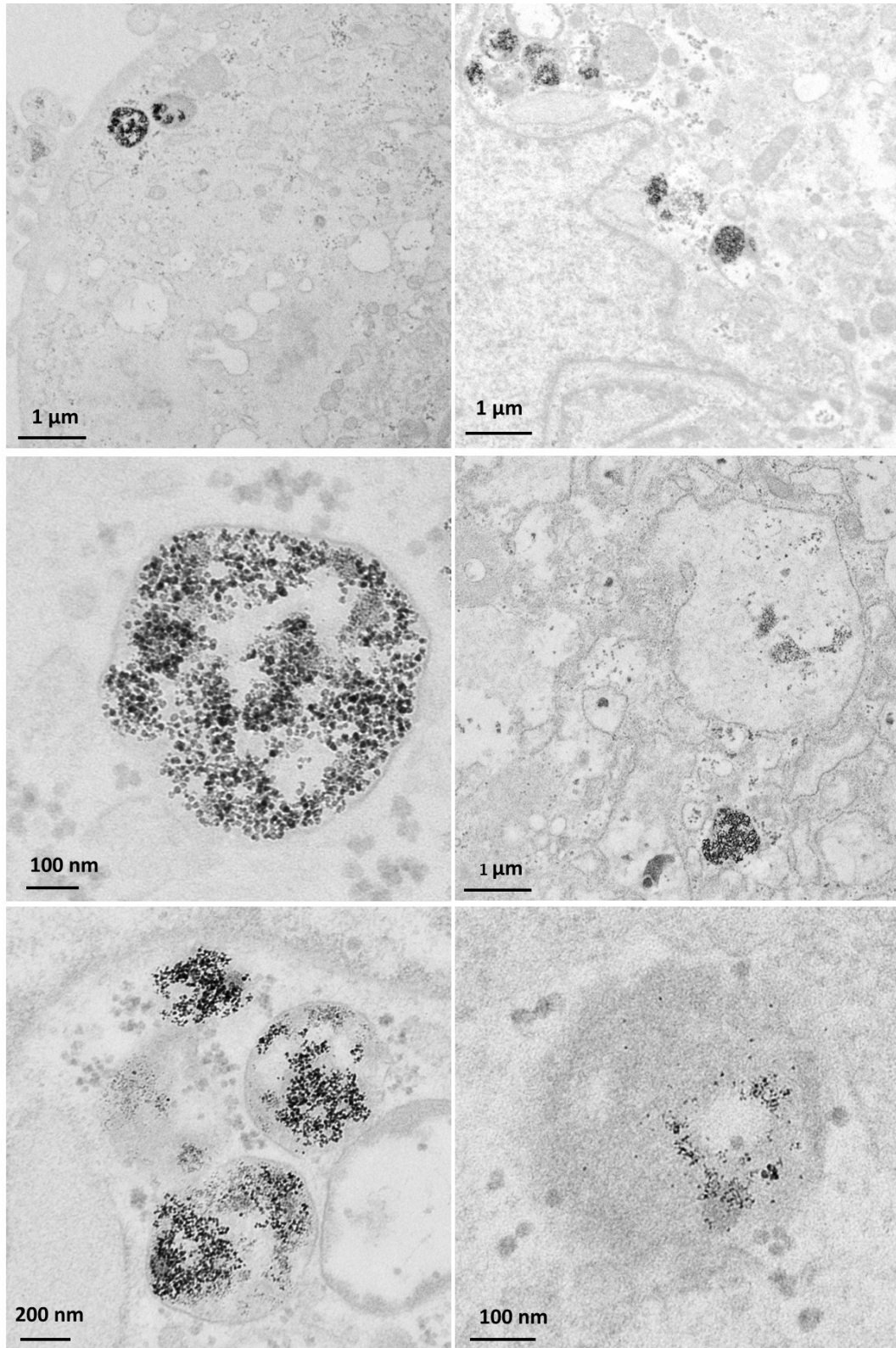
**Figure S10:** TEM images of cobalt ferrite ( $\text{CoFe}_2\text{O}_4$ ) within hMSCs after 9 days of culture under the biosynthesis conditions.



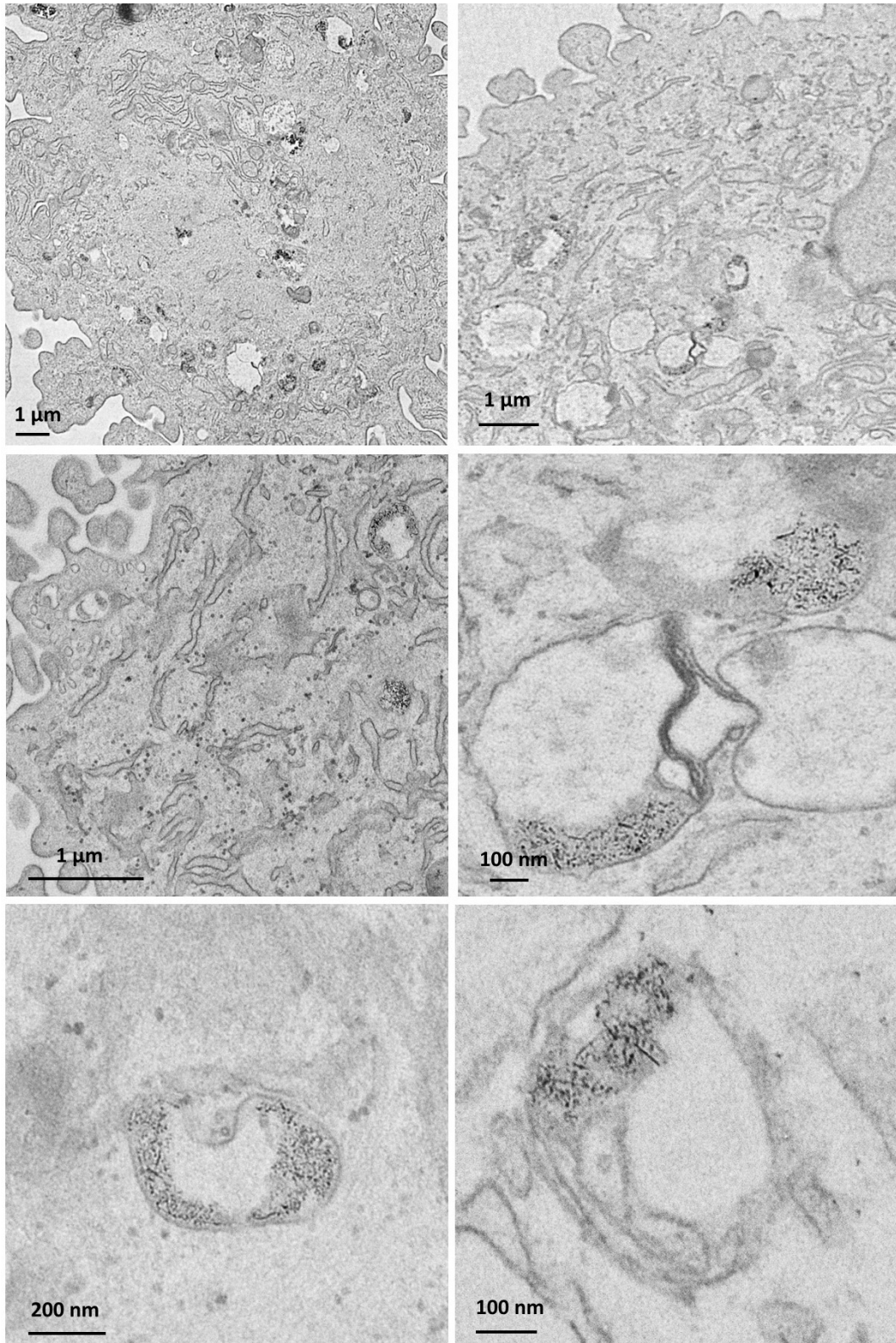
**Figure S11:** Localization of the newly produced iron nanostructures in hMSCs differentiated into adipocytes. (A, B) Immunofluorescence images on day 9 showing ferritin (green; detected with anti-ferritin primary antibody (Abcam, 1:100) and Alexa Fluor 488-conjugated secondary antibody (Thermo Fisher, 1:500)) and cell nuclei (blue, DAPI). Ferritin appears primarily as dots, consistent with iron storage in ferritin cores within endo-/lysosomes. (C-F) Iron deposits detected as small intracellular dots on day 21 using Perl's Prussian blue staining (5% potassium ferrocyanide in 10% hydrochloric acid for 35 min) and nuclear fast red counterstaining for 15 min. Scale bars = 20  $\mu\text{m}$ .



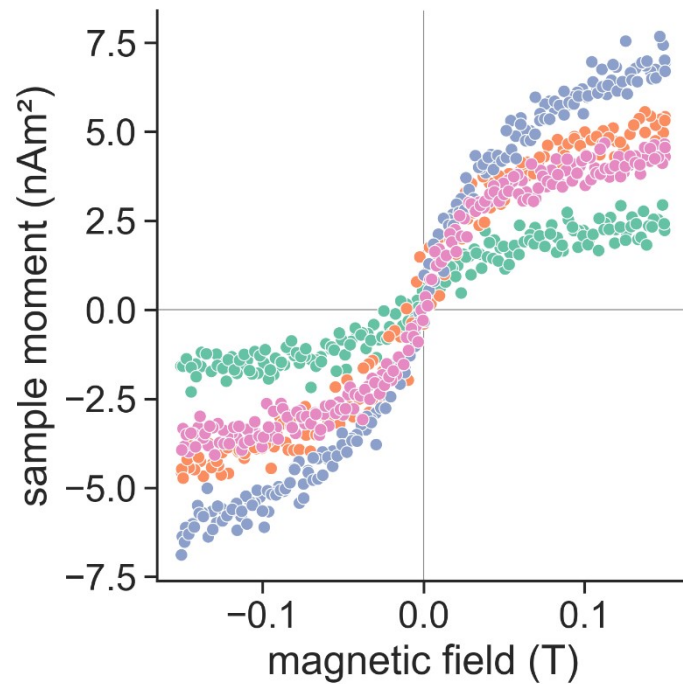
**Figure S12:** TEM images of magnetite ( $\text{Fe}_3\text{O}_4$ ) within hMSCs after 21 days of culture under the biosynthesis conditions.



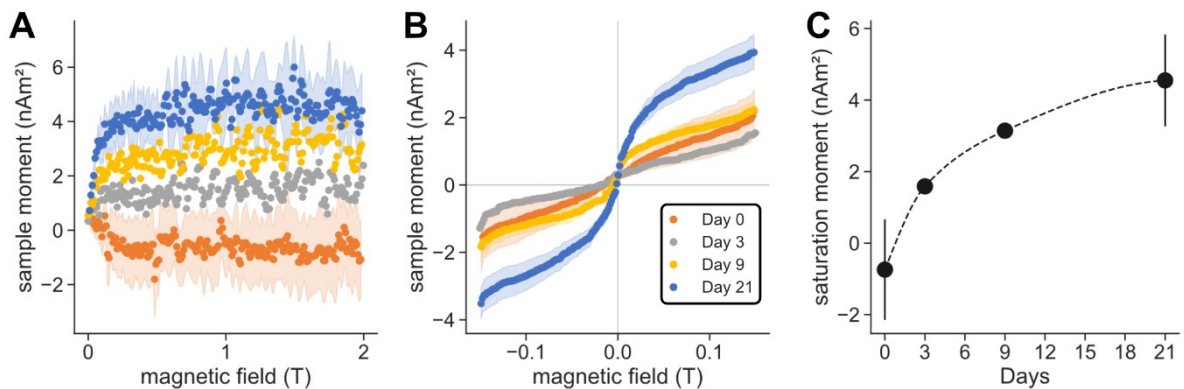
**Figure S13:** TEM images of cobalt ferrite (CoFe<sub>2</sub>O<sub>4</sub>) within hMSCs after 21 days of culture under the biosynthesis conditions.



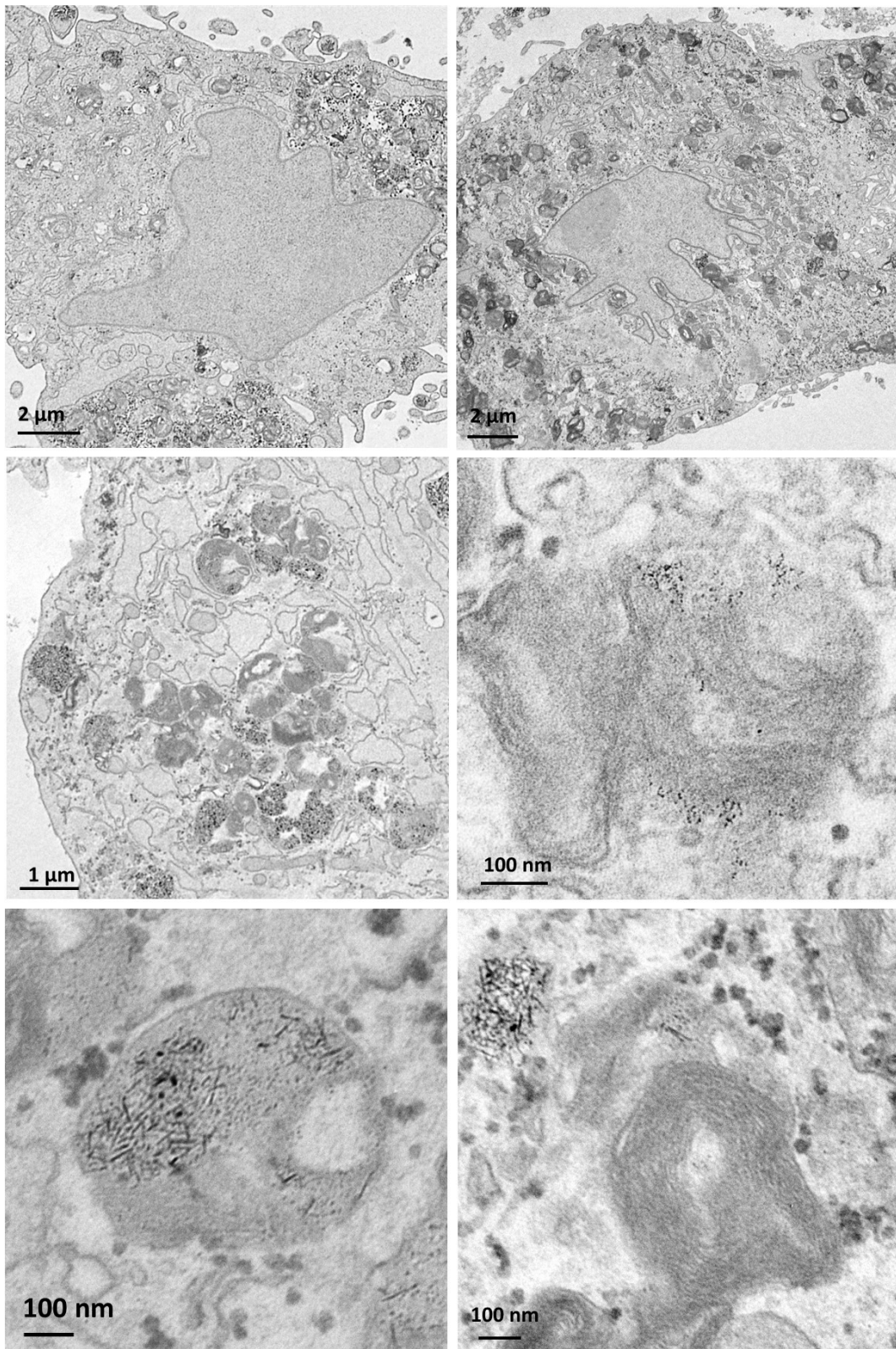
**Figure S14:** TEM images of ferrihydrite after their internalization within hMSCs (day 0).



**Figure S15:** Magnetization curves at low magnetic fields for samples incubated with ferrihydrite and kept in adipogenic-based biosynthesis culture for 21 days.



**Figure S16:** Cells incubated with ferrihydrite then cultured in medium keeping hMSCs undifferentiated and also known as initiating biosynthesis for 21 days were detached and fixed on day 0, 3, 9, or 21, and their magnetic signal was measured with a VSM at high (A) and low (B) magnetic fields. The magnetic moment at saturation was extracted from the high magnetic field curves and averaged for all replicates (C).



**Figure S17:** TEM images of ferrihydrite within hMSCs cultured under the biosynthesis conditions for 21 days.