Supplementary Information

M13 bacteriophage spheroids as scaffolds for directed synthesis of spiky gold nanostructures

Tam-Triet Ngo-Duc[1], Joshua M. Plank[2], Gongde Chen[3], Reed E. S. Harrison[4], Dimitrios Morikis[4], Haizhou Liu[3], Elaine D. Haberer [1,2]

[1]*Materials Science and Engineering Program, University of California, Riverside*
[2]*Department of Electrical and Computer Engineering, University of California, Riverside*
[3]*Department of Chemical and Environmental Engineering, University of California, Riverside*
[4]*Department of Bioengineering, University of California, Riverside*

Email: haberer@ucr.edu

Results and discussion

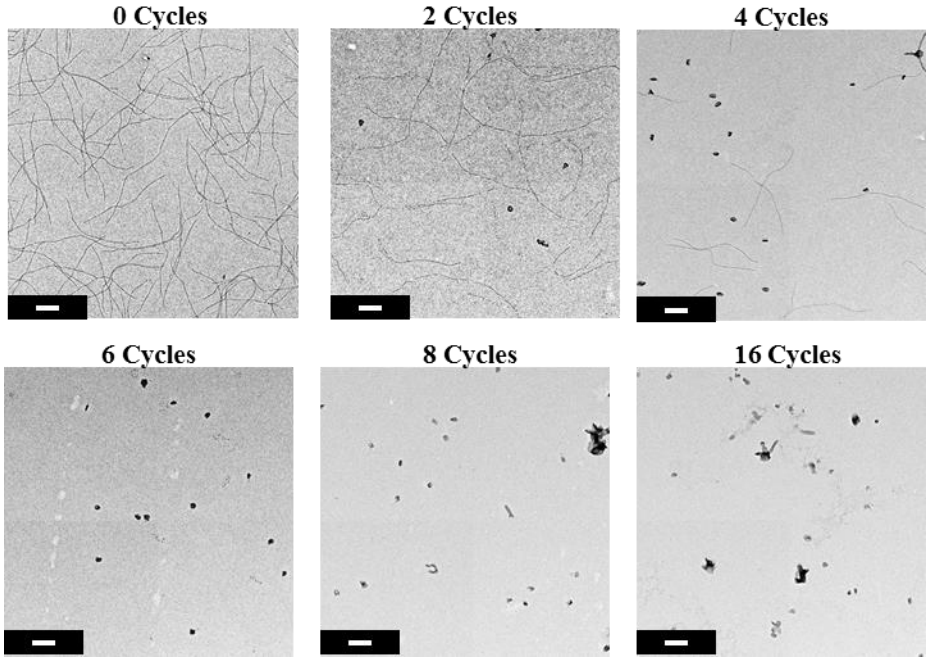

Fig. S1. Transmission electron microscopy (TEM) images of the gold-binding phage transformation progression with increasing cycle number. Scale bar: 200 nm.

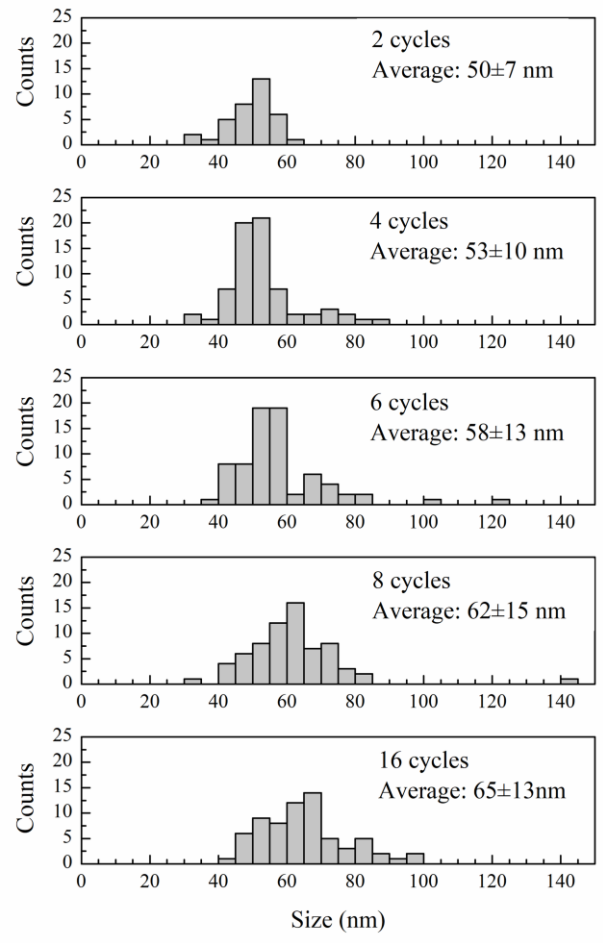

Fig. S2. Histograms of gold-binding M13 spheroid size distributions with increasing chloroform treatment cycle number (N ≥57).

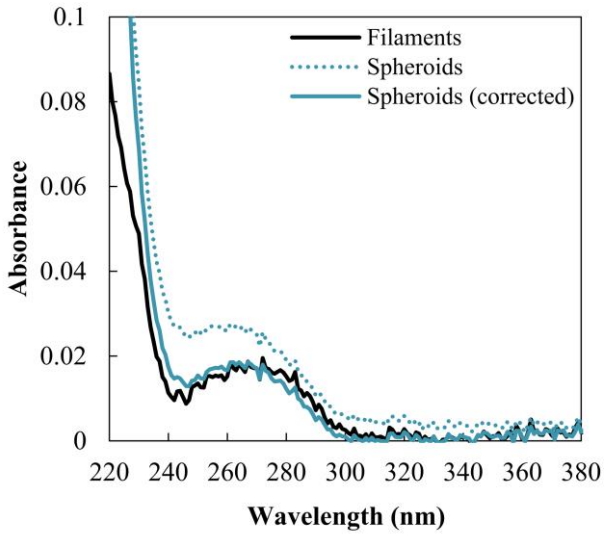

Fig. S3. UV-Vis absorbance spectra of gold-binding filaments, spheroids, and Rayleigh scattering-corrected spheroids. On average, the spheroid concentration was 99.8% of the initial filament concentration, indicating that very little viral template was lost during the conversion process.

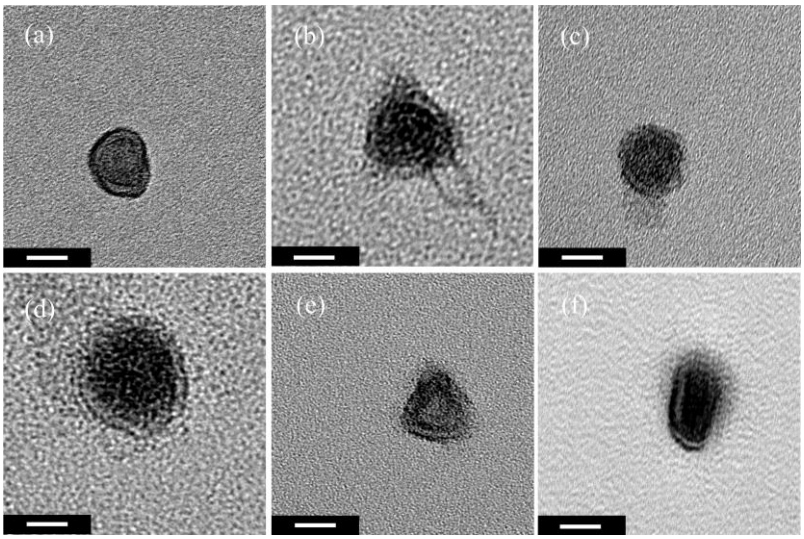

Fig. S4. (a-f) High magnification TEM images of gold-binding spheroids after 5 cycles, showing the characteristic shape of chloroform-treated Ff bacteriophage. Samples were stained with 2% uranyl acetate. Scale bar: 20 nm.

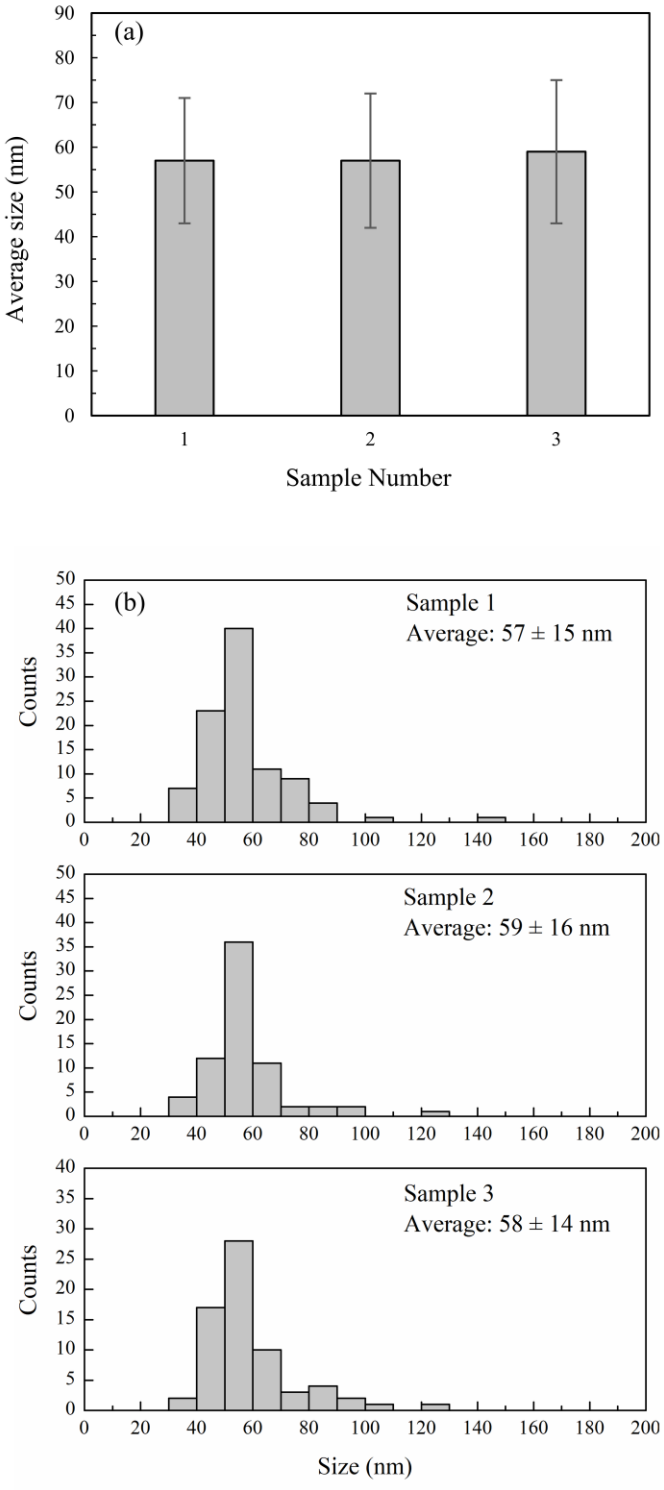

Fig. S5. (a) Average sizes and (b) size distributions from three samples of gold-binding spheroids created using a 5 cycle chloroform treatment process (N = 70).

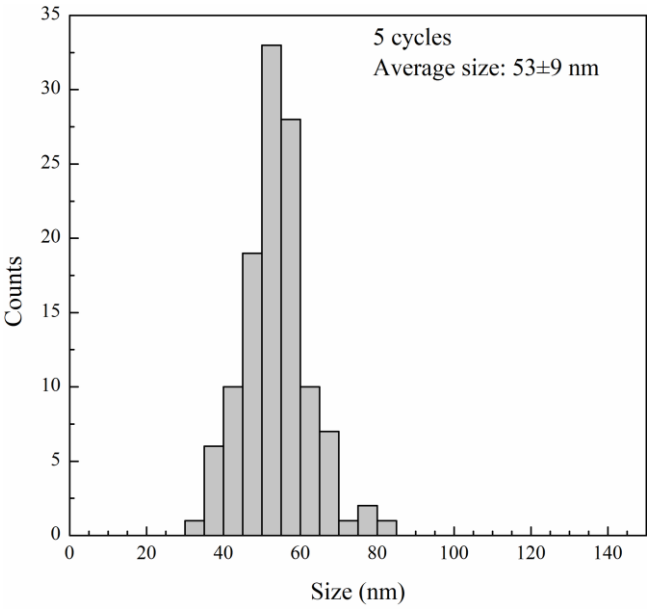

Fig. S6. Size distribution of wild-type M13 spheroids following a 5 cycle chloroform treatment process (N = 118).

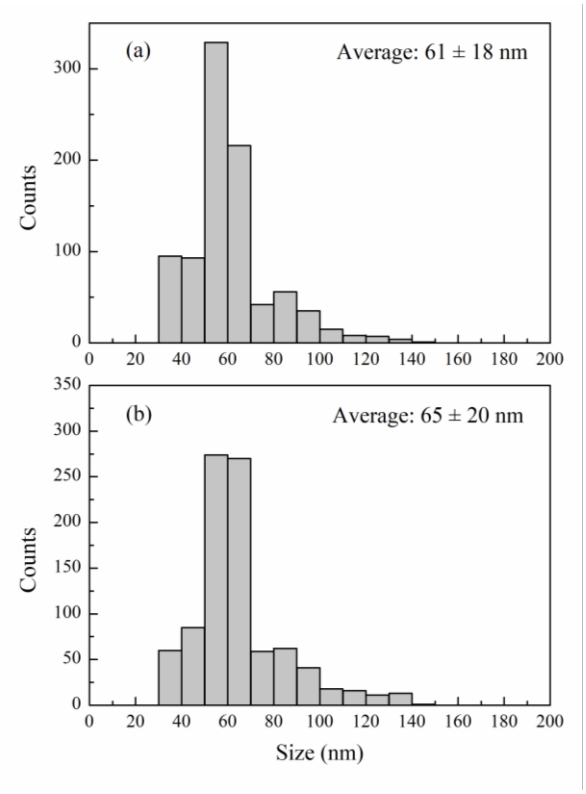

Fig. S7. Histograms of spheroid sizes for transformations completed with initial phage concentrations of (a) 5 x 10^8 pfu/µL and (b) 1 x 10^9 pfu/µL (N > 900).

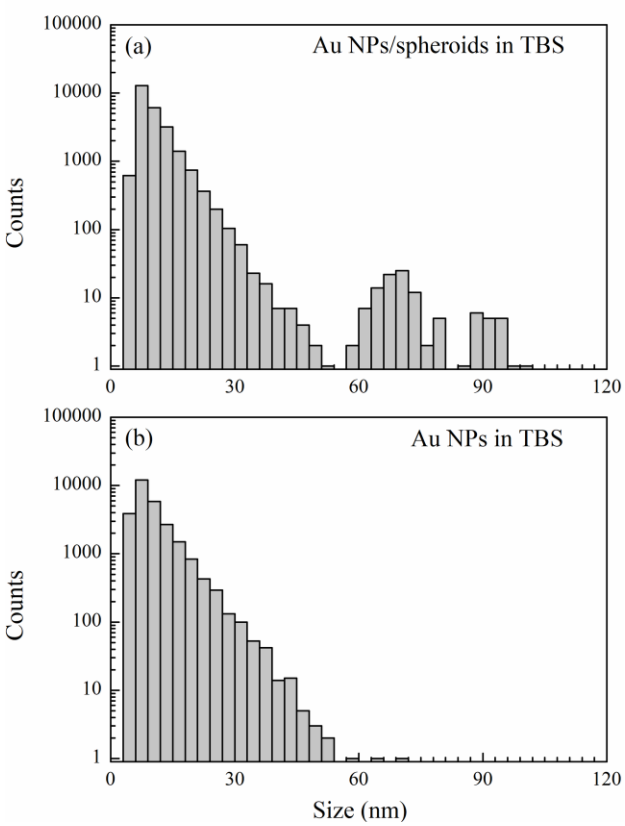

Fig. S8. Histograms of gold colloid assembly size when prepared in dilute TBS (a) with (N = 11600) and (b) without gold-binding M13 spheroids (N = 27900).

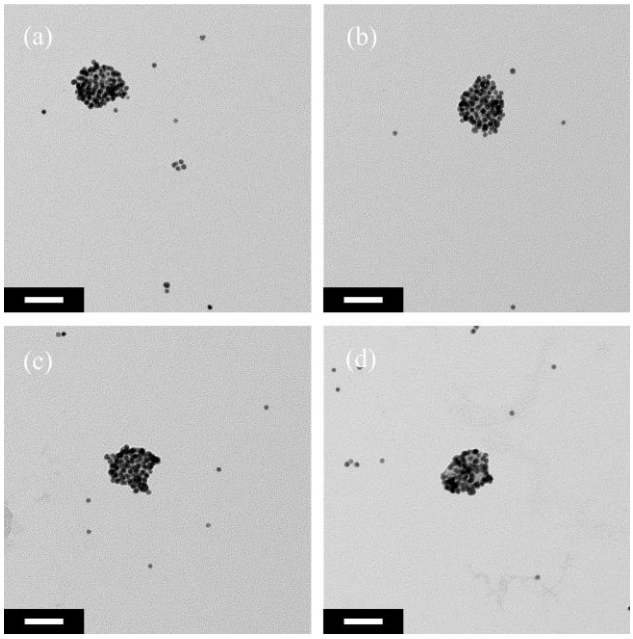

Fig. S9. (a-d) TEM images of 5 nm gold nanoparticles assembled on gold-binding spheroids. Samples were stained with 2% uranyl acetate to show spatial correlation between gold nanoparticle clusters and M13 spheroidal template. Scale bar: 50 nm.

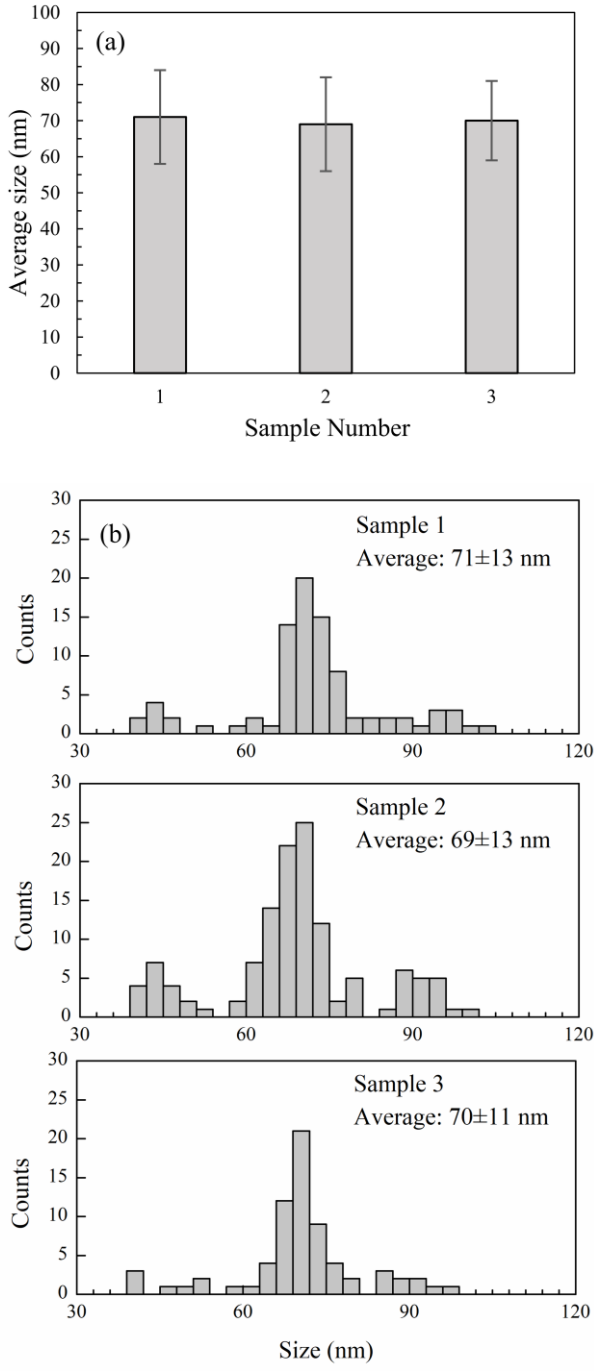

Fig. S10. (a) Average sizes and (b) size distributions from three samples of gold-binding spheroids decorated with gold nanoparticles ($N \geq 70$).

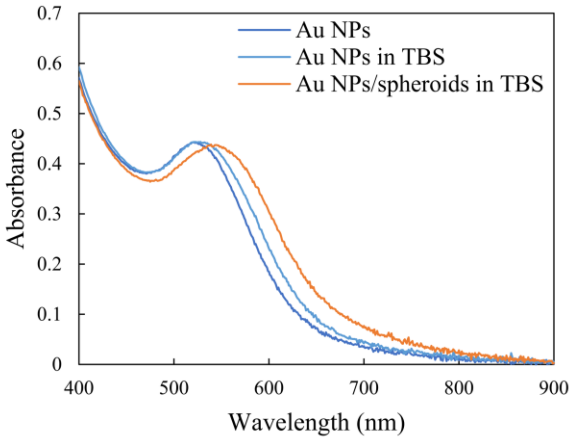

Fig. S11. UV-Vis absorbance spectra of as-received gold colloid, and gold colloid assemblies prepared in dilute TBS with and without gold-binding M13 spheroids.

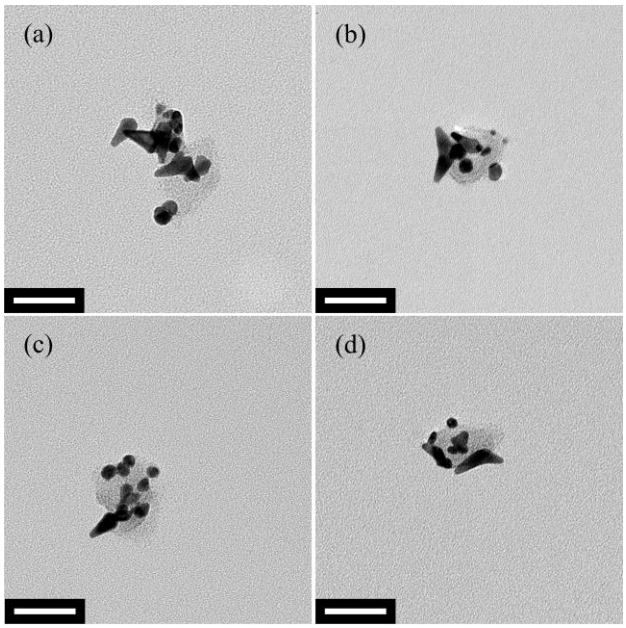

Fig. S12. (a-d) TEM images of gold-binding spheroid-templated gold synthesis products formed using a final $NaBH_4$ concentration of 31.3 µM. Samples were stained with 2% uranyl acetate such that viral proteins associated with the gold structures can be seen. Scale bar: 50 nm.

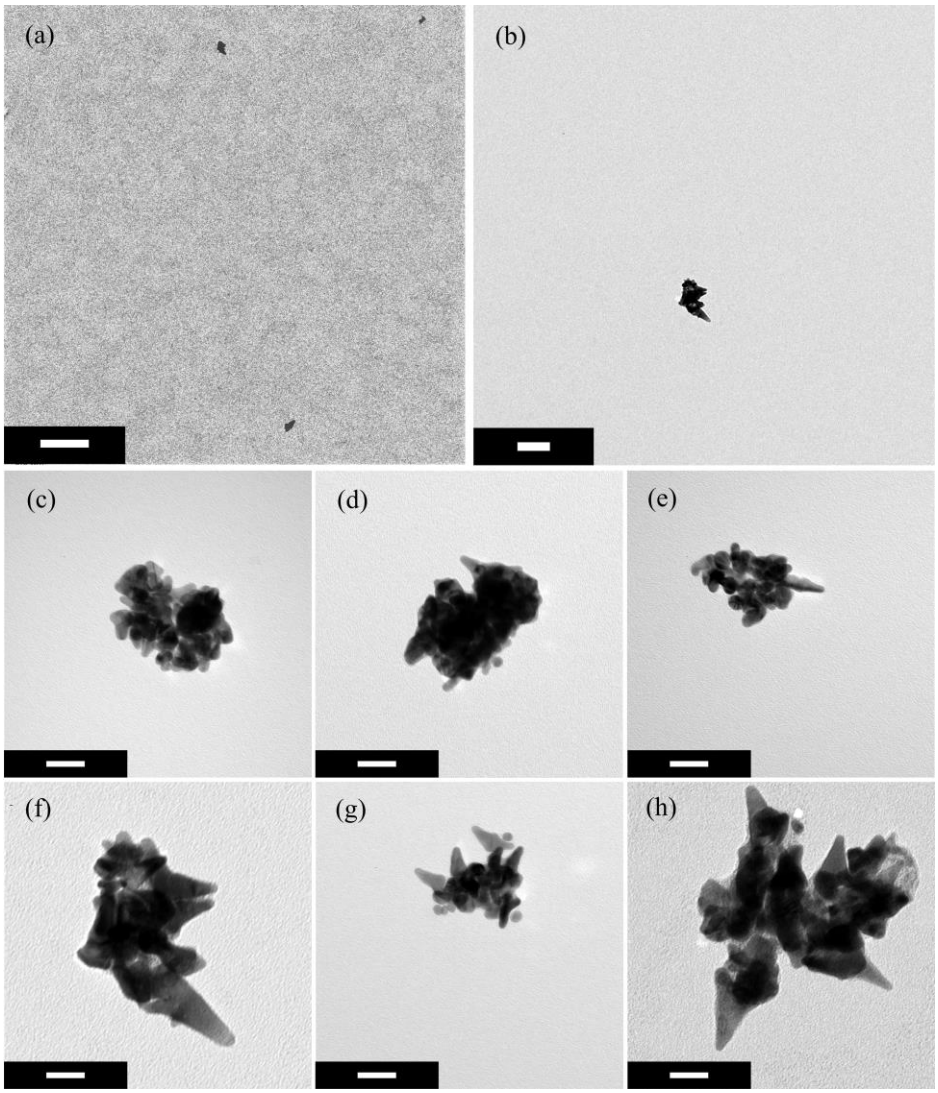

Fig. S13. TEM images of gold synthesis products formed in the presence of gold-binding spheroids using a final $NaBH_4$ concentration of 62.5 µM. (a) scale bar: 500 nm; (b) scale bar: 100 nm; (c-h) scale bar: 20 nm. A variety of spike-like morphologies were found on the spheroids producing a broad range of gold nanostructure sizes. Homogenous nucleation of gold unassociated with the template was not observed.

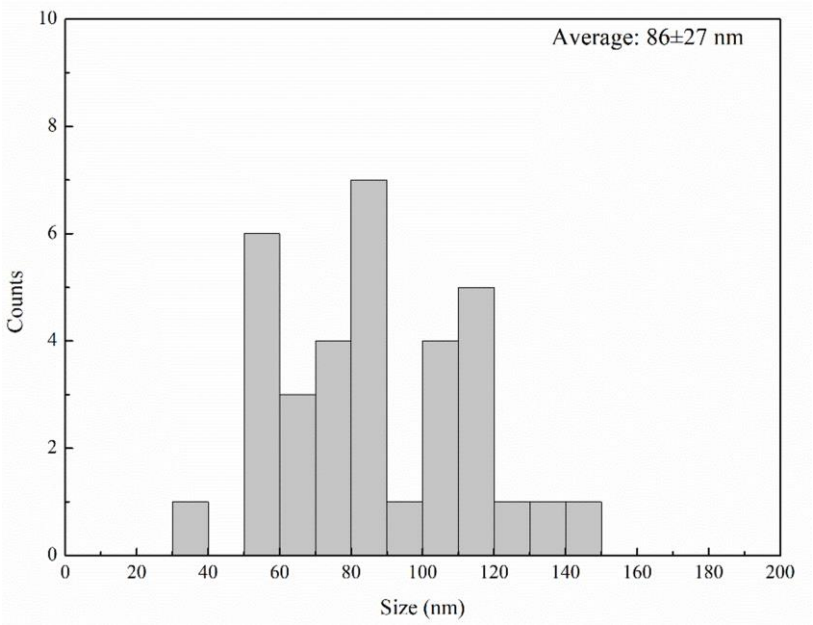

Fig. S14. Size distribution of the synthesized gold nanostructures on gold-binding spheroid templates using a final $NaBH_4$ concentration of 62.5 µM (N = 35).

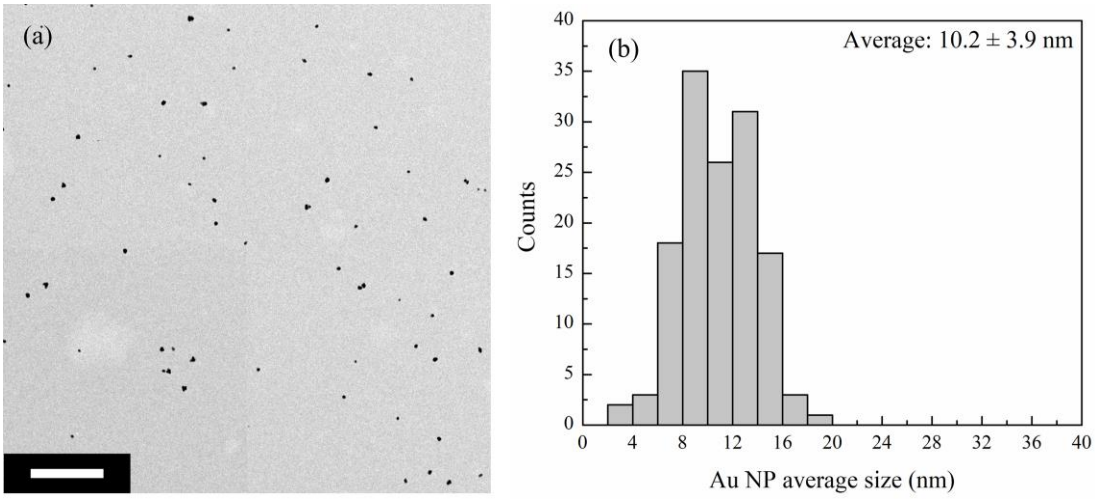

Fig. S15. (a) TEM image and (b) histogram of particle sizes for synthesis products formed without a gold-binding spheroidal viral template using a final $NaBH_4$ concentration of 62.5 µM (N = 136); scale bar: 200 nm.

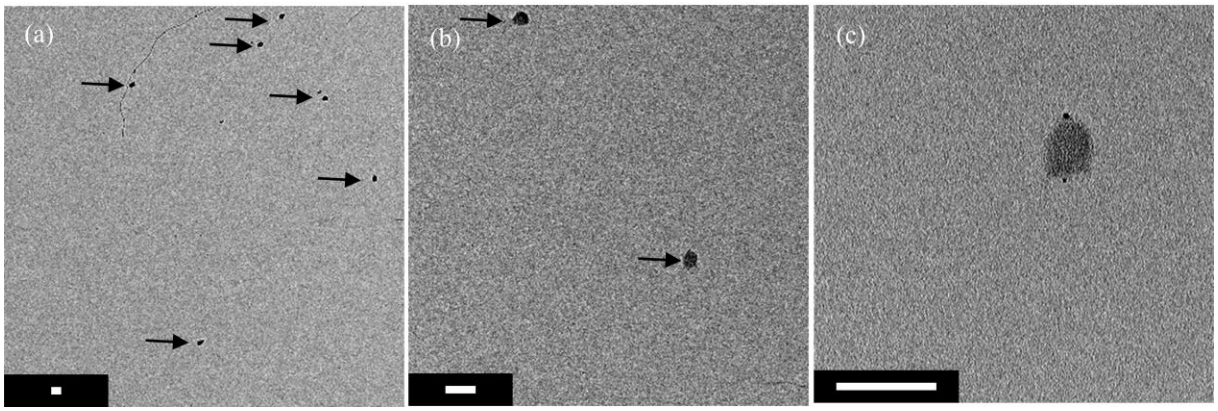

Fig. S16. (a-c) TEM images of gold synthesis products formed in the presence of wild-type spheroids using a final $NaBH_4$ concentration of 62.5 µM. Samples were stained with 2% uranyl acetate. Black arrows in lower magnification images indicate wild-type spheroids. Scale bar: 100 nm.