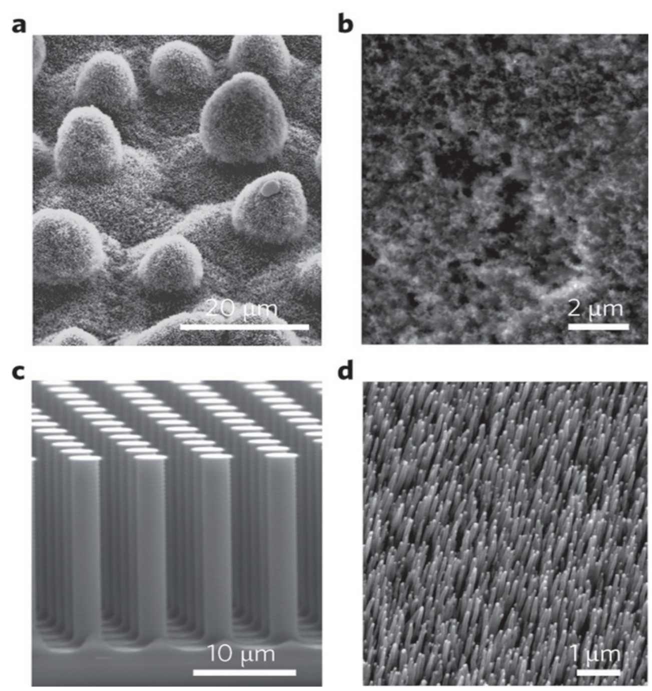
NanoScience – NanoTechnology / NST

ID Student: Activity 4

NST Instrumentation

1) In the previous activity we discussed how studying the surface of the Lotus flower could yield valuable information about how to prevent the growth of mold in our house's walls. How was the scientific community able to examine its surface in order to create artificial ones?

2) What do these surfaces represent?



Reused from Bocquet & Lauga (2011)

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3) Could we use optical microscopes for NST research and development? Why is that?

4) Do you know of any respective limitations of other measurement/ observation tools? Refer to them briefly.

Scanning probe microscopy

5) Based on the models below (a, b & c) can you describe the basic functioning principle of scanning probe microscopy?

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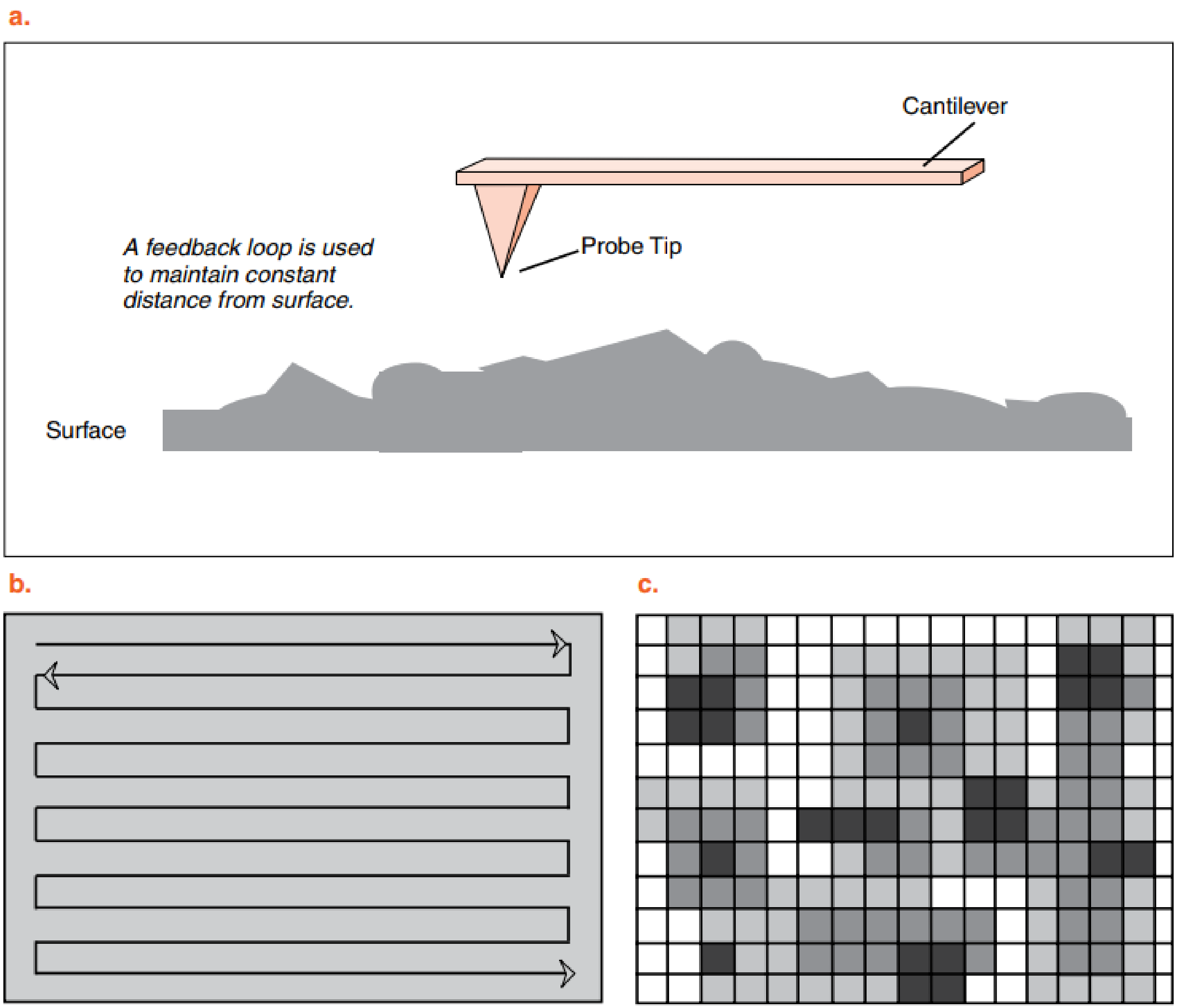

Reused from Pilkington (2020)

6) You are given the following data set which is derived from a scanning microscope. To what surface shape/ topography do you think it corresponds? [To check your answer download the *excel file _ Activity 4*, open it with **Excel Office** and go to **INSERT tab → Charts → Surface → 3-D Surface** to confirm].

	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14
s1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
s2	0	1	5	7	7	5	1	0	0	0	0	0	0	0
s3	0	5	8	10	10	8	5	0	0	0	0	0	0	0
s4	1	7	10	12	12	10	7	0	0	0	0	0	0	0
s5	1	7	10	12	12	10	7	1	0	0	0	0	0	0
s6	0	5	8	10	10	8	5	2	2	2	2	2	2	0
s7	0	1	5	7	7	5	1	2	4	4	4	4	2	0
s8	0	0	0	1	1	0	0	2	4	6	6	4	2	0
s9	0	0	0	0	0	0	0	2	4	6	6	4	2	0
s10	0	0	0	0	0	0	0	2	4	4	4	4	2	0
s11	0	0	0	0	0	0	0	2	2	2	2	2	2	0
s12	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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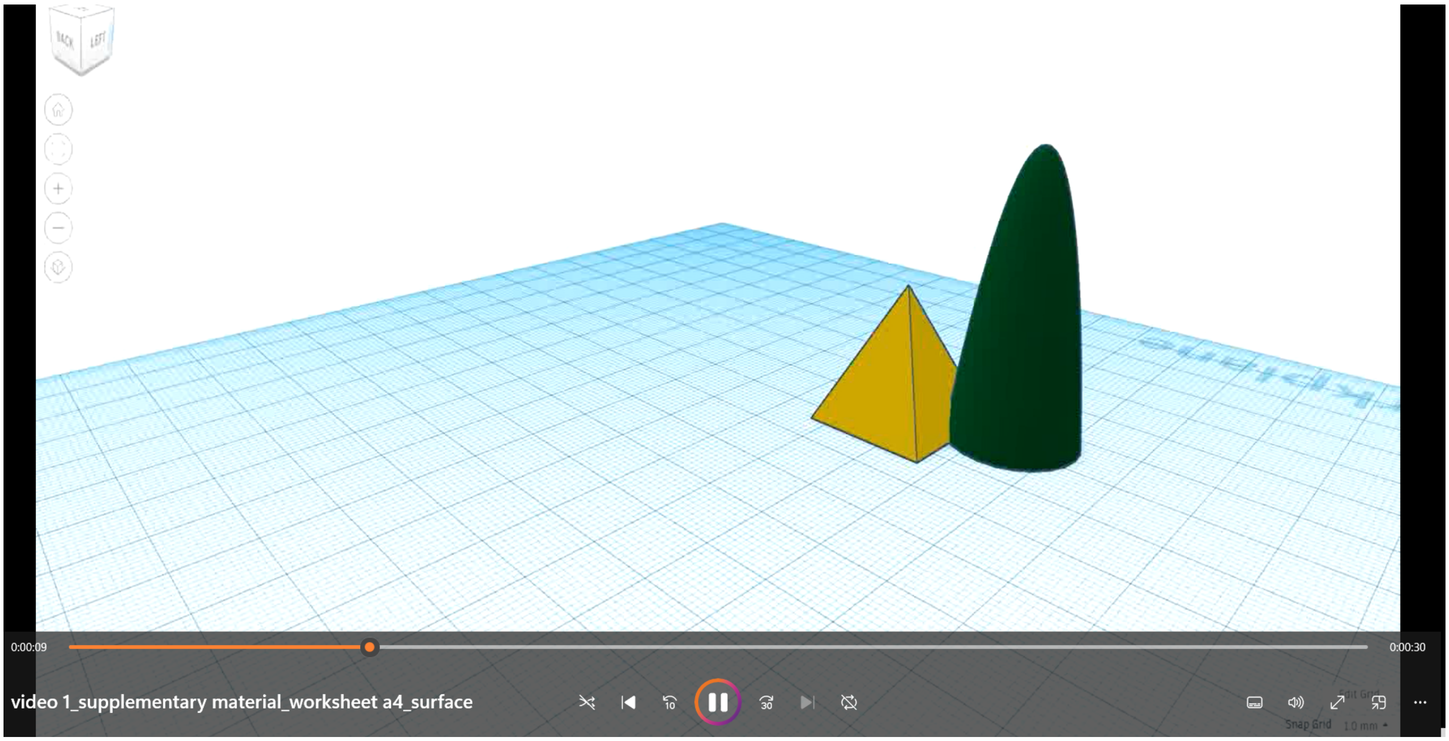
The following models are representations of this surface. Watch the video 1_ supplementary material_worksheet a4_surface.avi:
https://www.youtube.com/watch?v=RlQpxpC_8Ks&ab_channel=IdentitiesProject



7) Which representation is more accurate? What is this due to?

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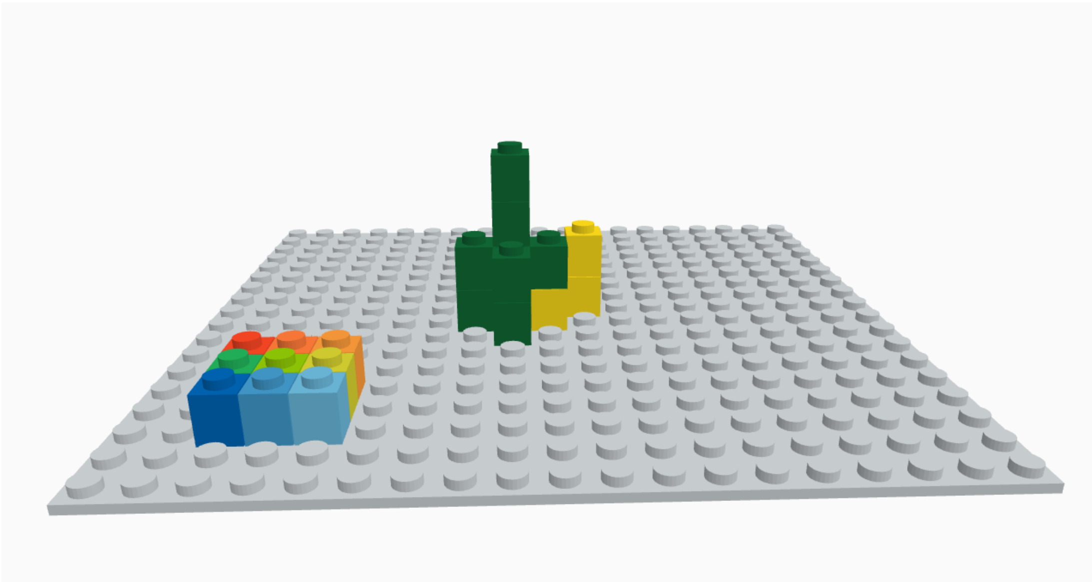

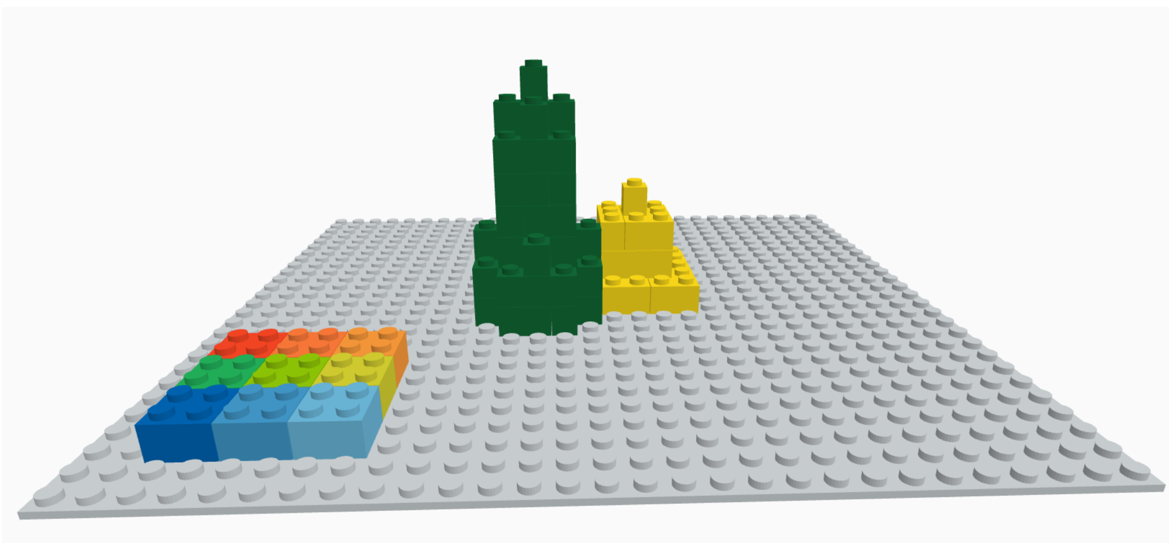

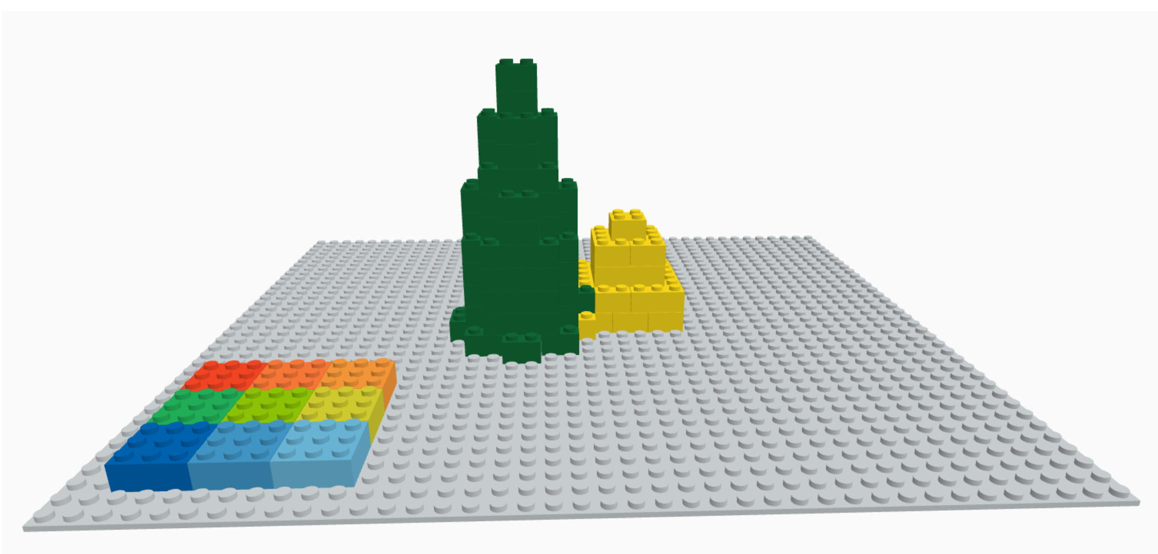

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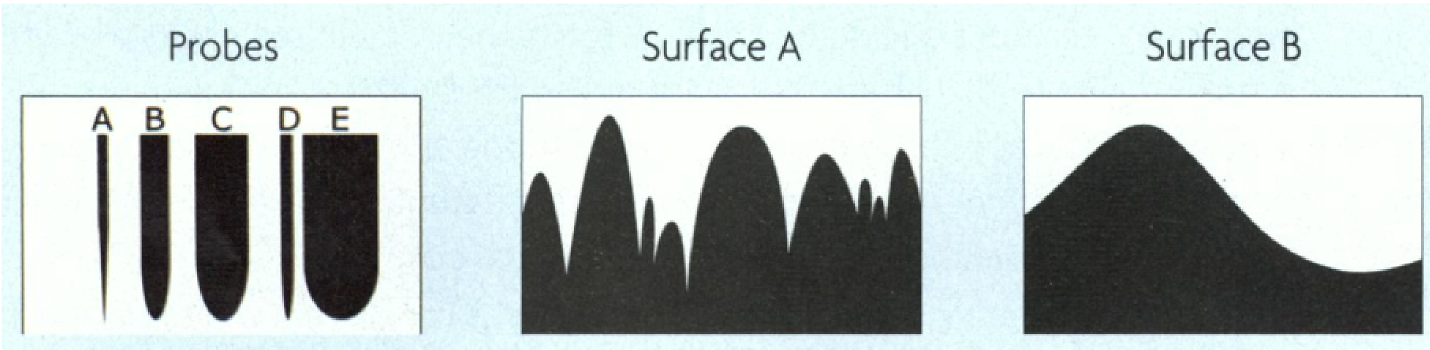
You are a scientist who maps surfaces. You have probes A, B, C, D, and E, shown on the left.

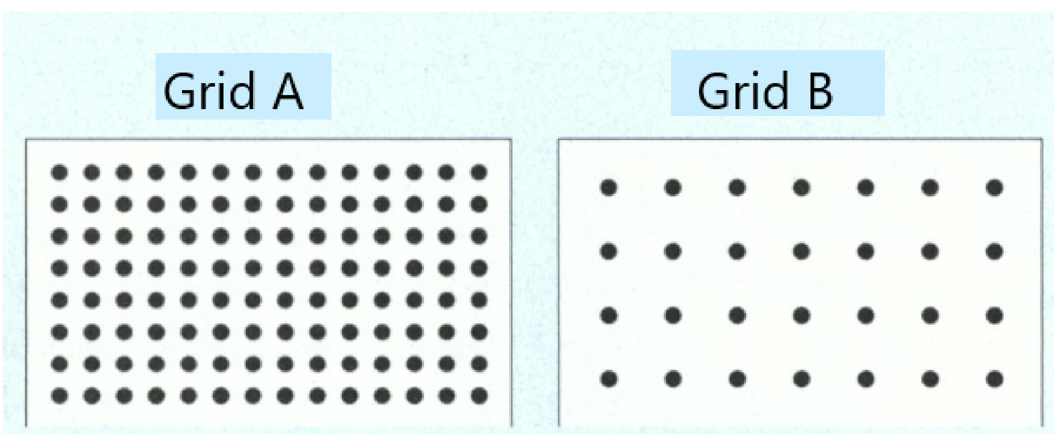


Reused from Kao et al. (2006)

9) Which probe would give you the best results for mapping Surface A? Why?

10) Which probes would give you an adequate result for mapping Surface B? Why?

You have at your disposal these two sampling grids to map Surface A.



Reused from Kao et al. (2006)

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11) Will your representations be similar? What will look different or the same?

12) If you think there will be differences, what will cause these differences?

13) If you wanted to map a surface in so much detail that you could see the individual atoms that make up the surface, what size would your probe and sampling grid have to be?

14) Can you now comment on the interplay between nanotechnology research and the development of scanning microscopy?

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Getting to know scanning microscopes

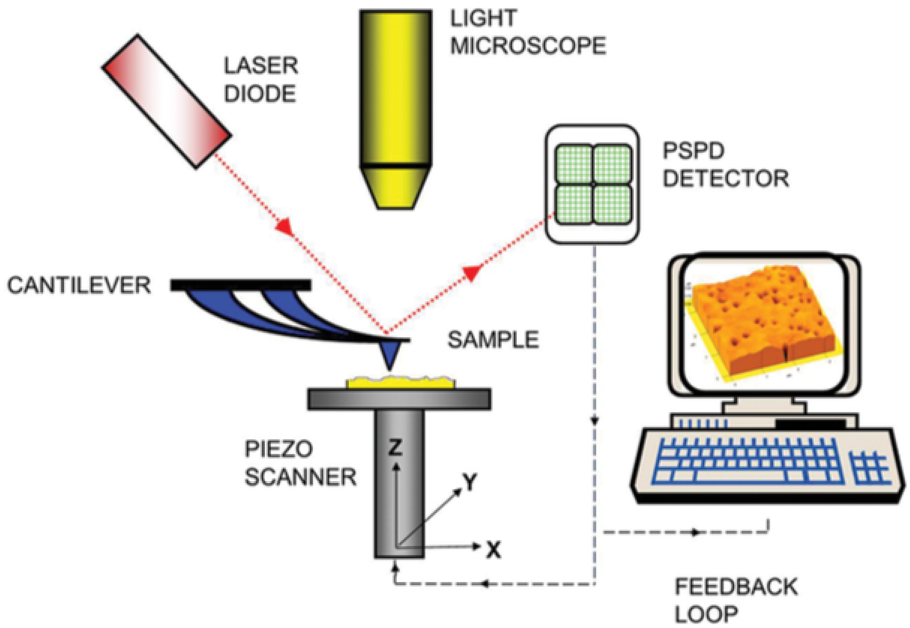
Atomic Force Microscope

The AFM brings a probe in close proximity to the surface.

Forces between the tip and the sample lead to a deflection of the cantilever according to Hooke's law.

This deflection is characterized by sensing the reflected laser light from the backside of cantilever with the position sensitive photodiode.

The position of the beam in the sensor measures the deflection of the cantilever and in turn the force between the tip and the sample.



Reused from James et al. (2016)

15) Do the visualizations of nano-surfaces produced by AFM constitute photographs of the surfaces? Describe how these representations were created.

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Read the following passage of Pheadon Avouris'(member of IBM's Research Division) interview describing their work on Scanning Tunneling Microscope (STM)

Avouris and his team would work late into the night to minimise the effect that vibrations made by people walking around the building would have on their ultra-precise experiments. '**As we went along, we noticed that there were changes on the surface as we were scanning it over and over**,' he remembers. '**And after we did some careful experimentation, we realised that some of the changes were not spontaneous – we were actually inducing these movements of atoms.**'

It became apparent that as the STM tip moved, mechanical forces could slide atoms along the surface. By applying a current, atoms could even be made to hop from the surface to the tip and back again. '**We got excited that besides being able to see "the atoms", we could also make changes in that scale, which was really unheard of up to that point. It was tremendous excitement**,' says Avouris.

source: https://www.chemistryworld.com/holy-grails/the-grails/atomic-manipulation

16) What is the advancement that NST instruments offer? What potential applicability can you imagine?

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Compare the images from AFM, TEM and SEM.

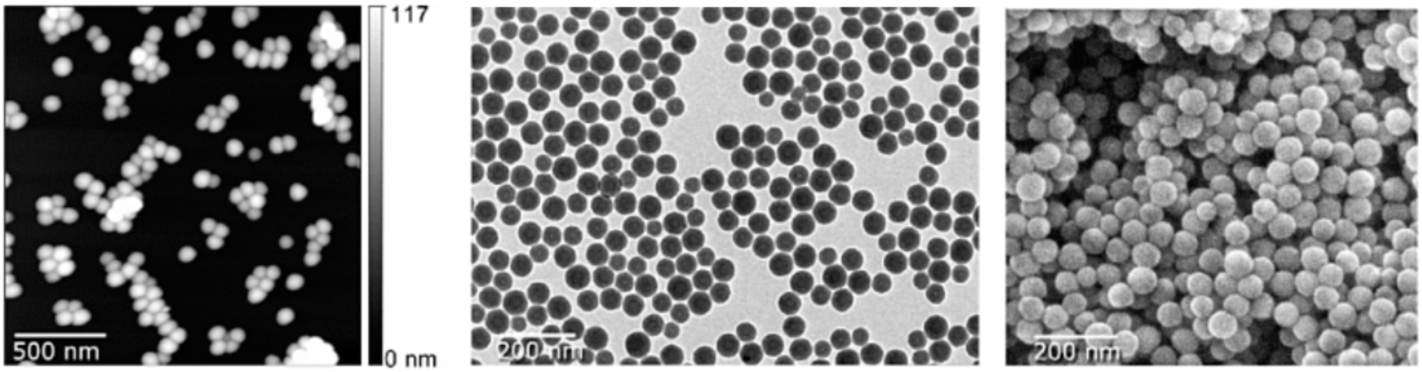

Fig. 1. Examples of silica nanoparticle images from AFM (left), TEM (center), and SEM (right).

Reused from Eaton et al. (2017)

17) What are the differences between them?

18) Where are these differences due to?

19) Which technique is more accurate for visualising silica nanoparticles?

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Reflection

20) What are the basic innovations and affordances that NST instruments have in comparison with conventional instruments?

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References

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