EXPERIMENT MANUAL

NANOTECHNOLOGY

THAMES & KOSMOS

WARNING.

- Not suitable for children under 15 years.
- For use under adult supervision.
- Contains some chemicals which present a hazard to health.
- Includes a highly flammable liquid (Isopropanol).
- Read the instructions before use, follow them and keep them for reference.
- Do not allow chemicals to come into contact with any part of the body, particularly the mouth and eyes.
- Keep small children and animals away from experiments.
- Keep the experimental set out of reach of children under 15 years old.

WARNING

— Chemistry Set. This set contains chemicals and/or parts that may be harmful if misused. Read cautions on individual containers and in manual carefully. Not to be used by children except under adult supervision.

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›››**KIT CONTENTS**

What's inside your experiment kit:

GOOD TO KNOW! If you are missing any parts or if you would like to reorder any of the parts, contact Thames & Kosmos customer service.

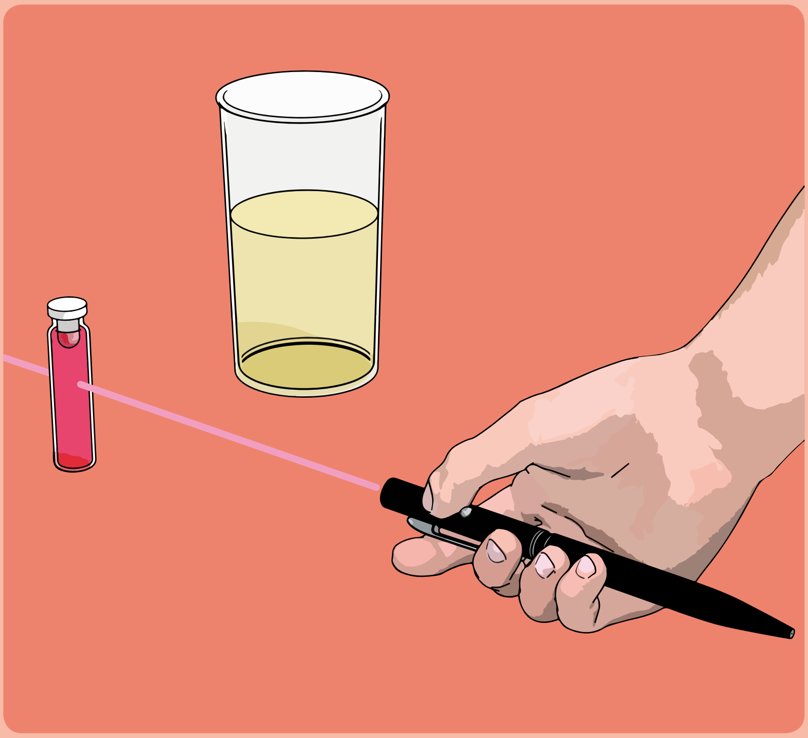
Any materials that are not included in the kit are indicated in *italic type* in the "You will need" section.

Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
❍	1	Die-cut sheet	1	715 524
❍	2	Game board	1	715 526
❍	3	Measuring tape	1	715 527
❍	4	Game piece	1	715 528
❍	5	Open plastic cube	1	715 529
❍	6	White plastic cubes	8	715 530
❍	7	200-mL measuring cups	2	700 560
❍	8	100-mL measuring cup	1	701 206
❍	9	Funnel	1	086 228
❍	10	Filter paper sheet	1	702 204
❍	11	Slides	4	704 256
❍	12	Petri dishes	3	702 184
❍	13	Pipettes	3	708 761
❍	14	Wooden stick	1	713 654
❍	15	Tea light candle	1	702 232
❍	16	Wooden clip	1	000 026
❍	17	Suction cup	1	700 181
❍	18	Chalk	1	773 292
❍	19	Wooden spatulas	4	000 239
❍	20	Paper clips	5	263 132
❍	21	Laser pointer	1	715 556
❍	22	Lid opener	1	070 177
❍	23	Measuring spoon	1	035 017
❍	24	Magnifying lens	1	311 137
❍	25	Tweezers	1	700 127
❍	26	Piece of blue cloth	1	715 555
❍	27	Floating bath putty	1	715 531
❍	28	Tube	1	704 331
❍	29	Container of sand (60 g)	1	774 748
❍	30	Screw nut	1	715 554
❍	31	Rubber band	1	714 730
❍	32	Mirror	1	702 221
❍	33	Gecko adhesive pad	1	715 552
❍	34	Activated charcoal (8 g)	1	033 202
❍	35	Lycopodium spores (3 g)	1	770 405
❍	36	Anti-fog agent (15 ml)	1	774 741
❍	37	Lotus-leaf fluid (15 ml)	1	774 742
❍	38	Colloidal gold (2 ml)	1	774 743

EXPERIMENT 32

Making the laser beam visible



YOU WILL NEED

› **Colloidal gold vial**
› **Laser pointer**
› **100-mL measuring cup**
› *Clear apple juice*

HERE'S HOW

››› Pour a little juice into the measuring cup and set the colloidal gold vial next to it.

››› Shine the pointer's laser beam through both liquids.

››› In which liquid do you see the beam? In which don't you? What might be the explanation?

KEYWORD: COLLOID

The colloidal gold particles don't settle to the bottom of the vial the way you would expect from larger particles. Instead, they bump against one another without accumulating. The reason has to do with electrostatic forces (forces of repulsion between equal electrical charges) and surfactants acting as "chemical spacers."

WHAT'S HAPPENING ?

In the last experiment, you learned how light can be scattered by small particles. So there must be a difference between the two liquids. In one case (the colloidal gold) the laser's light is scattered, and in the other it's not.

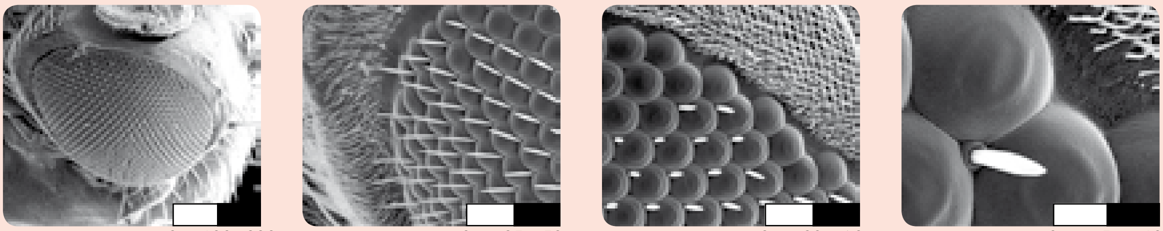
The reason has to do with the particles in the liquid and their size. Apple juice is mostly water, plus substances from the fruit: sugar, acids, and pigments. All these materials consist of relatively small molecules. For example, a sugar molecule, the structure of which you learned in Experiment 8, has a size of about 1 nm. Acid and pigment molecules also occur in about this size. They won't have any influence on the laser beam because they are too small in relation to the laser light's wavelength (650 nm).

The colloidal gold contains particles 50 nanometers in size. That makes them large enough to reflect the laser's light.

So a direct comparison shows how the fruit juice particles are too small to influence the laser, while the nanocolloid contains larger particles that scatter the light.

Scanning Electron Microscopy

Scanning electron microscopes (SEM) scan the studied object "line by line" with a fine electron beam. To do that, the object's surface must be electrically conductive. The electron beam causes electrons on the sample surface to be released. These so-called **secondary electrons** are captured by a detector brought above and to the side of the sample. Scanning electron microscopes are often used to study surfaces, since they can create images with excellent depth of sharpness.

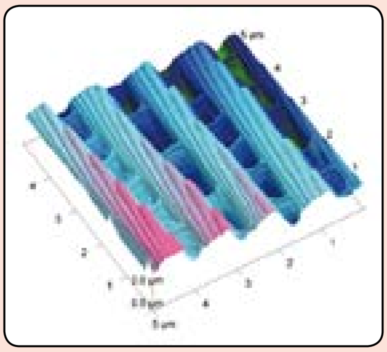


SEM images of a fly's eye

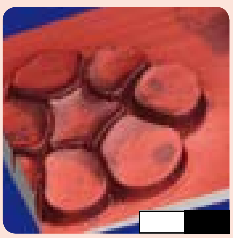
Atomic Force Microscopy

In this technology, a fine measuring tip is computer-guided along a surface a few nanometers above the sample. At this tiny distance, certain mutual reactions such as the van der Waals forces arise between the atoms of the measuring tip and the atoms and molecules of the object under investigation.

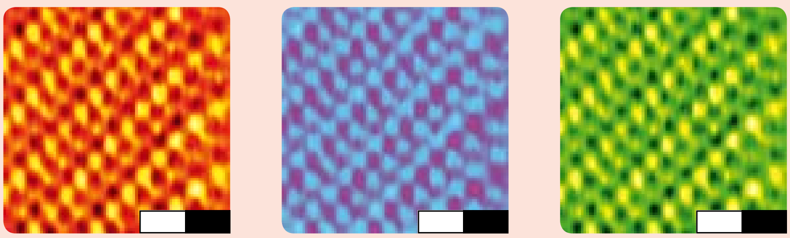
Depending on the nature of the surface, these forces can be stronger or weaker, and they will therefore deflect the measuring tip to varying degrees — in other words, they will cause the tip to move up or down by a few nanometers. These tiny movements can be measured and recorded to produce a precise image of the object's surface. An atomic force microscope can produce resolutions of up to 0.1 nm — allowing even individual atoms to be shown!



Structure of a butterfly's wing



Red blood cells



Individual atoms in a calcite crystal