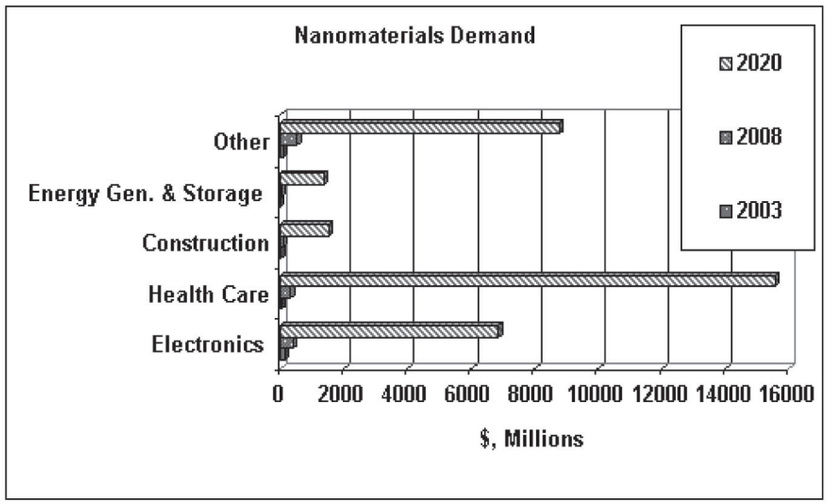
Lesson 3

Nanotube Applications I

• Nanotubes—one of the strongest materials that exist—are carbon atoms in the shape of a cylinder. Motor vehicles, electronic products and sporting goods all utilize nanotubes.

Before You Read

I *The bar chart below shows the demand for nanomaterials in several fields. In Unit 1 Lesson 4 we looked at the use of reporting verbs to describe a pie chart, and you may want to refer back to that lesson to refresh your memory on this subject. Then, work in pairs to describe the bar chart using reporting verbs.*



II *Nanotubes have many useful properties, and thus a wide variety of applications. In the box below are four applications. Please match them to the more detailed descriptions that follow.*

A. nanotube ropes

B. nano test tubes

C. nano-electronics

D. nanotube flat display devices

1. _____ Researchers found that carbon nanotubes could emit ring-shaped electron discharges in 1997. This property is being utilized to develop field emission displays.

2. _____ Tiny amounts of chemicals can be put into these to see how reactions occur in very small spaces.

3. _____ Nanotubes are either conducting or semi-conducting. This means that they can be used in electronic circuits to enable the development of more powerful computers.

4. _____ This is the next generation of carbon fibers that are even stronger than existing nanotubes.

Reading

The World's Smallest Radio I

Nanotechnology is arguably one of the most **overhyped** "next big things" in the recent history of applied science. According to its most radical advocates, nanotechnology is a molecular manufacturing system that will allow us to **fabricate** objects of practically any **arbitrary** complexity by mechanically joining molecule to molecule, one after another, until the final, atomically correct product emerges before our eyes.

The reality has been somewhat different: today the word "nano" has been diluted to the point that it applies to essentially anything small, even down to the "**nanoparticles**" in **commodities** as diverse as motor oil, sunscreen, lipstick and ski wax. Who, then, would have expected that one of the first truly functional nanoscale devices—one that would have a measurable effect on the larger, macroscale world—would prove to be...a radio? But the nanotube radio, invented in 2007 by physicist Alex Zettl and his colleagues at the University of California, Berkeley, performs a set of amazing feats: a single carbon nanotube tunes in a broadcast signal, amplifies it, converts it to an audio signal and then sends it to an external speaker in a form that the human ear can readily recognize. If you have any doubts about this assertion, just visit www.SciAm.com/nanoradio and listen to the song "Layla."

The nanotube radio, its fabricators say, could be the basis for a range of revolutionary applications: hearing aids, cell phones and iPods small enough to fit completely within the ear canal. The nanoradio "would easily fit inside a living cell," Zettl says. "One can **envision** interfaces to brain or muscle functions or radio-controlled devices moving through the bloodstream."

Zettl, who directs 30 investigators engaged in creating molecular-scale devices, decided to make nanotubes a focus of his work because they are remarkable structures. The question of who first discovered them is controversial, but Japanese physicist Sumio Iijima is generally credited with having put them on the scientific map, when in 1991 he announced finding "needlelike tubes" of carbon on the tip of a **graphite electrode** that emitted an **arc**, a **luminous** discharge of electricity.

Those nanotubes had some surprising properties. They came in a large variety of sizes and shapes: they were single-walled, double-walled and multiwalled. Some were straight, some were bent and some even looped back on themselves in **toroidal configurations**. Common to them all was their exceptional **tensile** strength, the resistance to being pulled apart along their length without breaking. The reason for this unusual property, Zettl says, is that "the force that holds the carbon atoms together in the carbon nanotube is the strongest bond in nature." Nanotubes are also excellent conductors of electricity, far better than copper, silver or even superconductors. "It's because the electrons don't hit anything," he explains. "The tube is such a perfect structure."

Based on the unique properties of nanotubes, Alex Zettl got the idea for a nanoradio when he decided he wanted to create tiny sensing devices that could communicate with one another and broadcast their observations wirelessly. "They were to do monitoring of environmental conditions," he says. They would be distributed in the field near some factory or refinery and would radio their results back to some collecting point. Anyone could then go to Google "and click on the air quality of a city and see it in real time."

During the course of some experiments aimed at producing a nanotube mass sensor, one of Zettl's graduate students, Kenneth Jensen, found that if one end of a carbon nanotube was planted on a surface, creating a **cantilever**, the beam would vibrate when a molecule landed on its free end. Molecules of different masses would make the beam vibrate at different frequencies. When Zettl noticed that some of these frequencies included those in the commercial radio band, the idea of using the cantilevered nanotube to make a radio became virtually irresistible.

Excerpt from "The world's smallest radio," published in *Scientific American*, March 2009

After You Read

Circle the answer to each question.

1. The first person who introduced nanotubes was (Zettl/Iijima/not mentioned)
2. According to the reading, (nanoparticles/nanotubes/nanocells) can be added to many products.
3. The first nanotube application was a radio which was invented by (Zettl/Iijima/not mentioned) in 2007.
4. This nanotube radio utilizes a (double-walled/multiple-walled/single-walled) carbon nanotube.
5. The nanotube radio could be planted into (the brain/a living cell/muscle).
6. Based on the reading, an application of this nanotube radio technology may one day benefit (nanotechnology research/the blind/the deaf).
7. Nanotubes are (flexible/rigid/not mentioned), and are capable of forming the strongest bonds in nature.
8. When nanotubes are pulled apart, they (are not broken/are easily broken/not mentioned).
9. The best conductors are (single-walled nanotubes/double-walled nanotubes/not mentioned).
10. Nanotubes have the strongest bond because of their (electrode emission/well-conduction/carbon atoms).

Vocabulary Comprehension

General Vocabulary

This vocabulary is used for general purposes.

cantilever	*n*	a beam or tube supported on only one end
overhype	*v*	to exaggerate the significance of something
fabricate	*v*	to manufacture
amplify	*v*	to increase the volume or strength of a signal
envision	*v*	to imagine
luminous	*adj*	very bright
configuration	*n*	the pattern that something is arranged in
toroidal	*adj*	shaped like a toroid, doughnut shaped

ESP Vocabulary

This vocabulary is commonly used in the fields of engineering and industry.

arbitrary	*adj*	not done for any particular reason
nanoparticle	*n*	a microscopic particle with at least one dimension less than 100 nm
commodity	*n*	an important product that is produced in large quantities and to same specifications by a number of different producers
graphite electrode	*n*	electrodes that are used in electric arc furnaces.
arc	*n*	a flash of light that happens when electricity flows between two separated points
tensile	*adj*	able to be stretched, bent and pressed

Exercise

Some synonyms for the words given above are listed below. Please write down the appropriate synonym from the vocabulary list in the box, and then use it to write a complete sentence.

Words	make, manufacture, put together	Vocab. Synonym	
Sentence			

Words	grow, become louder, increase	Vocab. Synonym	
Sentence			

Words	bright, shining	Vocab. Synonym	
Sentence			

Words	important, essence, core	Vocab. Synonym	
Sentence			

Words	arrangement, geometry, sequence	Vocab. Synonym	
Sentence			

Words	unplanned, for no good reason, random	Vocab. Synonym	
Sentence			

Words	imagine, picture, visualize	Vocab. Synonym	
Sentence			

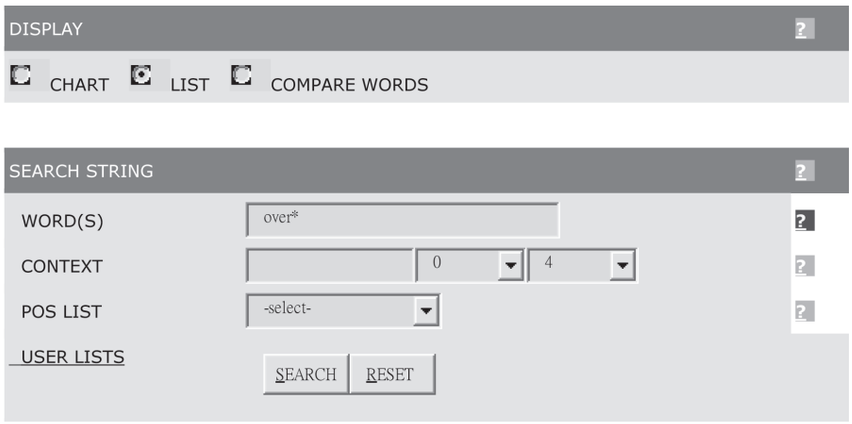
Words	electronic flows	Vocab. Synonym	
Sentence			

Language Focus

Corpus Tutorial

Words with the same prefix or suffix usually share similar connotations. In this section, we will learn how to use **COCA** to find words with the same prefix or suffix. There are some words with common prefixes in the reading, such as **over**hyped and **nano**particle. Let's go to **COCA** to search for other words that start with **over** and **nano**. When a word begins with **over**, it means that something is too much/many. A **nano** prefix means the word is related to nanotechnology. Knowing the meaning of a prefix can help us guess the meaning of a word.

In order to find the target words, we have to type **prefix*** in the **SEARCH STRING** section. Then, you can hit **SEARCH**. The results will be listed.



The most common words with the prefix **over** are as follows: **overall**, **overcome**, **overseas**, **overwhelming** and **overnight**.

*Although **some questions remain, overall** the findings suggest that this is a topic that deserves further research.*

*The project has serious problems to **overcome before it can be considered a success**.*

*More and more companies are moving their plants **overseas**.*

*The hype for this technology is **overwhelming, it's difficult to envision that it will be as revolutionary as the media claim**.*

*The product was so successful that the firm became an **overnight** success.*

Exercise

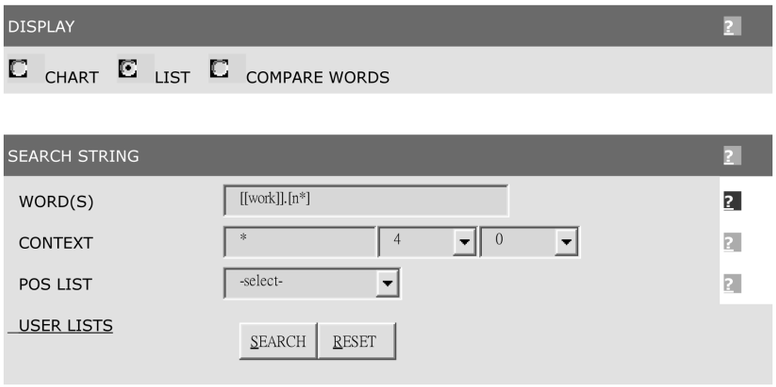
I *You can repeat the instructions above to search for the five most common words with the prefix **nano**.*

1.	2.	3.	4.	5.
nanotechnology				

Now, you can refer to the examples within ***COCA*** *or write sentences of your own.*

1. Nanotechnology enables us to create things at a very tiny scale.
2. _____
3. _____
4. _____
5. _____

In English, different parts of speech for a certain word sometimes share the same form. For example, **work** can be either a verb or a noun. Therefore, when we want to use **COCA** to look at the language behavior of words like this, we need to specify their part of speech. If we want to find out what words occur most frequently before the noun **work**, we can type **[[work]].[n*]** in the **WORD(S)** column. Select **4** and **0** in the **CONTEXT** column. Then click **SEARCH**.



The results are listed below:

SEE CONTEXT: CLICK ON WORD OR SELECT WORDS + [CONTEXT] [HELP...]

		CONTEXT	TOT		ALL	%	MI
1		SOCIAL	4502		132938	3.39	4.18
2		HARD	4367		118359	3.69	4.30
3		DOING	2474		139980	1.77	3.24
4		WHOSE	1161		74935	1.55	3.05
5		VOLUNTEER	535		8704	6.15	5.04

So the frequent combinations with the noun **work** are *social work, hard work, doing work, whose work* and *volunteer work.*

Exercise

II *Now use **COCA** to find the collocations for words with specific parts of speech. Write down the frequent combinations of the following words.*

1. function (verb) + (nouns) _____/_____/_____
2. (verb) _____/_____/_____ + function (noun)
3. (verbs) _____/_____/_____ + measure (noun)
4. measure (verb) + (nouns) _____/_____/_____
5. shape (verb) + (nouns) _____/_____/_____
6. (verbs) _____/_____/_____ + shape (noun)
7. broadcast (verb) + (nouns) _____/_____/_____
8. (verb) _____/_____/_____ + broadcast (noun)

Grammar—Adjectives: Present Participles and Past Participles

Two important types of adjectives in English are present participles and past participles. They are formed by adding the suffixes **ing** and **ed** to a verb stem, respectively. Although they are both adjectives, they have different meanings. In this part, we are going to learn the differences between present participles and past participles.

Exercise

I *First, please use the present participle form or the past participle form of the verb provided in parentheses to complete the following sentences from the article.*

1. Nanotechnology is arguably one of the most _____ (overhype) "next big things" in the recent history of _____ (apply) science.
2. Nanotechnology is a molecular _____ (manufacture) system that will allow us to fabricate objects of practically any arbitrary complexity.
3. The nanotube radio, invented in 2007 by physicist Alex Zettl and his colleagues at the University of California, Berkeley, performs a set of _____ (amaze) feats.
4. The nanoradio "would easily fit inside a _____ (live) cell," Zettl says.
5. One can envision interfaces to brain or muscle functions or radio-_____ (control) devices moving through the bloodstream.

6. Those nanotubes had some _____ (surprise) properties.
7. They came in a large variety of sizes and shapes: they were single-_____ (wall), double-_____ (wall) and _____ (multiwall).

Present participles and past participles can both be adjectives, but they have different meanings, as explained below.

1. As adjectives, present participles can describe how the objects they modify make people feel, whereas past participles describe the feelings of the subjects they modify.
   *The basketball game is **interesting**.*
2. Moreover, present participles possess an active voice, which means that the objects that they modify are able to perform the functions they denote. On the other hand, past participles possess a passive voice, which means that the states of the objects they modified are the consequences of certain actions.
   *This machine can function as a **lighting** device.*
   *Mary is trying to mend the **broken** fence.*
3. Finally, present participles describe an ongoing condition, whereas past participles describe a completed status.
   *I am talking about the **dancing** couple.*
   *John is a **retired** teacher.*

II *Please use the present participle or the past participle form of the verb provided in parentheses to complete the following sentences.*

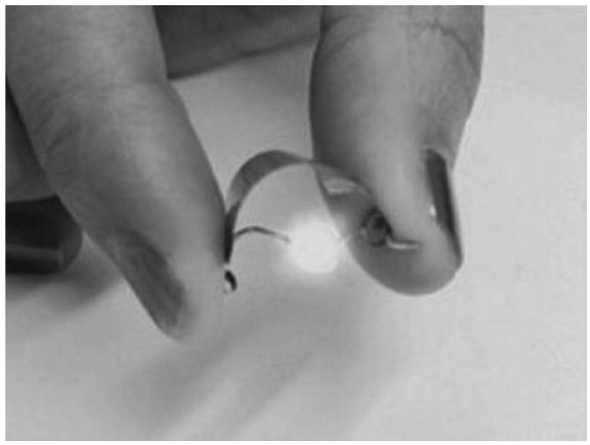
1. The tennis match that we went to last night was really _____ (excite).
2. To be honest, the party was not _____ (surprise) at all because I heard you guys talking about it the other day.
3. Ronald is pretty _____ (tire) of running the same experiment every day.
4. There seems to be no one living here. It looks like an _____ (abandon) house.
5. This is a really _____ (confuse) question. I can't solve it.
6. Bob is a really _____ (interest) person. That's why everyone likes to be friends with him.

7. After the typhoon, the garden was full of _____ (fall) leaves.
8. I knew that there was a _____ (hide) track on this CD.
9. Since my cell phone is being repaired, I need to buy a _____ (call) card for public telephones.
10. This is a _____ (cool) device that we use to keep the temperature of our computers down.

Task

Searching for information online

Nanotechnology has been applied in many areas, and some products, such as face creams and textiles, have already begun to hit the market. Here is a picture of a battery that utilizes nanotechnology.



In this part, you are going to practice using the Internet to search for information you need. Please work in groups of three to four. Find a product that utilizes nanotechnology, and search for the following details.

1. How is nanotechnology applied in this product?
2. What differences does the application of nanotechnology bring to this product?
3. Who is the target market for this product?

Please collect as much information as possible, and also find pictures to show what the product looks like. You will need to give a short presentation about this product at the end of the next lesson.