In this lesson you will examine some materials that are composed only of the element carbon. You will be provided models, labeled for identification, as model one, two, three and four, representing each of the materials.

**Part 1 – Models of carbon**

Examine each of the models and diagram the structure in its respective box below. Draw enough of the structure to show any repeating patterns and shapes.

Next to each of your drawings, describe in a way that you could use to explain to someone else, the structural characteristics and key features of the material.

<table>
<thead>
<tr>
<th>Model One</th>
<th>Description</th>
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<tbody>
<tr>
<td><img src="image" alt="Model One" /></td>
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<table>
<thead>
<tr>
<th>Model Two</th>
<th>Description</th>
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<td><img src="image" alt="Model Two" /></td>
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</table>
Using the models and the drawings you have created as a guide, list as many aspects of these materials as you can that are similar or different among them.

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Differences</th>
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Discussion
After a discussion of similarities and differences among these forms of carbon, what do you know now that you didn’t know before?

Questions
1. The different carbon materials that you have been examining, all of which are composed only of carbon, are referred to as “allotropes.” Based on the evidence that you have gathered over the course of investigating these models, what would your own definition be of the term allotrope?

2. The models you have been examining actually correspond to four allotropes of carbon, which are listed below. Write the number of the model that you think corresponds to the given allotrope in the blank next to the name.

   Model
   Graphite  _____
   Nanotube  _____
   Diamond  _____
   Buckyball _____

In Part 1 of this lesson you examined four common allotropes of carbon. Two of the members of this family, the buckyball and carbon nanotube, are key players in nanoscience because of their unique structure and behavior. In Part 2, which follows, we will take a closer look at the nature of these materials.
Part 2 – Buckyballs and nanotubes

1. Cut around the perimeter of the buckyball template
2. Cut along each dotted line to the darkened shape.
3. Cut out the shaded areas.
4. Beginning with the first numbered space, apply glue using a glue stick, on the side where the number is printed. Slide this ring under the adjoining ring, making a *five-sided hole surrounded by hexagons*.
5. Continue gluing the numbered shapes, making pentagon holes as you go, until the model is completed.
6. Draw a picture of your buckyball model in the box to the right. You do not have to draw the entire structure, but draw how it looks from one side of the sphere.

Questions:

1. Knowing that the geometric arrangement of atoms in a buckyball yields 12 pentagons and that all of the atoms in the structure lie at the vertices of a pentagon, describe a line of reasoning to determine the total number of carbon atoms in a buckyball.

   What do you think the chemical formula would be for a buckyball?

2. If you could examine the *inside* of a buckyball, what would you think you would find?

3. Scientists think that buckyballs could someday be used to transport other molecules into living cells for diagnosis and treatment of disease. What do you think would keep the molecules from “leaking out?”

4. What question would you want to ask so far about carbon or buckyballs?
**Comparing carbon nanotubes**

Use the transparencies provided to you to make three different models of carbon nanotubes. Draw a sketch of each model to show the arrangement of the carbon atoms for each of three models. You do not have to draw the entire tube; just draw it from the perspective of standing it on end and looking at it from the front side.

<table>
<thead>
<tr>
<th>model 1</th>
<th>model 2</th>
<th>model 3</th>
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**Questions:**

1. What do the lines in your transparent models represent?

2. Where are the atoms in your drawings?

3. What do you think would be inside a real nanotube?

4. Examine your nanotube models.
   (a) Describe how you could distinguish each type of nanotube from the others.

   (b) Give each of the models a name that you could use to distinguish one from another.

   Tube 1   Tube 2   Tube 3
Summary Questions:

1. Think about the models of the allotropes of carbon and how you imagine the real molecules might exist.
   a. Explain in what ways you think the models are like the real thing.
   b. What do you think that the models do not tell you about real materials the models represent?

2. Buckyballs and carbon nanotubes are still fairly new to scientists in the sense that some of their properties, as well as their potential hazards, are not known.
   a. Some people believe that when new materials, such as buckyballs and nanotubes, are advanced through technology, we should utilize them to their fullest potential for the maximum benefit to all. What is your opinion?
   b. What kinds of fears might some people have regarding new materials like these?
3. Despite their size, nanotubes have been shown to be as much as 200 times stronger than steel. Their electrical conductivity also varies with the three configurations, from conductor, semi-conductor, to non-conductor. Based on these properties, what do you think might be some possible uses for carbon nanotubes?

4. What do you think is the single most significant feature of buckyballs and nanotubes, compared to the other forms of carbon materials?

5. If you were to select one significant feature, more than any other, that makes the buckyball unique from the other allotropes, what would that one feature be?