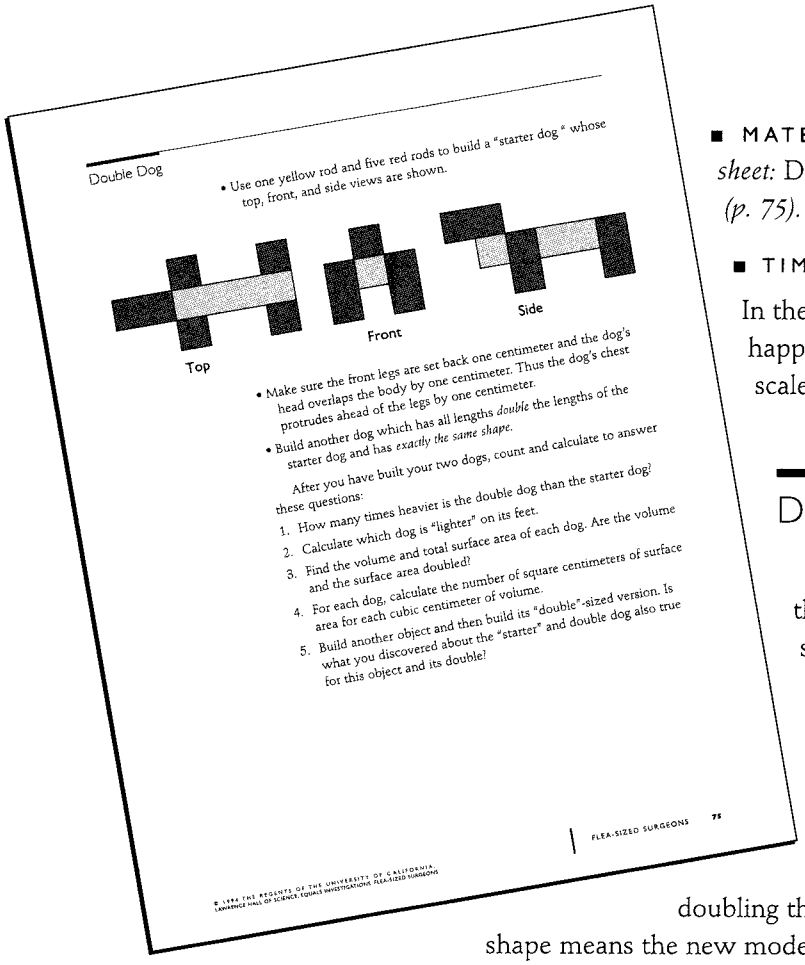
4 Scaling up to Double Size
Double Dog


Double Dog

• Use one yellow rod and five red rods to build a "starter dog" whose top, front, and side views are shown.

Top Front Side

• Make sure the front legs are set back one centimeter and the dog's head overlaps the body by one centimeter. Thus the dog's chest protrudes ahead of the legs by one centimeter.

• Build another dog which has all lengths *double* the lengths of the starter dog and has *exactly the same shape*.

After you have built your two dogs, count and calculate to answer these questions:

1. How many times heavier is the double dog than the starter dog?
2. Calculate which dog is "lighter" on its feet.
3. Find the volume and total surface area of each dog. Are the volume and the surface area doubled?
4. For each dog, calculate the number of square centimeters of surface area for each cubic centimeter of volume.
5. Build another object and then build its "double"-sized version. Is what you discovered about the "starter" and double dog also true for this object and its double?

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■ MATERIALS: *Cuisenaire rods, tac putty, student worksheet:* Double Dog *(p. 75);transparency:* Double Dog *(p. 75).*

■ TIME: *1 hour*

In the next two sessions students will study what happens to area, volume, and weight as objects are scaled up in size.

Double Dog

In the task *Double Dog,* students experience the effects of scaling up an object to a larger size while keeping the exact same shape. This may be their first experience in school with 3D similar shapes. However, most students will have had some experience with scaled-down models such as toy cars, action figures, dolls, etc.

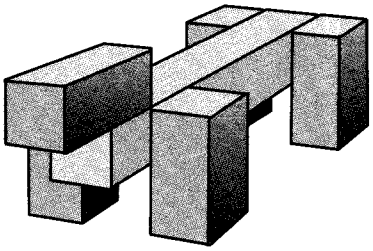
During this task remind them that doubling the "starter dog" keeping exactly the same shape means the new model will have the same shape from all viewpoints. For a 3 D object, this means doubling each of the three dimensions; length, width, and height. When dimensions are doubled, they will discover that surface area and volume are more than doubled. (In fact, they are multiplied by factors of four and eight respectively.)

■ BUILDING A DOUBLE DOG

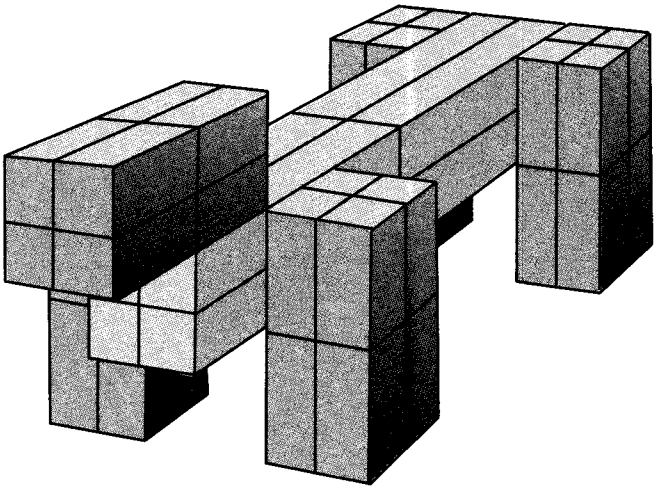
It is important that all groups begin with the same "starter dog." This same "starter dog" is also used in the next session in *Monster Dogs.*

Ask each group to build a "starter dog" with one yellow rod and five red rods like the one shown on page 27.

An important feature of this dog is that its front legs are set back one centimeter and the dog's head overlaps the body by exactly one centimeter. Thus the dog's chest protrudes ahead of the legs exactly one cubic centimeter.



The Starter Dog



■ THE DOUBLE DOG TASK

Each group builds another dog out of rods with double the dimensions of the starter dog and exactly the same shape. Mathematically, the two dogs are said to be similar. In building the double dog, it may be necessary to join rods of different colors to make longer rods.

Circulate about the classroom as students work. Many groups will take a ten-rod and five four-rods and build a dog. This dog, however, is far too skinny. For groups that build such a dog it may be useful to talk about scale models of 3D objects such as matchbox cars. If a matchbox car were only stretched out to twelve feet long, it wouldn't look like a real car at all. Not only must its length be stretched out, but its width and height must be stretched proportionately for the resulting car to have the same shape as a real car.

After a while most groups will build a dog shaped something like the one above (rod colors may vary but all the final dimensions should be the same). Don't show them the picture of this dog; let them figure it out for themselves. They can validate their own result by holding up the two dogs and sighting them with one eye.

Once a group has built an accurate version of the double dog, give each person in the group a sheet of square centimeter paper. Ask each of them to find the two dogs' surface areas and volumes and draw an accurate top, front, and side view of the starter dog and double dog.

* *The starter dog has a surface area of 62 cm^2 and a volume of 15 cm^3. The actual surface area and volume of the double dog should be 248 cm and 120 cm^3, respectively. If all groups don't come up with these numbers, ask groups to re-count and justify their answers until all agree. Let them convince each other. Also for your information, some answers:*

#1 Eight times as heavy;

#2 The small dog is lighter on its feet. Since both dogs are built of the same material, the weight of each cubic centimeter is the same for both. If 1 cm^3 weighs 1 unit, then the small dog has 15/4 = 3.75 units per cm^2 of foot area. The double dog has 120/16 = 7.5 units.

#3 see above.

#4 small 4.13; double 2.07. Since heat transfer takes place through the skin, the small dog would be twice as sensitive to temperature changes.

#5 You may have groups who built another object and its double share their information with the rest of the class.