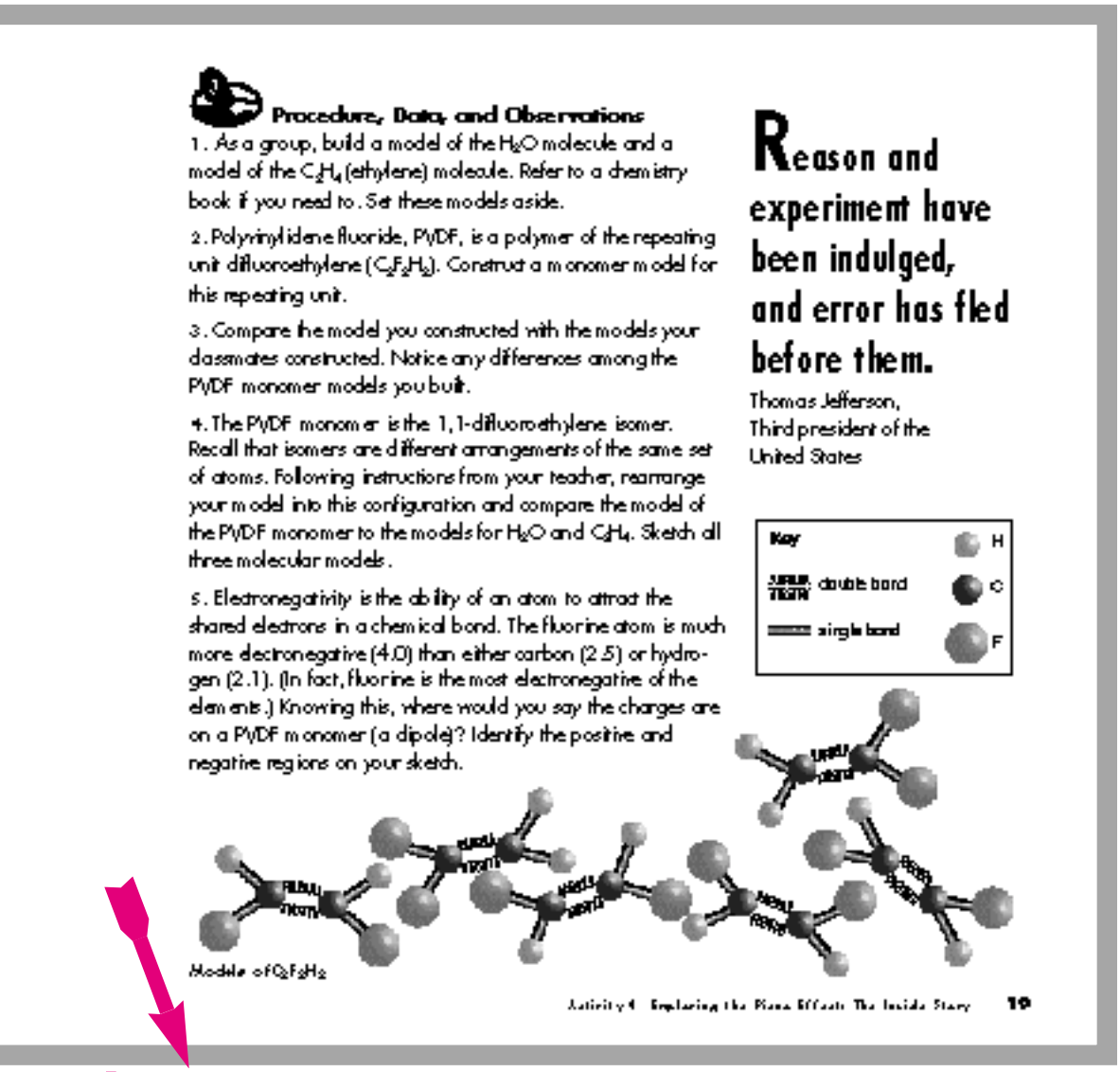

Procedure, Data, and Observations

1. As a group, build a model of the H_2O molecule and a model of the C_2H_4 (ethylene) molecule. Refer to a chemistry book if you need to. Set these models aside.

2. Polyvinylidene fluoride, PVDF, is a polymer of the repeating unit difluoroethylene ($C_2F_2H_2$). Construct a monomer model for this repeating unit.

3. Compare the model you constructed with the models your classmates constructed. Notice any differences among the PVDF monomer models you built.

4. The PVDF monomer is the 1,1-difluoroethylene isomer. Recall that isomers are different arrangements of the same set of atoms. Following instructions from your teacher, rearrange your model into this configuration and compare the model of the PVDF monomer to the models for H_2O and C_2H_4. Sketch all three molecular models.

5. Electronegativity is the ability of an atom to attract the shared electrons in a chemical bond. The fluorine atom is much more electronegative (4.0) than either carbon (2.5) or hydrogen (2.1). (In fact, fluorine is the most electronegative of the elements.) Knowing this, where would you say the charges are on a PVDF monomer (a dipole)? Identify the positive and negative regions on your sketch.

Reason and experiment have been indulged, and error has fled before them.

Thomas Jefferson,
Third president of the United States

Key
double bond
single bond
H
C
F

Models of $C_2F_2H_2$

Activity 4 Exploring the Piezo Effect: The Inside Story 19

Discussing the Quote

Let the class discuss ways in which error flees before reason and experiment in their classroom experiences. You might ask which they think makes error flee more quickly, reason or experiment. If you wish, point out that Jefferson was one of the earliest scientific thinkers in the United States. This quote comes from his *Notes on the History of Virginia.*

Note on Ethylene

Following the IUPAC system for naming organic compounds, ethylene would correctly be called ethene. However, the common name ethylene has been used for many years and is accepted by IUPAC. This book uses the familiar ethylene.

Procedure, Data, and Observations

1. Before students begin, you may wish to review with them the rules for building ball-and-stick models. You could demonstrate how to build a water molecule or a simple diatomic molecule with which they are familiar. Emphasize that such models are theoretical representations, intended to help them understand some of the properties of the molecules they represent, rather than exact structural replicas of actual molecules. If necessary, help students then build a model of ethylene, attaching the two carbons with a double bond and attaching two hydrogens to each carbon. Explain that they will use this model later to better understand the structure of PVDF.

2. If necessary, review with students the definitions of monomer and polymer. You might remind them that many of the organic molecules in their bodies are polymers. Allow them to build their difluoroethylene models, reminding them that each monomer should contain two carbons, two hydrogens, and two fluorines. As students arrange the $C_2F_2H_2$ isomers, point out that there are no "wrong" ways to construct the molecule as long as they use the right constituent atoms.

3. Review the definition of isomer if necessary. Based on this, ask students to explain how a single structural formula can yield more than one molecular model. The drawings on page 19 represent six possible combinations of two carbons, two hydrogens, and two fluorines. Only three are isomers of difluoroethylene. The PVDF isomer, CF_2CH_2, is second from the left.

4. Use the diagrams here and on page 25 to help student pairs change their monomer models into the proper isomer. Remind them that the PVDF monomer is one particular isomer, 1,1-difluoroethylene. The other two are 1,2 *cis*- and 1,2 *trans*-isomers. (In the *cis*-isomer, like groups are adjacent to each other, whereas in the *trans*-isomer like groups are diagonally across from each other.) If you wish, review these isomer names with your students. Hold up one of the correct isomers and tell students to rearrange their molecules until they are congruent with the example. Check with each group to make sure everyone has the correct arrangement. The models must match for students to be able to build polymers in Part B.

5. Go over the structure of the PVDF isomer in detail. Guide students to recognize the planar nature of this molecule, the relative sizes of the atoms, and the double bond between the carbons. Review the concept of electronegativity and the relative electronegativities of the constituent atoms. Show students how they can use electronegativity to locate the charged regions of the isomer. (Fluorine will be slightly negative and hydrogen slightly positive.)