List of Experiments

Epilogue

Misconceptions: They are hard; they have no rules; they are unstructured! The caption in one of Gary Larson's comics seems to best summarize this: "*Shhhh, Zog! . . . Here comes one now!*"

The work in this book represents a thorough and significant advance in the study of student misconceptions in chemistry. The research reported here, conducted in Germany, the United States, and Ethiopia, explored several common misconceptions about chemistry, and examined diverse ideas of conceptual change that describe how to correct or prevent such misconceptions.

This research adds to existing studies in two major ways: (1) it extends the diagnostic study of students' misconceptions, and (2) it uses a research methodology that allows for the testing of new approaches and strategies to avoid and cure this problem. In this direction one has to differentiate preconcepts and school-made misconceptions: the first ones are brought by young students from observing every-day life, the second ones are developed by inappropriate teaching or by difficult chemistry contents.

Empirical studies of the last decades show that in many countries the same misconceptions are found year after year and nothing changes to improve the situation. So the authors suggest several meaningful ways to prevent and deal with students' chemistry misconceptions. The first reported way is about students initially performing key experiments, followed by discussion of their ideas and understanding, and finally teaching the chemistry concept. The second approach starts by teaching the scientific concept, recounting students' individual misconceptions, finally comparing and defending the new attained chemistry concept by constructively criticizing their prior knowledge. Both ways involve the use of structural models and model drawings which help in the development of students' mental models to facilitate their understanding of the 3-D arrangement of atoms and ions – the base of understanding chemistry. In addition, students will improve their spatial ability with the use of structural models.

We urge everyone to apply the ideas in this book in his or her classroom presentations. Even with limited time and materials, some of the smaller, more simple changes can be accomplished. The authors hope that this book will stimulate serious discussions at all educational institutions to cure preconcepts and successfully to prevent school-made misconceptions. We expect that these

fruitful debates and studies will also take into account the need for new or reallocated methods to implement and support improved presentations of chemical material. We welcome comments about this work from students, teachers, and college-level faculty members.

In conclusion, we believe that the research and practical contributions of our studies will inspire future research in this area. Indeed, the design and the results of these studies will provide useful background for replication and expansion to other areas and topics in school and college STEM (Science, Technology, Engineering and Mathematics) courses. College STEM departments could also invite colleagues from schools or colleges of education to focus on issues of teacher preparation and professional development. This will also help improve the scientific literacy of *all*.

A final thought: We would like to quote Albert Einstein, *"You do not really understand something unless you can explain it to your grandmother"*. This is not just a cute and interesting statement, but it is also true. We hope that, with the help of to the material presented in this book, more grandmothers will receive clear and truthful explanations and fewer chemistry misconceptions.